

We are just one solar system in the galaxy...



Do we belong in this universe? (and how could we know?)

Stephen Freeland UMBC

*Are we an
accident?*

You live here

Was this likely?

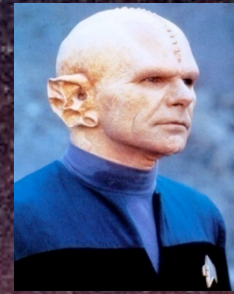
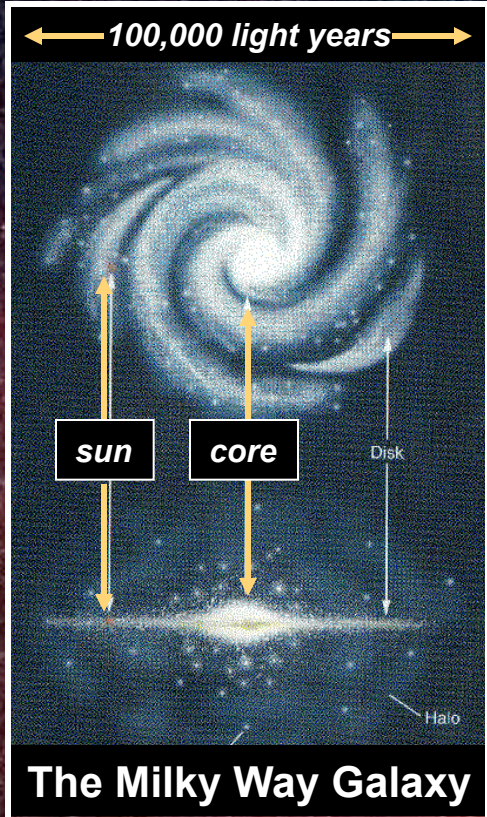
(why?)

*Are we
alone?*

*Could it equally
well have been
somewhere else?*

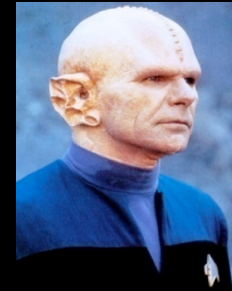
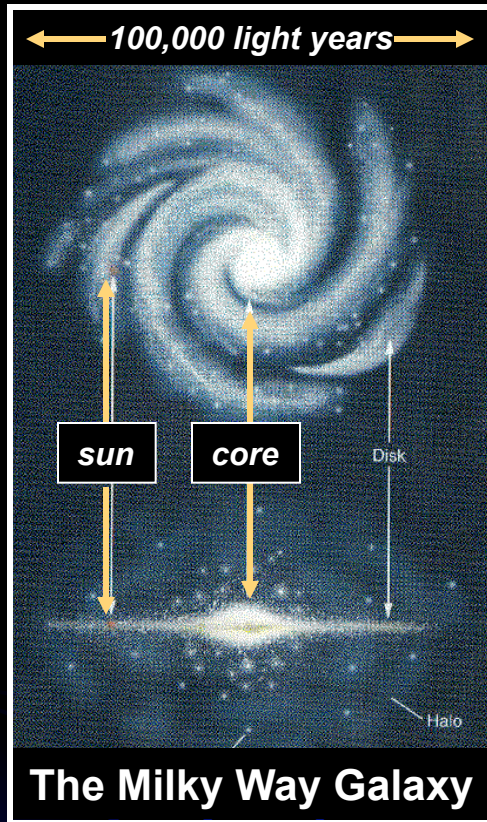
*Would other
life be like us?*

So do we expect a galaxy teeming with life?



STAR TREK

Or are we likely to be alone?



STAR TREK

“THE WEDGE STRATEGY”

an internal memo from the Discovery Institute (the leading research center for anti-evolutionary “Intelligent Design” research), first seen on the Internet in 1999



The proposition that human beings are created in the image of God is one of the bedrock principles on which Western civilization was built... Yet a little over a century ago, this cardinal idea came under wholesale attack by intellectuals drawing on the discoveries of modern science...thinkers such as Charles Darwin...portrayed humans not as moral and spiritual beings, but as animals or machines who inhabited a universe ruled by purely impersonal forces...The cultural consequences of this triumph of materialism were devastating.

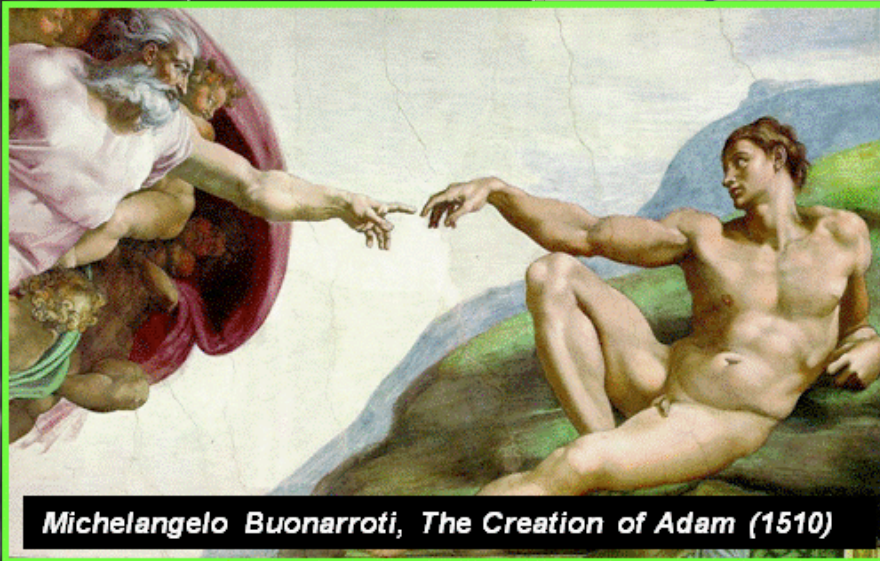
adapted from
<http://astro.if.ufrgs.br/>



by astronomical tables (notwithstanding the stay of the sun in the dayes of Joshua, and the going back of it in the dayes c Ezekiah) happened upon the 23 day of the Julian October; from thence concluded that from the evening preceding that first day of the Julian year, both the first day of the creation and the first motion of time are to be deduced.

the Annals of the World iv (1658)

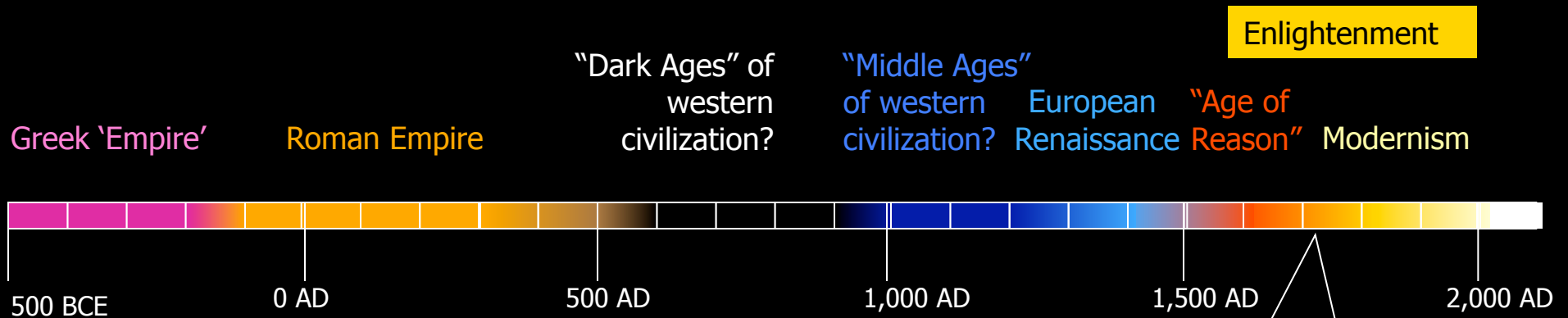
calculated from Biblical genealogy
e. the earth is 6000 years old.



Michelangelo Buonarroti, The Creation of Adam (1510)

"the garden of eden"
Museum, London





Emmanuel Kant influenced Europe and America with his philosophy that separated God (a noumenal concept) from the physical realities (phenomena) that can be explored through scientific knowledge.



- 1) **Reason** is the most significant and positive capacity of the human;
- 2) reason **enables one to break free from primitive, superstitious beliefs** that imprison us in irrational ignorance;
- 3) reason **makes all humans equal** and, therefore, deserving of equal liberty and treatment before the law;
- 4) **beliefs** of any sort **should be accepted only on the basis of reason**, and not on traditional authority;

The Cosmos of the Middle Ages (i)

adapted from
<http://astro.if.ufrgs.br/>

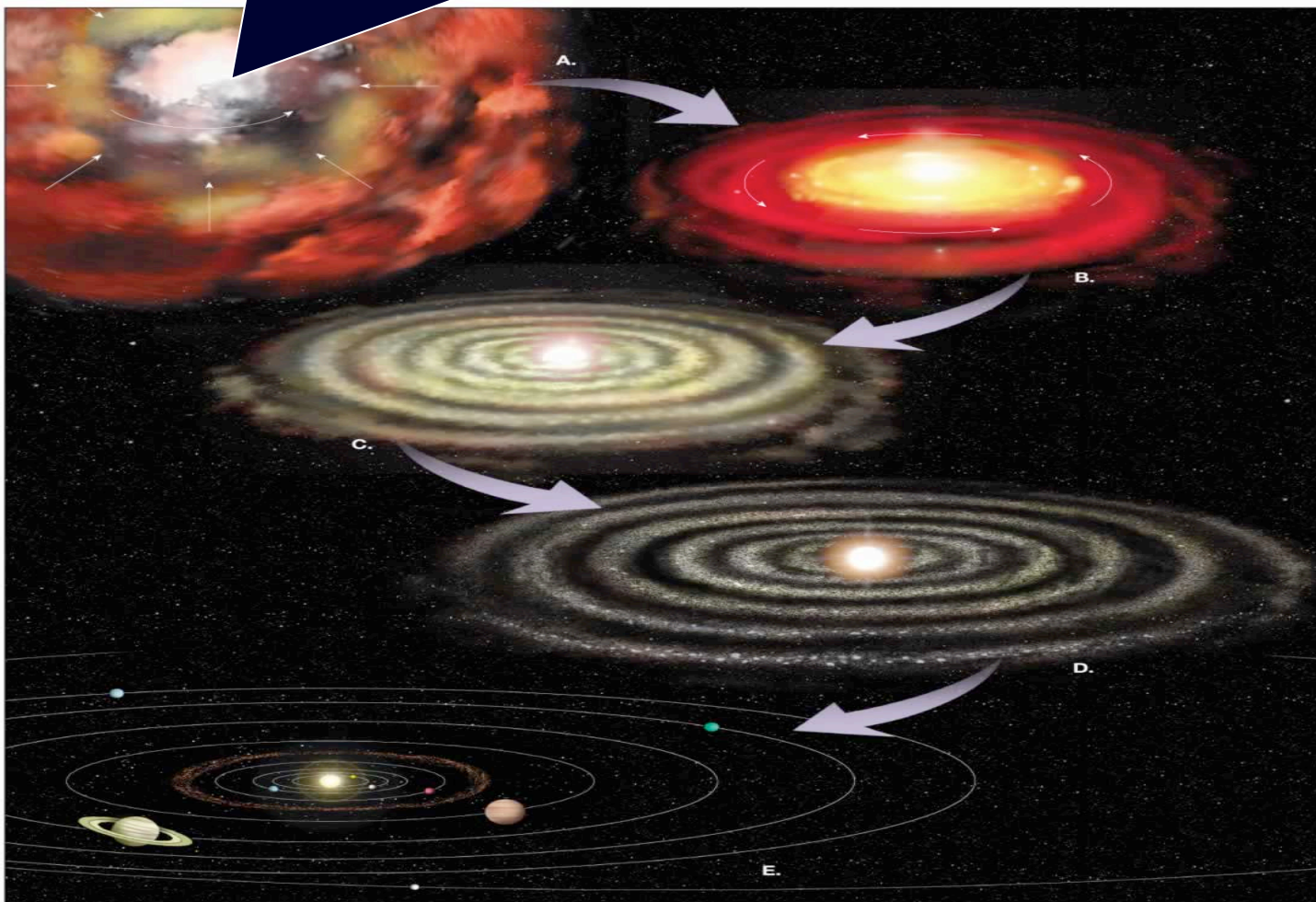


The Universe under the 'enlightenment'

Kant's 'Nebula Hypothesis' (1755) was that stars & planets formed from vast clouds of 'space dust' (nebulae)



Immanuel Kant
(1724-1804)

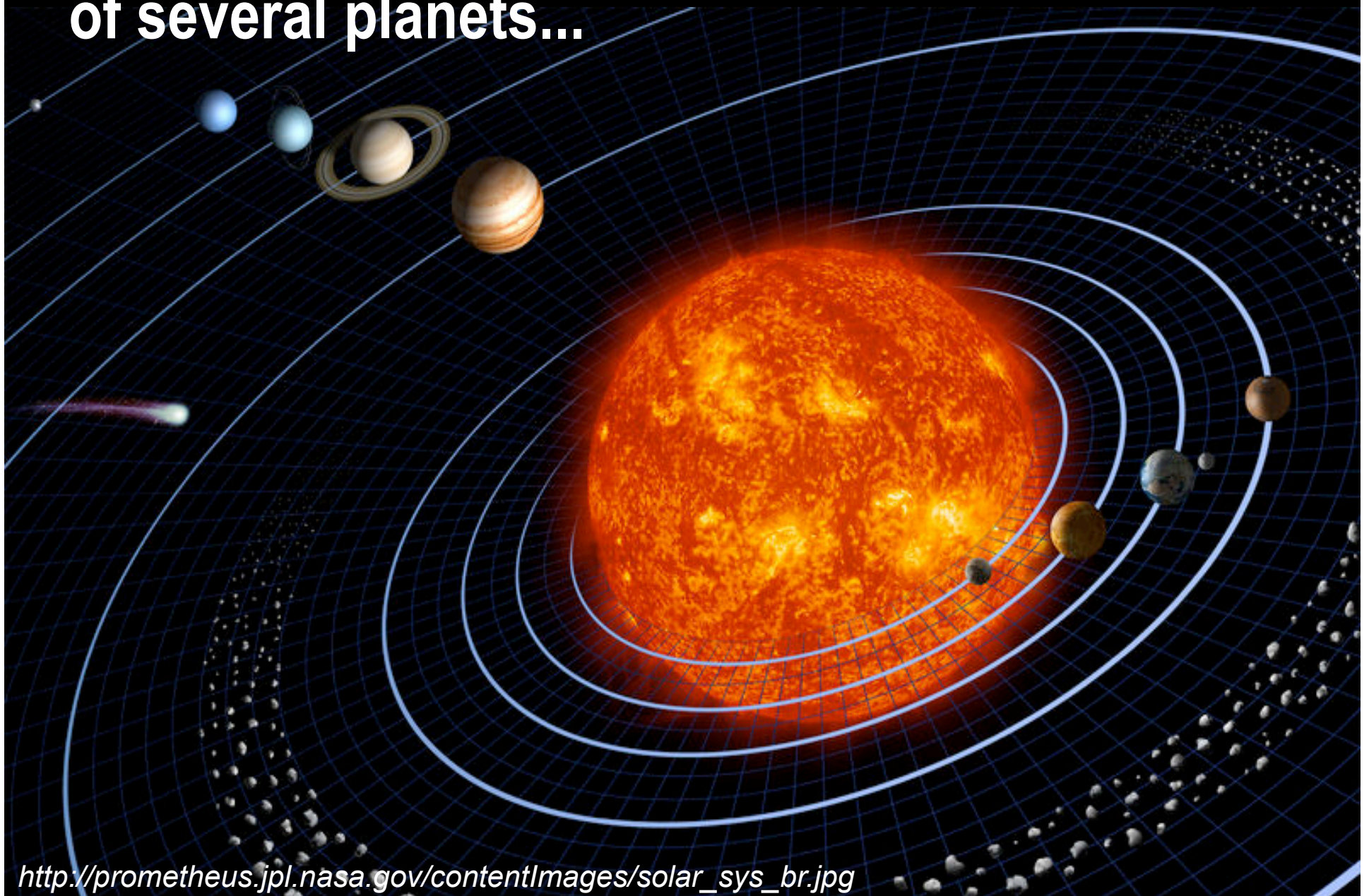


15th~18th centuries develop a “mechanical universe”



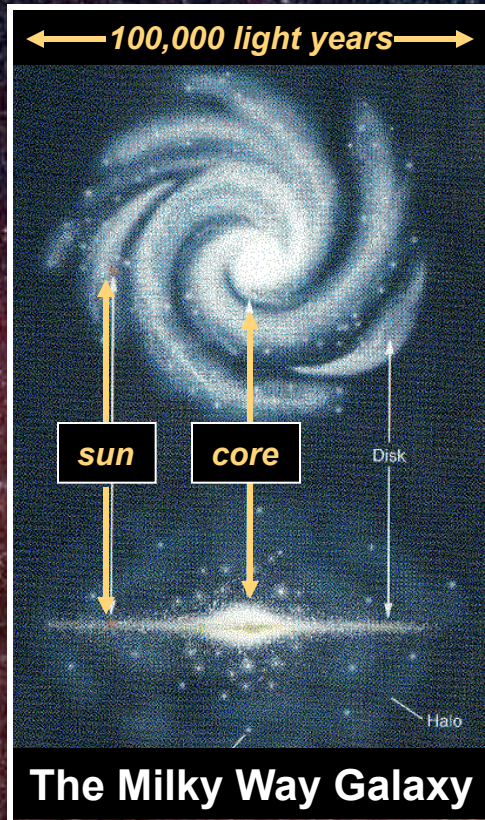
...a universe that makes logical sense, like a machine

**Modern physics understands our Earth is just one
of several planets...**



http://prometheus.jpl.nasa.gov/contentImages/solar_sys_br.jpg

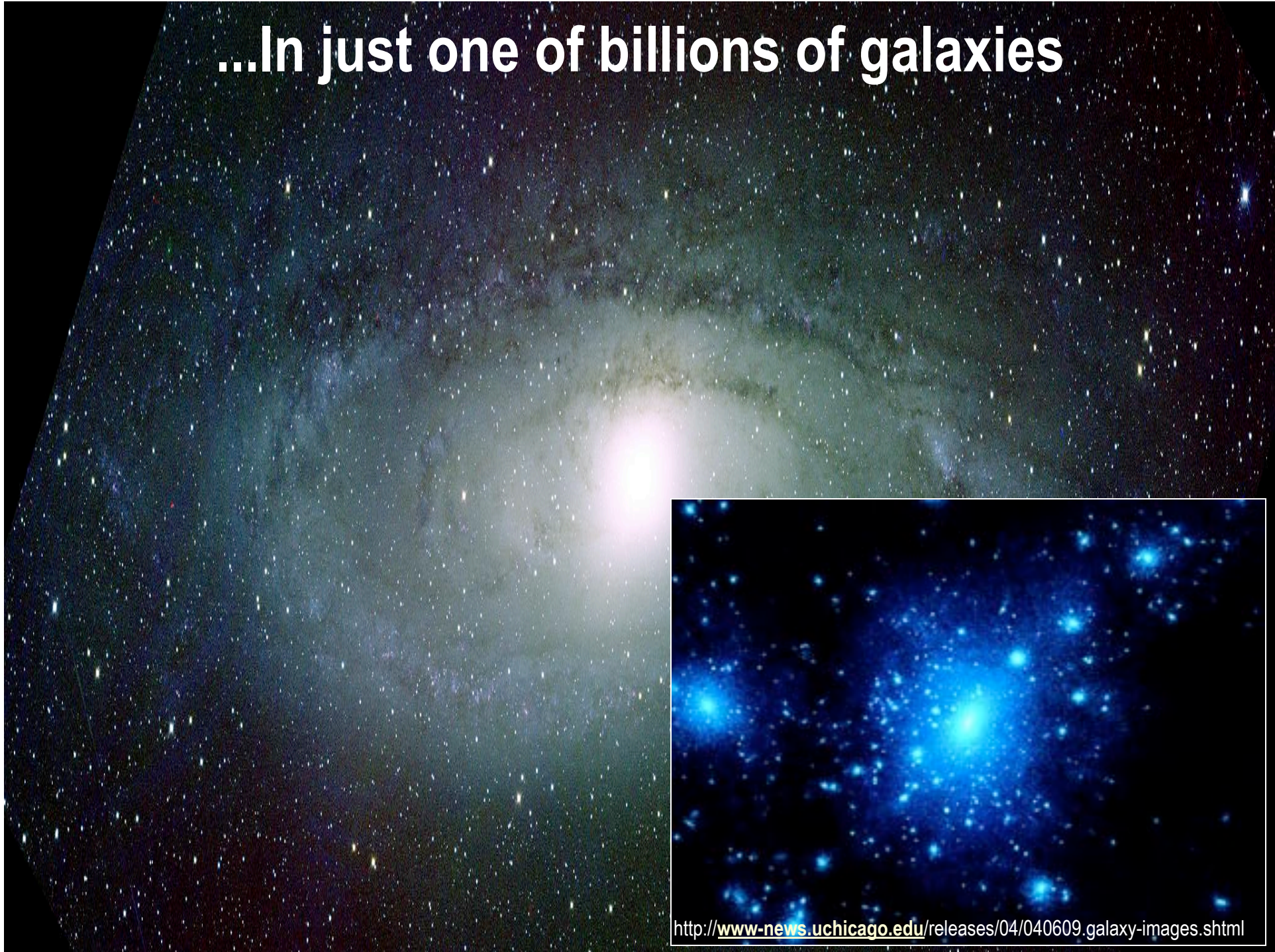
...in just another star system...



