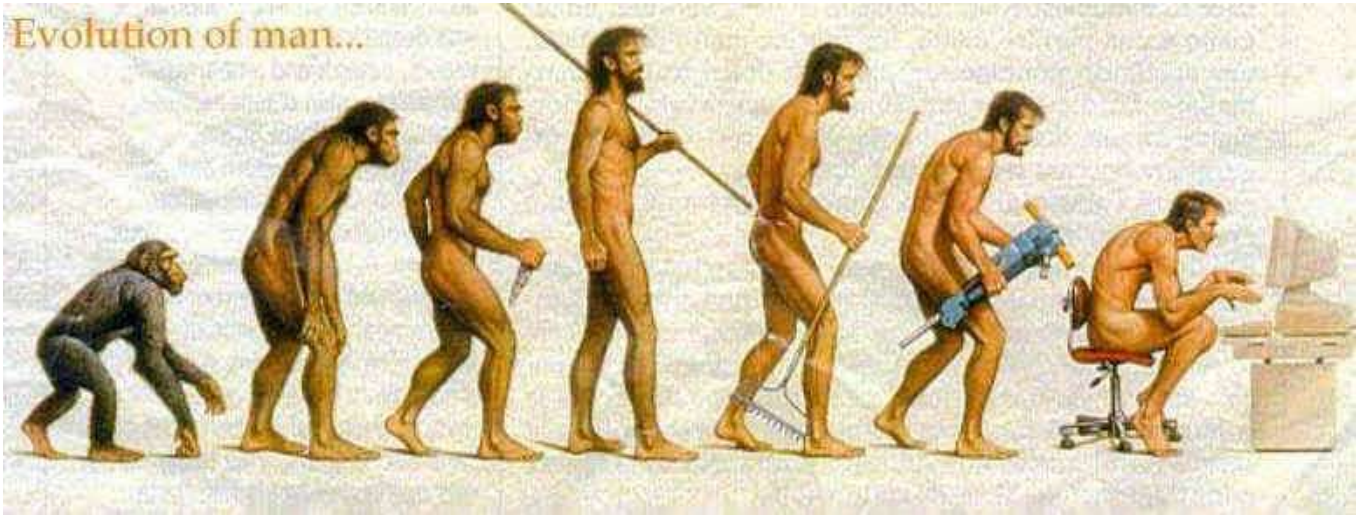
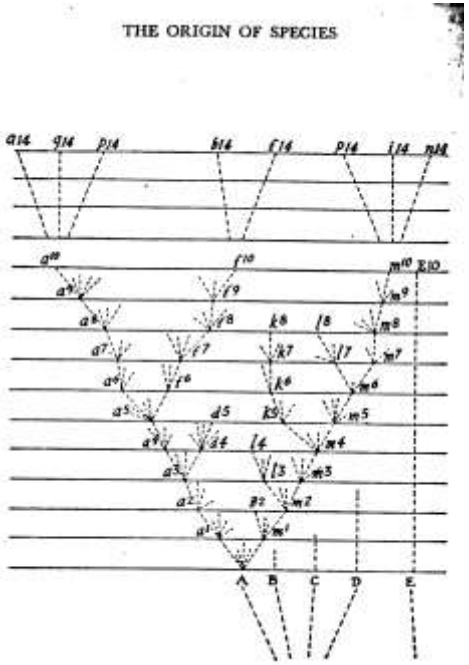
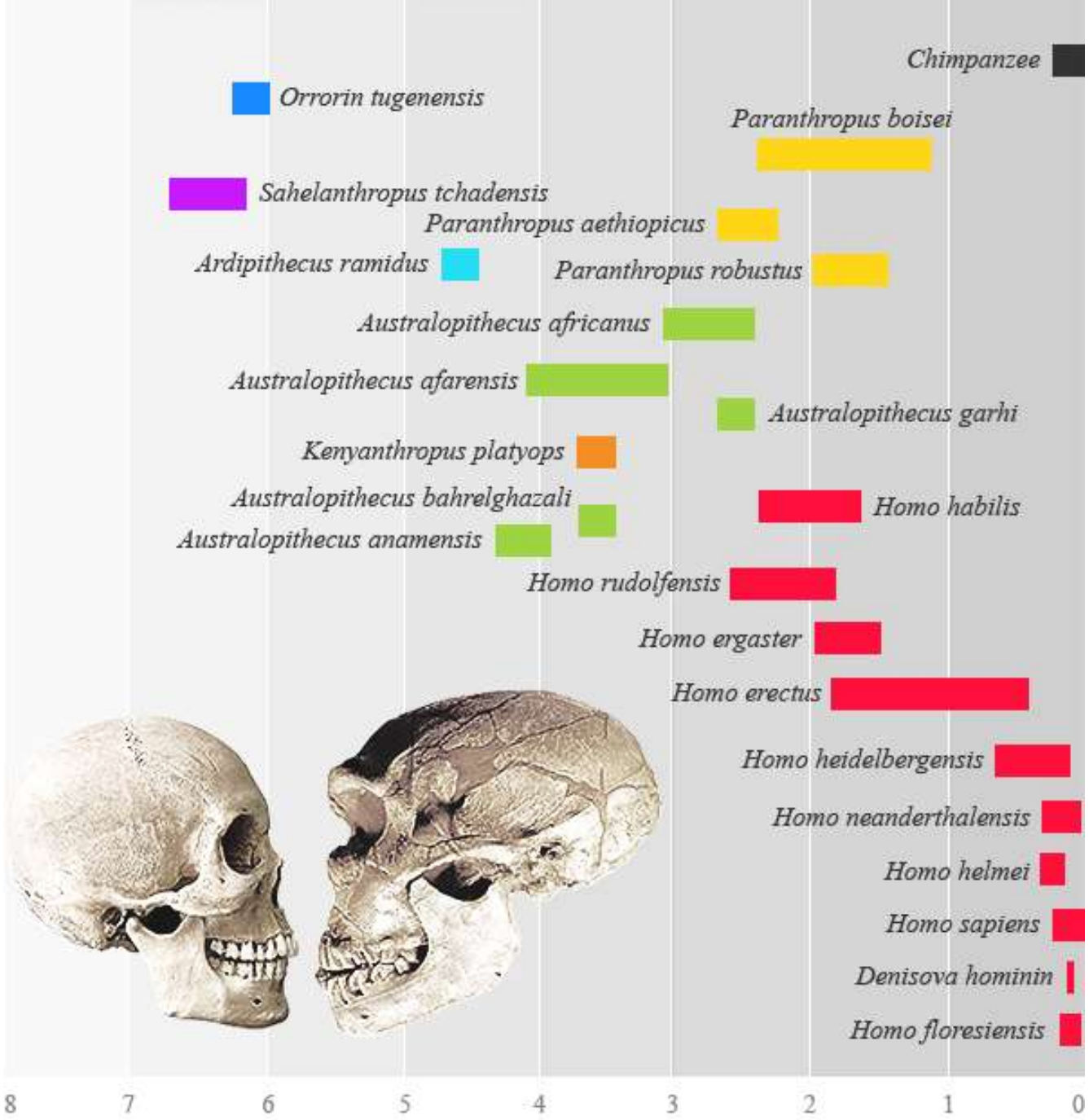
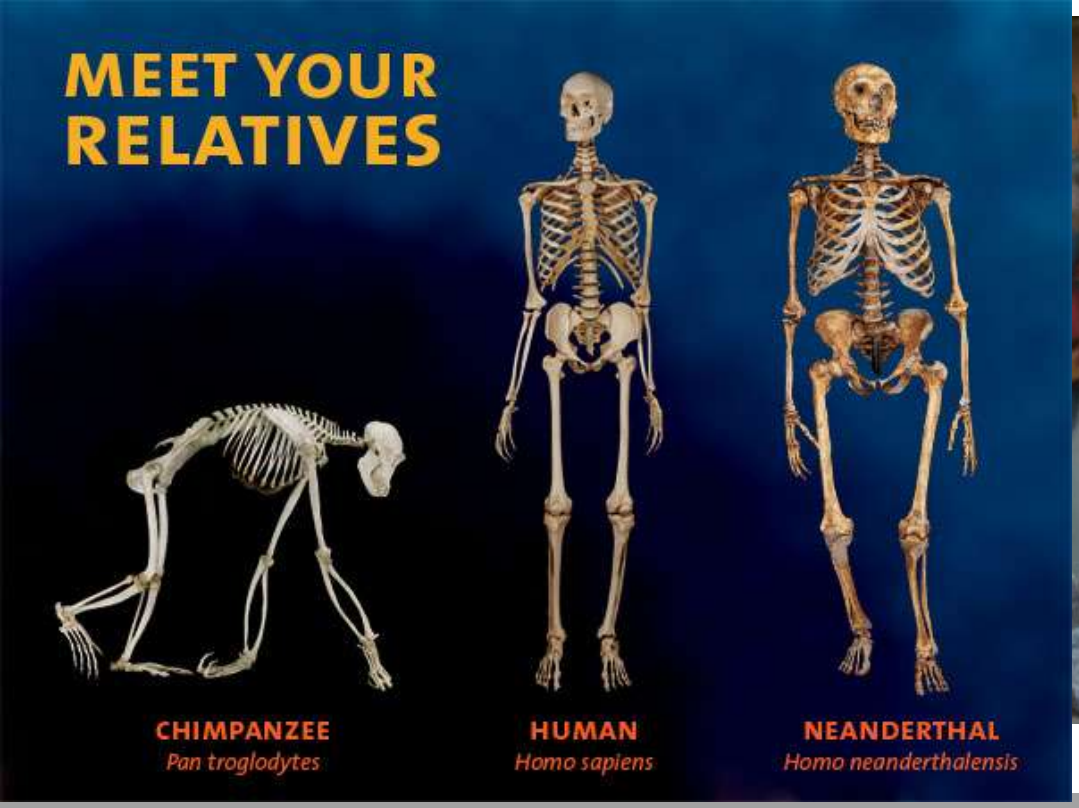
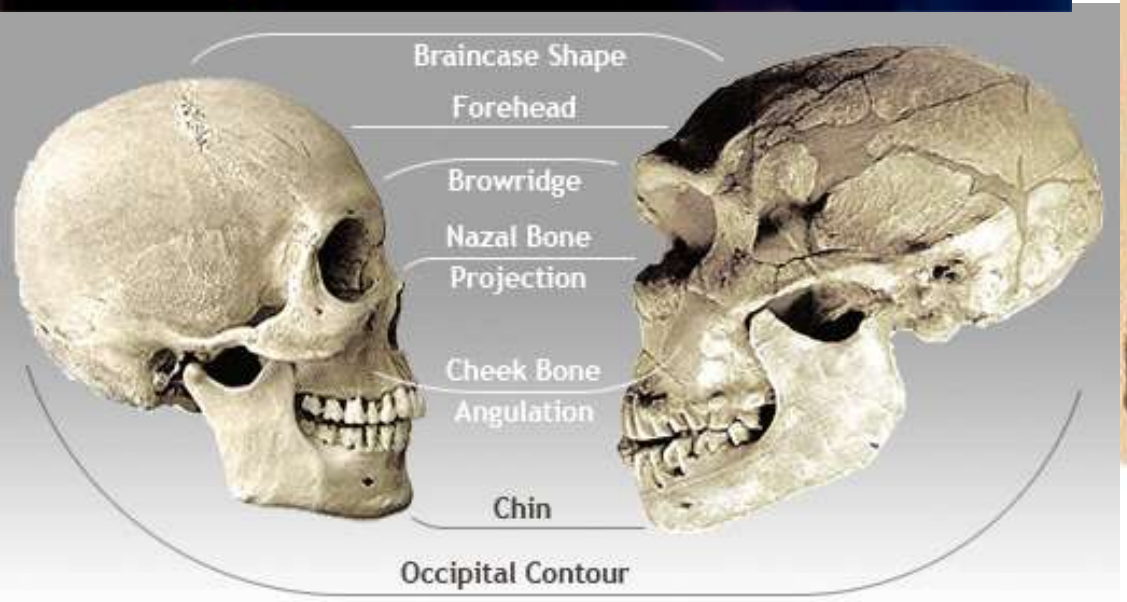
History of Evolutionary Thinking






Chimpanzee
Orrorin tugenensis
Paranthropus boisei
Sahelanthropus tchadensis
Paranthropus aethiopicus
Ardipithecus ramidus
Paranthropus robustus
Australopithecus africanus
Australopithecus afarensis
Australopithecus garhi
Kenyanthropus platyops
Australopithecus bahrelghazali
Homo habilis
Australopithecus anamensis
Homo rudolfensis
Homo ergaster
Homo erectus
Homo heidelbergensis
Homo neanderthalensis
Homo helmei
Homo sapiens
Denisova hominin
Homo floresiensis
8
7
6
5
4
3
2
1
0



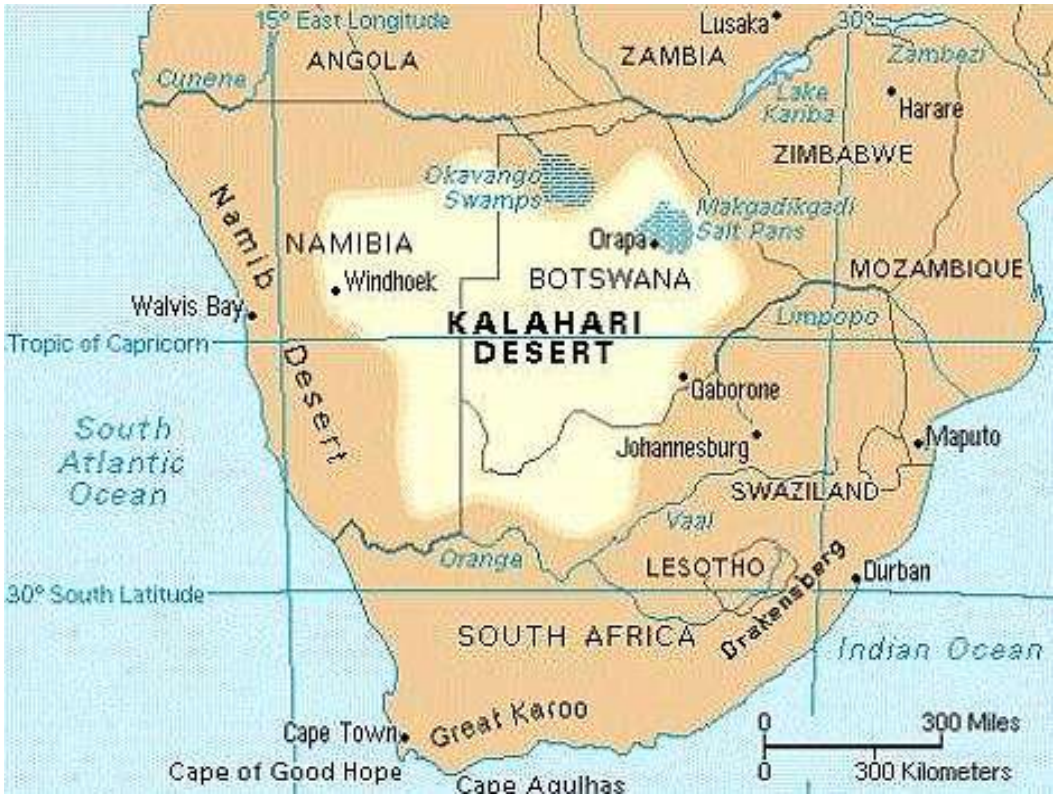


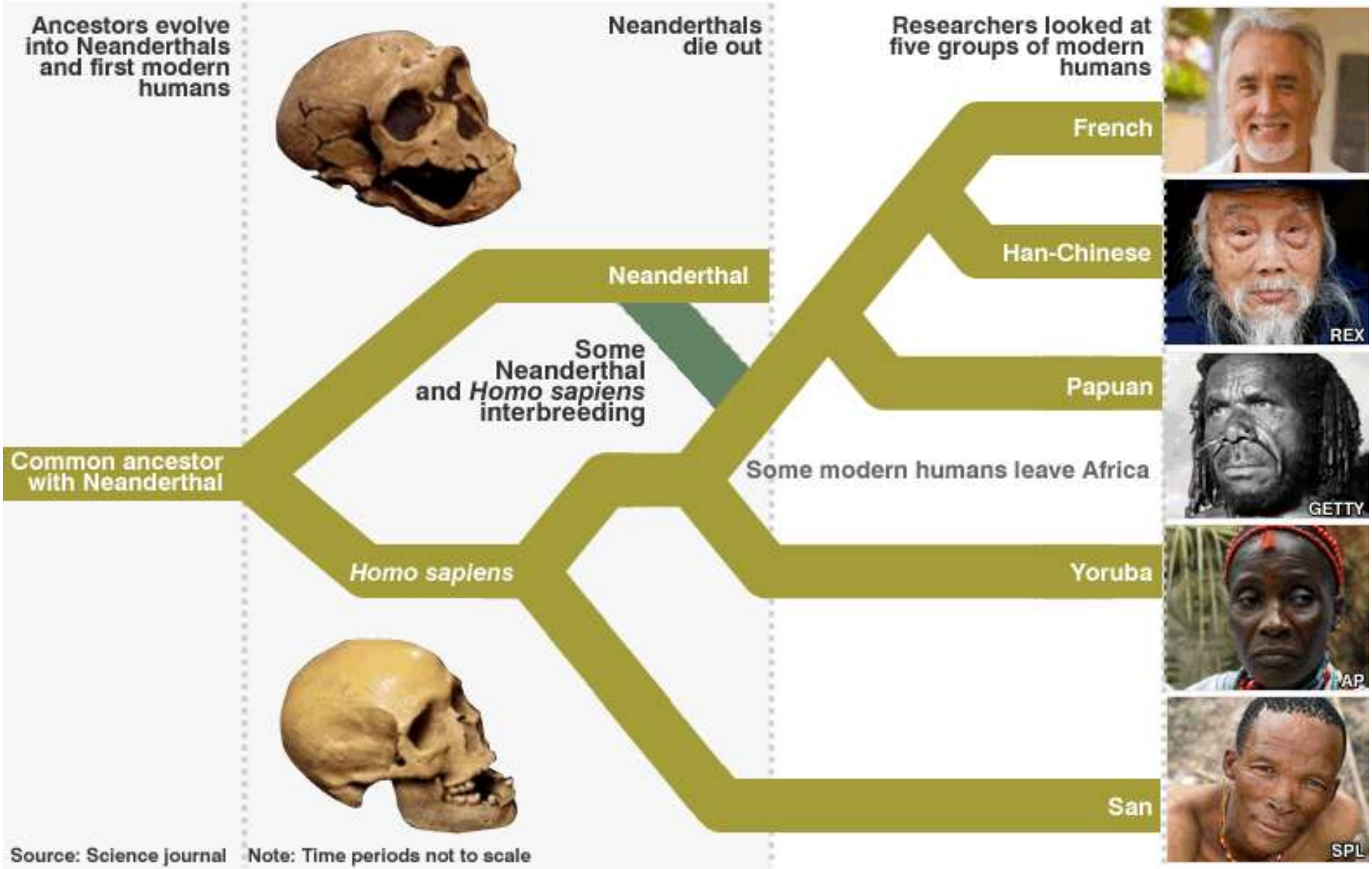
26,000 year old Cro-Magnon
Mammoth Ivory self portrait

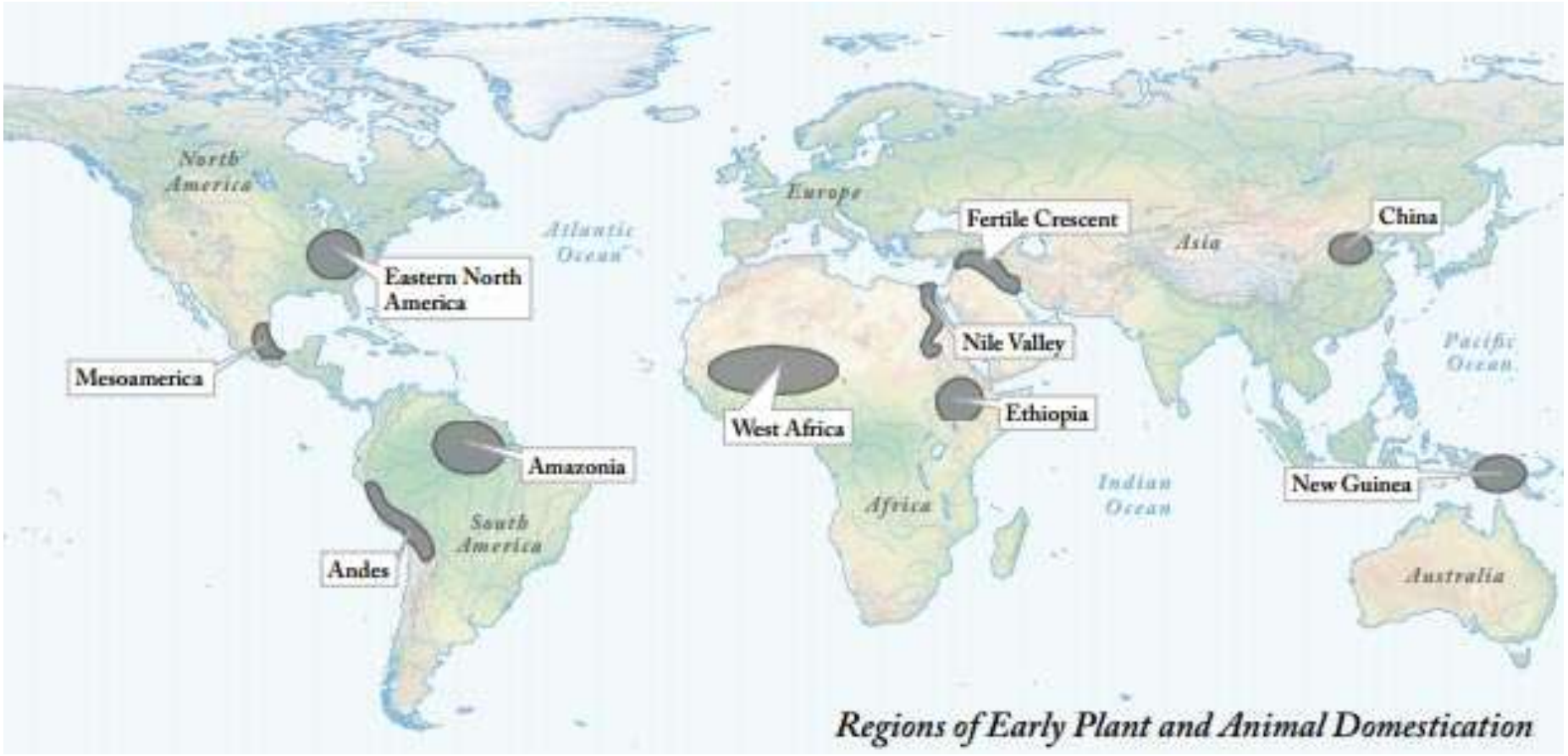
Cave Paintings – Lascaux, France – Cro-Magnon - 17,300 years old

Shamanism – Nature Worship - Animism

"In the very earliest time,
when both people and animals lived on earth,
a person could become an animal if he wanted to
and an animal could become a human being.
Sometimes they were people
and sometimes animal
and there was no difference.
All spoke the same language.
That was the time when words
were like magic.
The human mind had mysterious power.
.....
Nobody could explain this:
That's the way it was."
Translated from Innuit by Edward Field


15° East Longitude
ANGOLA
Lusaka
ZAMBIA
30°
Zambezi
Cunene
Lake Kariba
Harare
ZIMBABWE
Okavango Swamps
Makgadikgadi Salt Pans
Namib
NAMIBIA
Orapa
Windhoek
BOTSWANA
MOZAMBIQUE
Walvis Bay
KALAHARI DESERT
Limpopo
Tropic of Capricorn
Gaborone
Desert
South Atlantic Ocean
Johannesburg
Maputo
SWAZILAND
Vaal
Orange
LESOTHO
Durban
30° South Latitude
SOUTH AFRICA
Drakensberg
Indian Ocean
Great Karoo
Cape Town
0
300 Miles
Cape of Good Hope
Cape Agulhas
0
300 Kilometers


Ancestors evolve into Neanderthals and first modern humans
Neanderthals die out
Researchers looked at five groups of modern humans
French
Han-Chinese
Papuan
Yoruba
San
Neanderthal
Some Neanderthal and Homo sapiens interbreeding
Common ancestor with Neanderthal
Homo sapiens
Some modern humans leave Africa
REX
GETTY
AP
SPL
Source: Science journal
Note: Time periods not to scale



Regions of Early Plant and Animal Domestication

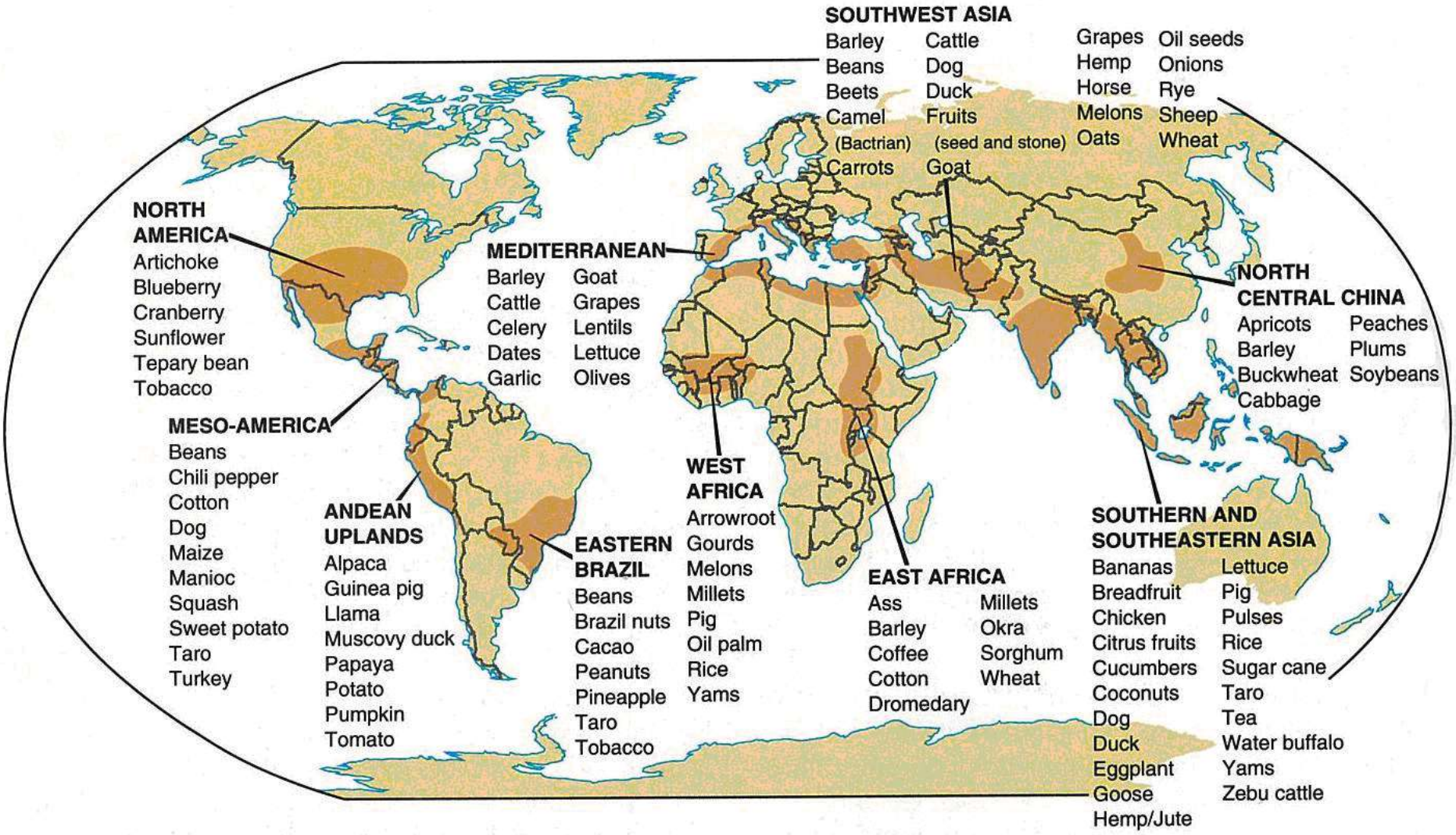
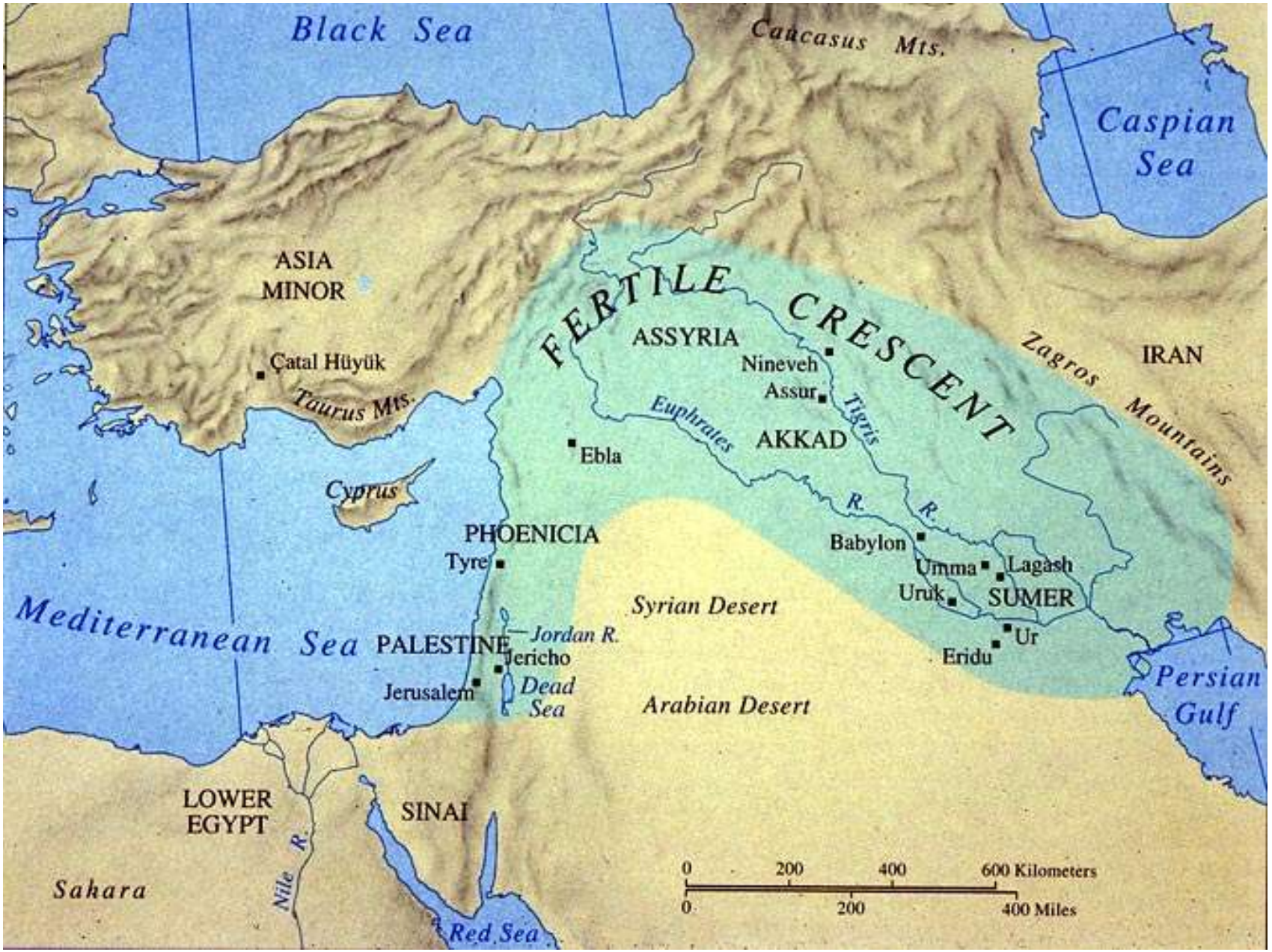


Figure 7–1. This map shows the origins of the world's food crops and domesticated animals. These plants and animals have been so widely redistributed, however, that today's leading producers of many of these are not the same as the areas in which they were first domesticated.