“This ... image from NASA's Spitzer Space Telescope shows hundreds of thousands of stars crowded into the swirling core of our spiral Milky Way galaxy”

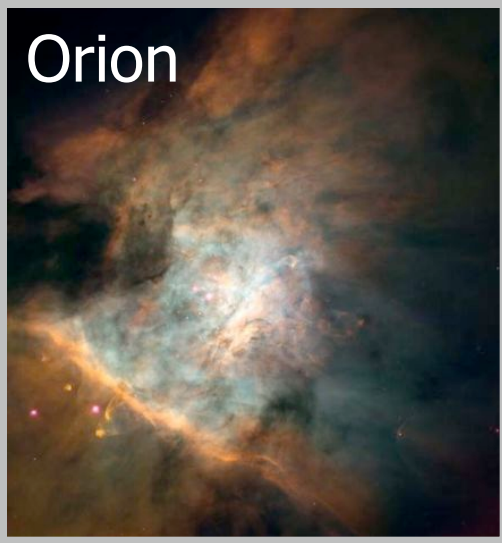
NASA mission news 01.10.06
<http://www.nasa.gov/vision/universe/starsgalaxies/spitzer-20060110.html>

...In just one of billions of galaxies

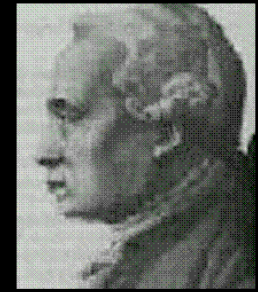


http://www-news.uchicago.edu/releases/04/040609_galaxy-images.shtml

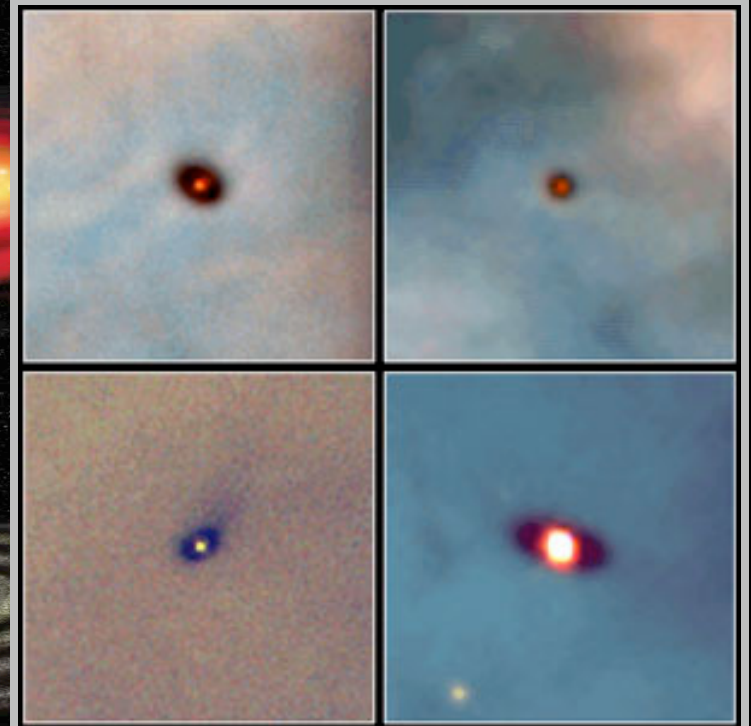
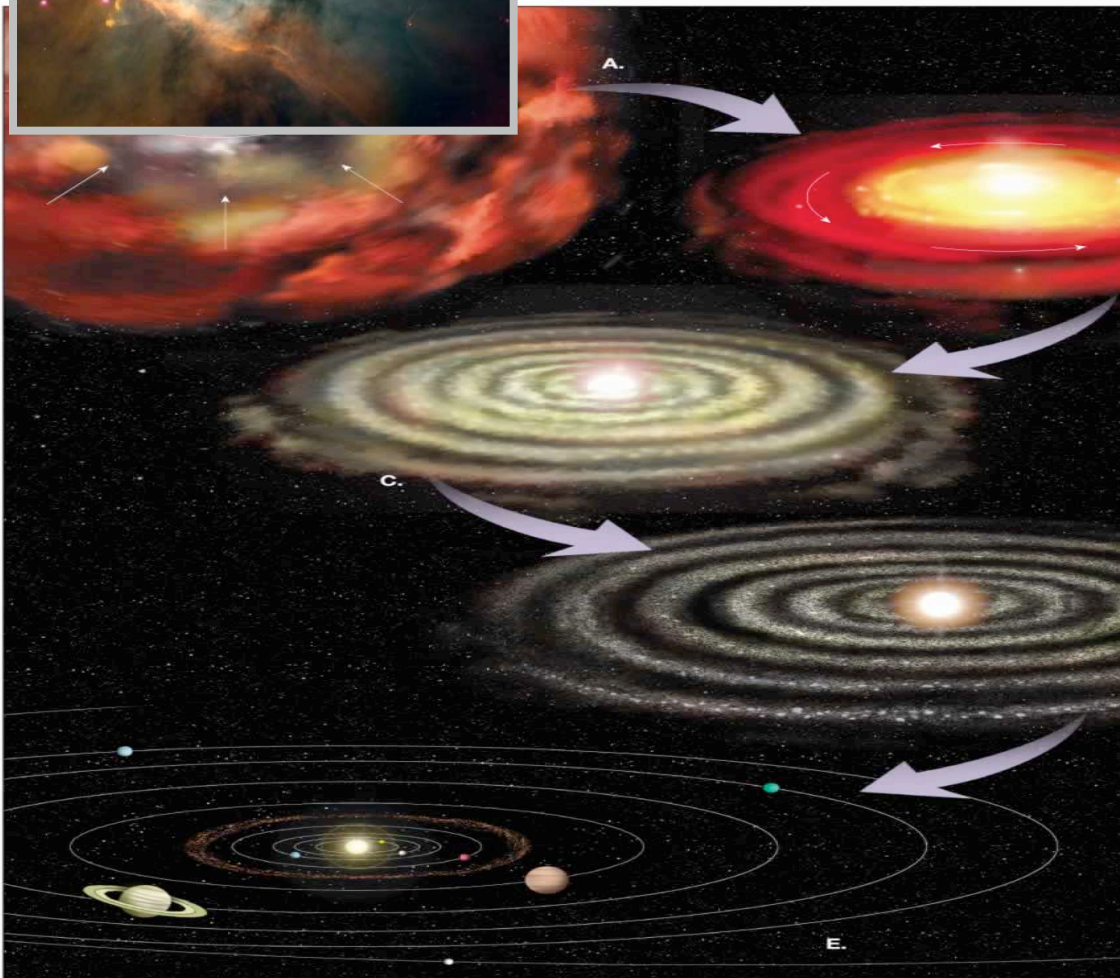
Orion



(Modern science
essentially backs up
Kant's theorizing)



Immanuel Kant
(1724-1804)



Hubble images of protoplanetary discs
around young stars in the Orion nebula
(Hubble space telescope)

The Medieval Cosmos II

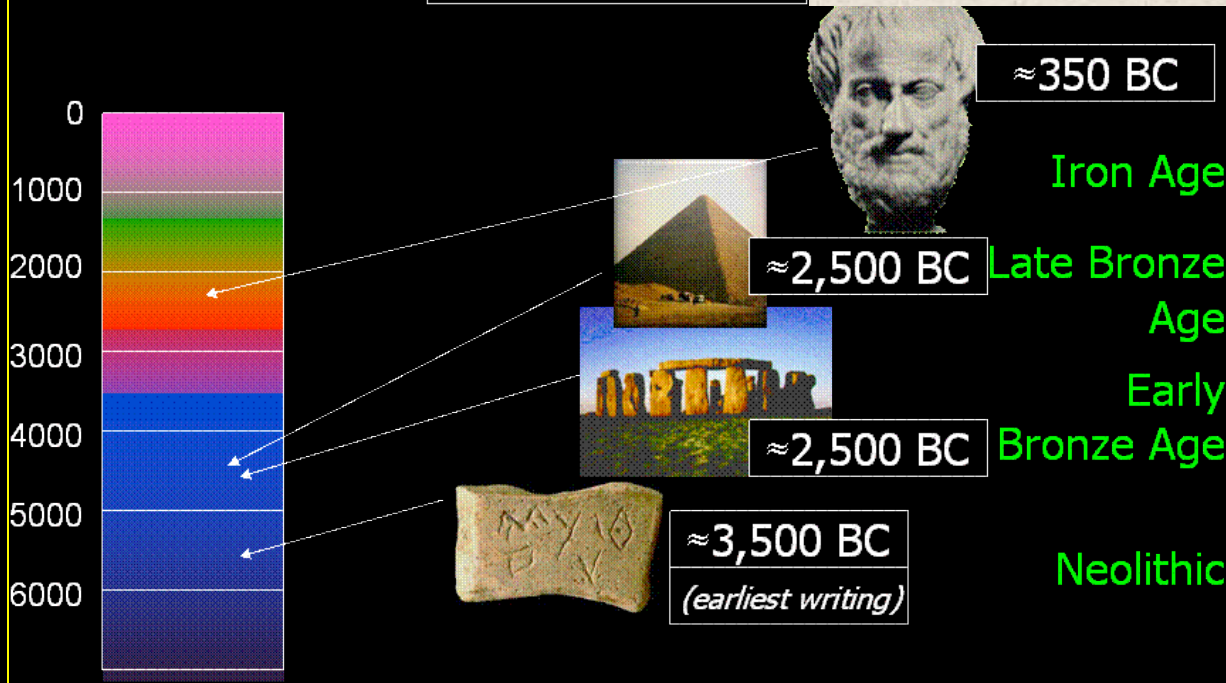
In 1658 publication, archbishop Ussher calculated from Biblical genealogy that the earth was created in 4004 BC: *i.e.* the earth is 6000 years old.



James Ussher
(1581-1656)

by astronomical tables (notwithstanding the stay of the sun in the dayes of Joshua, and the going back of it in the dayes c Ezekiah) happened upon the 23 day of the Julian October; from thence concluded that from the evening preceding that first day of the Julian year, both the first day of the creation and the first motion of time are to be deduced.

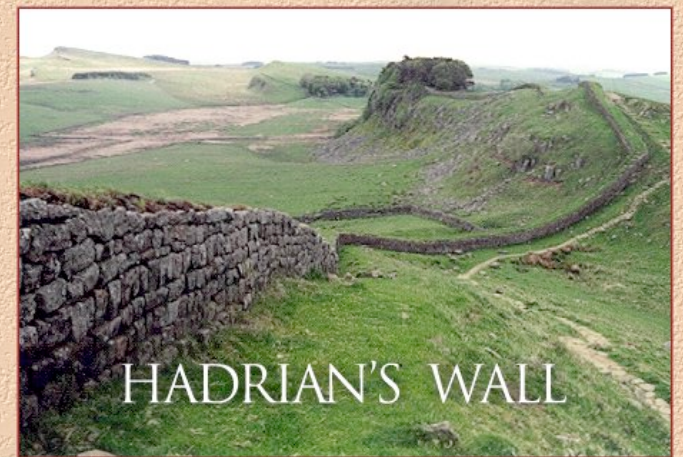
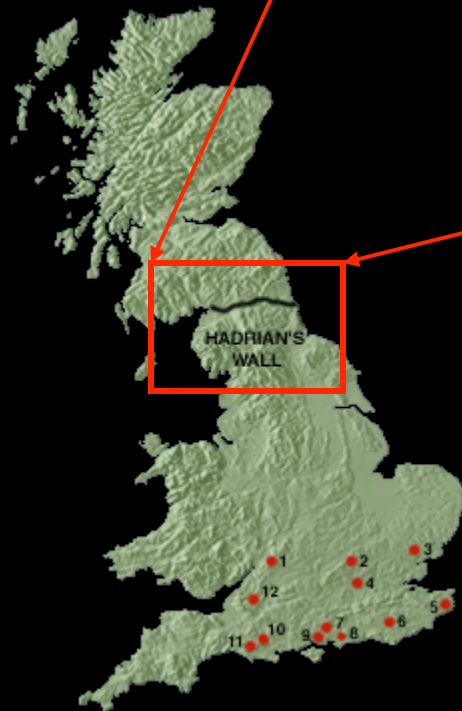
— J. Ussher, *The Annals of the World iv* (1658)



◆ 18th Century Enlightenment geology



James Hutton
1726-1797



◆ 18th Century Enlightenment geology



James Hutton
1726-1797



Hadrian's wall
today



(artist's
depiction)
Hadrian's wall
1700 years
before Hutton

6,000 Yrs?



Enlightenment geology



by astronomical tables (notwithstanding the stay of the sun in the dayes of Joshua, and the going back of it in the dayes c. Ezekiah) happened upon the 23 day of the Julian October, from thence concluded that from the evening preceding that first day of the Julian year, both the first day of the creation and the first motion of time are to be deduced.

— J. Ussher, *The Annals of the World* (1658)

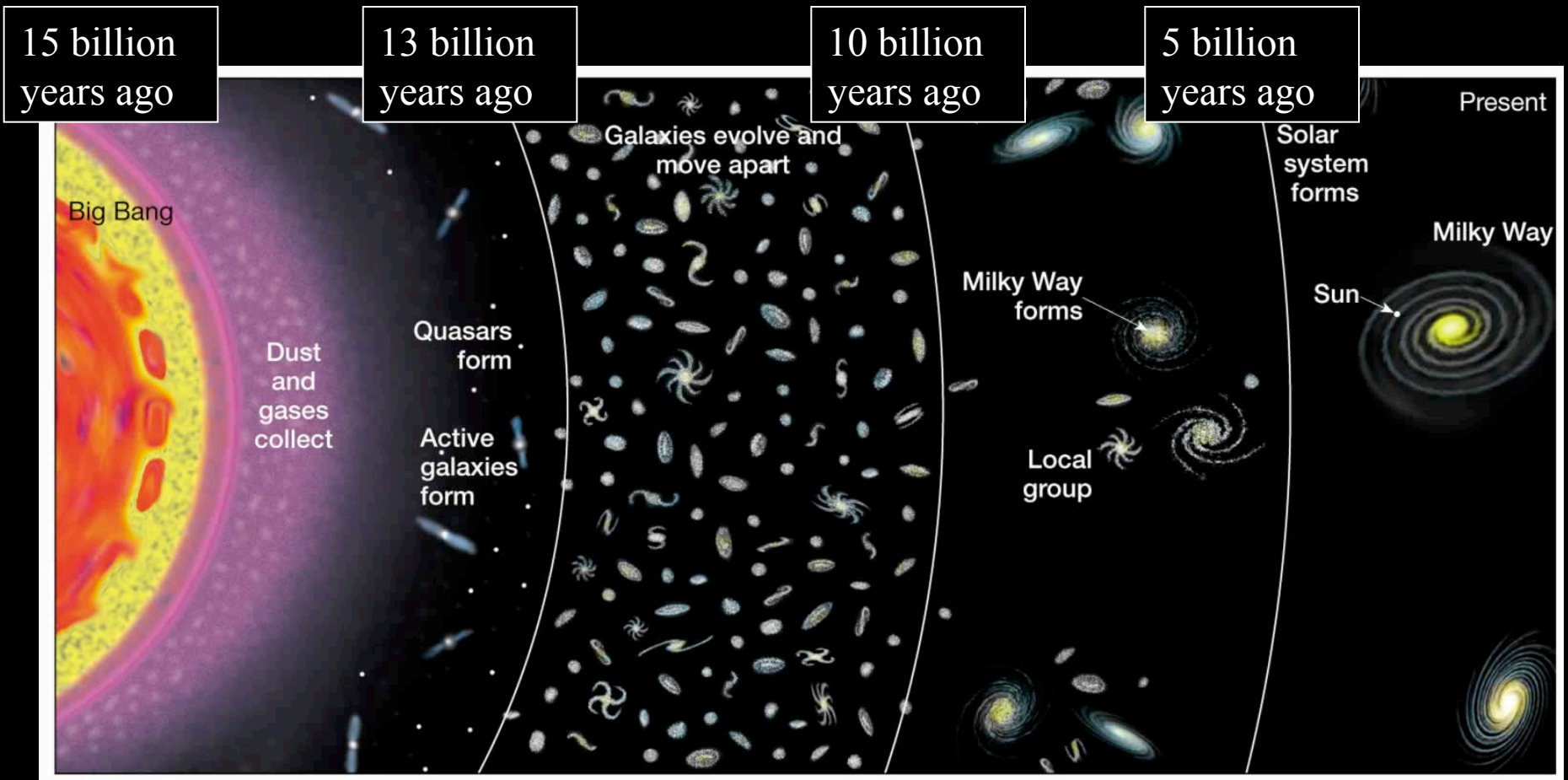


James Hutton
1726-1797

"When we consider the earth] We find no vestige of a beginning, no prospect of an end."

Theory of the Earth (1785)

The view from modern physics



Time & Space for 15% of earth's history

Epoch

Pleistocene

Most recent 5% of life on earth = Pleistocene



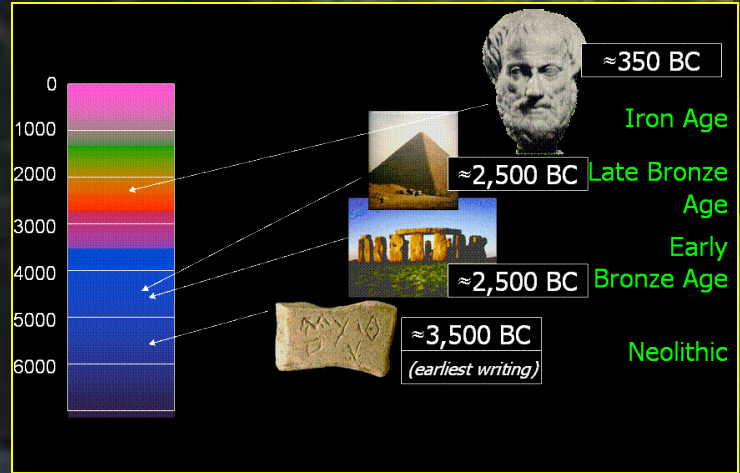
Most recent 5% of that has seen humanity spread from Africa

Cambrian explosion

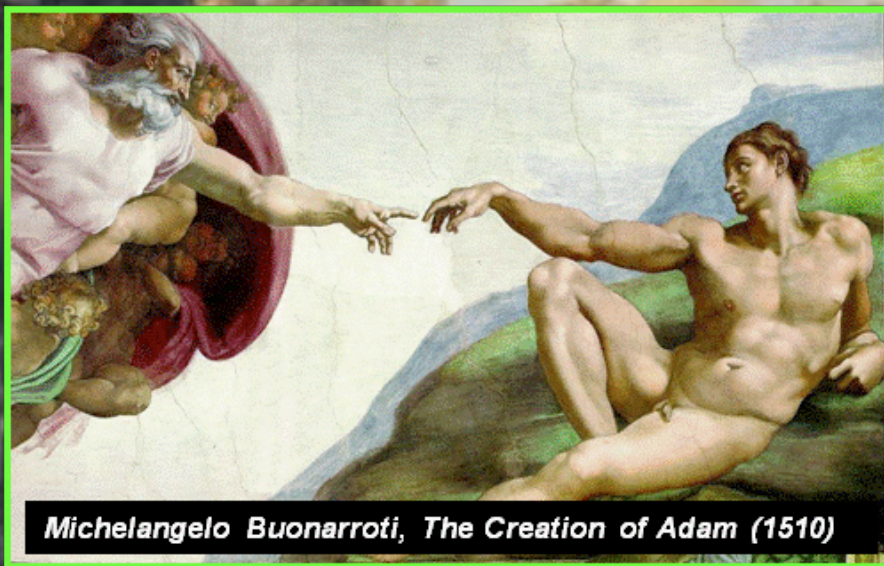


Most recent 5% of *that* has seen the whole of recorded history

Oldest fossils



The Cosmos of the Middle Ages (iii)



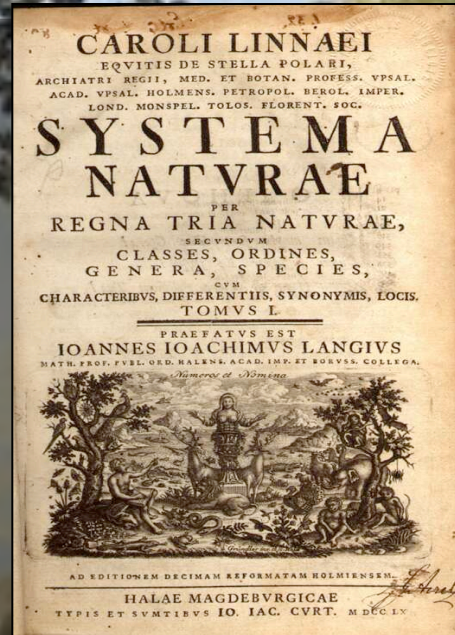
Michelangelo Buonarroti, *The Creation of Adam* (1510)



Adam naming the animals

◆ A systematic approach to biological nature

Carl Linnaeus (1707-1778)



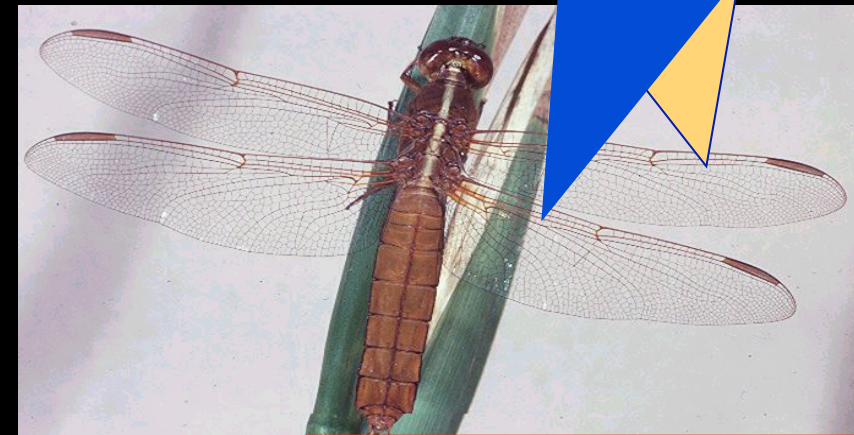
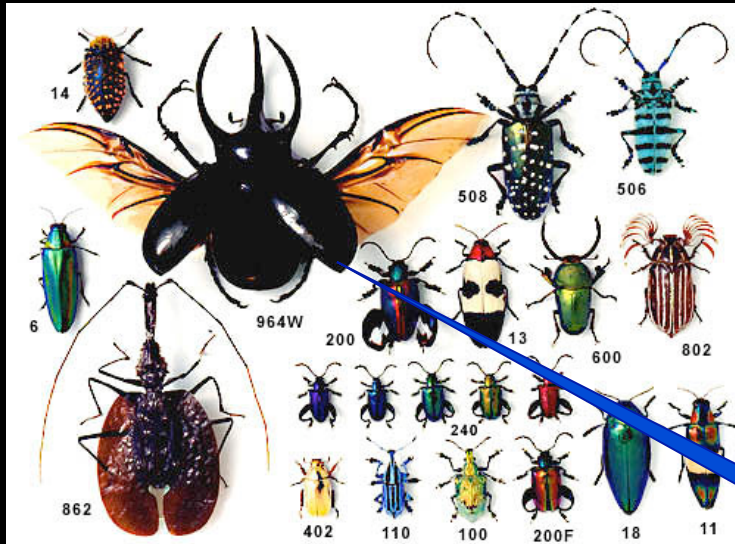
Systema naturae: 1st edition, 10 pages published 1735; within his lifetime it went as far as a 13th edition of 3,000 pages!