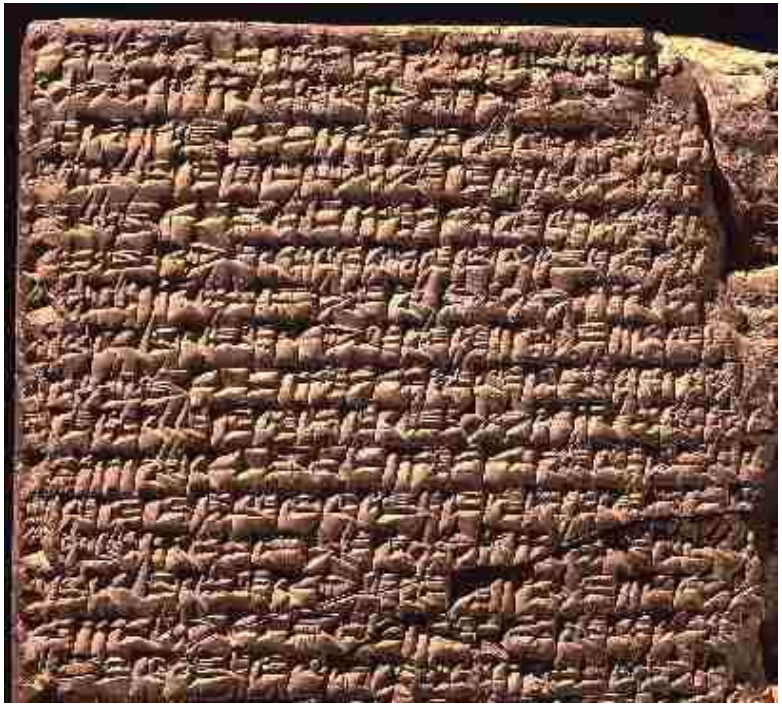
Domestication of Plants and Animals



Agriculture and domesticated animals allowed first cities, larger economy, writing etc.

Eridu, founded 5,400 BC

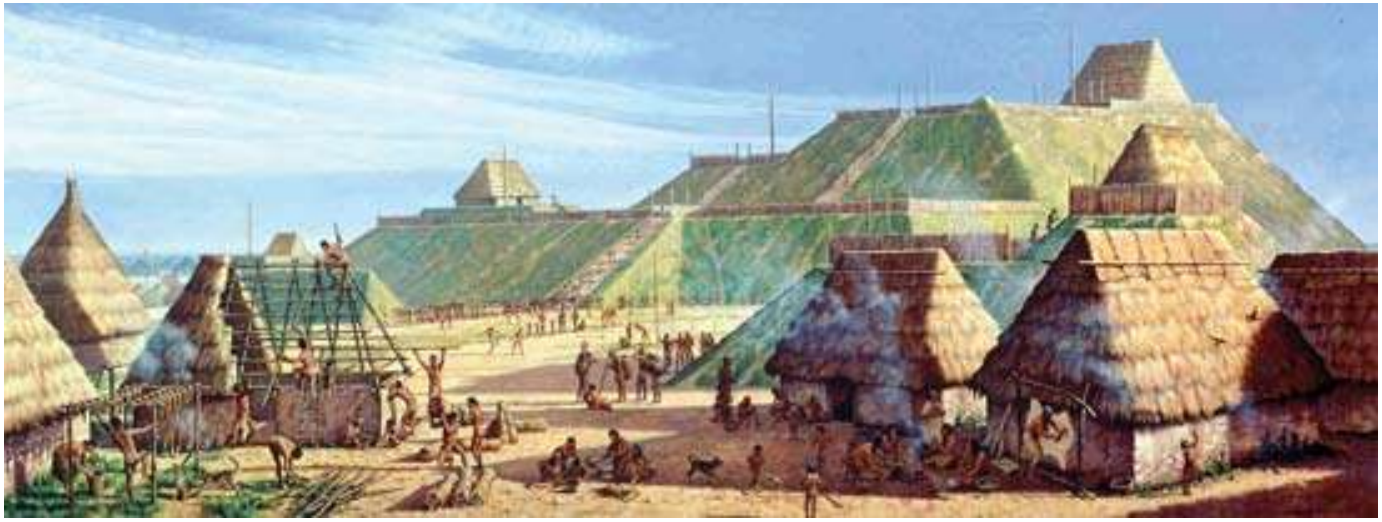
early Sumerian clay tablet with cuneiform script



creation myths

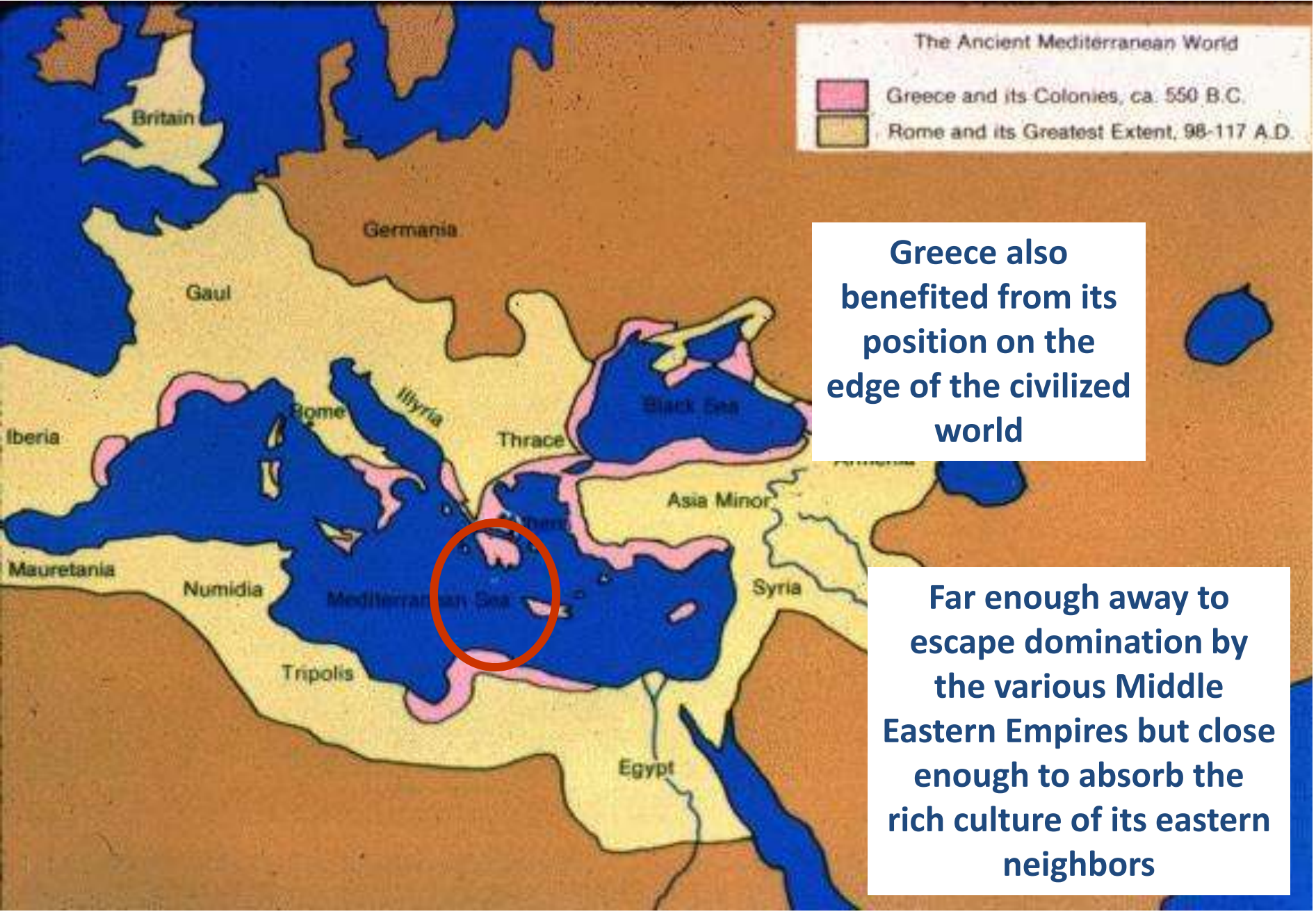
Teotehuacan, Mexico

Cahokia,
Illinois

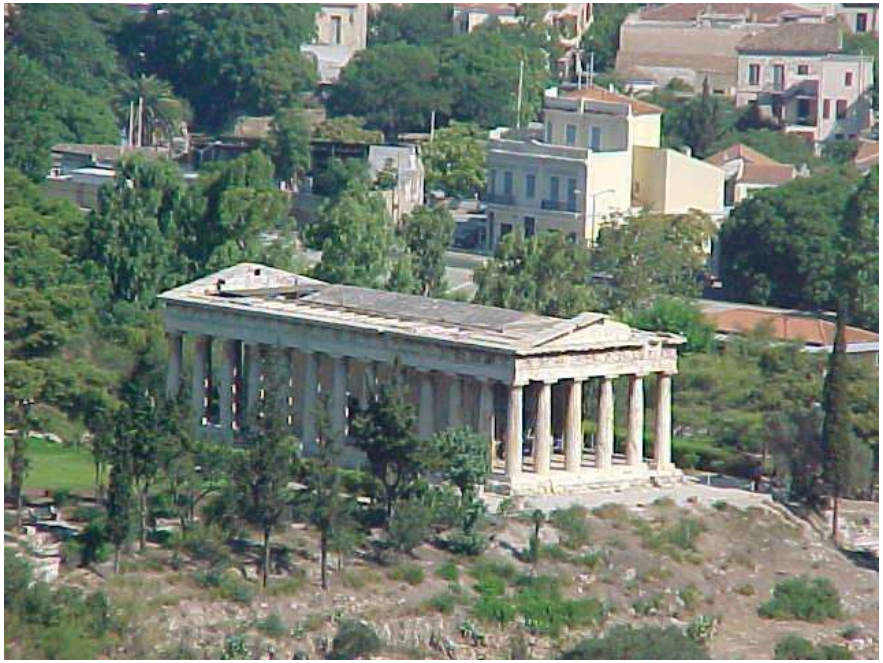


ANCIENT GREECE

- Region of isolated valleys, hills, small plains, peninsulas, and islands
  - Sea formed its focal point
- Nothing more than barbarous fringe area to older civilizations of the Middle East
  - Tiny, unimportant, and poor in natural resources

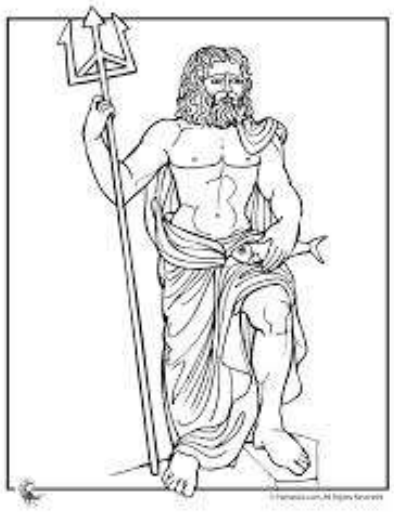

The Ancient Mediterranean World
Greece and its Colonies, ca. 550 B.C.
Rome and its Greatest Extent, 98-117 A.D.
Britain
Germania
Gaul
Iberia
Rome
Illyria
Thrace
Black Sea
Asia Minor
Mauretania
Numidia
Mediterranean Sea
Syria
Tripolis
Egypt
Greece also benefited from its position on the edge of the civilized world
Far enough away to escape domination by the various Middle Eastern Empires but close enough to absorb the rich culture of its eastern neighbors

Greek Architecture



Lincoln Memorial

Greeks wrote books (scrolls) and maintained large libraries
Major works were later copied by Romans
Many lost during the Dark Ages



Polytheistic – many gods; contrasts strongly with the monotheism of Judaism, Christianity, and Islam.

Democracy – citizens vote for elected officials.

These permitted the development of philosophy and early science, because neither an all-powerful single god nor a powerful priesthood claimed a monopoly on thought about the natural and supernatural. Nothing prevented Greeks from coming to different conclusions and debating issues openly.

This permitted the early development of three great Greek science traditions:

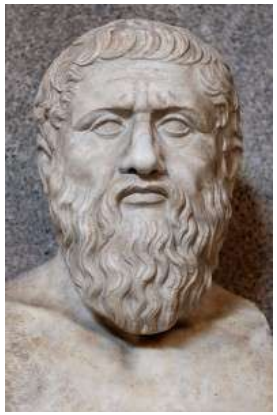
Natural History: Detailed knowledge of the lives of local plants and animals: Aristotle wrote *Historia animalium,* an encyclopedia about animals; Theophrastus wrote about plants.

Biomedical Tradition of school of Hippocrates, whose works developed a great body of anatomical and physiological knowledge and theory.

Philosophy of Science: seek natural causes for natural phenomena. They frequently sought a unifying concept, and some postulated an ultimate cause or "key element" from which all else originated.

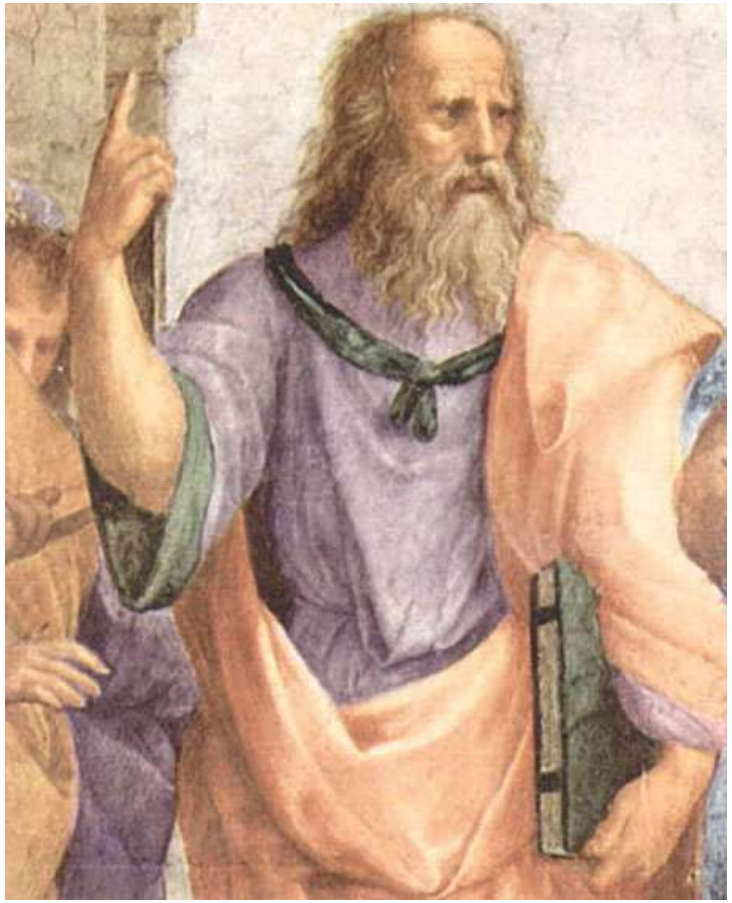
Greek
Philosophers and Thinkers

- Philosophers: Socrates, Plato, Aristotle
- Logical thinking, rhetoric, politics
- Playwrights: Sophocles, Euripides, Aeschylus
- Science and Mathematics: Hippocrates, Epicurus, Archimedes, Pythagoras
- Academies for higher education



Plato's school of philosophy, founded approximately 385 BC at Akademia

fresco by Raphael (1509–1510), of an idealized Academy, Plato and Aristotle entering



Plato (c. 427 BC – c. 347 BC)

- immensely influential classical Greek philosopher, mathematician,
- student of Socrates, teacher of Aristotle,
- writer of philosophical dialogues, and founder of the Academy in Athens.
- Along with his mentor, Socrates, and his student, Aristotle, Plato helped to lay the foundations of Western philosophy and science.

Plato's Idealism

- The observable world is no more than a shadowy reflection of underlying ideal forms.
- The ideals are true and eternal, more real than what we see with the senses.
- Triangle Example – no matter what the angles are, it remains a triangle
- Became basis for Essentialism, the search for eternal "ideal forms" in objects and animals.
- He had little use for observations of natural history, and his emphasis on the soul permitted, through his followers, a connection with later Christian dogma which dominated the thinking of western society up to the 17th century.

THE PLATONIC DIVIDE

heaven ---/--- earth

perfect ---/--- corrupted

divine ---/--- human

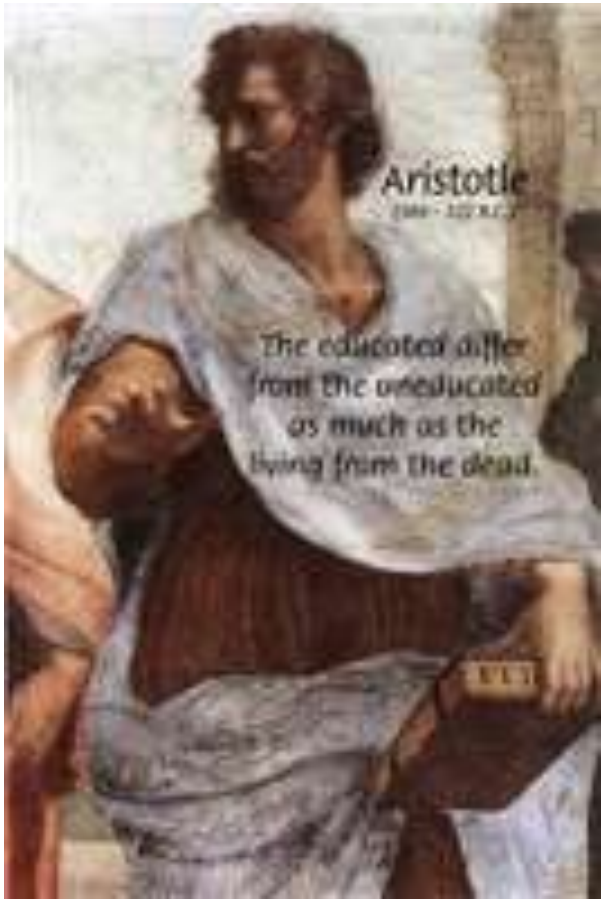
eternal ---/--- finite

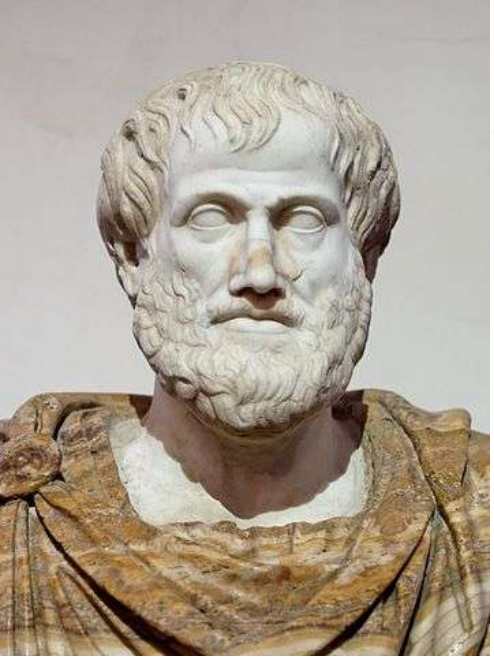
spiritual ---/--- material

pure ---/--- contiminated

Aristotle (384-322 BC)

- Student of Plato
- Knowledge of biological matters was vast.
- Wrote books about life histories of animals, and about reproductive biology, intensely interested in the phenomenon of biological diversity.
- Grouped animals according to certain criteria and his arrangement of the invertebrates was superior to that of Linnaeus 2000 years later.
- Interested in the characteristics of plants and animals, which he felt had biological meaning, or, as we would say today, adaptive significance.
- Aristotle was not satisfied to ask how-questions, but was amazingly modern by also asking why-questions. Why does a species end up with a particular set of characteristics and not another?





Aristotle's *Scala Naturae*

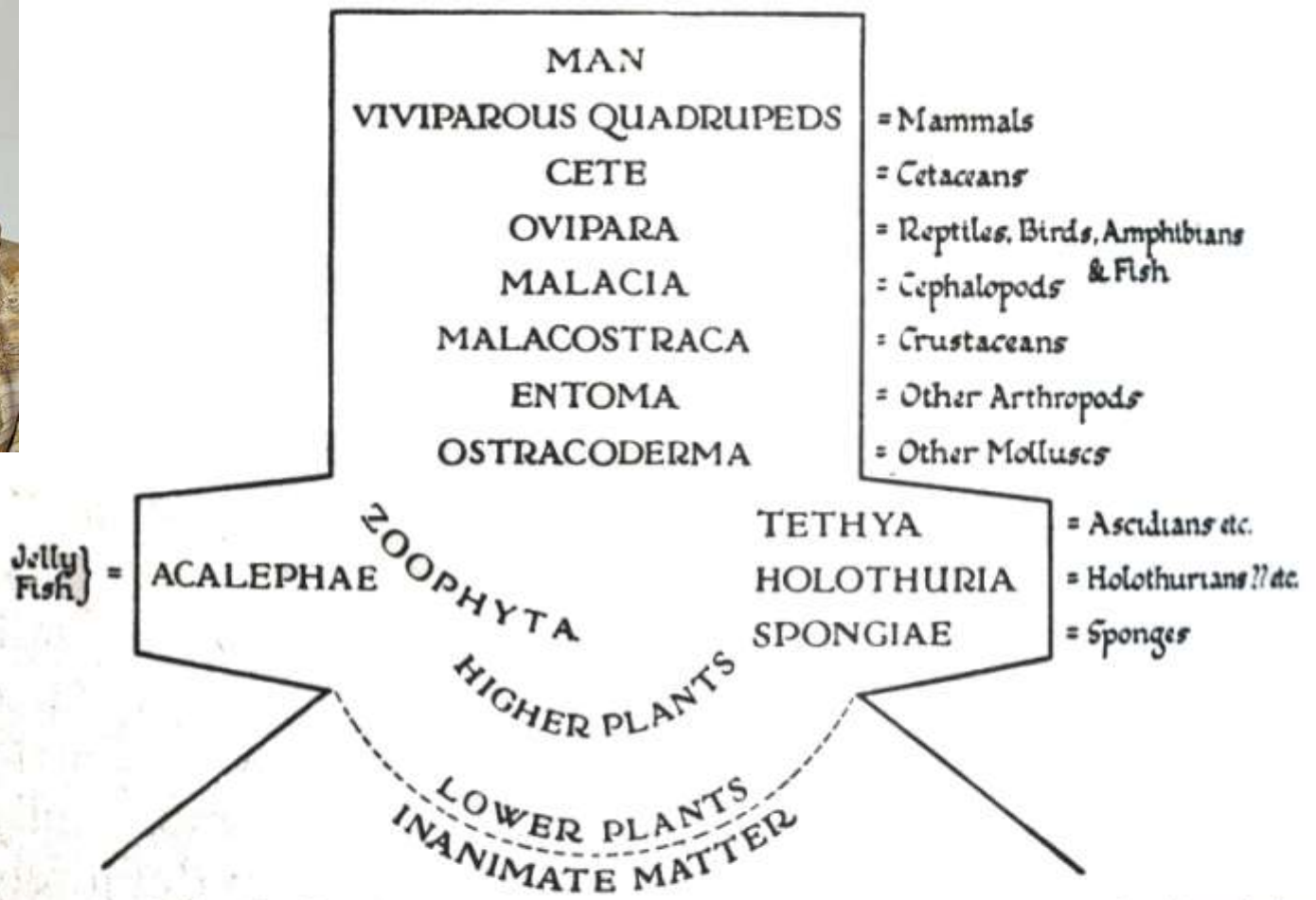
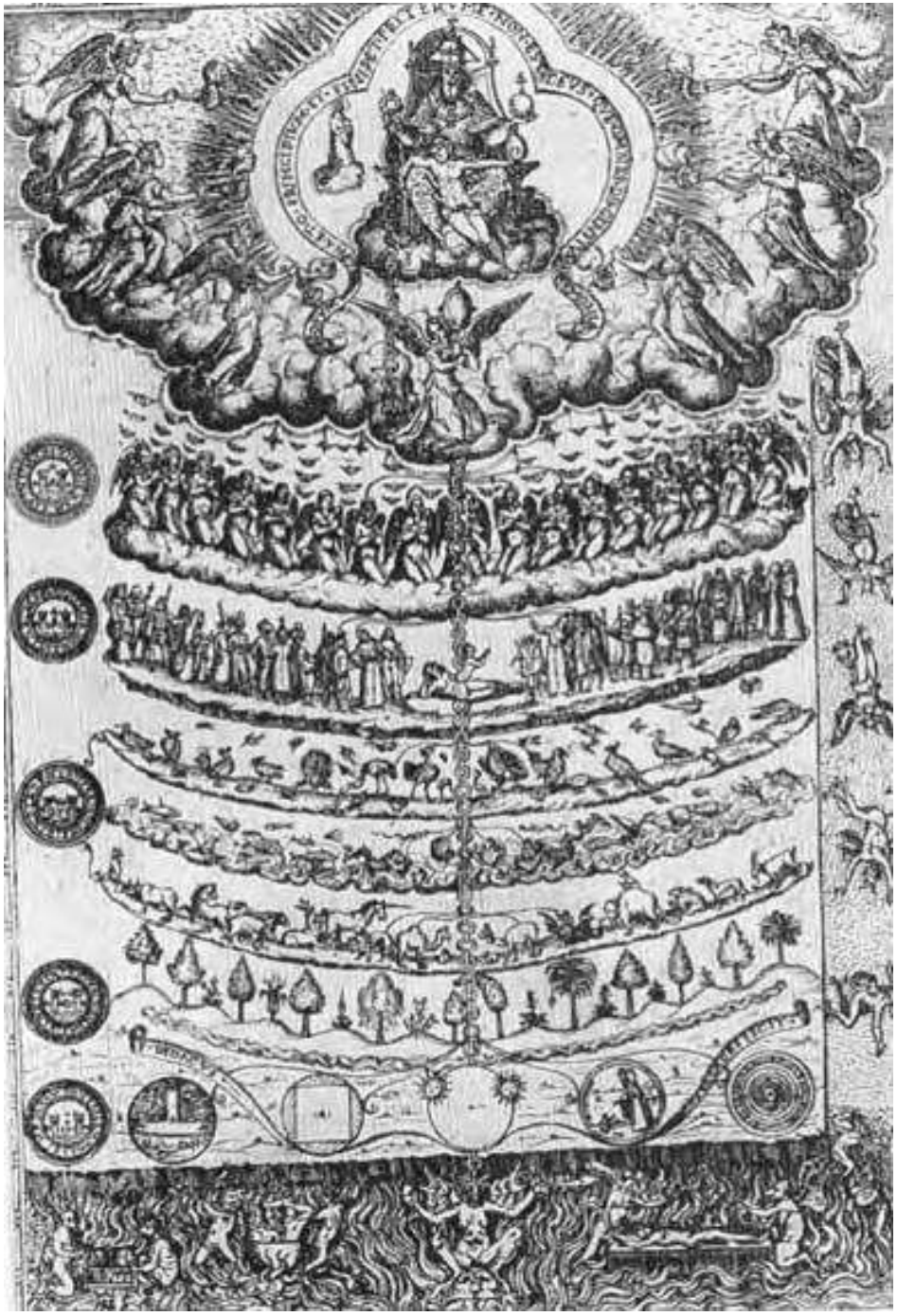


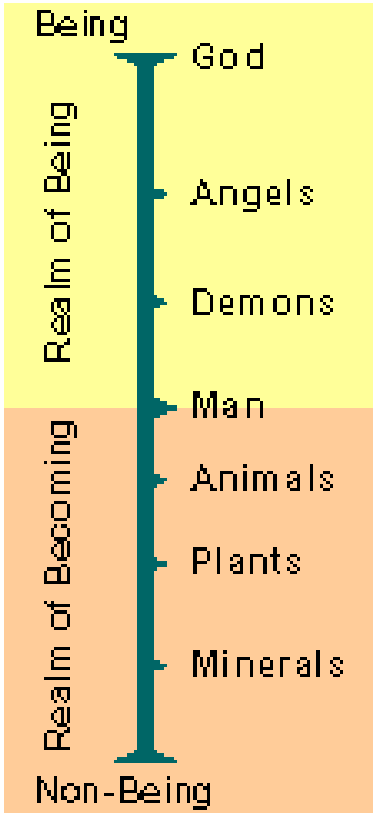
FIG. 18. The *Scala Naturae* or 'Ladder of Life' according to the description of Aristotle.



Great Chain of Being

1579, Didacus Valades, *Rhetorica Christiana*

hierarchical structure of all matter and life, believed to have been decreed by God



Middle Ages

- Collapse of Rome, barbarian invasions.
- Decline of science and inquiry in the “West”. Dark Ages.
- Reunification of Europe under Charlemagne.
- Age of herbalists, alchemists
- Greek authorities maintained (Aristotle, Galen) without question. No “why questions”.
- Latin was the common language of Church and scholars (botany)

- **Arab scholars** translated works of Greeks, contributed to fields of math and chemistry.

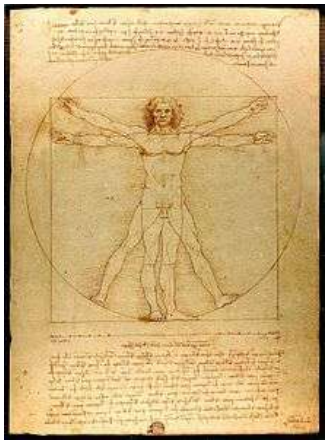
The Christian World View:

When Christianity took over from the Roman pagans in “the West,” the Greek concept of an eternal, essentially static world (or the cycles seen by some) were replaced by the concept of creation.

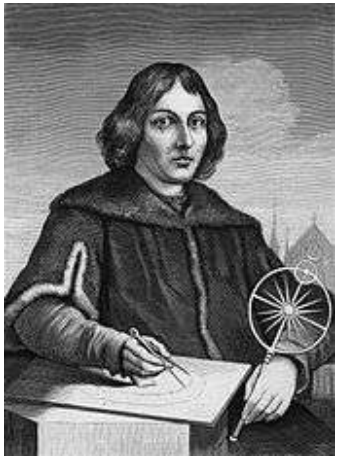
The world according to the Bible is a recently created one. This dogma precluded the need or the possibility of asking why-questions or of harboring any thought of evolution.

Cyclic elements of degradation and divine intervention were retained, but catastrophes were limited to the Flood and the Day of Judgment.

Saint Augustine (5th C. AD) and Thomas Aquinas (13th C. AD) laid the theological groundwork. Creation was interpreted to mean that at the time of creation, God infused the earth with the necessary power to produce living things by a natural process that represented the unfolding of divine plan. **The earth was a few thousand years old and destined for destruction**.