Adam naming the animals

◆ ...finds simple, objective groups of life

2 pairs of equal sized wings



elytra



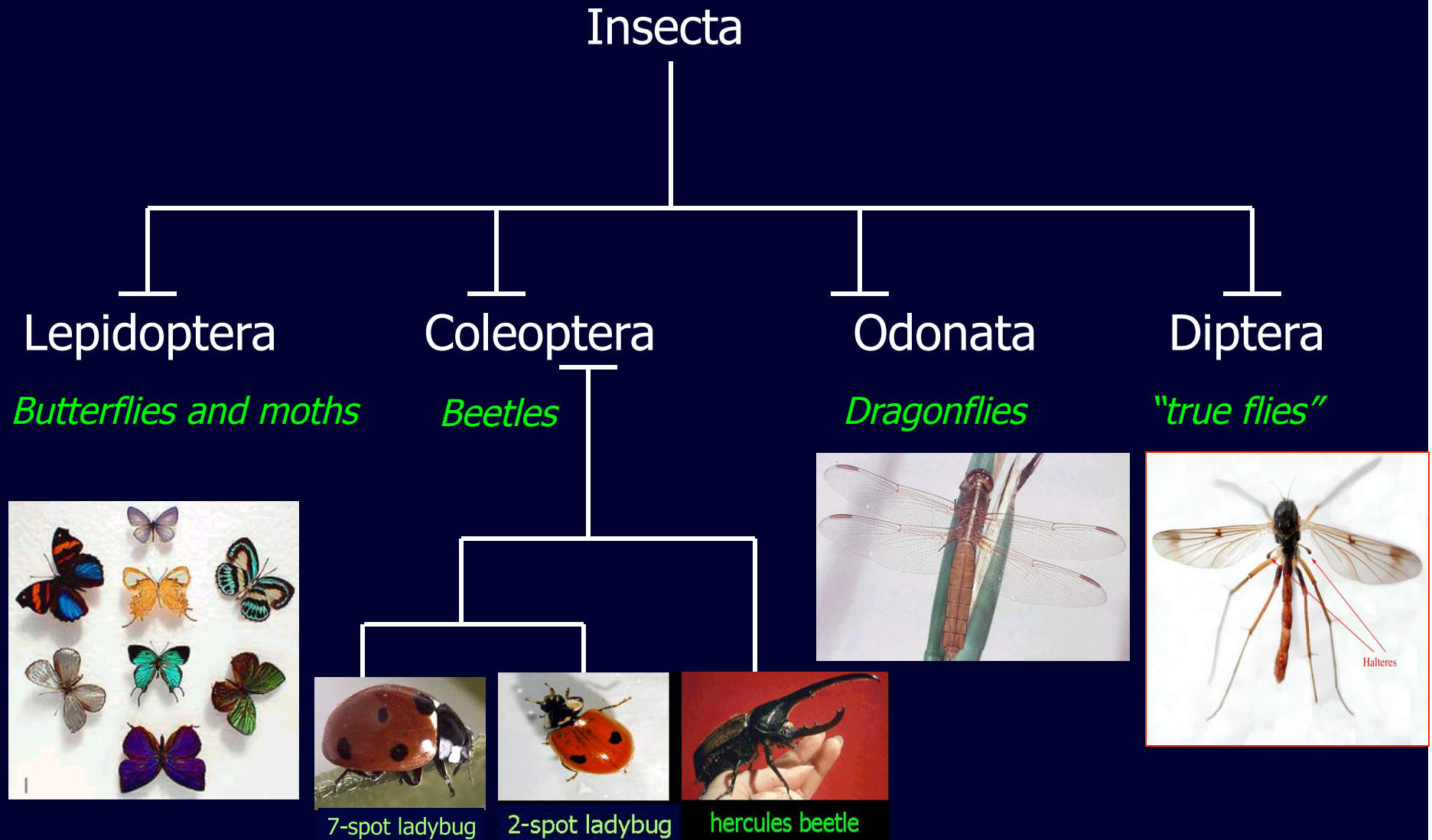
Large, colored pairs of wings, always exposed and interlocked



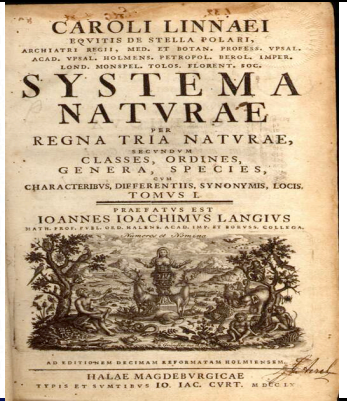
"Halteres": hind wings reduced to 'stabilizers'

(note the same basic body parts, but different defining wing characteristics)

◆ *that provide a natural, objective classification system*



◆ For ALL of life on earth



Animalia

Insecta

mammalia

Scarabaeidae

Coccinellidae

Hominidae

Dynastes

Adalia

Homo

hercules

2-punctata

7-punctata

Sapiens



Kingdom

Class

Family

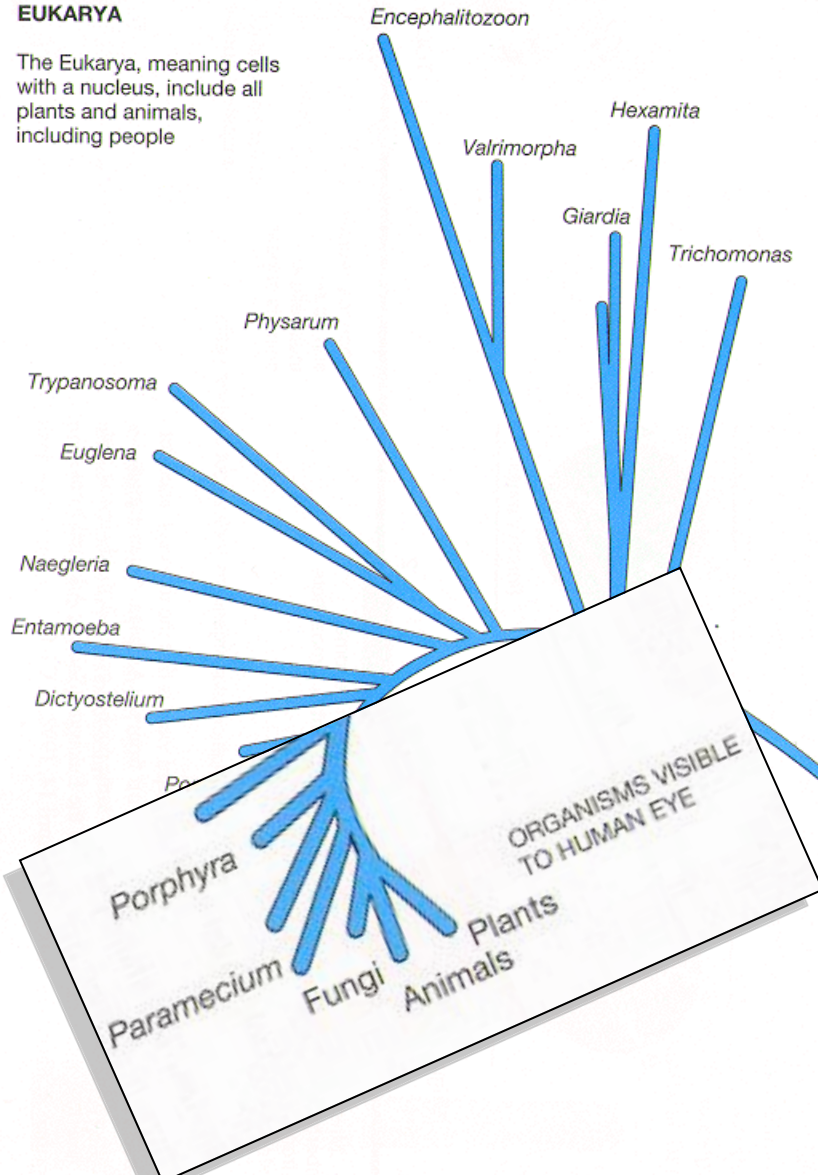
Genus

Species

◆ A modern genetic view of life's classification...

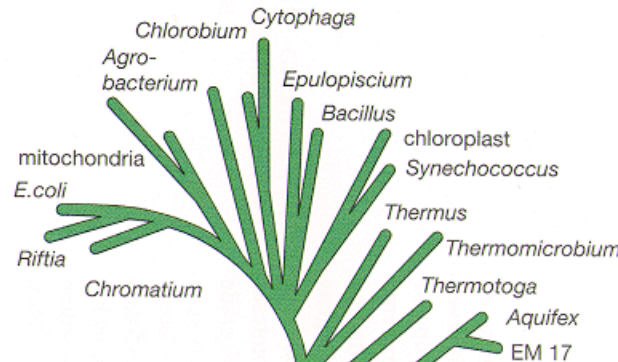
EUKARYA

The Eukarya, meaning cells with a nucleus, include all plants and animals, including people



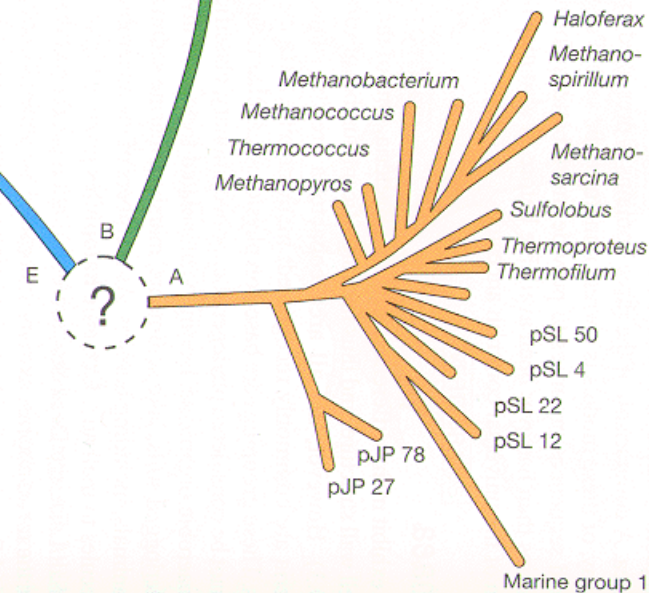
BACTERIA

Bacteria are single-celled organisms with no nucleus.



ARCHAEA

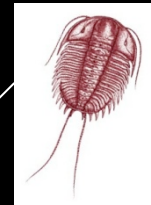
The Archaea look like bacteria but have different genes for managing and reading out their DNA.



<http://cas.bellarmine.edu/tietjen/Ecology/Domains0.gif>

Adapted from Carl Woese and Norman R. Pace, New York Times, April 14, 1998

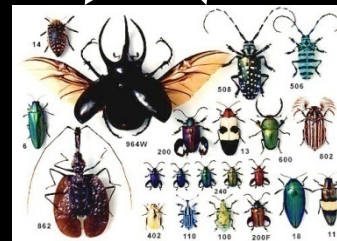
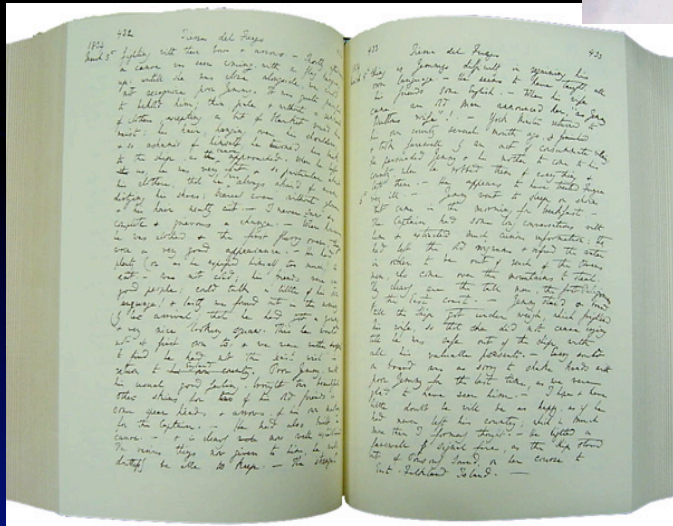
◆ Charles Darwin observes that a natural process could produce these (and other) patterns...



Arthropod

Insect

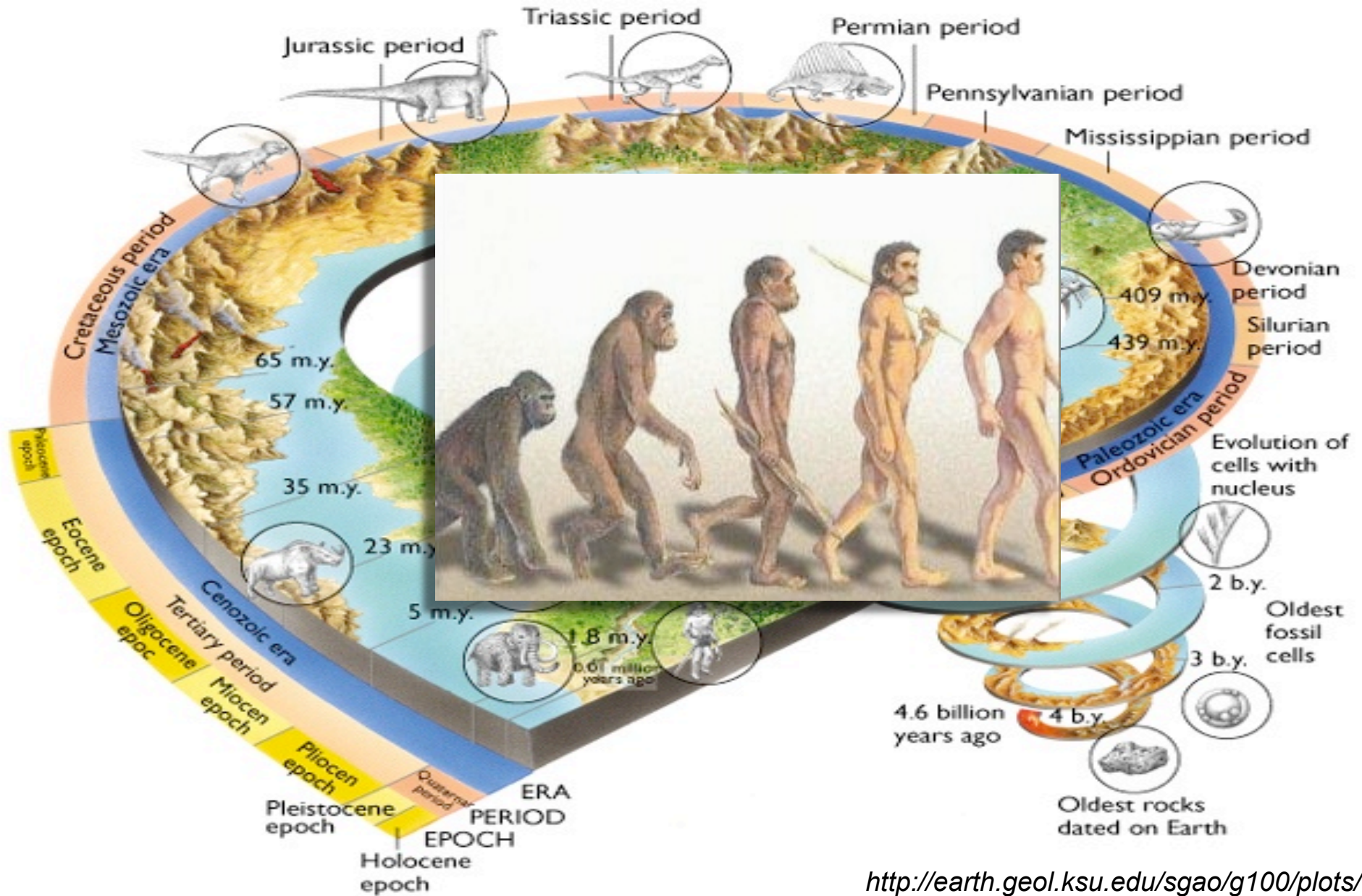
Arachnid



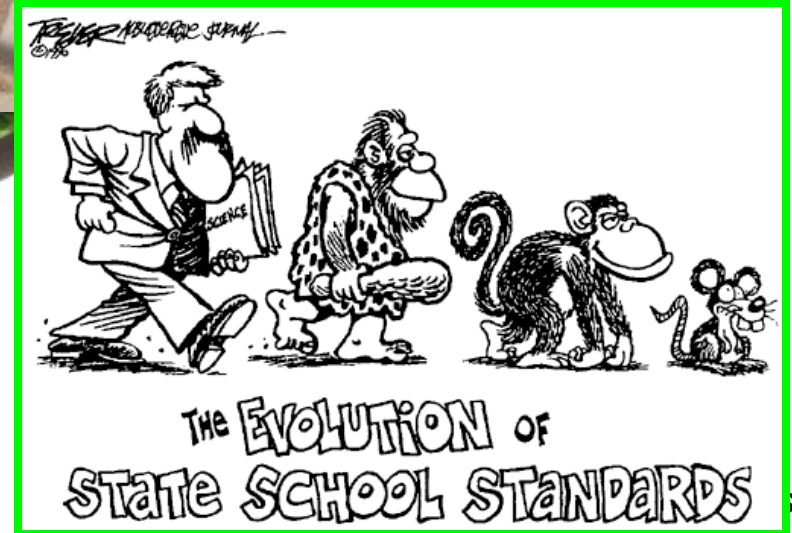
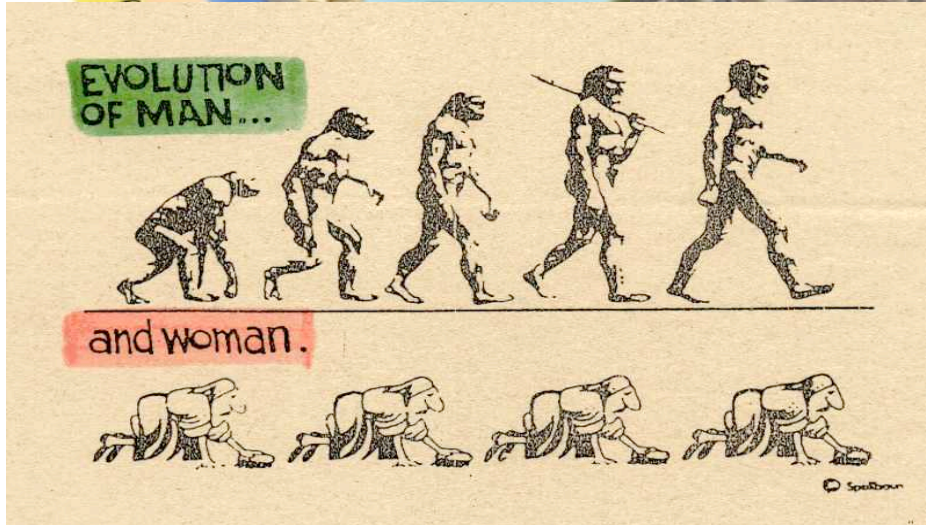
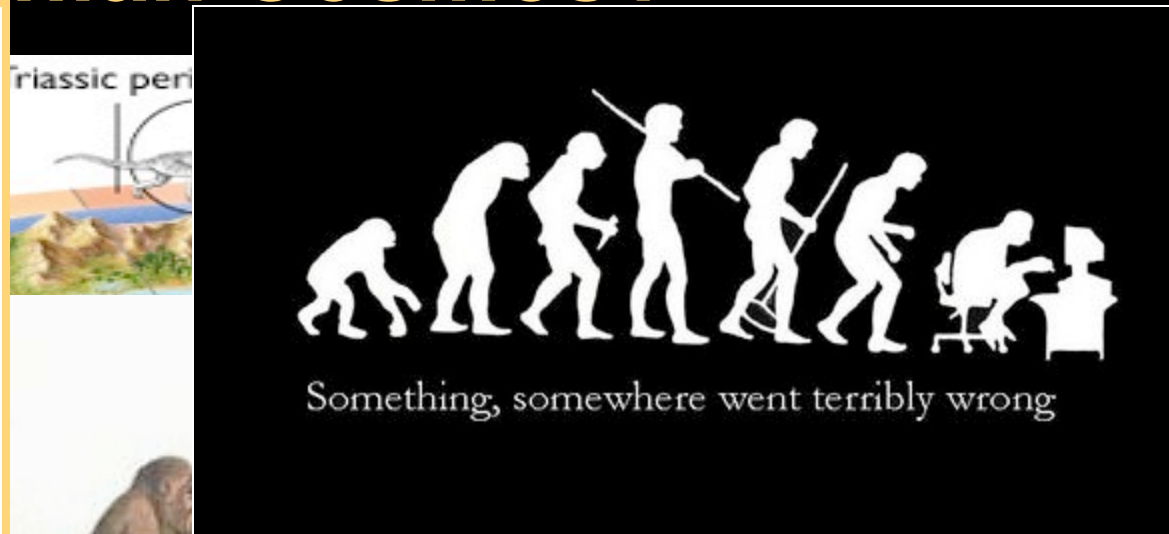
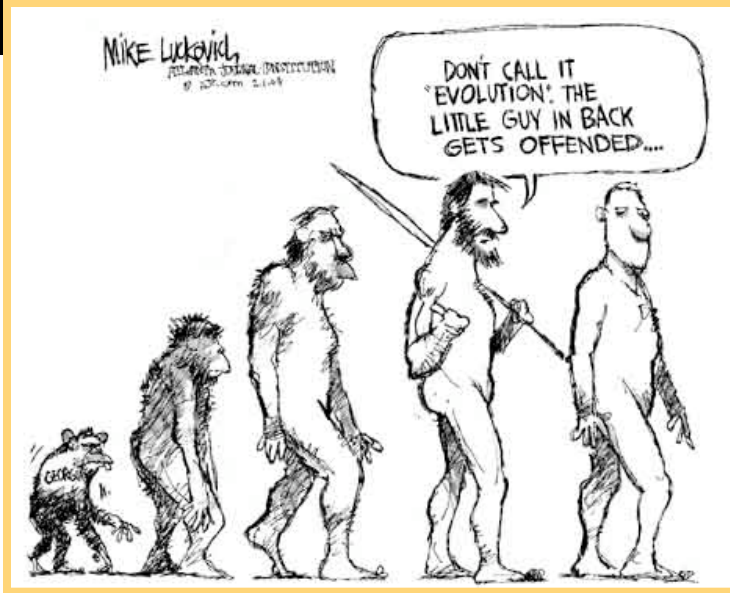
Beetle

As different species separate from one another at different times, the time since separation will determine their overall level of similarity

The post-Darwinian Cosmos?



The post-Darwinian Cosmos?



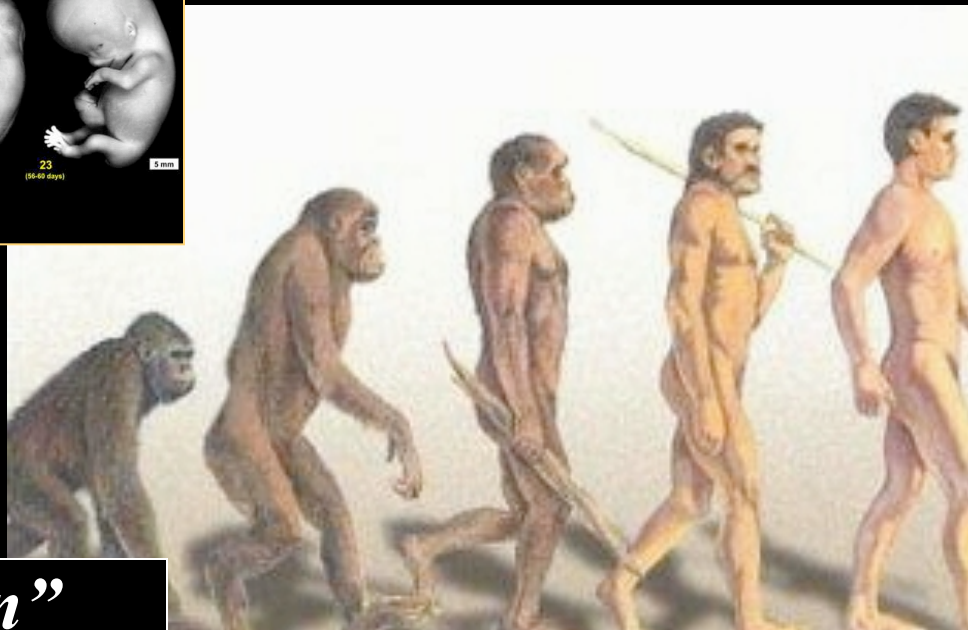
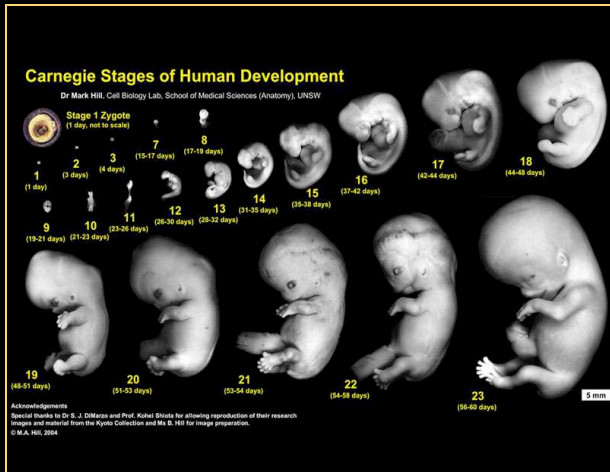
Darwin used the word **evolution** exactly once in the whole of *the Origin of Species*:

“Thus, from the war of nature, from famine and death, the most exalted object which we are capable of conceiving...directly follows. There is grandeur in this view of life... that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.”

- Literally the final word of the final paragraph of the final chapter...



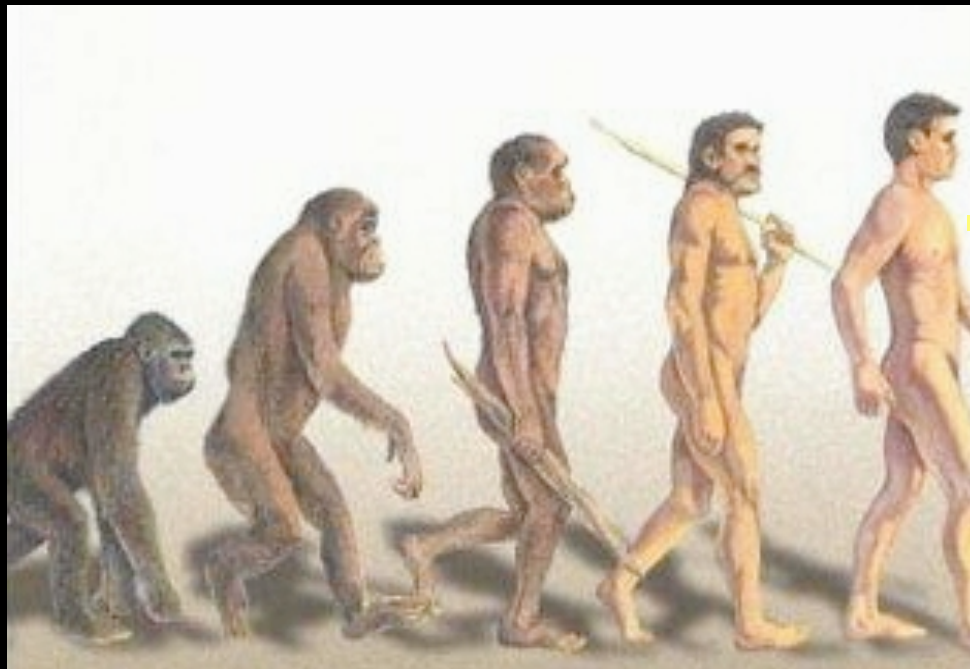
The ladder of evolutionary progress...



“Evolution”

From Latin *evolvere* “to unroll” : entered the English language via pre-Darwinian developmental biologists who saw an analogy between *progressive development of zygote into adult* and *progressive development of simple species into more sophisticated species*

◆ The ladder of evolutionary progress...

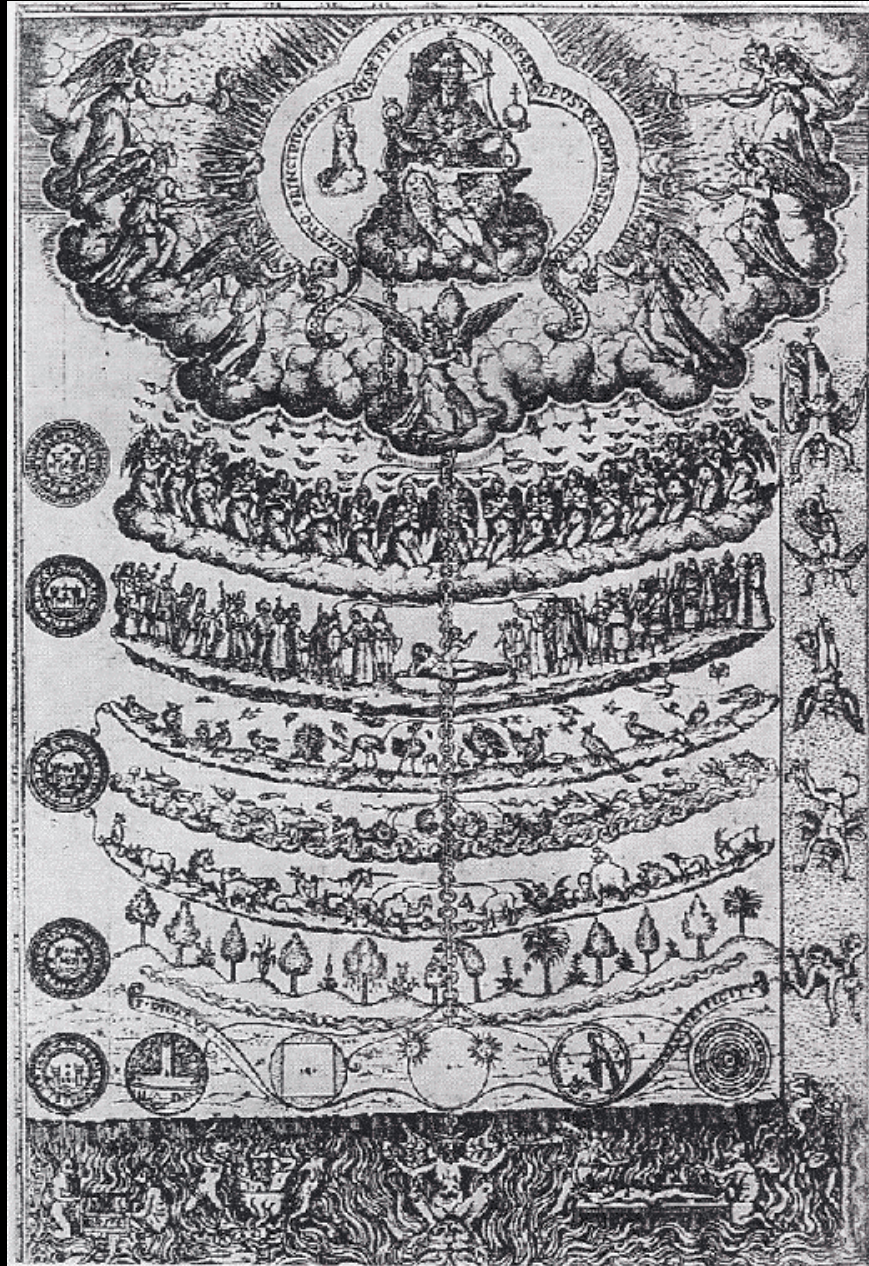


(lower) ←

→ (higher)

...the idea of a ladder of evolutionary progress implies that each living species is somewhere, higher or lower, on this ladder...

Scala Naturae: the Great Chain of Being



Higher

→ God



→ **Humans**

→ Animals

→ Plants

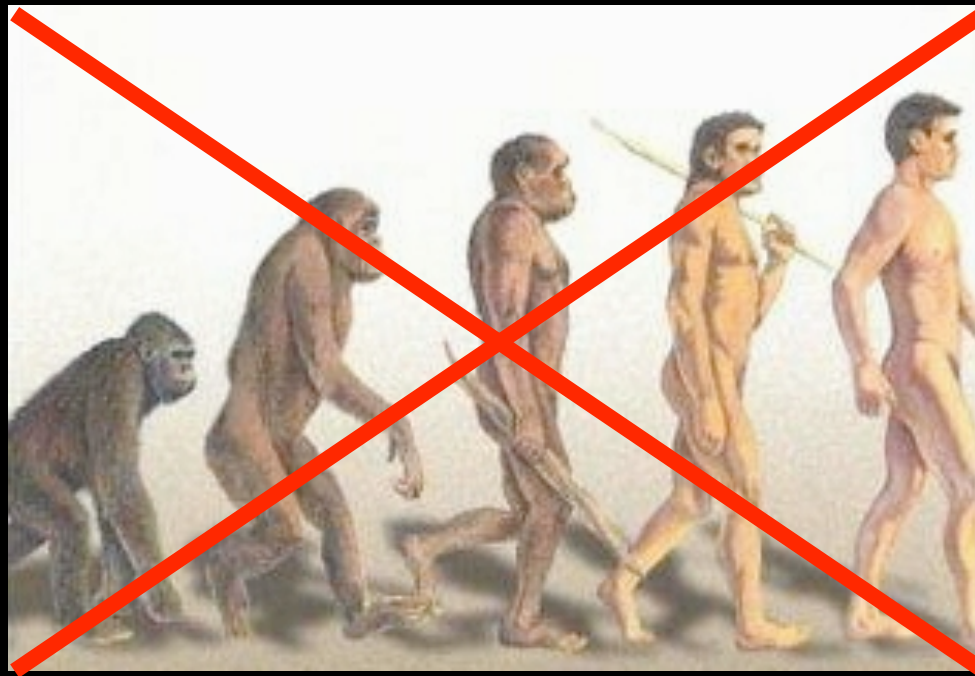
→ Rocks

→ Non being

Lower

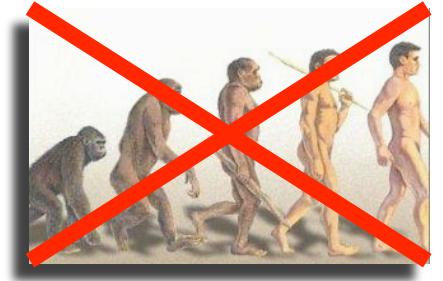
◆ The ladder of evolutionary progress...

...was born with Aristotle, developed by the Catholic Church, and theologically inspired natural historians (e.g. Linnaeus)

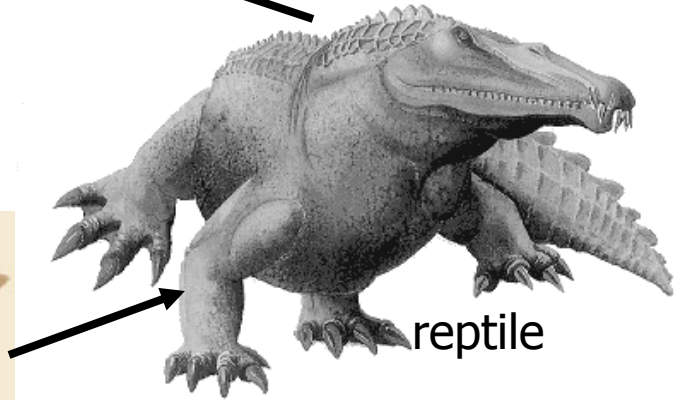


and died with Darwin's theory...

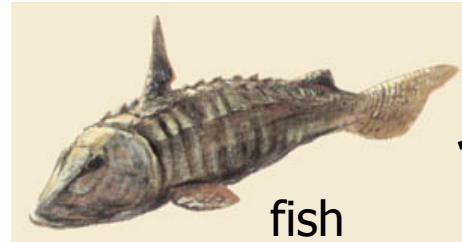
◆ Natural selection & progress



mammal



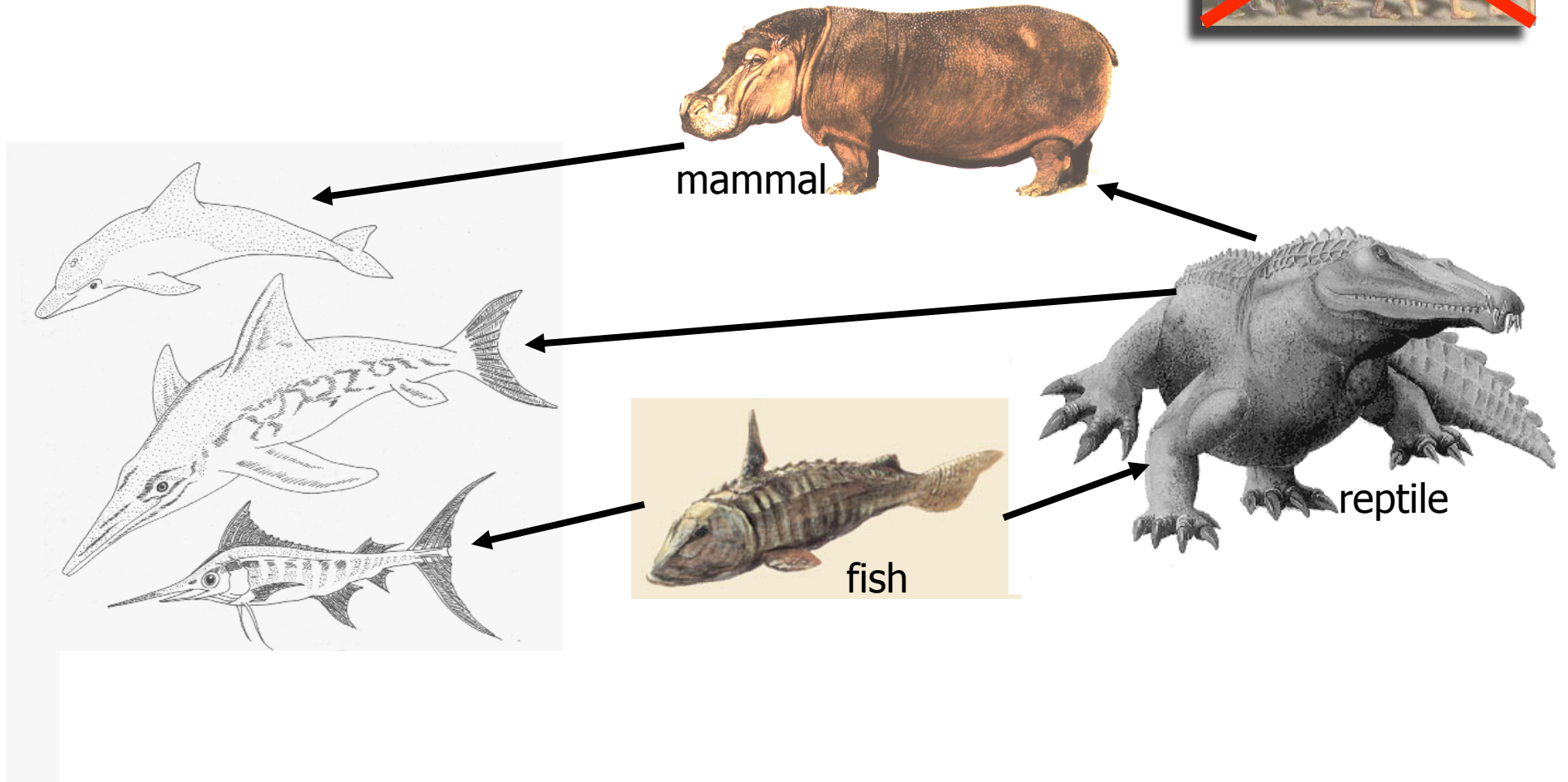
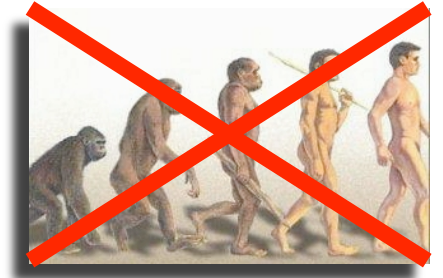
reptile



fish

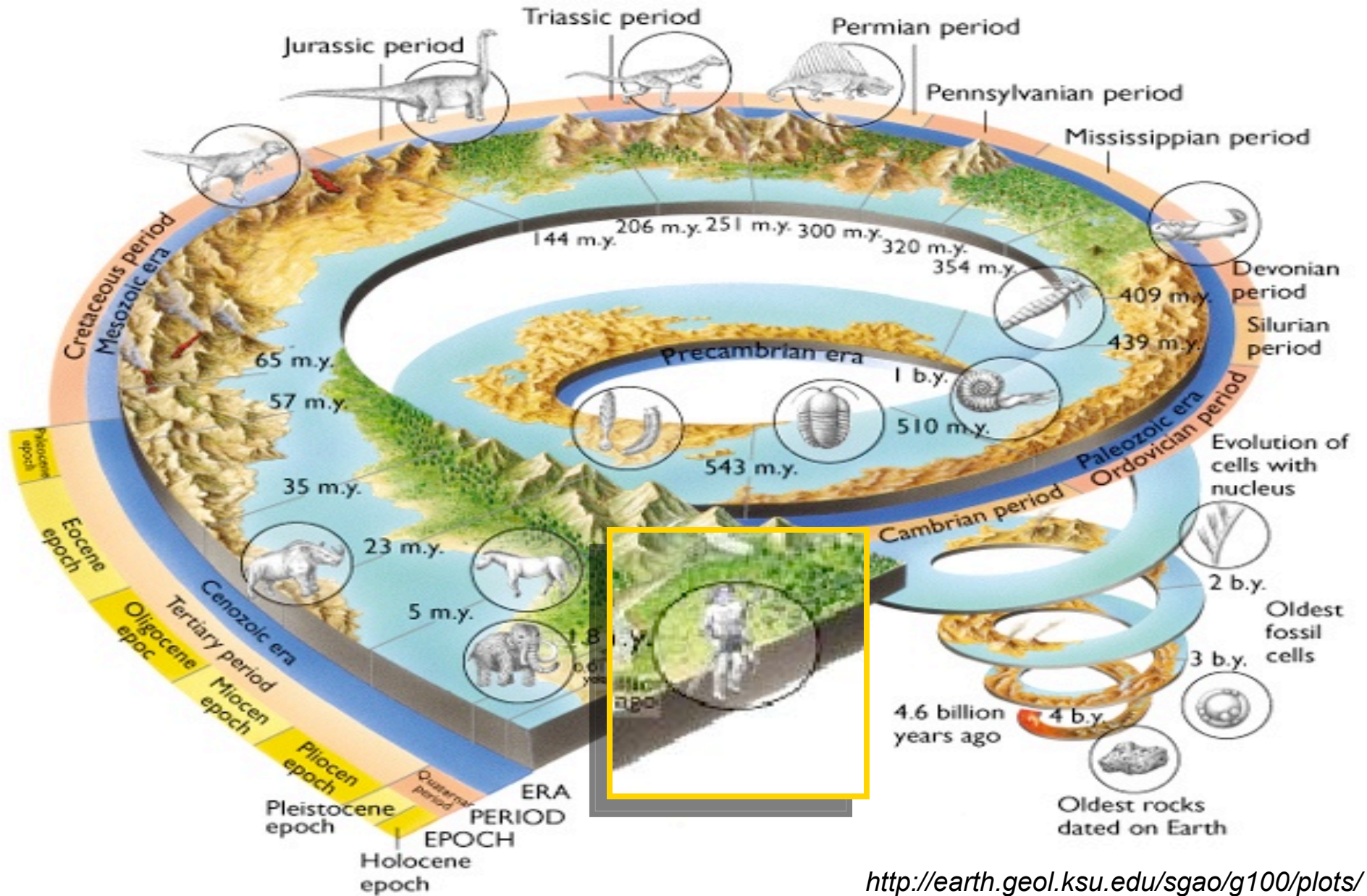
Progress: from fish to reptiles to mammals?

◆ Natural selection & progress

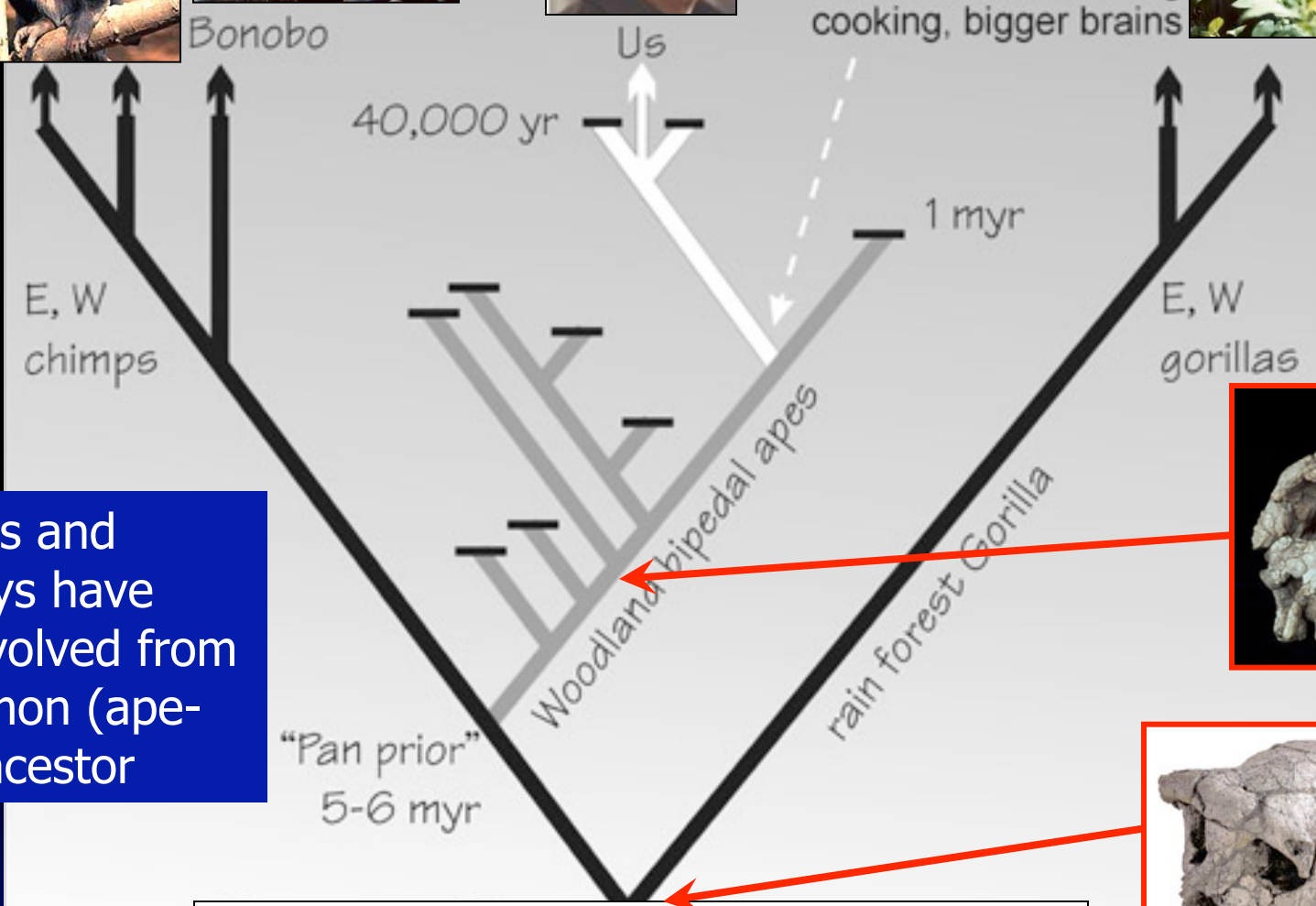


Progress: from fish to reptiles to mammals?

Has evolution been leading to us?