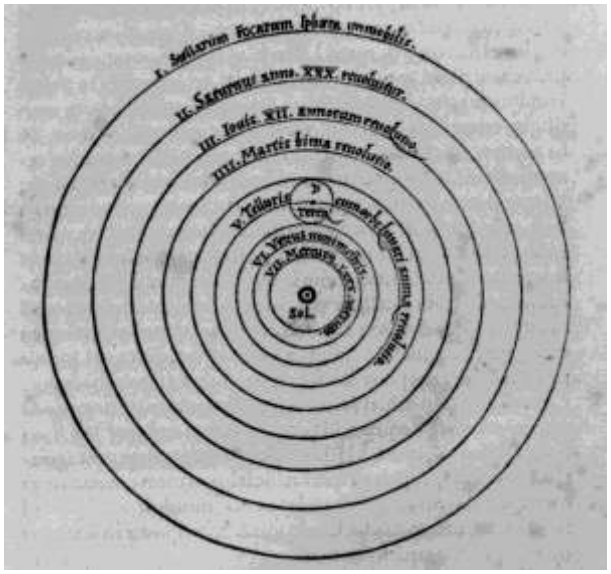


Renaissance “Rebirth” 1300 – 1700



- Age of discovery and exploration.
- Discovery of New World
- Time of great interest in , philosophy, art, music, politics, science, religion, and education.
- Availability of paper and moveable type helped spread books and information.
- Rediscovery of ancient Latin and Greek texts in monasteries of Europe.
- Copernicus – heliocentric solar system
- Old doctrines questioned.

Copernicus (1473-1543) postulated a heliostatic theory in his De Revolutionibus Orbium Coelestium (1543).

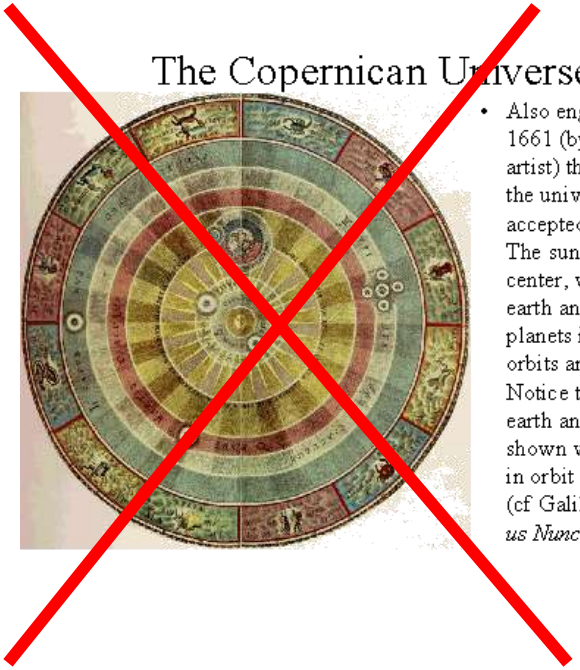


The fixed and limited view of the universe held in the Middle Ages was replaced by broader horizons, based on geographical and astronomical observations and study, in the 16th century.

In the Copernican Universe the Earth no longer held the central position.

Society looked to astronomy, mathematics, and physics for natural laws which could be comprehended by the human mind, and this search was not in conflict with religion.

Galileo: forced to recant



Bruno: burned at the stake

This enlightened view did not extend to the authoritarian orthodoxy of the Roman Catholic Church, which confronted heretics and blasphemers with sure and certain fate of destruction by fire on Earth and in hell.

In the 17th Century, the offices of the Inquisition burned the astronomer Giordano Bruno at the stake, and forced Galileo to recant his belief in the Copernican universe.

Not exactly an atmosphere that encourages thinking!!

ANNALES

VETERIS TESTAMENTI,

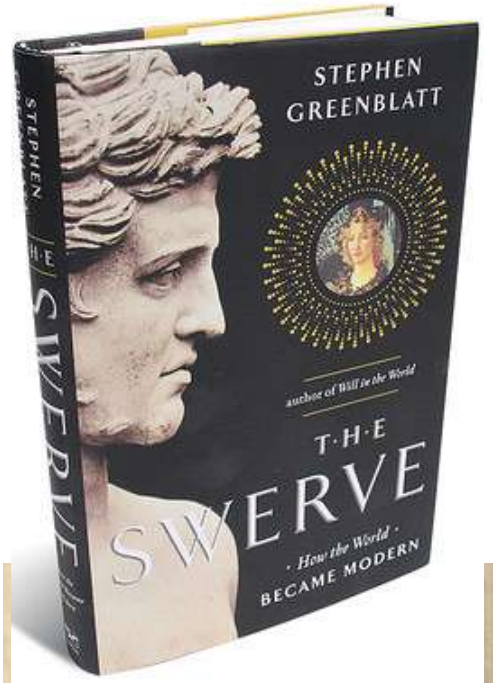
à primâ Mundi origine deducti.

IN PRINCIPIO creavit DEUS Cœlum & Terram. [*Genes.* I. 1] quod temporis principium (juxta noſtram Chronologiam) incidit in noctis illius initium, quæ XXIII. diem Octobris præceſſit, in anno Periodi Julianæ 710.

Primo igitur ſeculi die (*Octob.* 23. *feriâ* 1.) cum ſupremo Cœlo creavit Deus Angelos: deinde ſummo operis faſtigio primùm perfecto, ad ima Mundanæ hujus fabricæ fundamenta progreſſus miran-

Bishop Ussher, *Annalium pars postierior*, 1654. – following a strict interpretation of the Bible the **exact moment of Creation was calculated on Sunday, October 23, 4004 B.C.**

This was believed to be true for centuries, and may still be held as true by some.



- Renaissance humanists such as **Poggio Bracciolini** (1380-1459) sought out in Europe's monastic libraries the Latin literary, historical, and oratorical texts of Antiquity.
- Rediscovered work of Lucretius and Epicurus, offered a powerful alternative to church doctrines.
- **Epicurus,** building on the foundation laid by Democritus, believed everything is made of unchanging atoms which whirl about and collide at random. He established a well thought-out materialistic explanation of the inanimate and living world, **all things happening through natural causes**.

Carolus Linnaeus

1707 - 1778

Tried to name and classify all organism

Binomial nomenclature

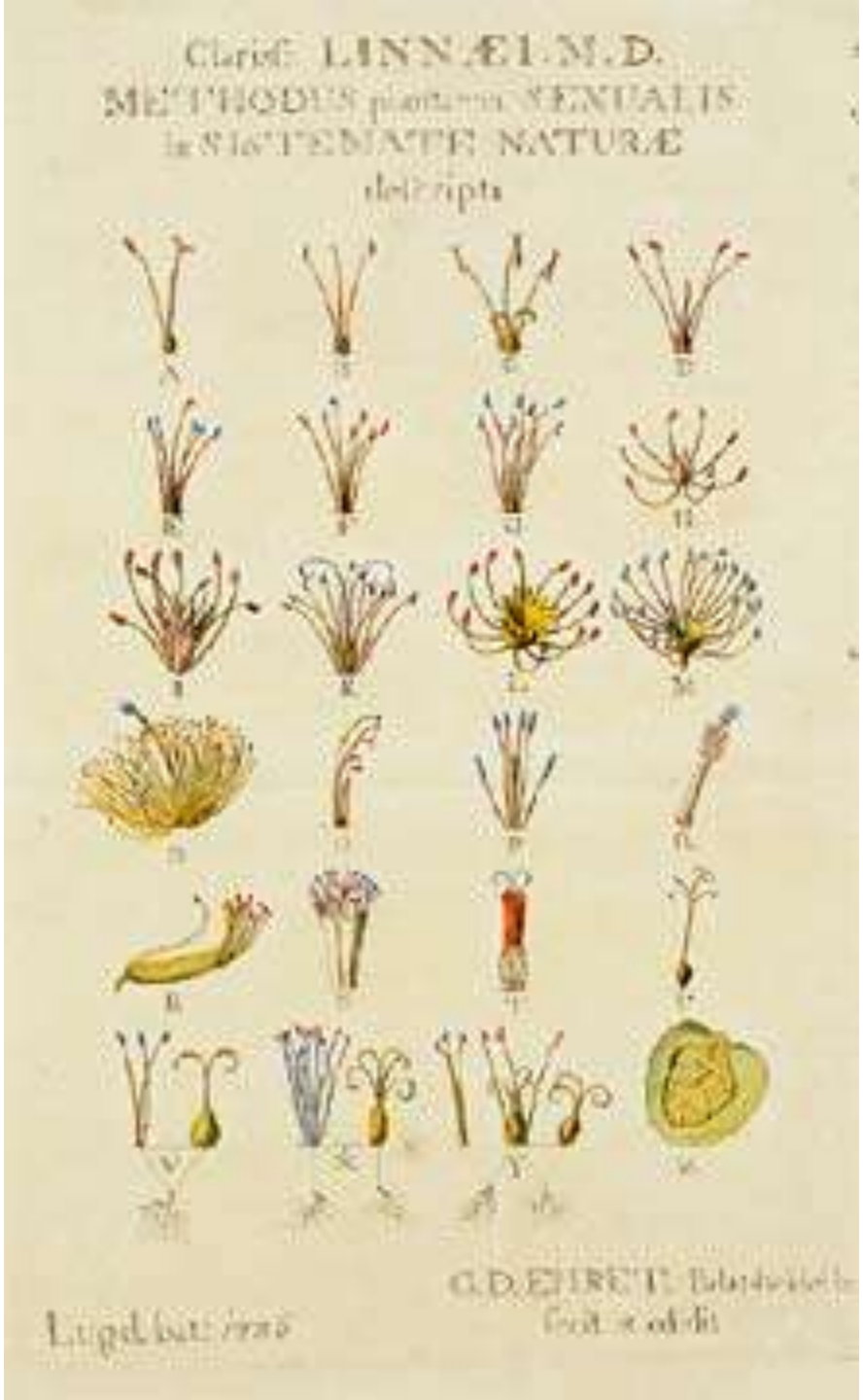
Species Plantarum - 1753

System of Classification

"Sexual System"

Classes - number of stamens

Orders - number of pistils



A View of the Twenty-four Claſſes of the SEXUAL SYSTEM *of* LINNÆUS, *with their Names and Characters; alſo the Numberand Explanation of Orders contained in each.*

Number of the Claſſes.	*Their Names and Characters.*	*Number of Orders in each.*	*Their Names, expreſſive of the Number of Female Parts or Styles.*	*Number.*
1.	MONANDRIA. One fertile ſtamen, i. e. having the *Anthera*.	2	1. Monogynia,	1
			2. Digynia,	2
2.	DIANDRIA. Two fruitful *Stamina* or male parts.	3	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
3.	TRIANDRIA. Three ditto.	3	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
4.	TETRANDRIA. Four ditto, all of equal length, by which it is diſtinguiſhed from the fourteenth claſs.	3	1. Monogynia,	1
			2. Digynia,	2
			3. Tetragynia,	4
5.	PENTANDRIA. Five ditto.	6	1. Monogynia,	1
			2. Digynia,	2
			3. Triginia,	3
			4. Tetragynia,	4
			5. Pentagynia,	5
			6. Polygynia,	many
6.	HEXANDRIA. Six ditto, all of equal length, by which this is diſtinguiſhed from the ſixteenth claſs.	5	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
			4. Tetragynia,	4
			5. Polygynia,	many
7.	HEPTANDRIA. Seven ditto.	4	1. Monogynia,	1
			2. Digynia,	2
			3. Tetragynia,	4
			4. Heptagynia,	7
8.	OCTANDRIA. Eight ditto.	4	1. Monogynia,	1
			2. Digynia,	2
			3. Trigynia,	3
			4. Tetragynia,	4
9.	ENNEANDRIA. Nine ditto.	3	1. Monogynia,	1
			2. Trigynia,	3
			3. Hexagynia,	6

10. DECAN-

6. Aloë foliis ovato-lanceolatis carnoſis apice triquetris: angulis inerme dentatis. *Hort. cliff.* 131. *Hort. upſ.* 86. *Roy. lugdb.* 24.
Aloë africana minima atroviridis, ſpinis herbaceis numeroſis ornata. *Boerh. lugdb.* 2. *p.* 131. *t.* 131.
Habitat in Æthiopiæ *campeſtribus.* ♄
Flores *in hoc genere ſpecierum certiſſimi indices conjungunt Margaritiferam & Arachnoideam.*

9. ALOE floribus ſeſſilibus reflexis imbricatis priſmaticis. *Uvaria.*
Aloë foliis linearibus radicalibus membranaceis. *Hort. cliff.* 133. *Roy. lugdb.* 23.
Aloë africana folio triangulari longiſſimo & anguſtiſſimo, floribus luteis fœtidis. *Comm. hort.* 2, *p.* 29. *t.* 15. *Seb. theſ.* 1. *p.* 29. *t.* 19. *f.* 3.
Habitat ad Cap. b. Spei. ♄

AGAVE.

1. AGAVE foliis dentato-ſpinoſis, ſcapo ramoſo. *Gen. nov.* 1102. *americana.*
Agave foliis ſpinoſo-dentatis mucronatisque. *Hort. upſ.* 81.
Aloë foliis lanceolatis dentatis ſpina terminatis radicalibus. *Hort. cliff.* 130. *Roy. lugdb.* 22.
Aloë folio in oblongum mucronem abeunte. *Bauh. pin.* 286.
Habitat in America *calidiore.* ♄

2. AGAVE foliis dentatis, ſtaminibus corollam æquantibus. *vivipara.*
Aloë americana polygona. *Comm. rar.* 65. *t.* 65.
Habitat in America.
Confer. Aloe americana ſoboliferà. *Herm. lugdb.* 16. *t.* 17.

3. AGAVE foliis dentato-ſpinoſis, ſcapo ſimpliciſſimo. *Gen. nov.* 1102. *virginica.*
Aloe foliis lanceolatis ſpina cartilaginea terminatis, floribus alternis ſeſſilibus. *Gron. virg.* 152.
Habitat in Virginia. ♄

4. AGAVE foliis integerrimis. *Gen. nov.* 1102. *fœtida.*
Aloe foliis integerrimis patentiuſculis aculeo-terminatis, radice cauleſcente. *Hort. cliff.* 132.
Aloe americana, viridi rigidiſſimo & fœtido folio, Piet dicta indigenis. *Comm. hort.* 2. *p.* 35. *t.* 18.