Human evolution: Darwin's claim

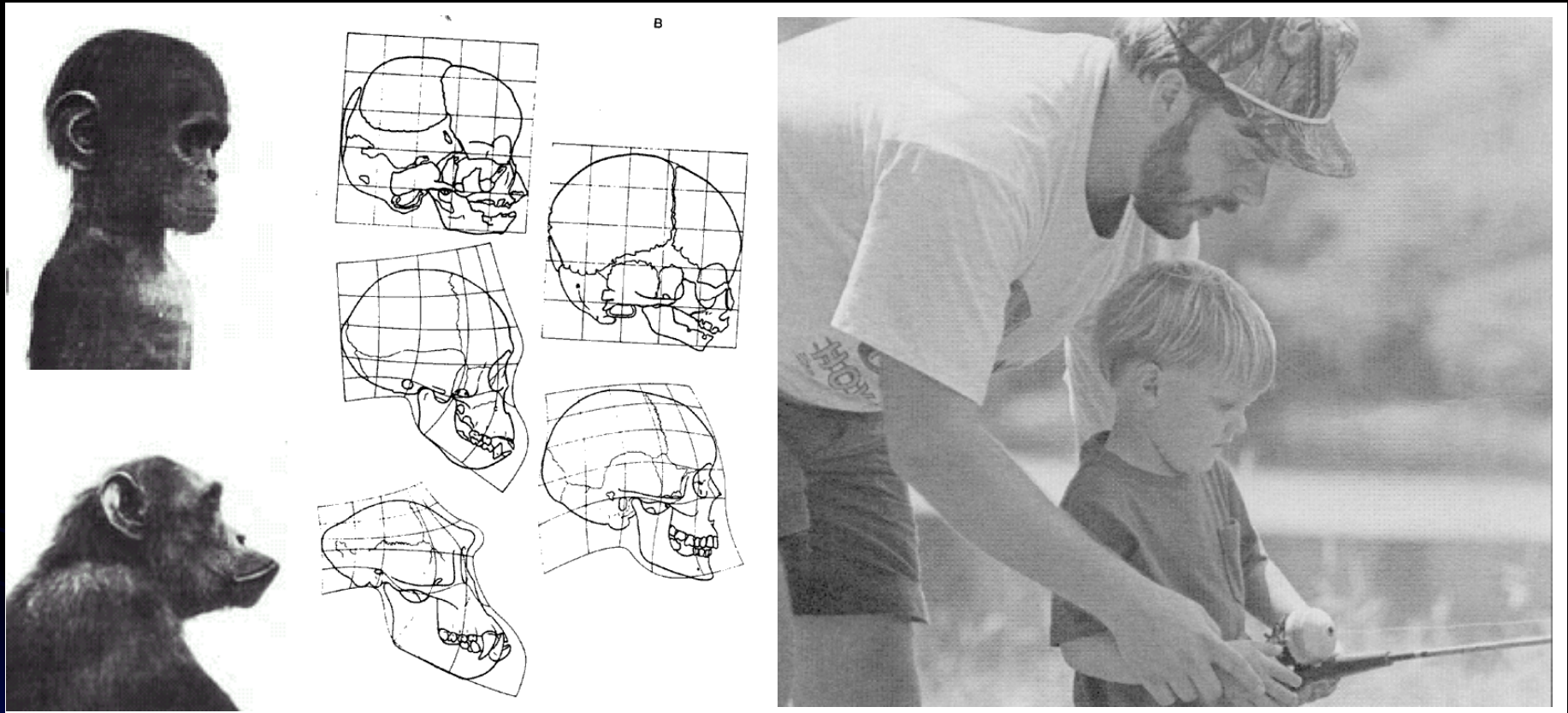


Humans and monkeys have both evolved from a common (ape-like) ancestor

Ancestor to apes, chimps and humans



◆ Human Evolution – a story of Neoteny



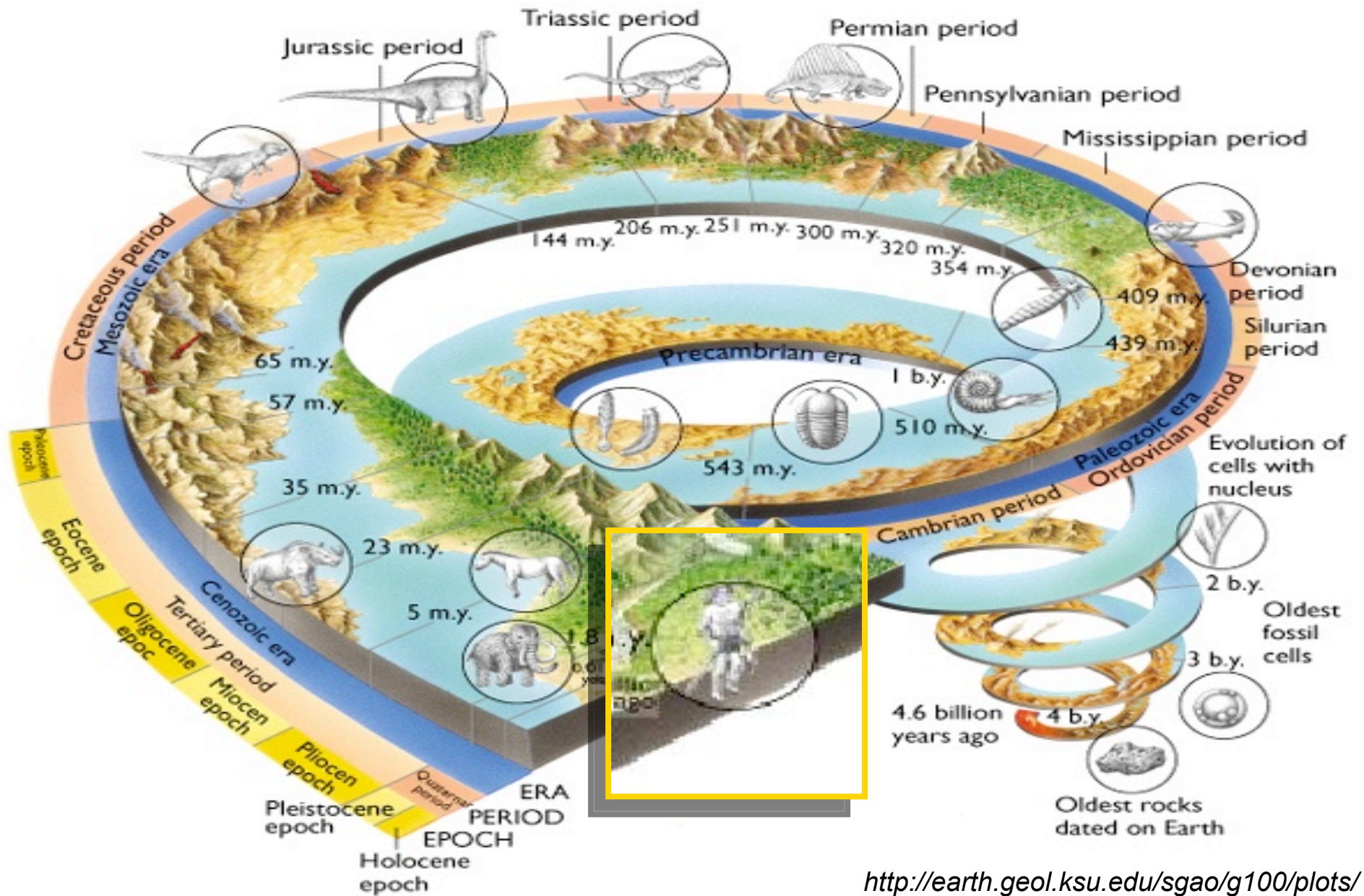
THEORY #1: ratio of brain:body is enlarged ~ selection for increased intelligence drove *homo sapiens* evolution

◆ Human Evolution – a story of Neoteny



THEORY #2: prolonged sexual selection for “beauty” that equates to child-like facial characteristics... Large eyes, button noses...produces intelligence as an accidental byproduct

Has evolution been leading to something like us?



◆ Extinction

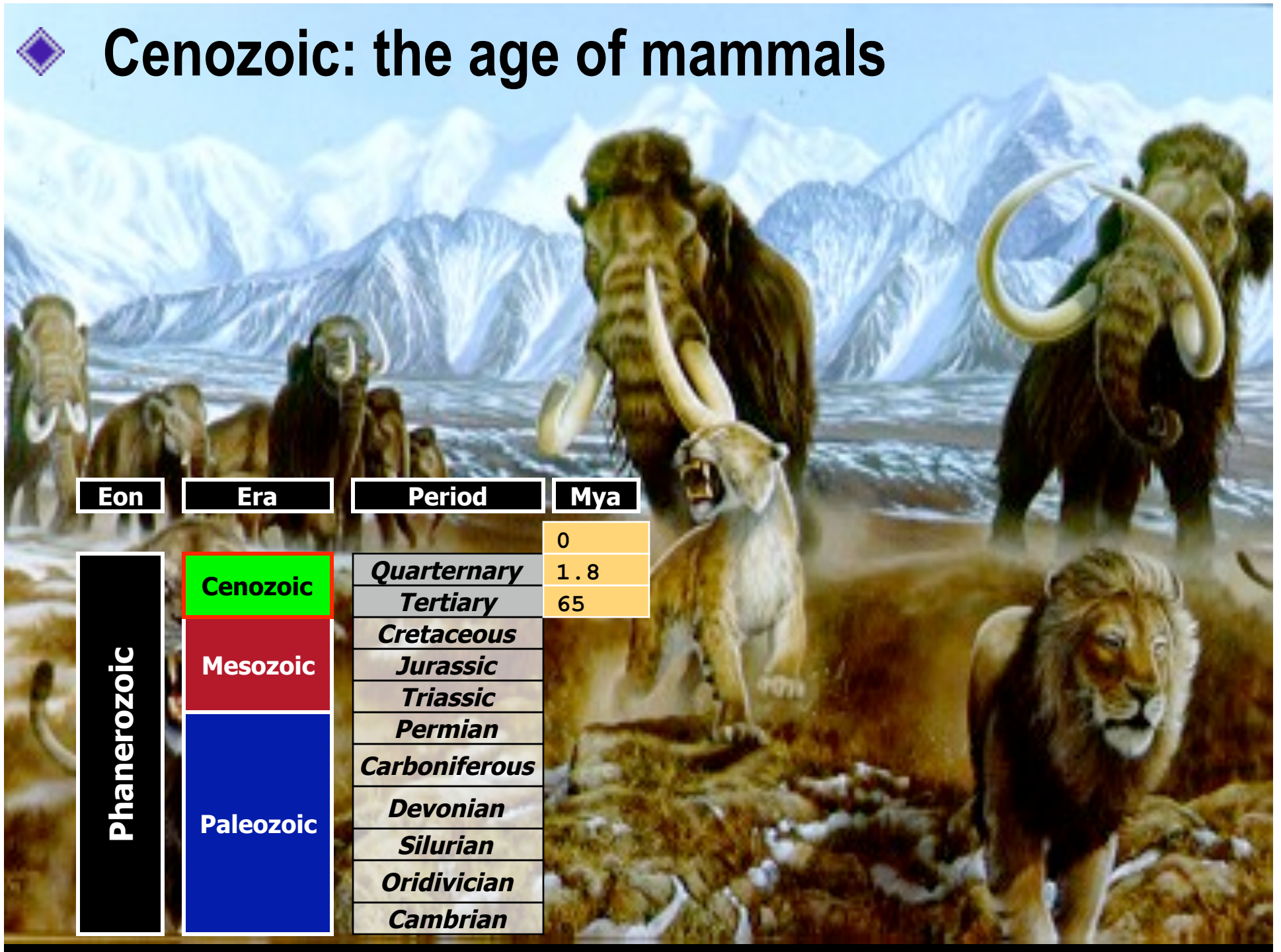
without them [fossils], no one would have ever dreamed that there were successive epochs in the formation of the globe.



*George Cuvier
(1769 to 1832)*

According to modern estimates, the fossil record indicates that approximately 99.9% of species that have ever lived are extinct

◆ Cenozoic: the age of mammals



Eon	Era	Period	Mya
Phanerozoic	Cenozoic	<i>Quarternary</i>	0
		<i>Tertiary</i>	1.8
	Mesozoic	<i>Cretaceous</i>	65
		<i>Jurassic</i>	
		<i>Triassic</i>	
	Paleozoic	<i>Permian</i>	
		<i>Carboniferous</i>	
		<i>Devonian</i>	
		<i>Silurian</i>	
		<i>Oridivician</i>	
		<i>Cambrian</i>	



Cenozoic: the age of mammals?

Today, there are about 5,000 species of mammal and about 10,000 species of bird

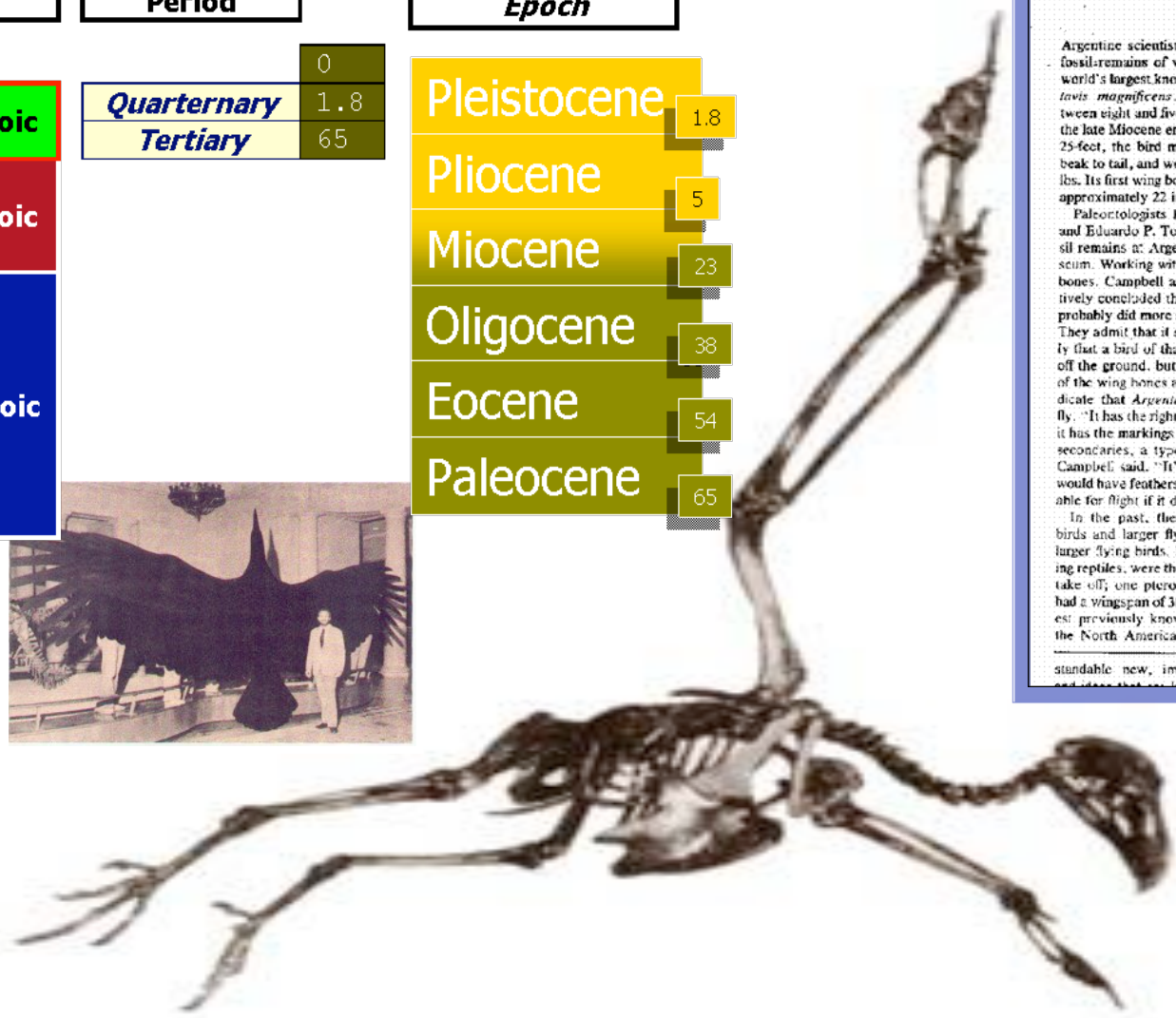
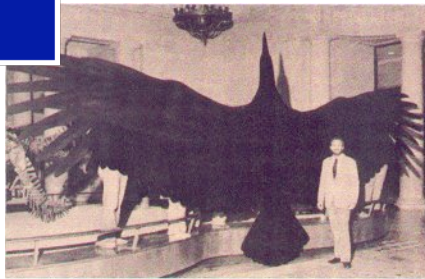




Cenozoic: the age of mammals?

the Argentinean teratorn

Era	Period	Epoch
Cenozoic	Quarternary	0 - 1.8
	Tertiary	1.8 - 65
Mesozoic		
Paleozoic		Pleistocene (1.8 - 0)
		Pliocene (5 - 1.8)
		Miocene (23 - 5)
		Oligocene (38 - 23)
		Eocene (54 - 38)
	Paleocene (65 - 54)	



Flying Giants Found

Argentine scientists have unearthed the fossil-remains of what seems to be the world's largest known flying bird, *Argentavis magnificens*. The bird lived between eight and five million years ago, in the late Miocene era. With a wingspan of 25-feet, the bird measured 11 feet from beak to tail, and weighed in at 160 to 170 lbs. Its first wing bone, the humerus, was approximately 22 inches long.

Paleontologists Kenneth E. Campbell and Eduardo P. Tonni identified the fossil remains at Argentina's La Plata Museum. Working with leg, wing, and skull bones, Campbell and Tonni have tentatively concluded that the enormous bird probably did more soaring than flapping. They admit that it seems initially unlikely that a bird of that size could even get off the ground, but believe that the size of the wing bones and their markings indicate that *Argentavis magnificens* did fly. "It has the right size wing bones, and it has the markings on the wing bones of secondaries, a type of flight feathers," Campbell said. "It's unlikely that a bird would have feathers and wing bones suitable for flight if it didn't fly."

In the past, there have been larger birds and larger flying animals, but no larger flying birds. Pterosaurs, giant flying reptiles, were the biggest creatures to take off; one pterosaur found in Texas had a wingspan of 30 to 35 feet. The largest previously known flying birds were the North American *Teratornis incred-*

Based on his studies of another teratorn fossil, *Teratornis merulini*, Campbell believes that the teratorns were predators. "The long, narrow hooked beak and the type of jaw mechanism found in this species are similar to those of the pterosaur *Pteranodon* and the marine bird called *Osteodontornis orri*. Both had wingspans of almost 16 feet.

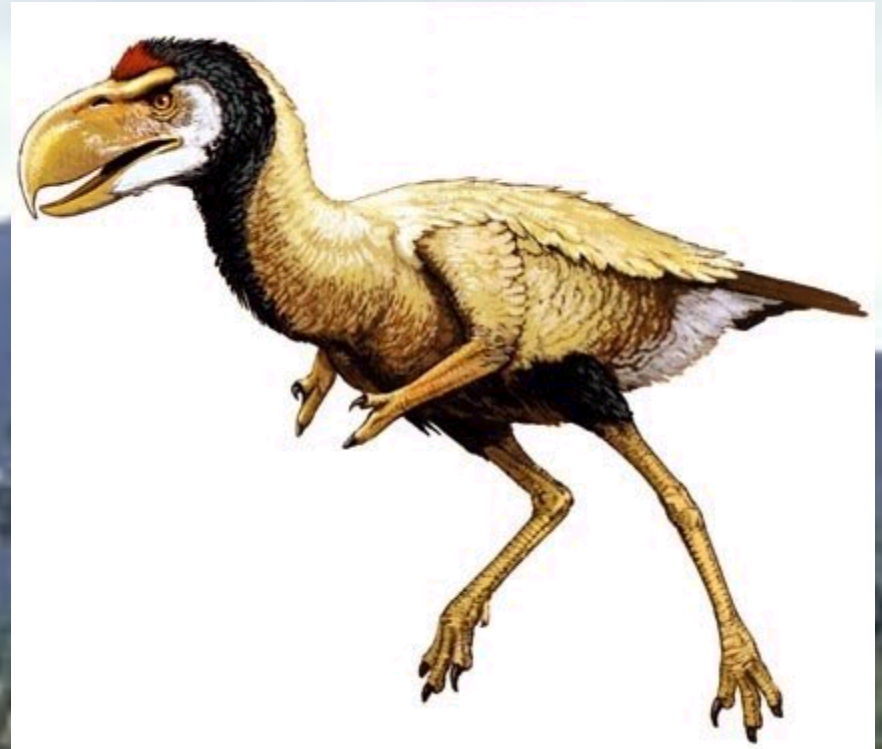
standable new, important information and more that can be learned about





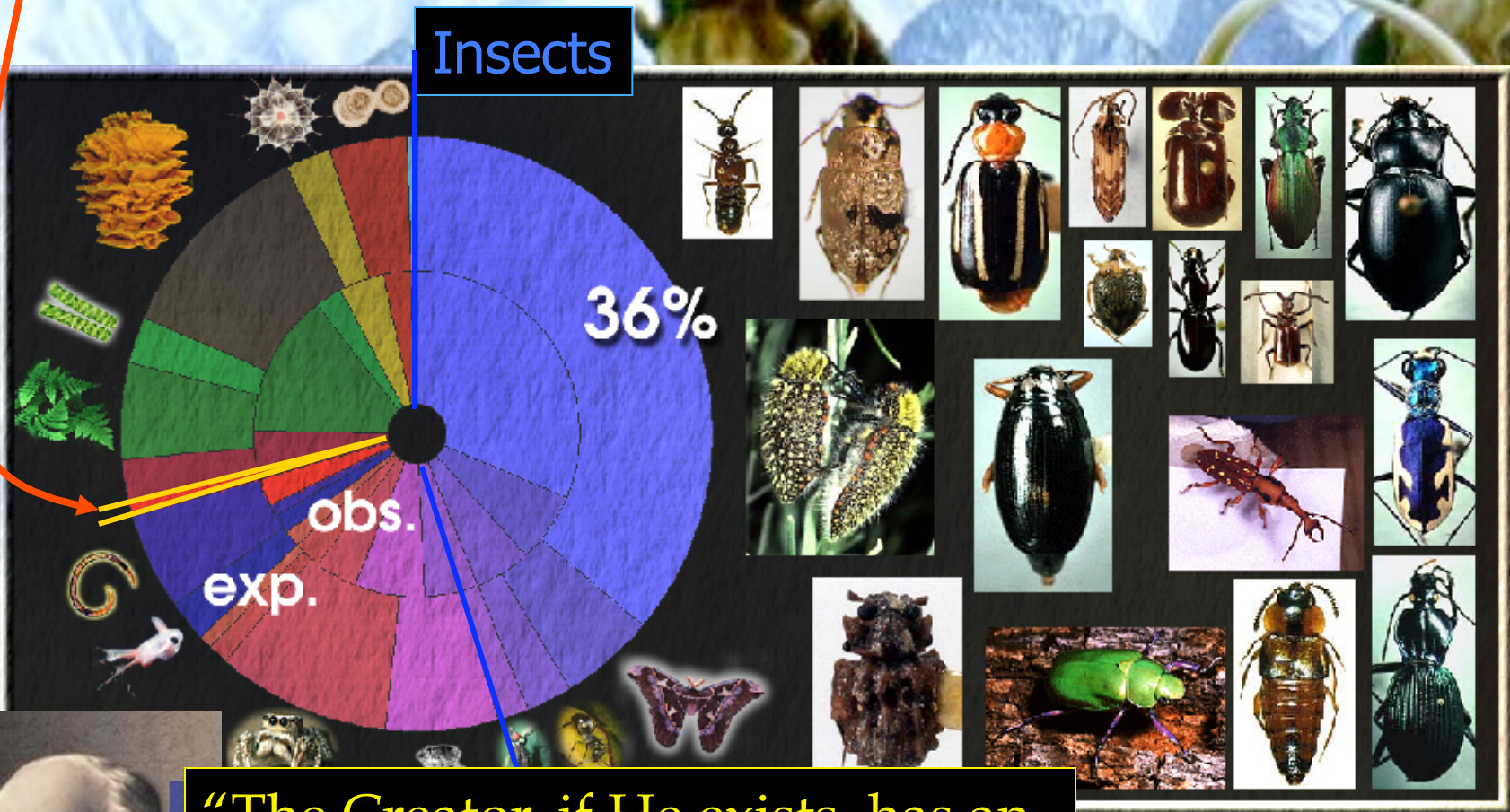
Cenozoic: the age of mammals?

the S. American Phoruscacid



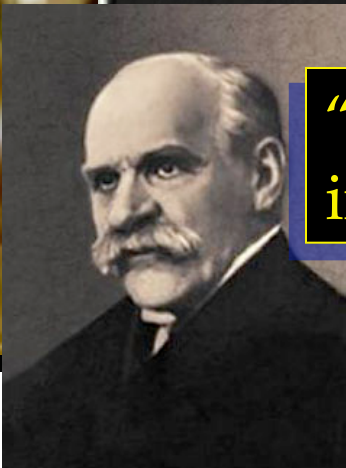
◆ Biodiversity of today's world

Chordates: fish, amphibians, birds, reptiles and mammals



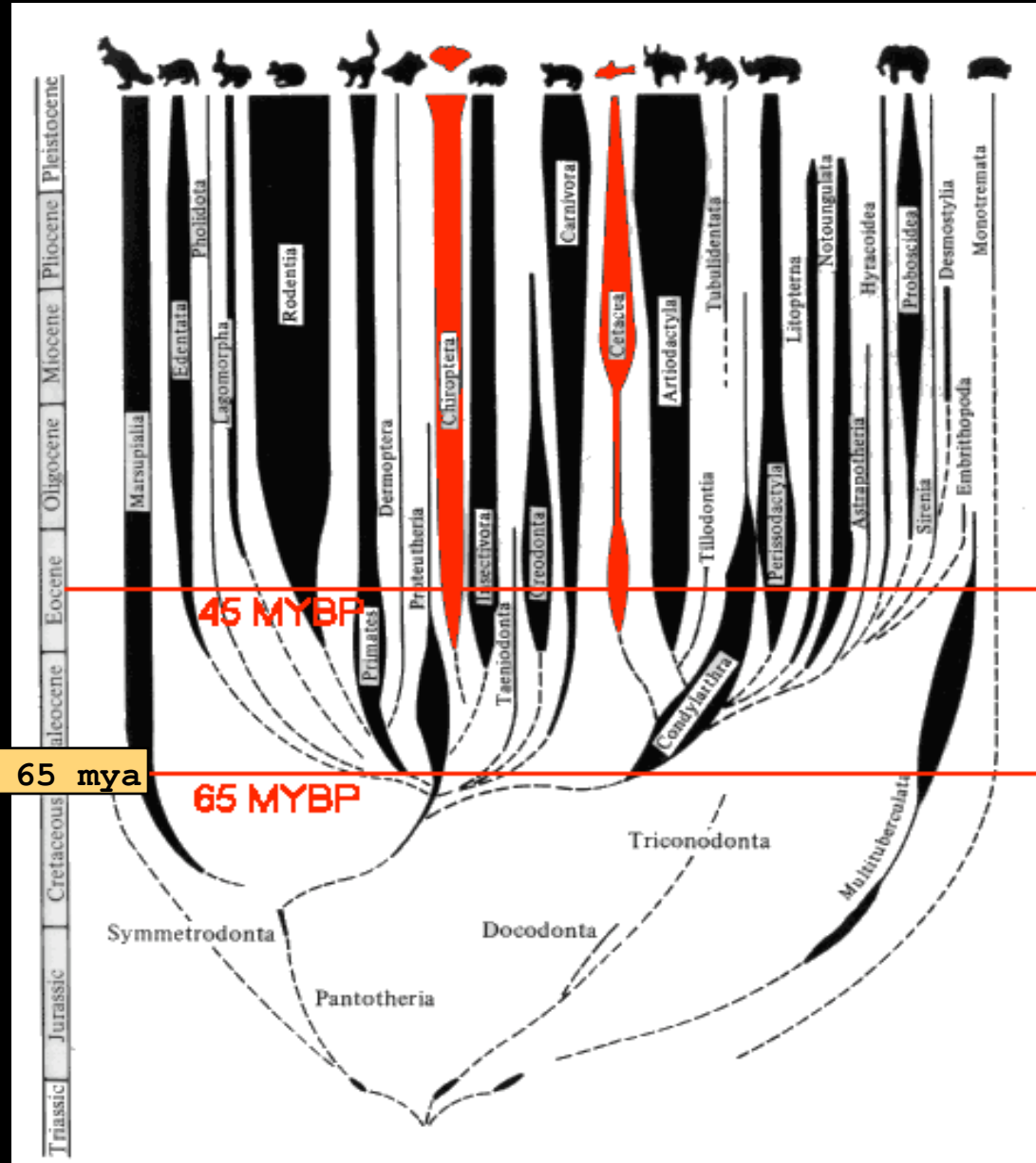
"The Creator, if He exists, has an inordinate fondness for beetles"

J.B.S. Haldane (1892-1964)



(mammals: 65 million years of evolutionary diversification)

Eon	Era	Period
Phanerozoic	Cenozoic	Quaternary
		Tertiary
	Mesozoic	Cretaceous
		Jurassic
		Triassic
	Paleozoic	Permian
		Carboniferous
		Devonian
		Silurian
		Ordovician
		Cambrian

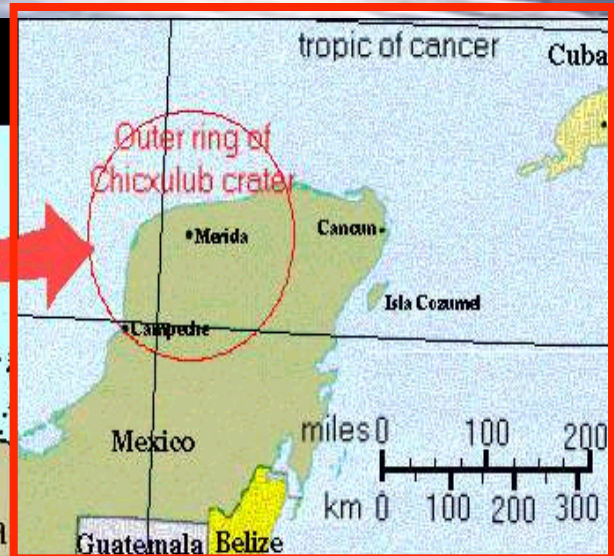


◆ So what brought on the “age of the mammals”?