Linnaean Hierarchy

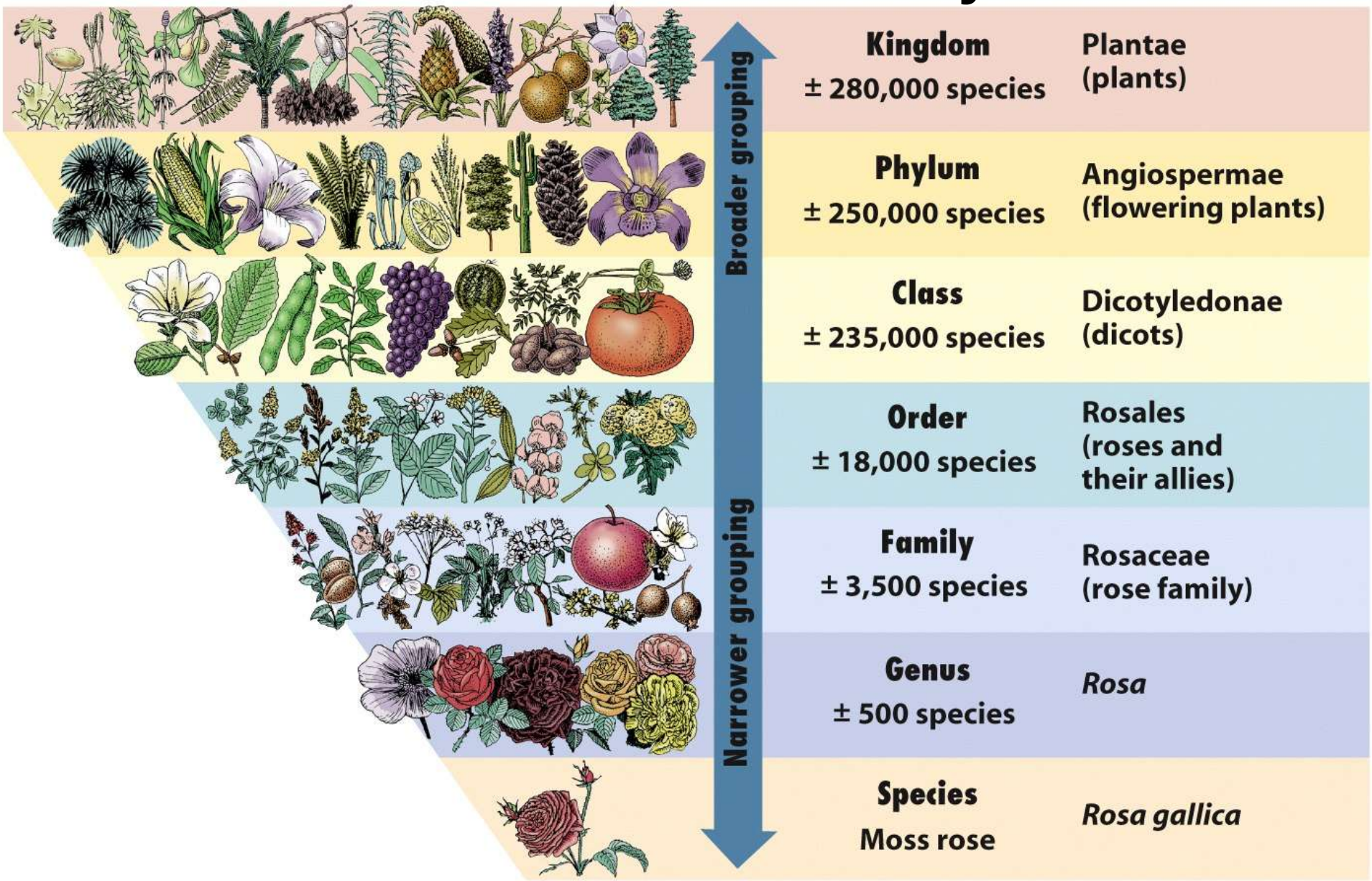


Figure 2-6 Discover Biology 3/e

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Georges-Louis Leclerc, Comte de Buffon (1707-1788)

Head of King's Botanical Garden, Paris.

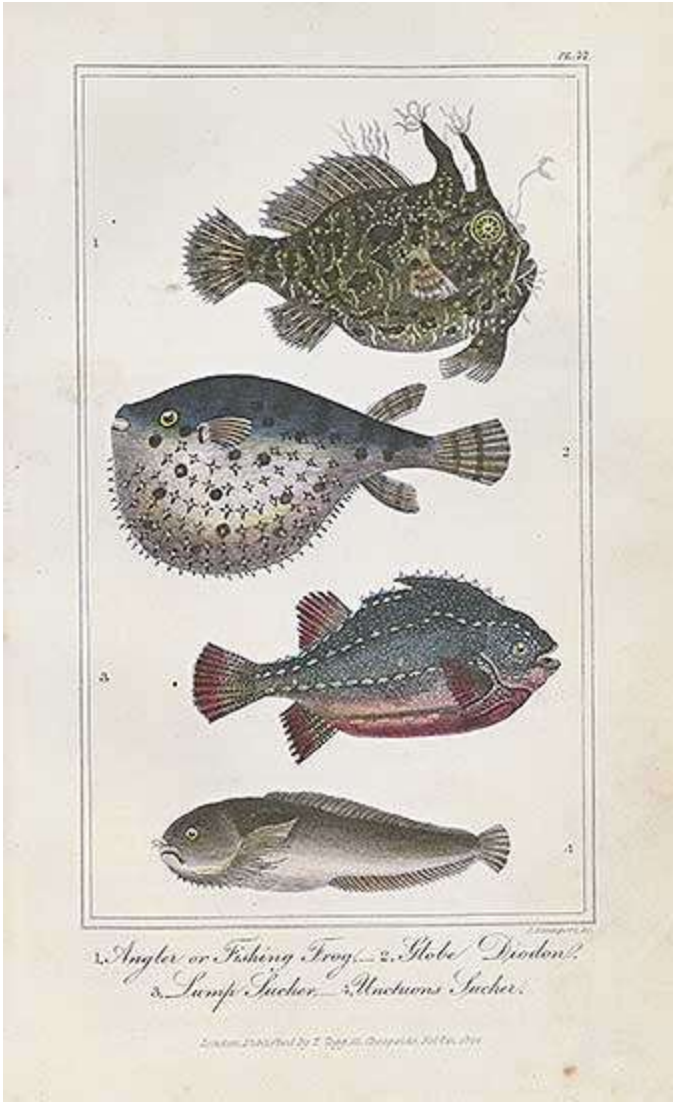
Originally trained in math and physics

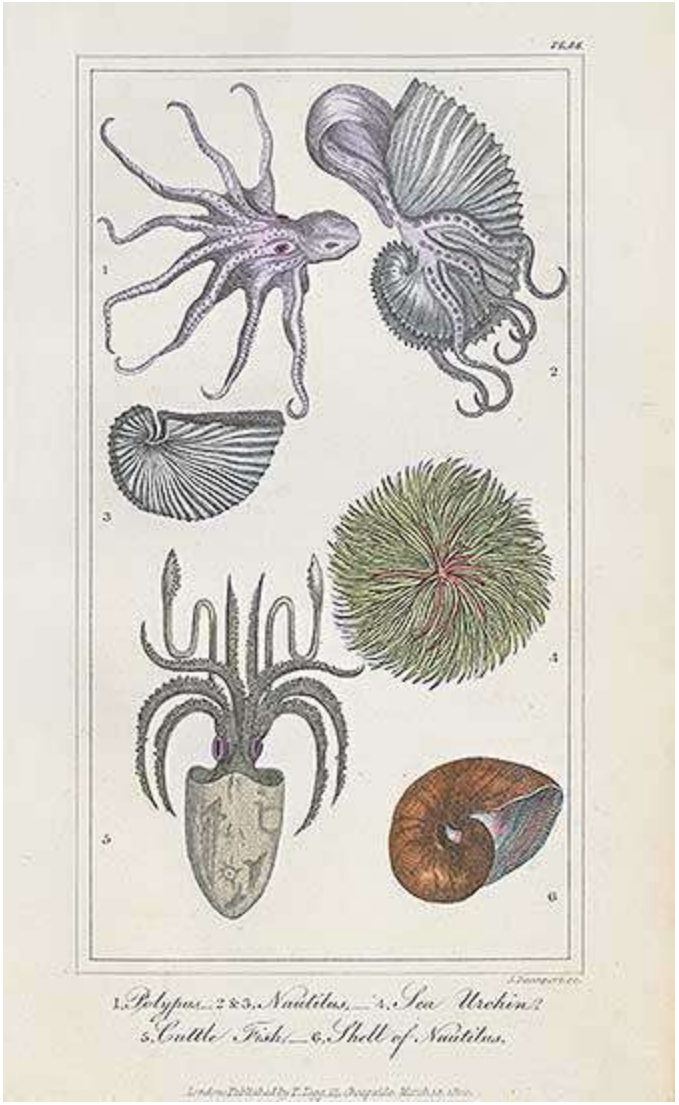
Published Natural History, 44 volumes, popular encyclopedia of natural history

Saw the need to go beyond the lists of Linnaeus to a more general set of laws which would explain the diversity of organisms and which might portray a more dynamic, changing view of life on earth.

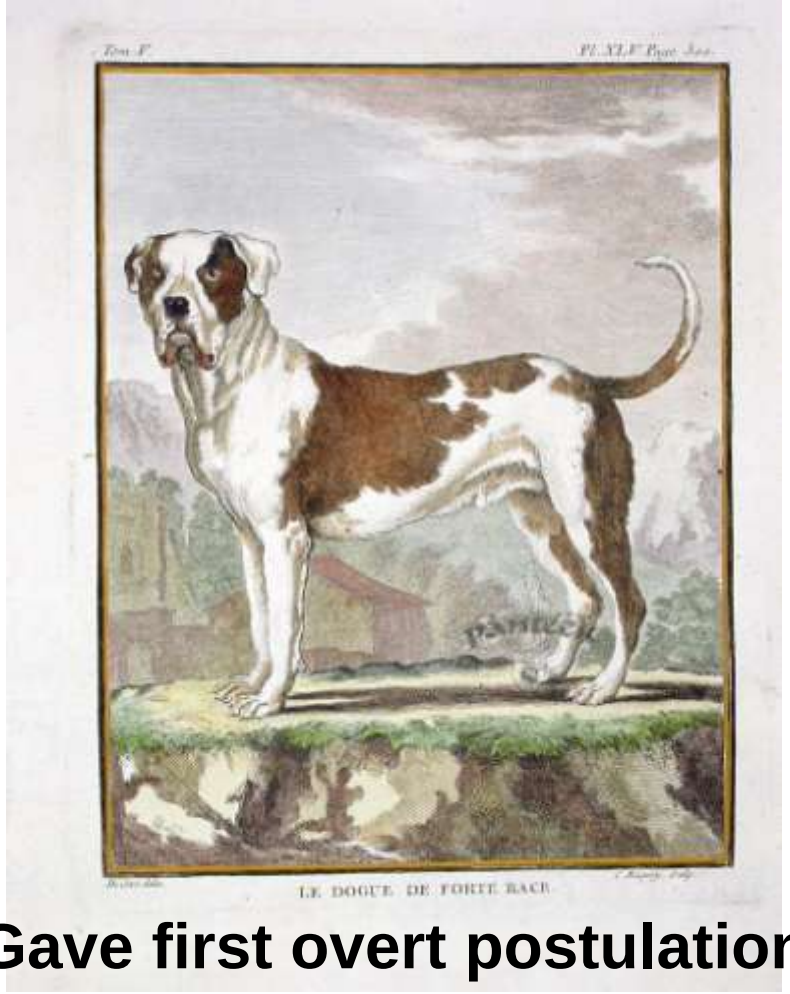
Saw less order than Linnaeus

Basically, groping for evolutionary explanations.





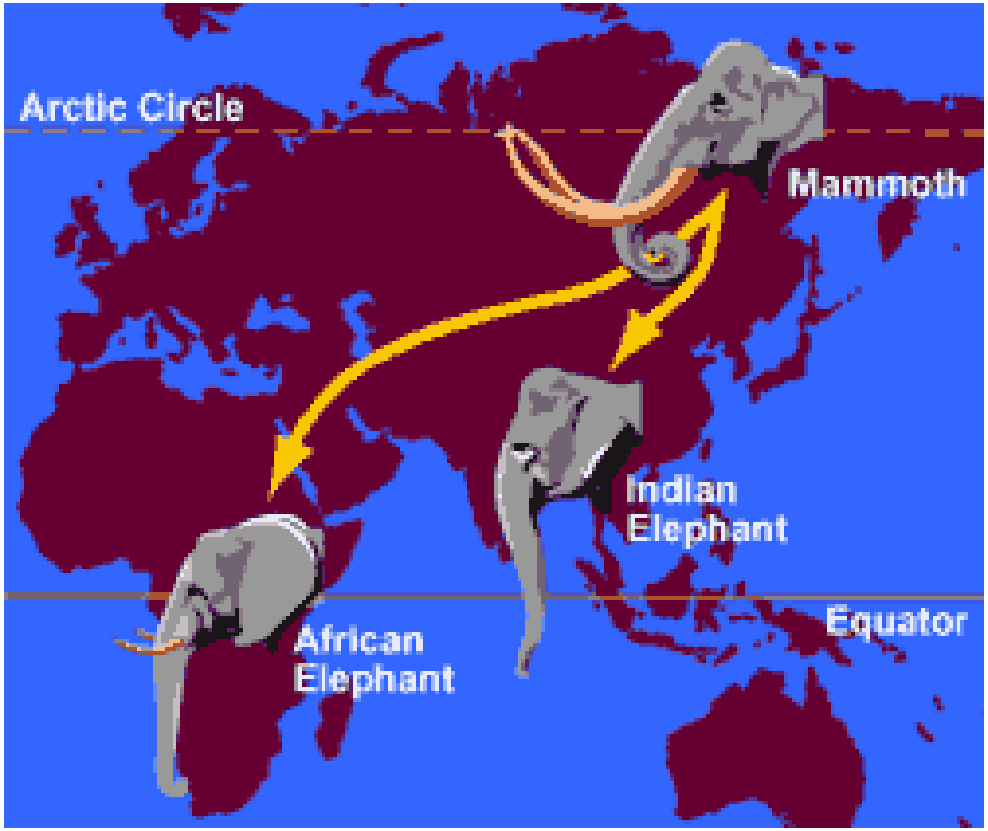
Like Linnaeus, Buffon drew and named many organisms on earth.



Gave first overt postulation that organisms might gradually change over generations by inheriting characteristics from their parents.

Proposed a flawed mechanism of change that was based on the different types of foods that were eaten.

Proposed Indian and African elephants evolved from migrating herds of Mammoths,



Because he lacked data supporting his ideas, and because his proposed mechanism of change was viewed as preposterous even at the time, his radical ideas never caught on, but they marked an important change in perception about the relationships among species.

Some of Buffon's Observations

Despite similar environments, different regions have distinct plants and animals, considered to be the first principle of biogeography.

Suggested that species may have both "improved" and "degenerated" after dispersing from a center of creation.

Stated openly that the earth originated much earlier than 4004 BC, the date determined by Archbishop James Ussher.

Calculated that the age of the earth was 75,000 years , basing his figures on the cooling rate of iron tested at his Laboratory.

Suggested species distinctions could be based on reproductive barriers, close to biological species concept of today.

Jean Baptiste de Monet, Chevalier de Lamarck (1744-1829)

Most important pre-Darwinian student of evolution

Soldier, then studied botany, mentored by Buffon, later switched to invertebrates.

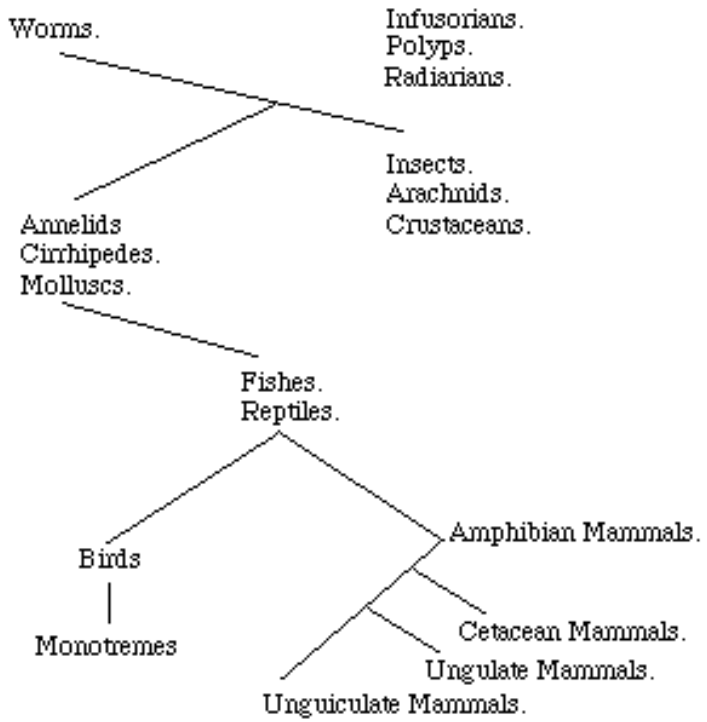
Famous for studies of invertebrates, published 7 volume work on them, clarified relations. Coined term “invertebrate”.

His studies of molluscs convinced him that species do change, tried to find an explanation for how this could occur.

Did not accept catastrophism.

The French naturalist Jean-Baptiste Lamarck put forward the idea that species changed over time in 1809 in his book *Philosphie Zoologique*. His process, though, was very different from that imagined by Darwin fifty years later. Lamarck suggested the idea of **transformism**.

He **did not** suggest that lineages branched and went extinct.



Lamarck - Philosophical Zoology of 1809

Proposed that evolution was a kind of continuous ladder (like Aristotle and Buffon).

Simple organisms entering at the bottom rung and working their way up. Like most scientists of the time, he assumed that simple organisms were constantly arising by spontaneous generation.

Then they entered the ladder and began climbing toward man and other complex creatures.

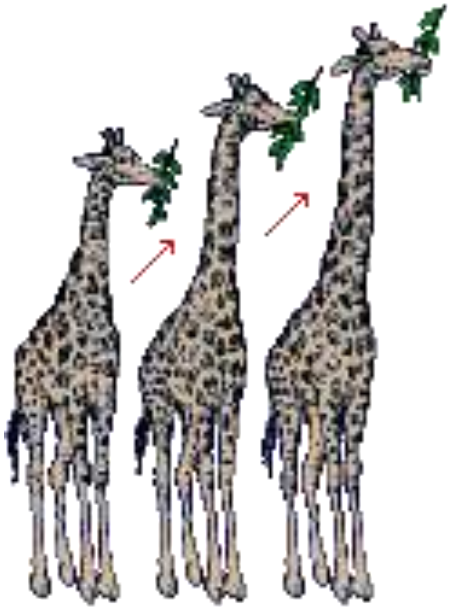
Inner nature or essence of life which drives it to become more complex.

Theory of Inheritance of Acquired Characters

Organs grew in size if used in life, and degenerated if not used.

This growth or degeneration could be passed on to offspring

The long necks of giraffes is the most-remembered example Lamarck used, insinuating that giraffes stretched their necks purposefully in order to reach the leaves on high branches, and then by successive generations passed their longer, stretched necks on to their offspring.



Spontaneous Generation

Long held belief that small organisms could arise spontaneously from mud or organic matter

Aristotle claimed he had witnessed it.

Commonly held belief until mid 1800s

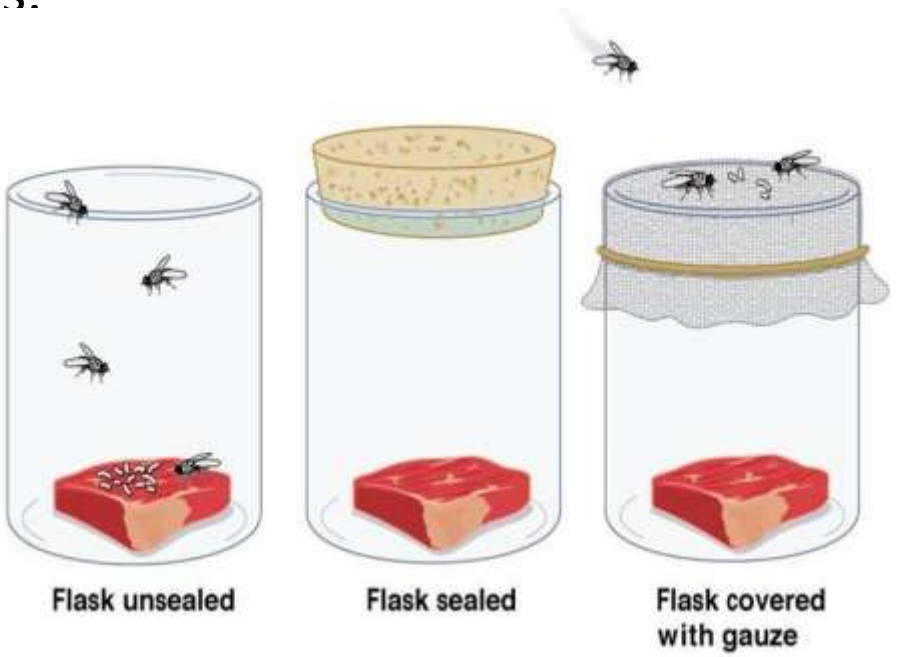
Francesco Redi (1626-1698), a student of Galileo

Took a large vase and put a piece of meat inside it, and then covered the vase with a piece of gauze.

Noted that grubs formed only when the eggs, gathered from the gauze, were placed on the meat.

Demonstrated that insects originated from other insects and that, consequently, spontaneous generation was not a valid concept.

Redi also founded parasitology, and performed experiments on how to exterminate worms.



William Smith (1769-1839)

"Father of English Geology".

Worked as an engineer for digging canals and coal mining.

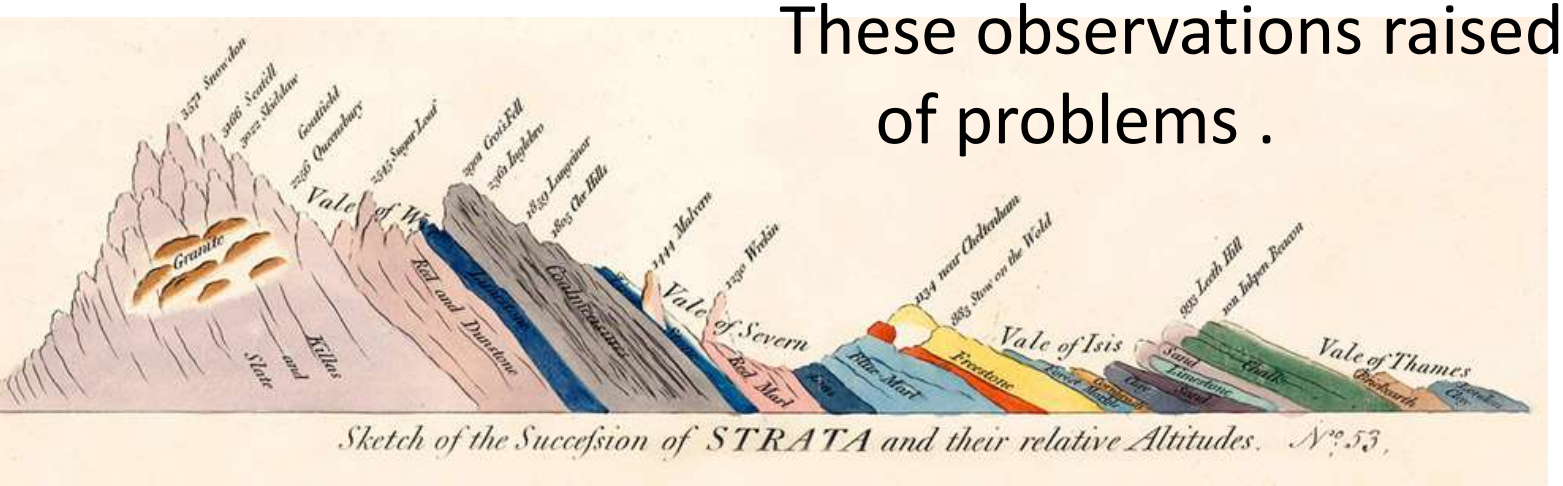
Studies rock layers (strata).

Identified layers by fossils.

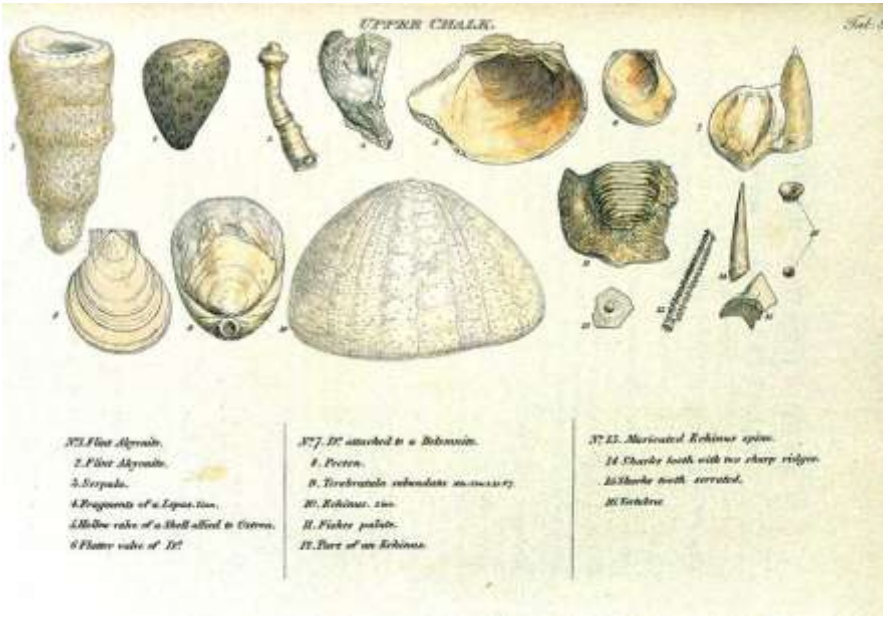
Discovered that strata were continuous, integral layers.

Mapped the entire country.

These observations raised a number of problems .




STRATA
ENGLAND and WALES
SCOTLAND
THE
GERMAN
OCEAN
IRISH SEA
THE ENGLISH CHANNEL


UPPER CHALK.

Smith discussed two problems:

- If the fossils he had found at different levels had been created at different times and not all at once; and
- If some of the fossil animals were not now in existence (extinct),

Had God changed his mind about retaining those animals? Had He started over a few times until this most recent cycle? These were profoundly disturbing questions.

George Cuvier (1769-1832)

Famous French comparative anatomist

Professor of Vertebrate Zoology at the Paris Natural History Museum

Very interested in fossils.

Extended Linnaean classification to Phyla

Included extinct fossils in his classification (established science of Paleontology).

Did not accept idea of evolutionary change. Claimed that is not what is seen in fossil record. Instead they seem to arise abruptly.

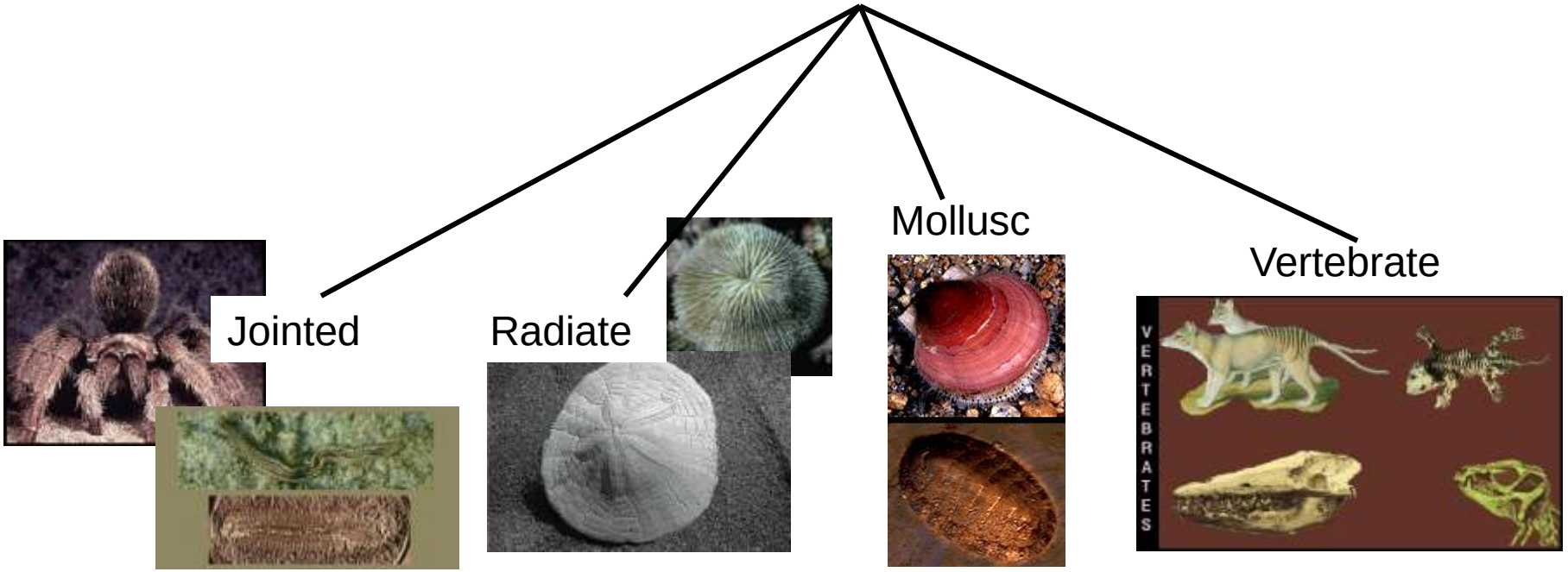
Did not think there was enough time for gradual evolution.

Thought fossils and rock strata were due to cataclysms, upheavals, floods.

Thus all present organisms arose within time span of bible.

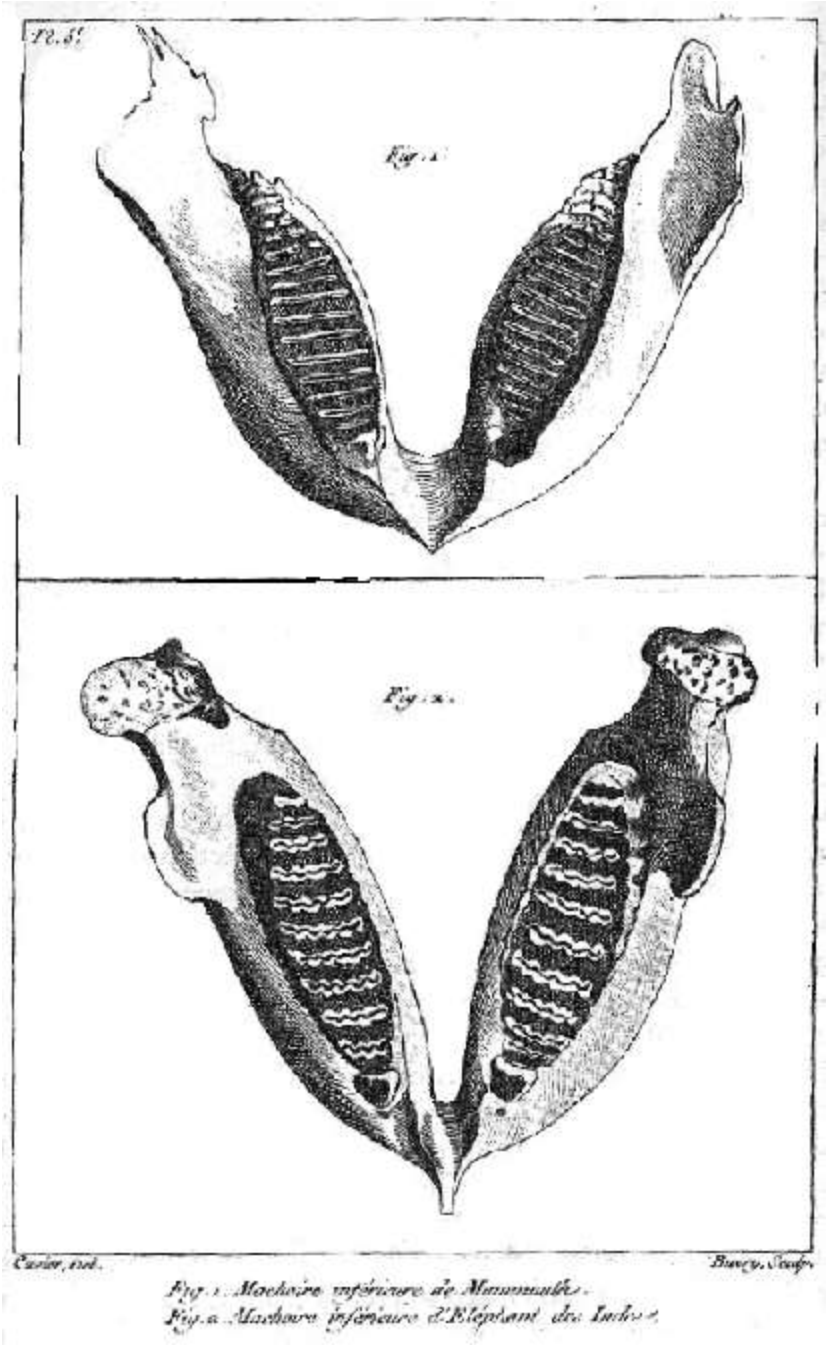
Cuvier was without doubt one of the most brilliant scientists who ever lived. He single-handedly founded the fields of comparative anatomy and vertebrate paleontology. He showed how he could use a few bones to reconstruct the shape of the whole animal by understanding functional groupings of bones. He also showed that some parts of animals were so basic as to be common to all, but that other more specialized characteristics differed from one group to another. Using a system based on anatomical differences, Cuvier divided all animals into four branches, based on these most basic differences in body plans:

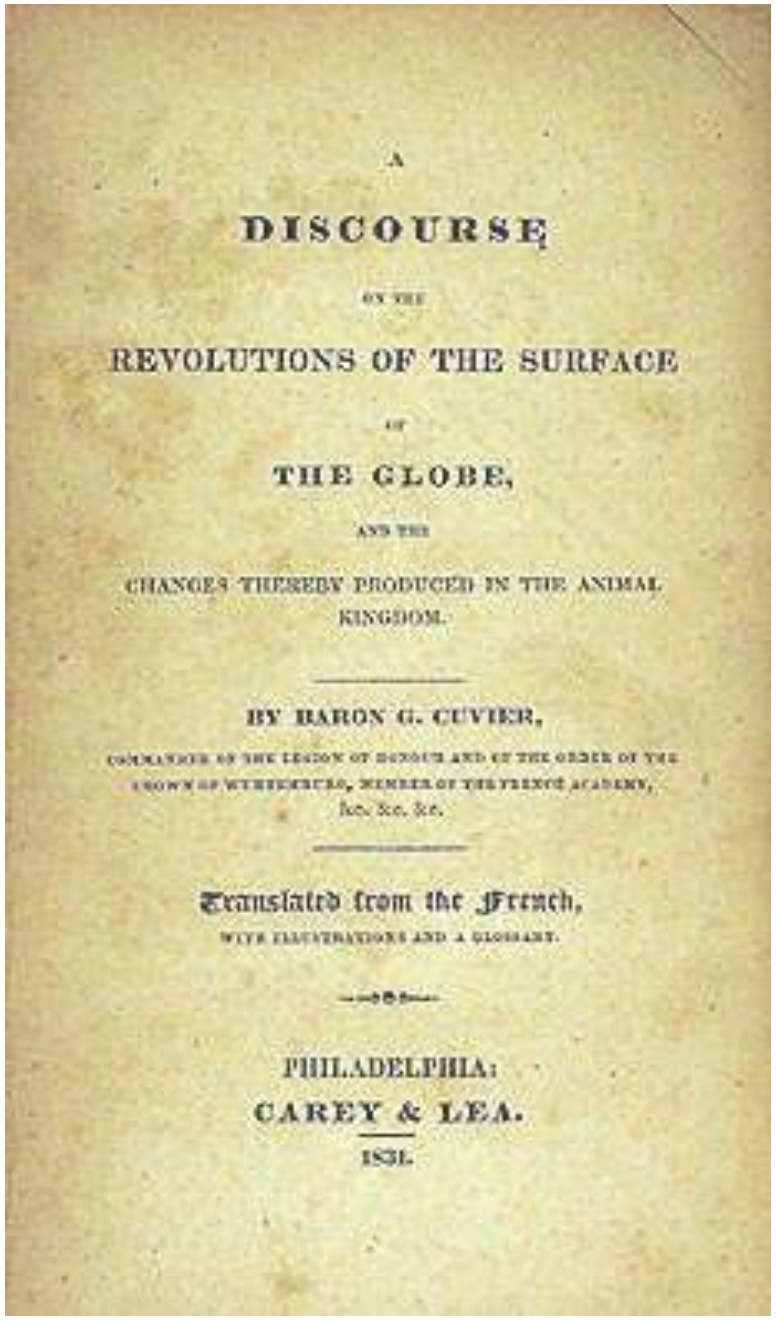
Although he believed in the fixity of species, the branch system allowed the possibility of separate development over time in each branch.



Some science historians believe that Cuvier's **biggest contribution by far was to confirm that extinctions were real**.

He showed, for example, that the forms buried in the fossil record were not the same as similar forms on earth today, such as the comparison of mammoth jaws with those of elephants shown at right.





A

DISCOURSE

ON THE

REVOLUTIONS OF THE SURFACE

OF

THE GLOBE,

AND THE

CHANGES THEREBY PRODUCED IN THE ANIMAL KINGDOM.

BY BARON G. CUVIER,

COMMANDER OF THE LEGION OF HONOUR AND OF THE ORDER OF THE CROWN OF WURTEMBURG, MEMBER OF THE FRENCH ACADEMY, &c. &c. &c.

Translated from the French,

WITH ILLUSTRATIONS AND A GLOSSARY.

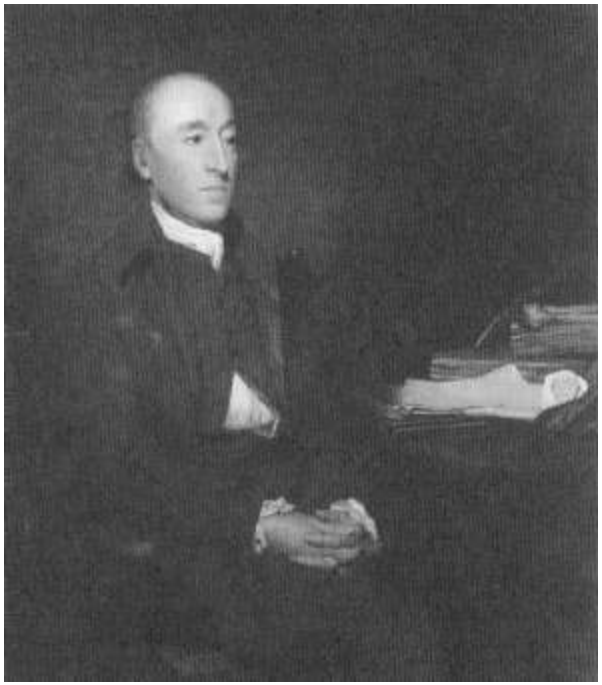
PHILADELPHIA:

CAREY & LEA.

1831.

To answer William Smith's dilemma, and to address his own discoveries of dinosaur remains in strata covered by other layers containing fossil oysters and other sea life, Cuvier proposed that before the Biblical flood there had been another catastrophic flood that had wiped out preexisting life. This accounted for their absence from the modern world.

The school of catastrophism also explained why there were no human remains in the fossil record, as this pre-Biblical flood occurred before humans existed.



James Hutton (1726 - 1797):

Argued against Catastrophists

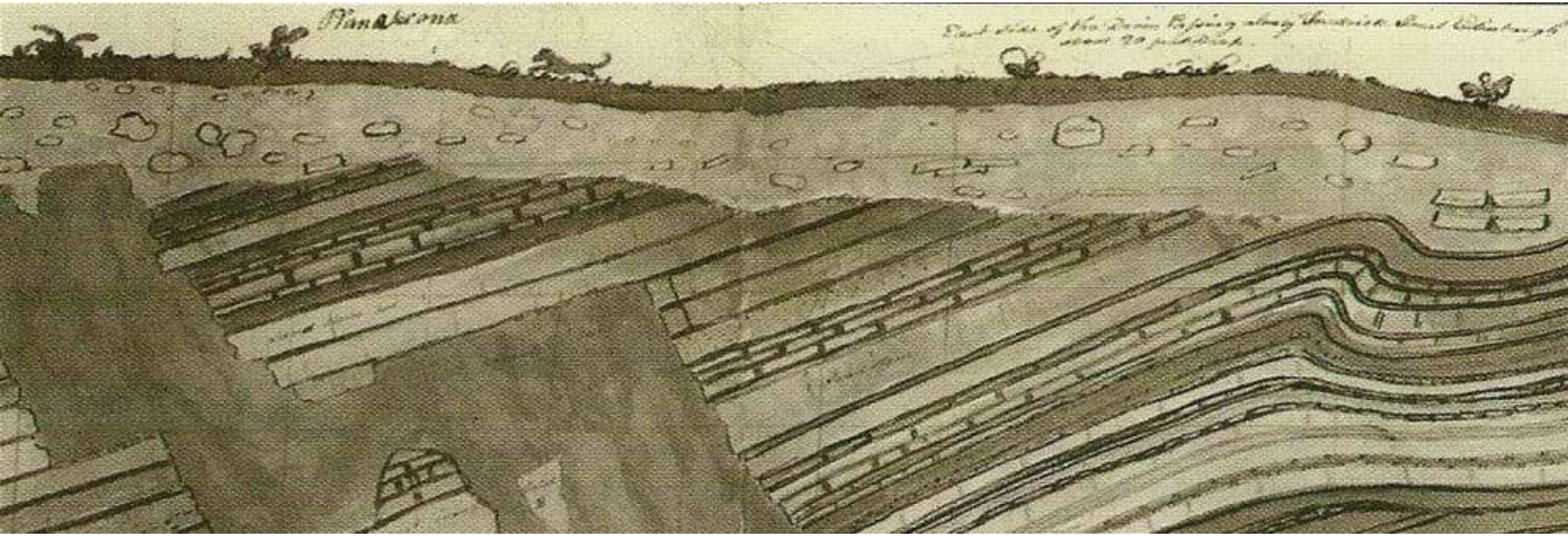
Studied the effects of weathering and soil erosion, as well as the action of rivers in cutting out valleys,

Argued that, given enough time, the mechanisms at work in the everyday environment would have been sufficient to produce those phenomena which the catastrophists claimed were caused by catastrophic floods.

‘***uniformitarianism*** - slow and uniform processes at work can explain modern geology.*’.*

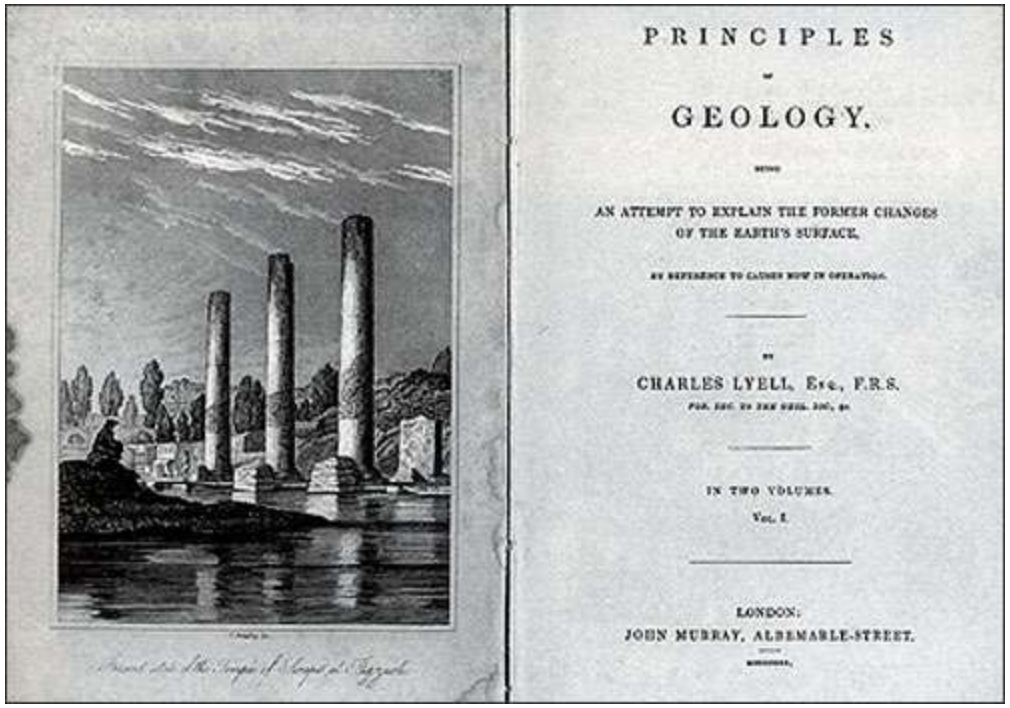
Hutton was attacked by the catastrophists because his theory of erosion and volcanic activity did not make sense if the earth were only six thousand years old. He was stung repeatedly by public accusations of atheism and poor logic.

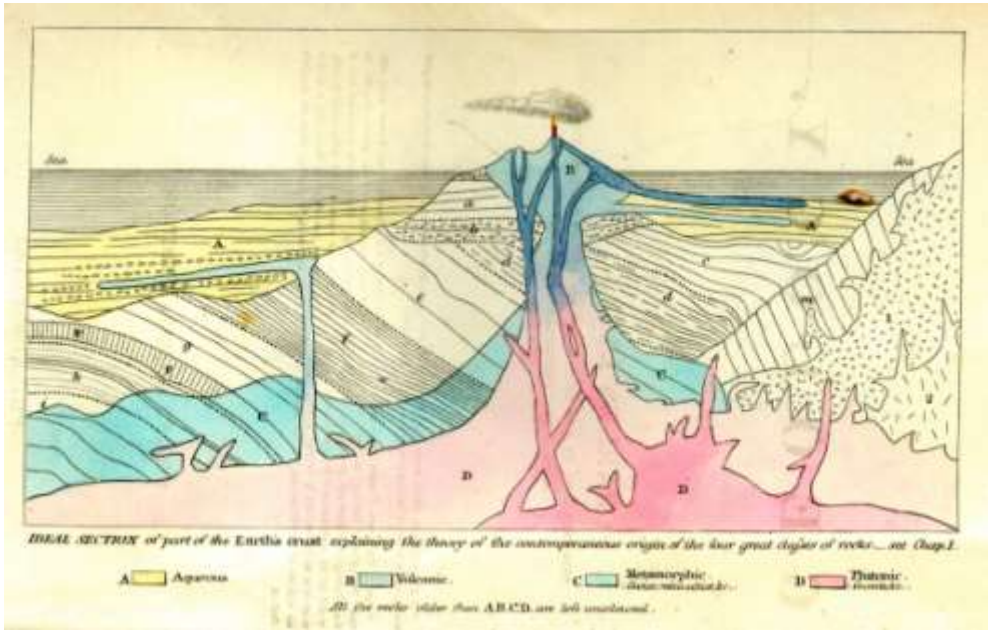
Uniformitarianism - slow and uniform processes at work can explain modern geology.'



Hutton "we find no vestige of a beginning, no prospect of an end"

These rocks in Scotland are Hutton’s Section, showing magma extruding up among layers of sedimentary rocks, supporting Hutton’s view that slow and continuous processes have contributed importantly to the current distribution of land formations. Previously, all rocks were thought to have been deposited from the seas.





Charles Lyell (1797-1875) –

Scottish geologist popularized the idea of Uniformitarianism in 1830-1833 with a 3 volume work on Principles of Geology. Contemporary of Charles Darwin.

Sharp catastrophic discontinuities are not common, actually very rare and local.

Changes in geological record arise from natural forces of erosion by wind and rain, volcanoes and flood deposits. Governed by laws of motion

Earth must be very old

Concluded that the same forces were operating at the same rate at his time as they had millions of years ago.

Lyell and Darwin became friends, but Lyell believed that living species were fixed and not related by common descent.