- Cenozoic
- Mesozoic
- Paleozoic
- Proterozoic
- Archean
- Hadean

Tertiary 65 mya
Cretaceous

A worldwide layer of compressed ash from 65 mya

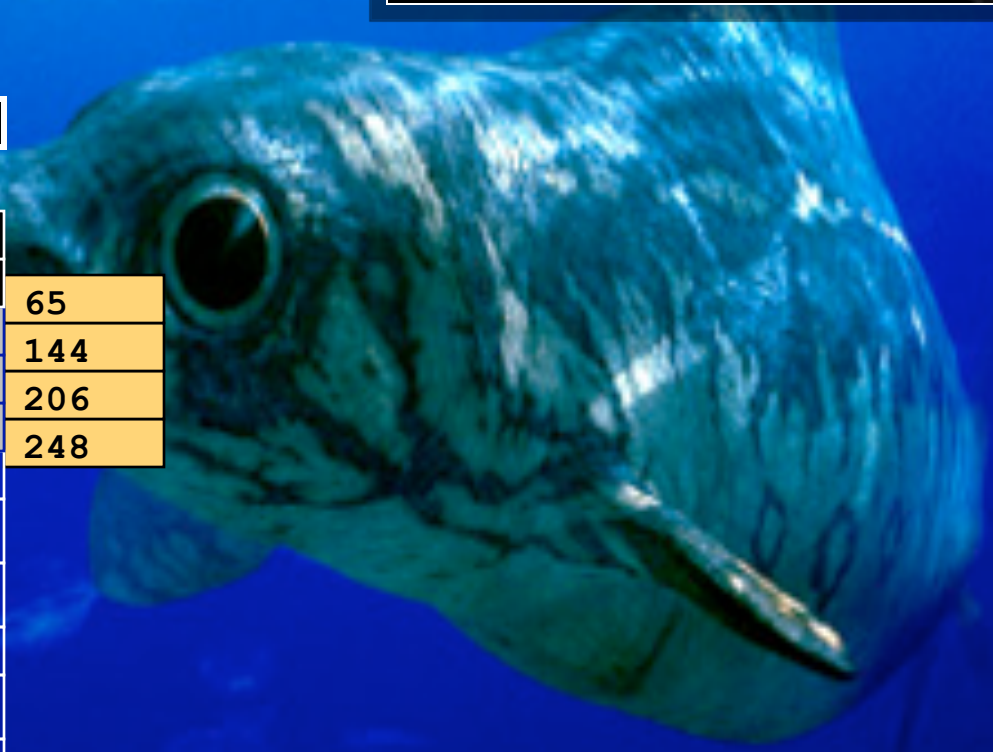


◆ Mesozoic: age of reptiles

Quetzalcoatlus – 65 mya
(with a 50 ft wingspan, the
largest creature ever to fly)



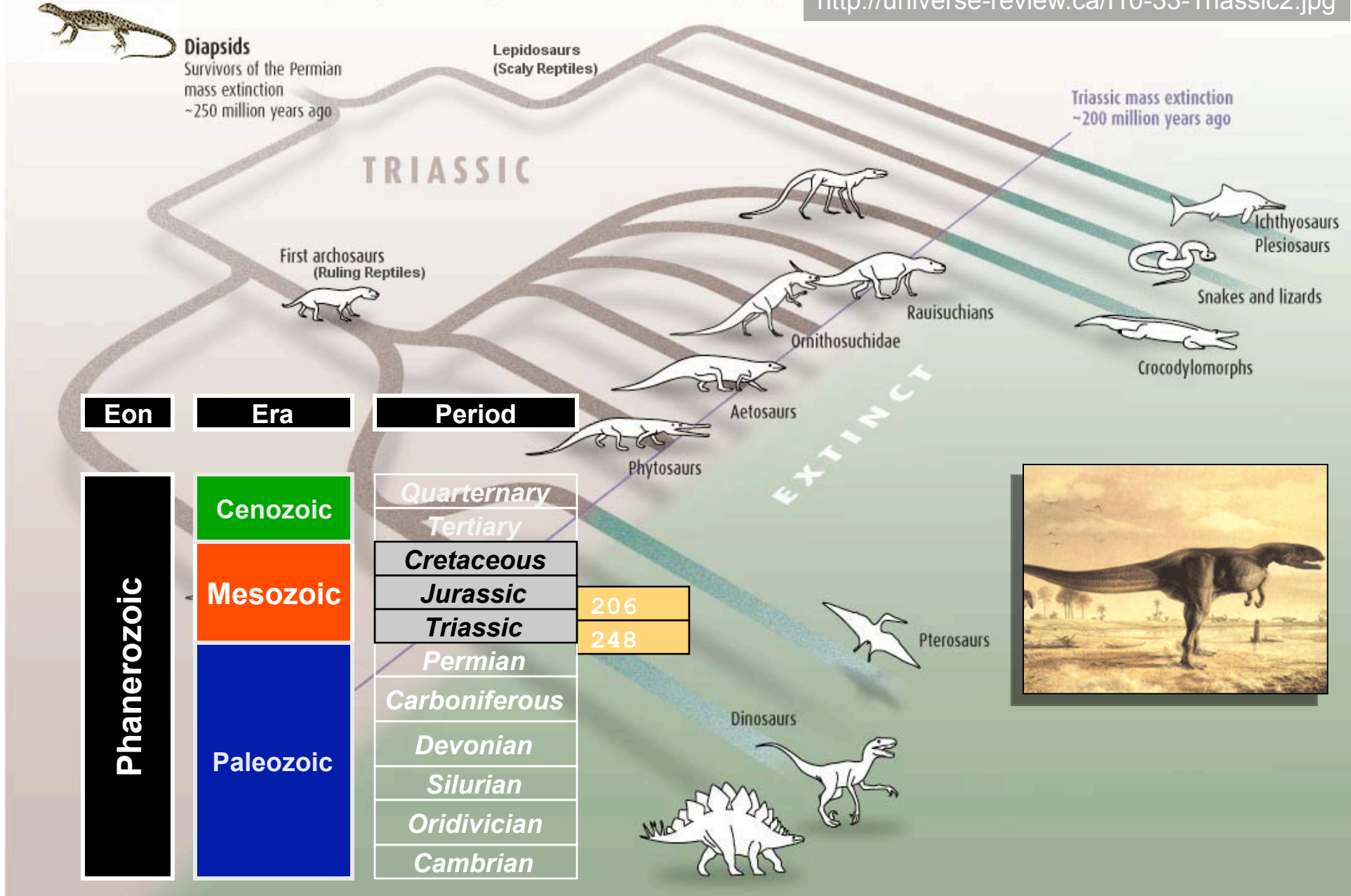
Eon	Era	Period	
Phanerozoic	Cenozoic	Quarternary	
		Tertiary	65
	Mesozoic	Cretaceous	144
		Jurassic	206
		Triassic	248
		Permian	
		Carboniferous	
	Paleozoic	Devonian	
		Silurian	
		Oridivician	
		Cambrian	



And what brought on the age of reptiles?

THE FORGOTTEN EXTINCTIONS

The end of the Triassic period about 200 million years ago saw the disappearance of at least four major groups of giant reptiles, clearing the way for the age of the dinosaurs
<http://universe-review.ca/I10-33-Triassic2.jpg>



◆ The greatest mass extinction of them all...

~ 95% of known life went extinct.

Super-volcanic activity, possible asteroid impact and drastic change in climate wrought havoc...



Eon	Era	Period
Phanerozoic	Cenozoic	Quarternary
	Mesozoic	Tertiary
		Cretaceous
		Jurassic
	Paleozoic	Triassic
		Permian
		Carboniferous
		Devonian
		Silurian
		Oridivician
	Cambrian	

248

◆ Cambrian: early experiments in animal architecture

The image is a composite illustrating the Cambrian period. It features a blue-tinted illustration of marine life on the left, a central green-tinted illustration of a diverse Cambrian ecosystem with various organisms like trilobites and arthropods, and a bottom section with a geological time scale and fossil images. The time scale includes Eon, Era, and Period columns, with the Cambrian period highlighted in grey and dated 543. Two fossil images are shown: Opabinia and Marrella.

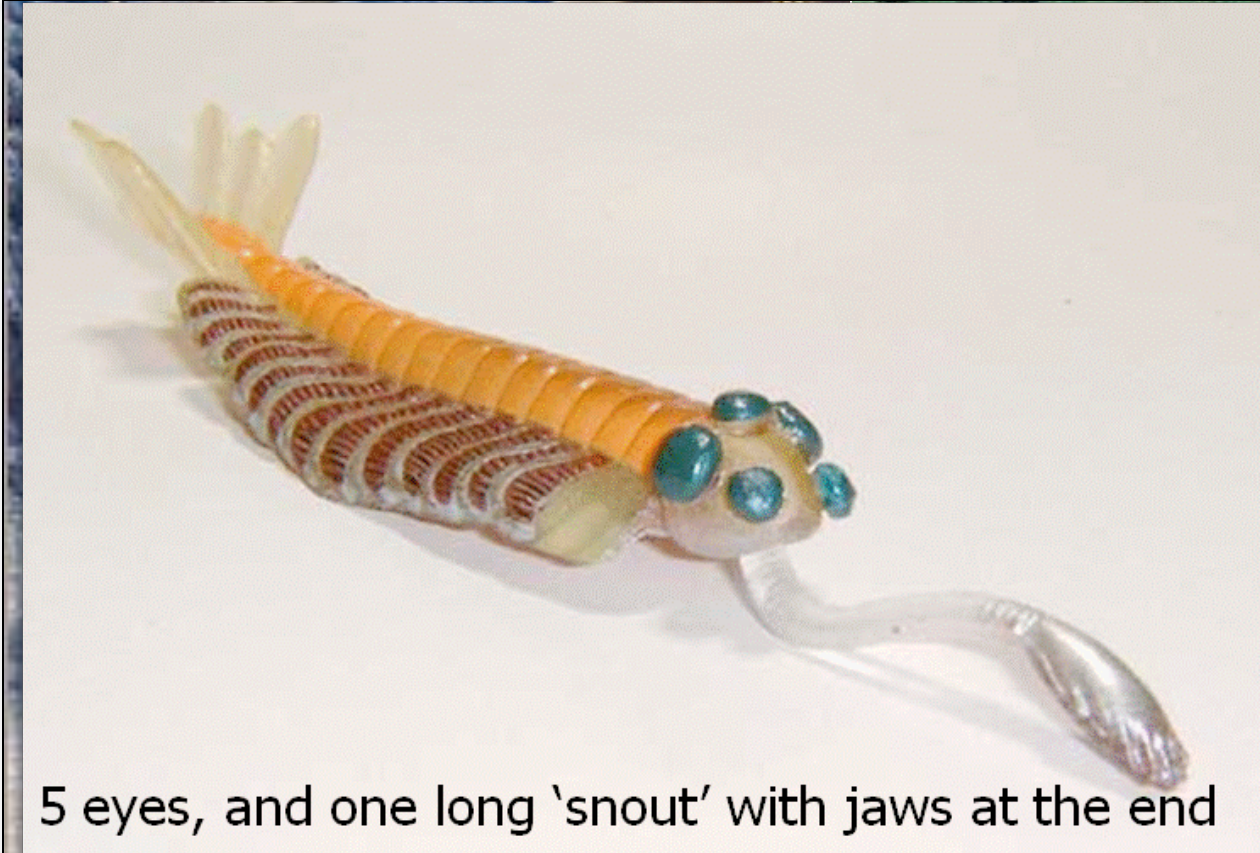
Eon	Era	Period
Phanerozoic	Cenozoic	Quaternary
		Tertiary
	Mesozoic	Cretaceous
		Jurassic
		Triassic
	Paleozoic	Permian
		Carboniferous
		Devonian
		Silurian
		Oridivician
		Cambrian

490
543

Opabinia

Marrella

◆ Cambrian: early experiments in animal architecture



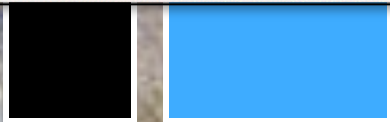
5 eyes, and one long 'snout' with jaws at the end



Opabinia

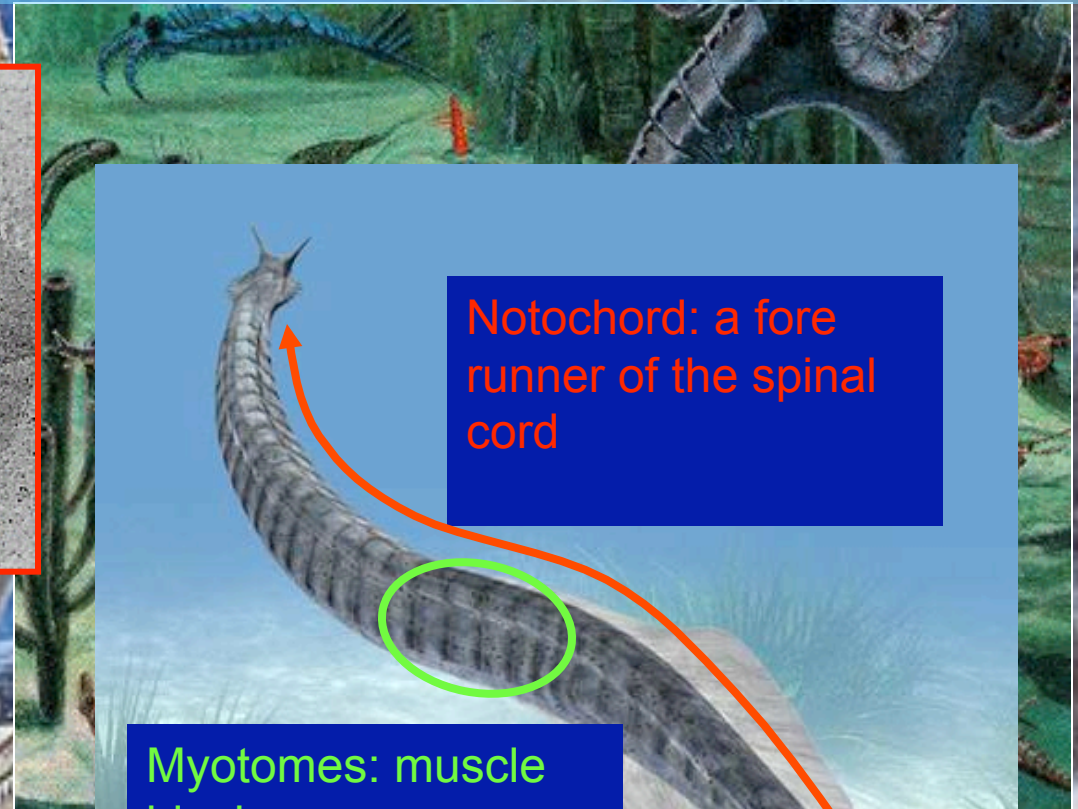


Marrella



<i>Oridivician</i>	490
Cambrian	543

◆ Cambrian: early experiments in animal architecture



Notochord: a fore runner of the spinal cord

Myotomes: muscle blocks

<http://www.3d-art.co.uk/3dpages/3ded/dk-3.html>

Eon	Era	Period
Proterozoic	Cenozoic	Quaternary
		Tertiary
	Mesozoic	Cretaceous
		Jurassic
		Triassic
	Paleozoic	Carboniferous
Carboniferous		

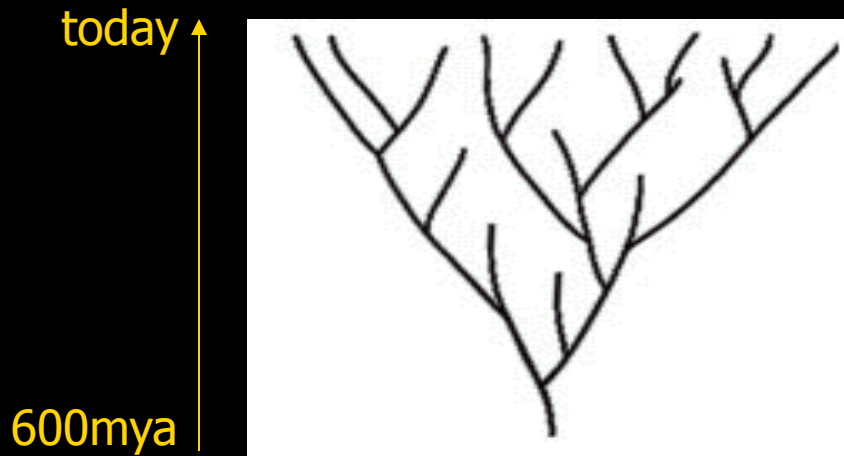
~ representative of the group that gave rise to all vertebrates (fish, amphibians, reptiles, birds mammals, humans)

		Cambrian	490
			543

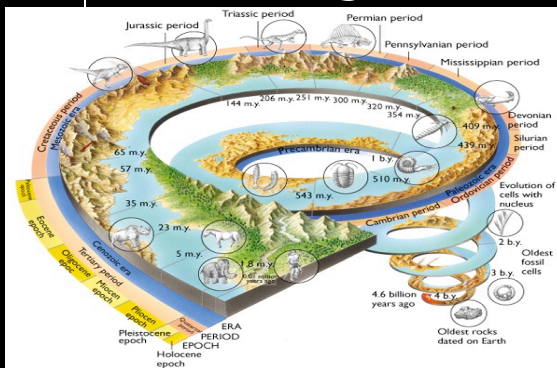
http://www.pbs.org/wgbh/nova/link/images/hist_img_02_camb.jpg

◆ What is the Burgess Shale telling us?

Stephen J Gould: If we re-ran the "tape of life", would today's world look anything like the one we see around us? (Wonderful Life)



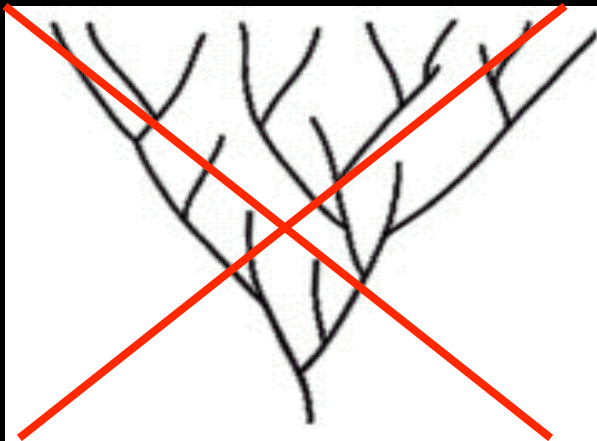
Model 1: life steadily grows in diversity and complexity



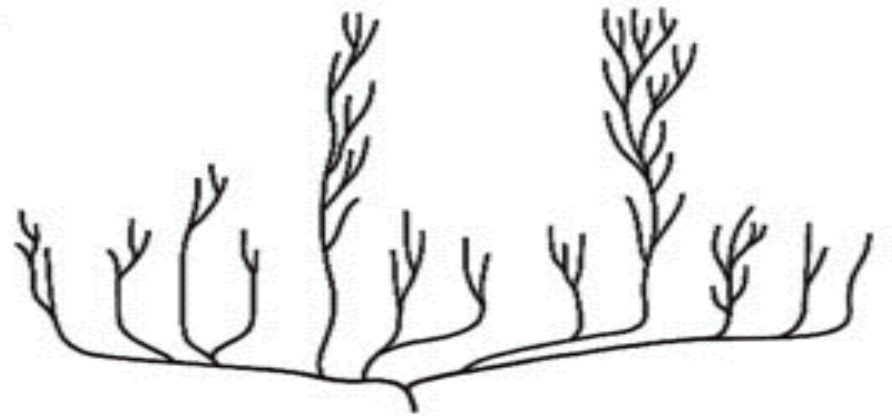
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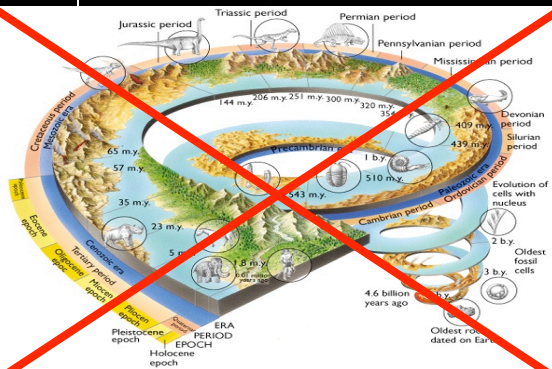
today ↑
600mya ↓



Model 1: life steadily grows in diversity and complexity



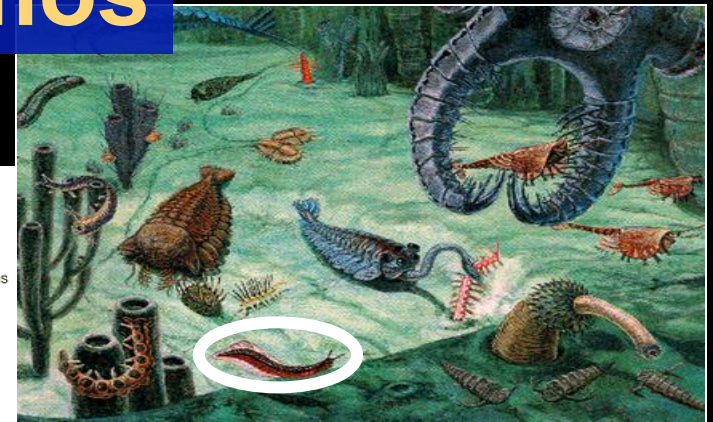
Model 2: Today we see diversification within a few major groups that are a near random sample spared from catastrophic mass extinctions...



Gould's view of the cosmos

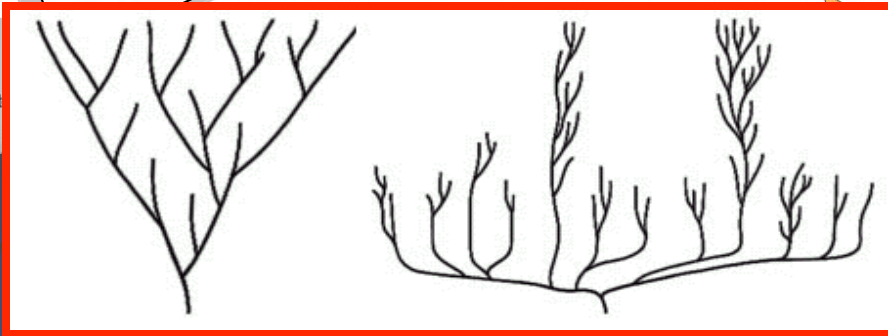
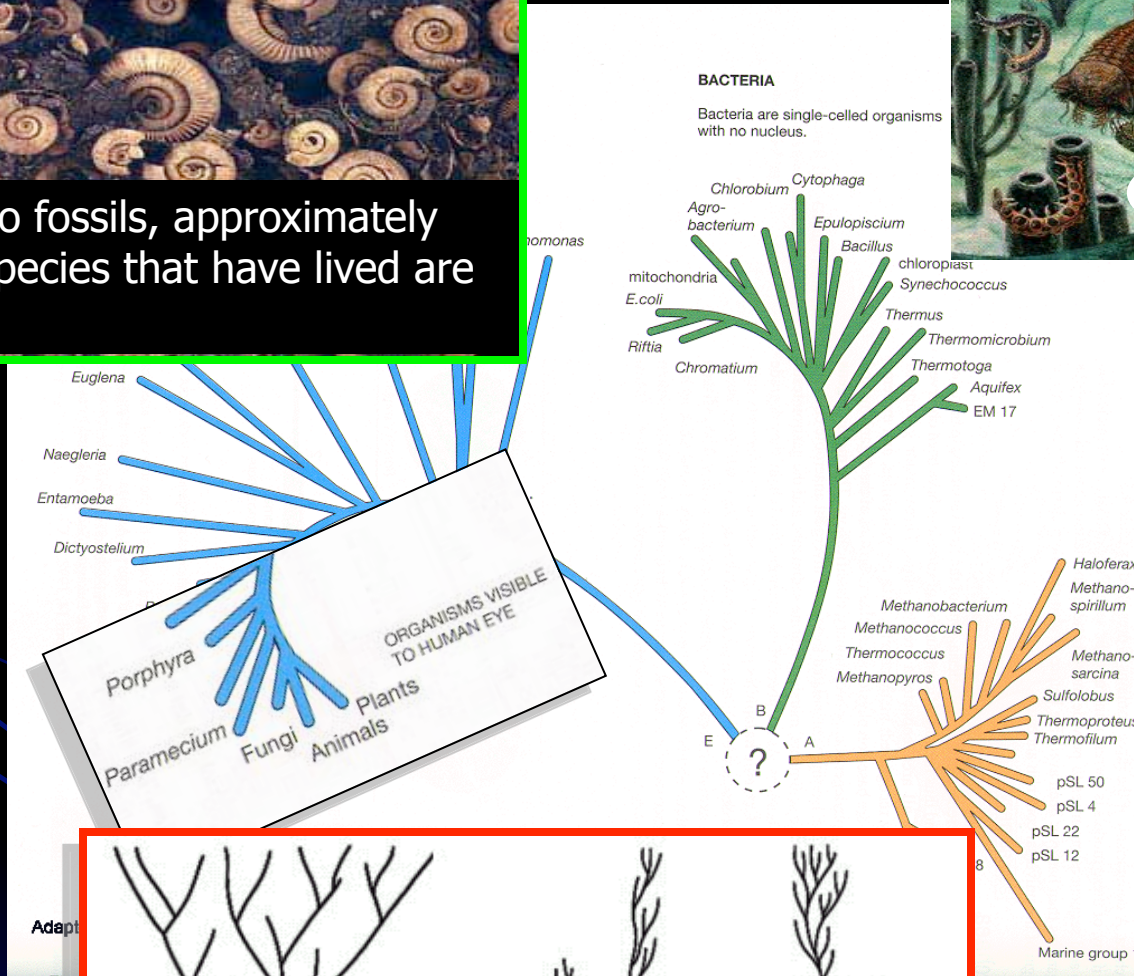


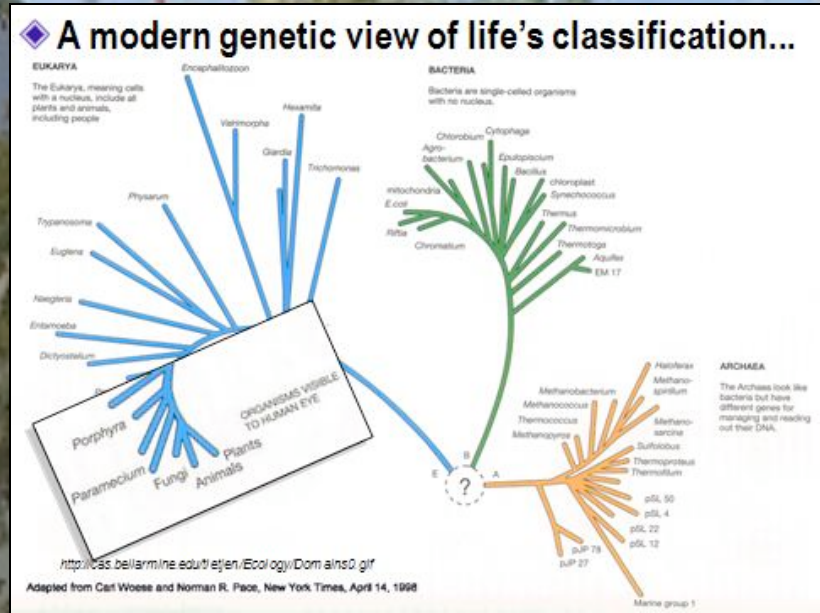
According to fossils, approximately 99.9% of species that have lived are extinct



BACTERIA

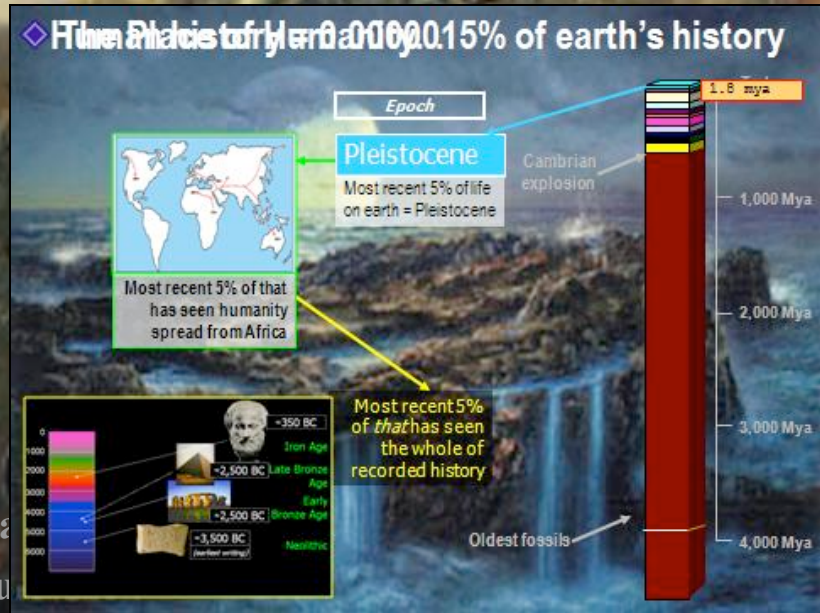
Bacteria are single-celled organisms with no nucleus.





Gould's view of the cosmos

According to fossils, approximately 99.9% of species that have lived are extinct.



"The great
gton Mu

“THE WEDGE STRATEGY”

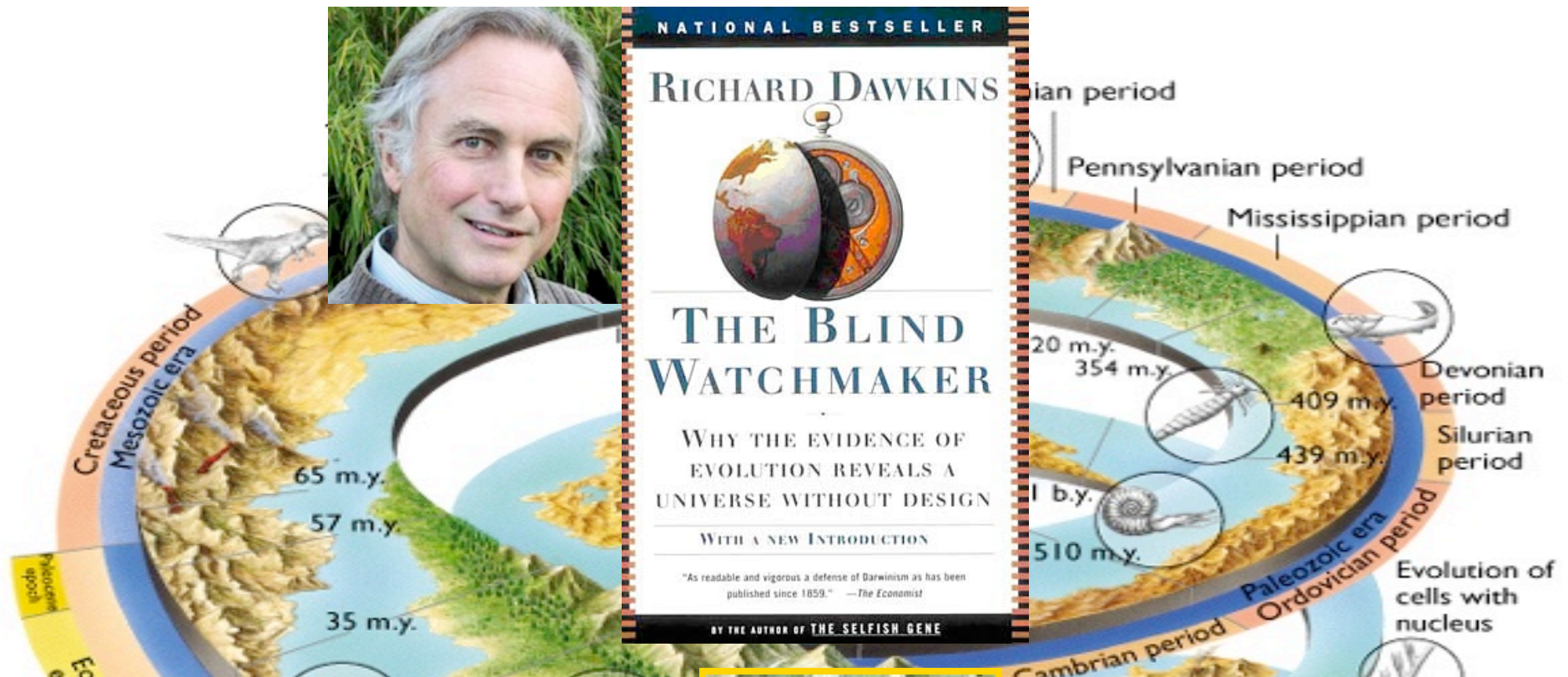
an internal memo from the Discovery Institute (the leading research center for anti-evolutionary “Intelligent Design” research), first seen on the Internet in 1999

CENTER FOR
& SCIENCE
CULTURE



The proposition that human beings are created in the image of God is one of the bedrock principles on which Western civilization was built... Yet a little over a century ago, this cardinal idea came under wholesale attack by intellectuals drawing on the discoveries of modern science...thinkers such as Charles Darwin...portrayed humans not as moral and spiritual beings, but as animals or machines who inhabited a universe ruled by purely impersonal forces...The cultural consequences of this triumph of materialism were devastating.

But couldn't God have created through evolution?



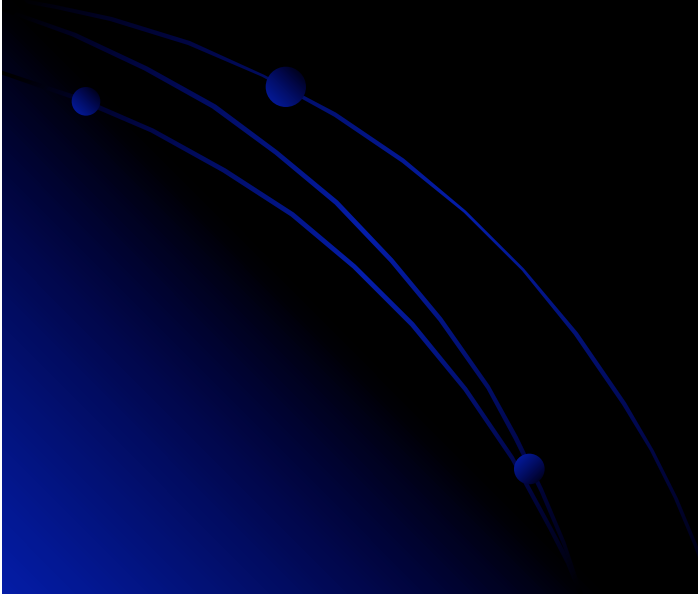
The total amount of suffering per year in the natural world is beyond all decent contemplation. During the minute that it takes me to compose this sentence, thousands of animals are being eaten alive, many others are running for their lives, whimpering with fear, others are slowly being devoured from within by rasping parasites, thousands of all kinds are dying of starvation, thirst, and disease. It must be so. If there ever is a time of plenty, this very fact will automatically lead to an increase in the population until the natural state of starvation and misery is restored. ... The universe that we observe has precisely the properties we should expect if there is, at bottom, no design, no purpose, no evil, no good, nothing but pitiless indifference.

Richard Dawkins, "God's Utility Function," published in Scientific American (November, 1995), p. 85

The Age of Reason II

The name given to that period of human life at which persons are deemed to begin to be morally responsible. This ... literally understood applies to all who have reached "the years of discretion"

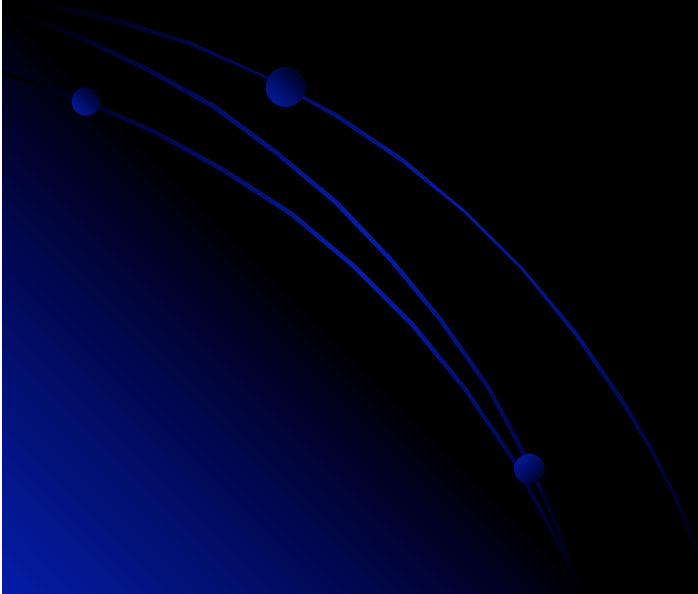
The Catholic Encyclopedia Online - 1997





After sleeping through a hundred million centuries we have finally opened our eyes on a sumptuous planet, sparkling with colour, bountiful with life. Within decades we must close our eyes again. Isn't it a noble, an enlightened way of spending our brief time in the sun, to work at understanding the universe and how we have come to wake up in it? This is how I answer when I am asked -- as I am surprisingly often -- why I bother to get up in the mornings.

-- Richard Dawkins, excerpt from Chapter I, "The Anaesthetic of Familiarity," of *Unweaving the Rainbow: Science, Delusion and the Appetite for Wonder* (1998)





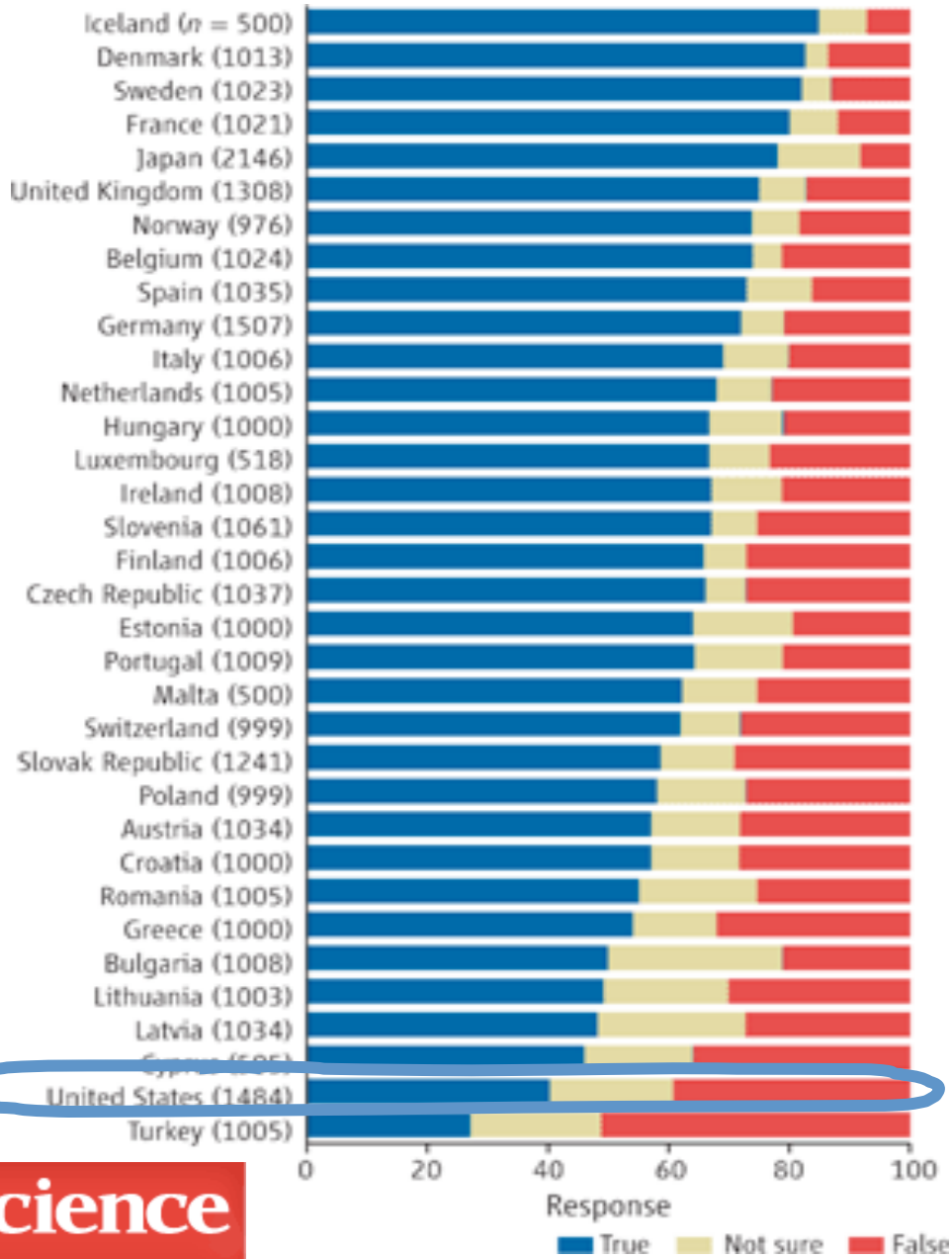
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"...since Holy Scripture can be understood in many ways, one should be ready to seek a new understanding whenever current understanding is found to be false, lest holy Scripture be exposed to the ridicule of unbelievers, and become an obstacle to their believing"

Thomas Aquinas (1224-1274)

Is Evolution True?



What the world thinks...

Science

AAAS

Science Magazine > 11 August 2006 > Miller et al., pp. 765 - 766

Polling Data

Which of the following statements comes closest to your views on the origin and development of human beings? 1) Human beings have developed over millions of years from less advanced forms of life, but God guided this process; 2) Human beings have developed over millions of years from less advanced forms of life, but God had no part in this process; 3) God created human beings pretty much in their present form at one time within the last 10,000 years or so.

	May 2006	Sept. 2005 (*)	Nov. 2004
Man developed, with God guiding	36%	31%	38%
Man developed, but God had no part in process	13%	12%	13%
God created man in present form	46%	53%	45%
Other / No opinion	5%	4%	4%

(*) The September 2005 poll question was: "Which of the following statements comes closest to your views on the origin and development of human beings? 1) Human beings have evolved over millions of years from other forms of life and God guided this process; 2) Human beings have evolved over millions of years from other forms of life, but God had no part in this process; 3) God created human beings in their present form exactly the way the Bible describes it."

Source: Gallup / CNN / USA Today

Methodology: Telephone interviews with 1,001 American adults, conducted from May 8 to May 11, 2006. Margin of error is 3 per cent.

What the
American
public
think...

...In a little more detail...

Results for the 1991-NOV-21 to 24 poll were:

Belief system	Creationist view	Theistic evolution	Naturalistic Evolution
Group of adults	God created man pretty much in his present form at one time within the last 10,000 years.	Man has developed over millions of years from less advanced forms of life, but God guided this process, including man's creation.	Man has developed over millions of years from less advanced forms of life. God had no part in this process.
Everyone	47%	40%	9%
Men	39%	45%	11.5%
Women	53%	36%	6.6%
College graduates	25%	54%	16.5%
No high school diploma	65%	23%	4.6%
Income over \$50,000	29%	50%	17%
Income under \$20,000	59%	28%	6.5%
Caucasians	46%	40%	9%
African-Americans	53%	41%	4%

1997-NOV data is little changed.

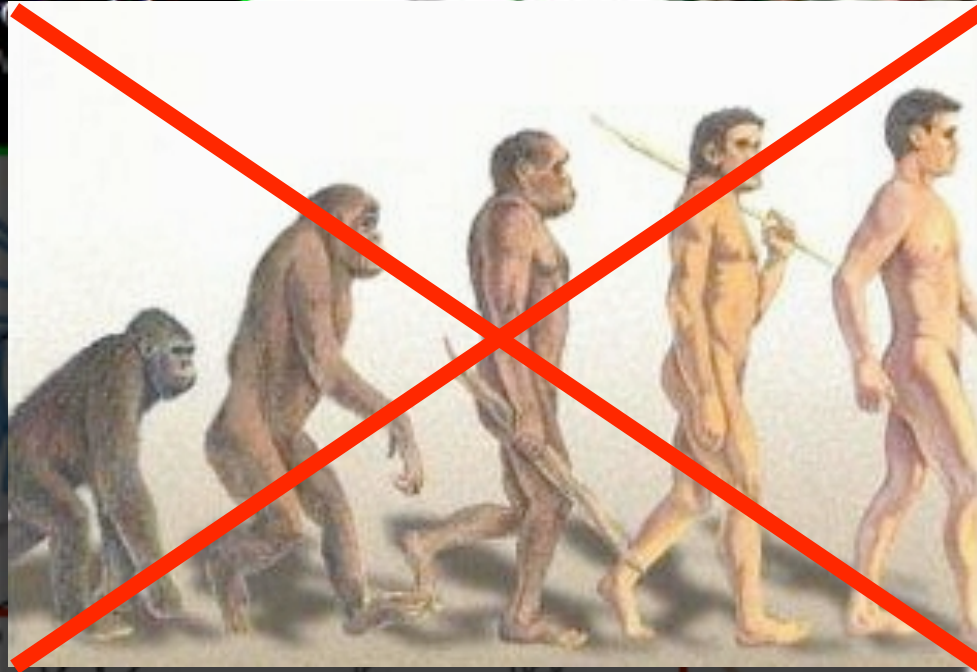
Gallup polling, as reported by http://www.religioustolerance.org/ev_publi.htm

An orthodox 20th century view of evolution

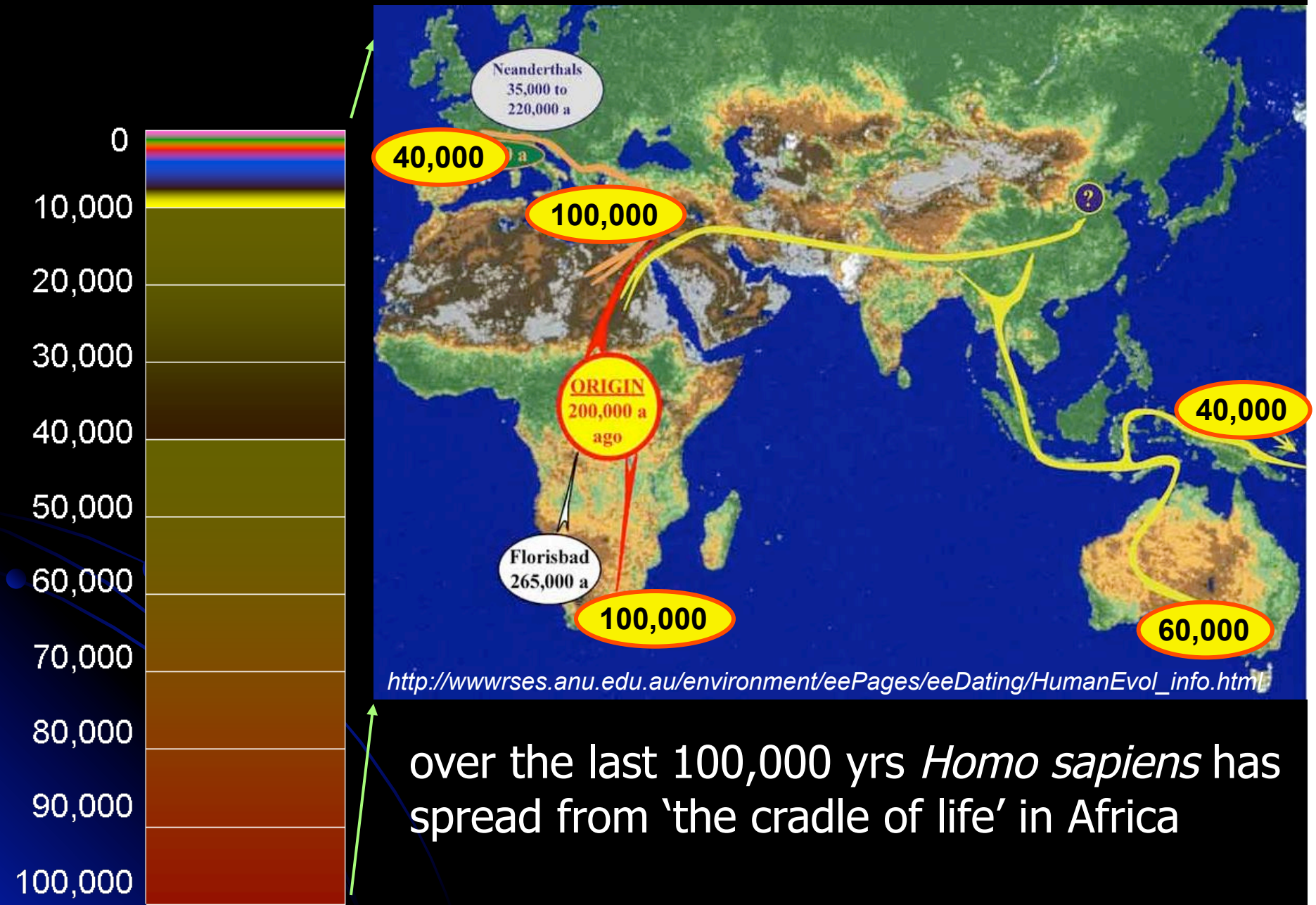


According to fossils, approximately 99.9% of species that have ever existed are now extinct

BACTERIA
Bacteria are single-celled organisms with no nucleus.



◆ the Spread of *H Sapiens*



over the last 100,000 yrs *Homo sapiens* has spread from 'the cradle of life' in Africa

◆ The Pleistocene: extinction of large mammals

When humans reached their various areas...

Neanderthals
35,000 to
220,000 a

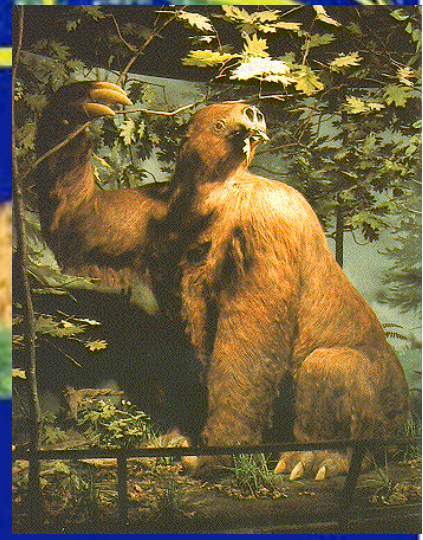
40,000 a

100,000 a

ORIGIN
200,000 a
ago

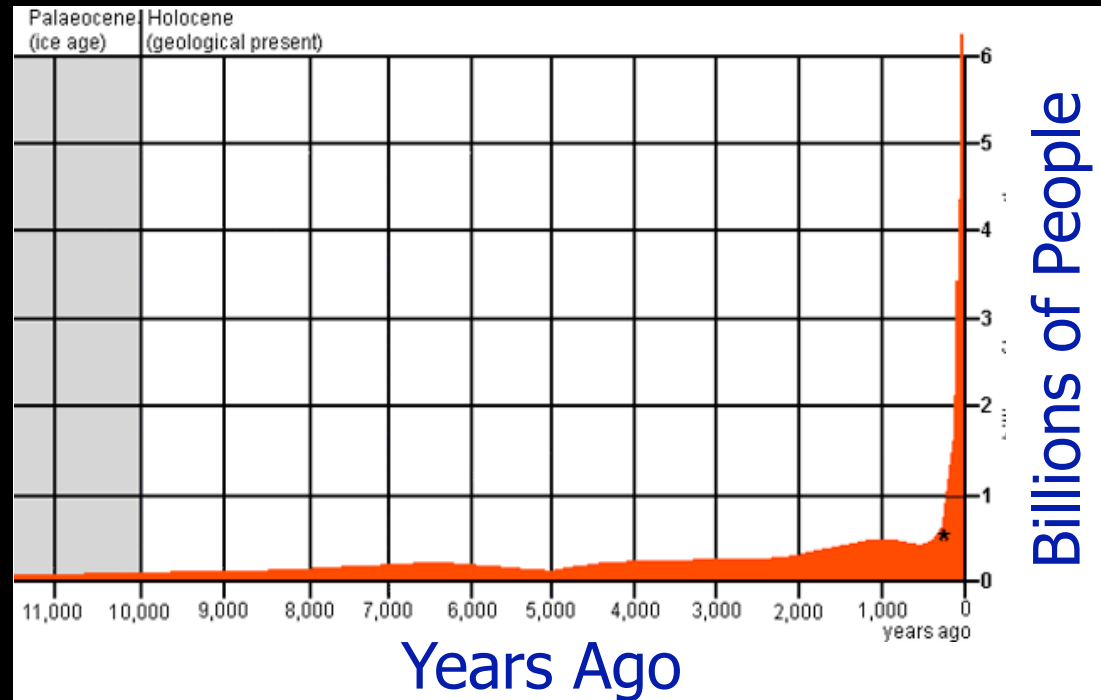
100,000 a

40,000 a



Pleistocene	1.8
Pliocene	5
Miocene	23
Oligocene	38
Eocene	54
Paleocene	65

◆ What makes humans special?



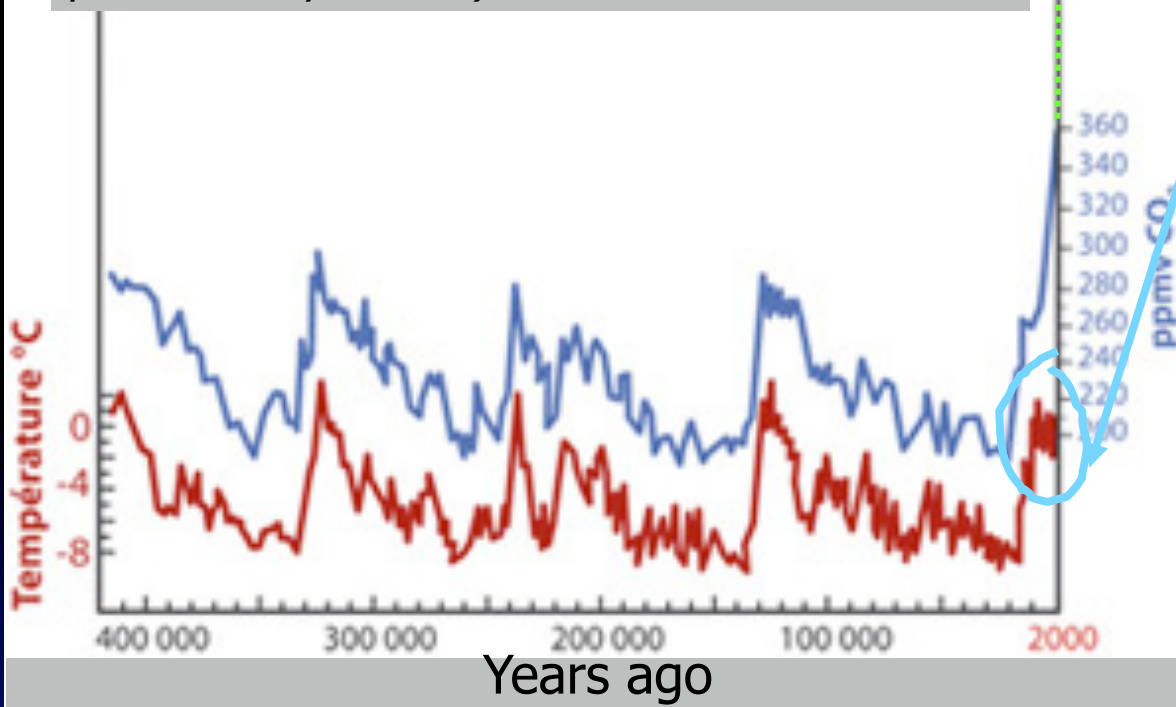
We believe that current extinction rates may be as much as 40 times the normal "background" rate for extinction, based upon the record over long periods of geological time. This may soon reach 400 times the "normal", average, rate of extinction.

- 1) ~20% of bird species in the world have become extinct in the last 2000 years, mainly after human colonization of islands
- 2) Populations of migratory songbirds in the eastern United States have declined by 50 percent from the 1940s to the 1980s, and many species are extinct locally
- 3) ~20% of freshwater fish species may have become extinct in recent times
- 4) 4~5% percent of the plant species in the United States were extinct by the end of 1999
- 5) As many as 34% of the invertebrates in Germany may have become extinct
- 6) In the past 60 years, as many as 50% of the species of fungi in Europe may have become extinct.

◆ and the future?

http://ec.europa.eu/research/rtdinfo/special_pol/03/article_2599_en.html

In the last two centuries, due to the industrial revolution, CO2 levels have gone outside the 'envelope' of regular cyclical CO2/temperature variation of the last 400,000 years (ppmv = parts per million by volume).

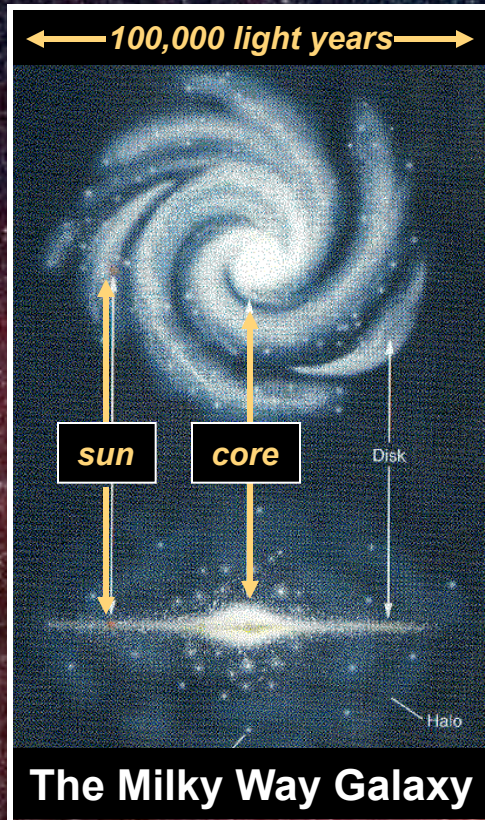


then next ~100 years, if things don't change...



Roger Ebert: "In 39 years, I have never written these words in a movie review, but here they are: You owe it to yourself to see this film. If you do not, and you have grandchildren, you should explain to them why you decided not to."

in just another star system...



“This ... image from NASA's Spitzer Space Telescope shows hundreds of thousands of stars crowded into the swirling core of our spiral Milky Way galaxy”

NASA mission news 01.10.06
<http://www.nasa.gov/vision/universe/starsgalaxies/spitzer-20060110.html>

Science versus philosophy...

"The scientific method requires that an hypothesis be ruled out or modified if its predictions are clearly incompatible with experimental tests ... Note this also implies that a theory must be testable. Theories which cannot be tested...do not qualify as scientific theories..."

Wolfs, "Introduction to the Scientific Method"

"Aristotle maintained that women have fewer teeth than men; although he was twice married, it never occurred to him to verify this statement by examining his wives' mouths." *Bertrand Russell*

The Drake Equation

~ calculates N, the likely number of communicative, intelligent civilizations in our galaxy:

The number of planets, per star, that can support life

The proportion of these where intelligence emerges

The rate of star formation in our galaxy

The proportion of stars that form planets

The proportion of these planets where life evolves

The proportion of these that achieve interstellar communication

The lifetime of these civilizations

$$N = R \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

The Drake Equation

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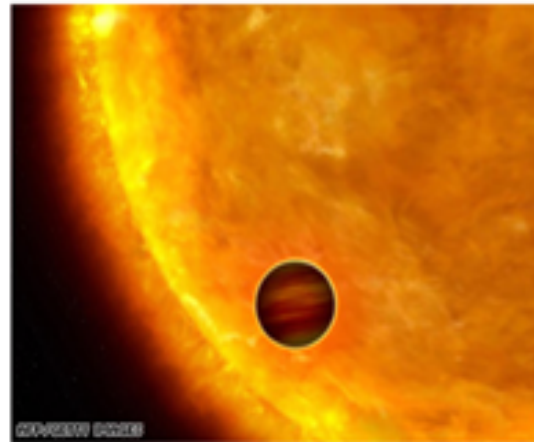
The number of planets that can support life

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The proportion of stars that form planets

$$N = R \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

(CNN) -- As NASA prepares to hunt for Earth-like planets in our corner of the Milky Way galaxy, there's new buzz that "Star Trek's" vision of a universe full of life may not be that far-fetched.



An artist's impression shows a planet passing in front of its parent star. Such events are called transits.

Pointy-eared aliens traveling at light speed are staying firmly in science fiction, but scientists are offering fresh insights into the possible existence of inhabited worlds and intelligent civilizations in space.

There may be 100 billion Earth-like planets in the Milky Way, or one for every sun-type star in the galaxy, said Alan Boss, an astronomer with the Carnegie Institution and author of the new book "The Crowded Universe: The Search for Living Planets."

He made the prediction based on the number of "super-Earths" -- planets several times the mass of the Earth, but smaller than gas giants like Jupiter -- discovered so far circling stars outside the solar system.

Boss said that if any of the billions of Earth-like worlds he believes exist in the Milky Way have liquid water, they are likely to be home to some type of life.

"Now that's not saying that they're all going to be crawling with intelligent human beings or even dinosaurs," he said.

"But I would suspect that the great majority of them at least will have some sort of primitive life, like bacteria or some of the multicellular creatures that populated our Earth for the first 3 billion years of its existence."

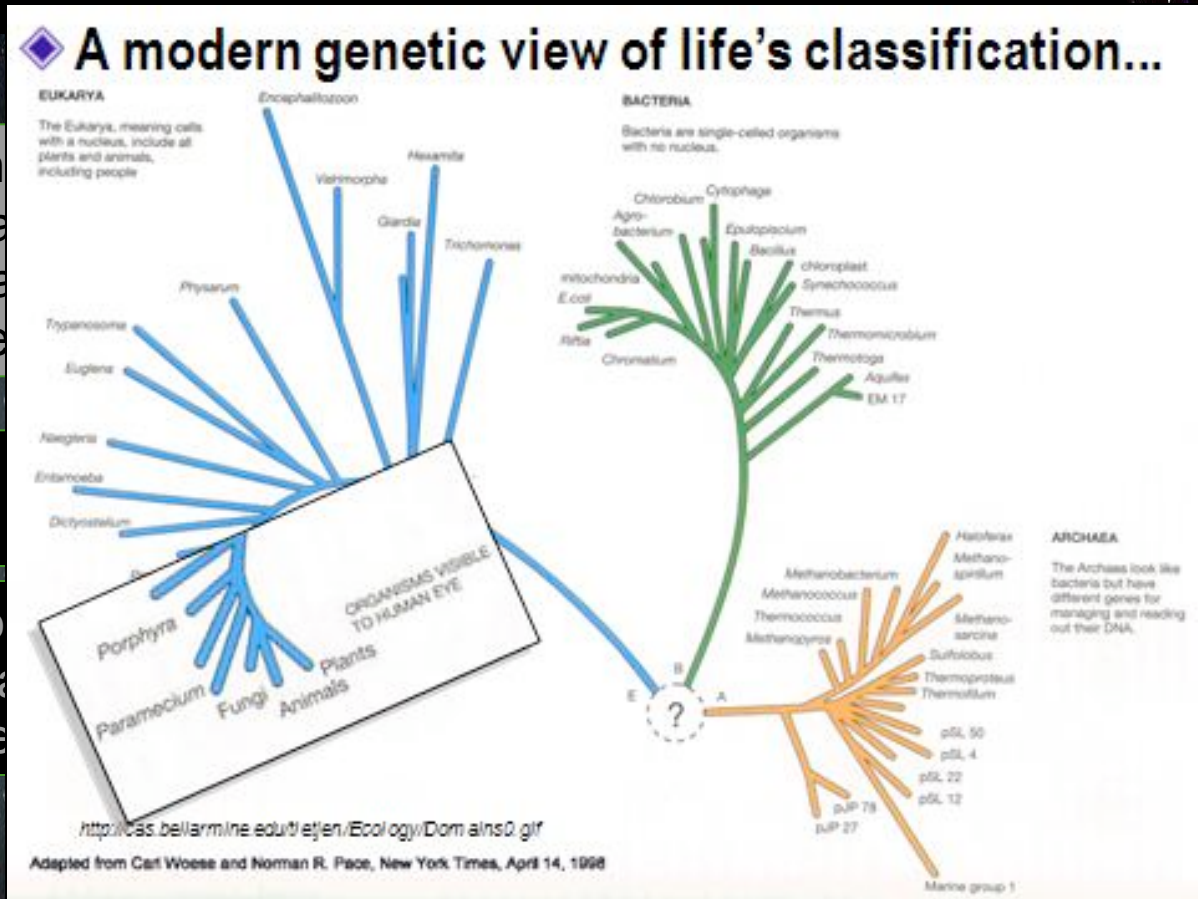
Putting a number on alien worlds

Other scientists are taking another approach: an analysis that suggests there could be hundreds, even thousands, of intelligent civilizations in the [Milky Way](#).

Researchers at the University of Edinburgh in Scotland constructed a computer model to create a synthetic galaxy with billions of stars and planets. They then studied how life evolved under various conditions in this virtual world, using a supercomputer to crunch the results.

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The
planets
that
life

The rate of star formation
in our galaxy

The proportion
of stars that
form planets

these civilizations

$$N = R \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

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The proportion of these where intelligence emerges

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The proportion of stars that form planets

The proportion of these planets where life evolves

The proportion of these that achieve interstellar communication

The lifetime of these civilizations

$$N = R \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

Life on Earth gets off to an early start...

Nature (1996) 384:55-9. **“Evidence for life on Earth before 3,800 million years ago”**, *Eiler JM, Mojzsis SJ, Arrhenius G.*

“It is unknown when life first appeared on Earth. The earliest known microfossils (approximately 3,500 Myr before present) are structurally complex, and ... required a long time to develop this degree of complexity ... Here we ... provide evidence for the emergence of life on Earth by at least 3,800 Myr before present.”

Oldest known
fossil signs of
life



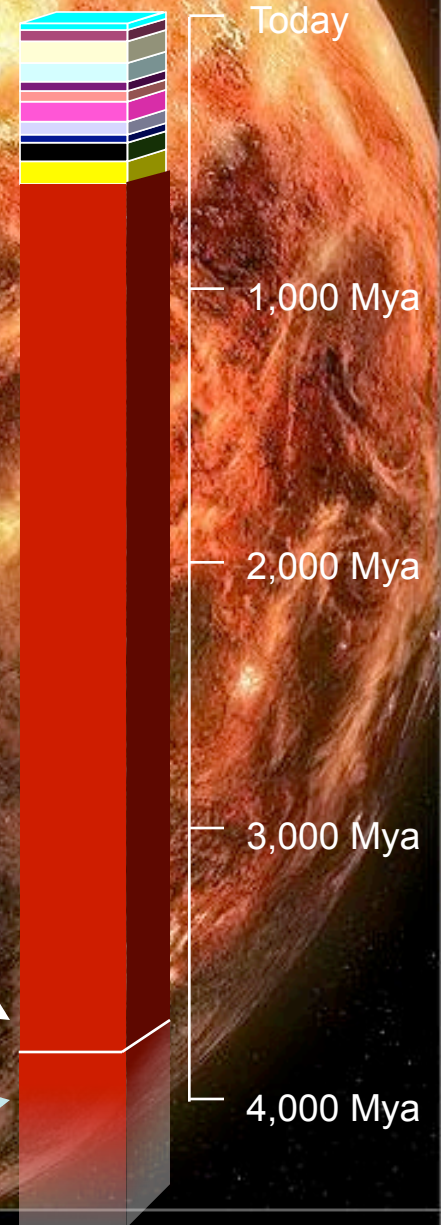
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Oldest known
fossil signs of
life



The earth was a molten mass, pummeled by BIG impacts

"we are stardust; we are golden. we are billion year old carbon"

Joni Mitchell , "Woodstock"

Inside a star, gravitational forces condense hydrogen and nuclear fusion begins: hydrogen is fused into helium, which in turn is converted into carbon and onwards into oxygen, neon, magnesium, silicon, sulfur and iron ... When the star exhausts its "fuel" the core can collapse resulting in a spectacular explosion, producing a gas-cloud that expands at a rate of about 10,000 km/s. The cloud slows and dissipates, seeding the inter-stellar neighborhood with heavy elements and providing the shock waves that initiate new star formation.

www.novaspace.com/GICLEE/Pool/Supernova.html

...amino acid delivery from space seems very likely!

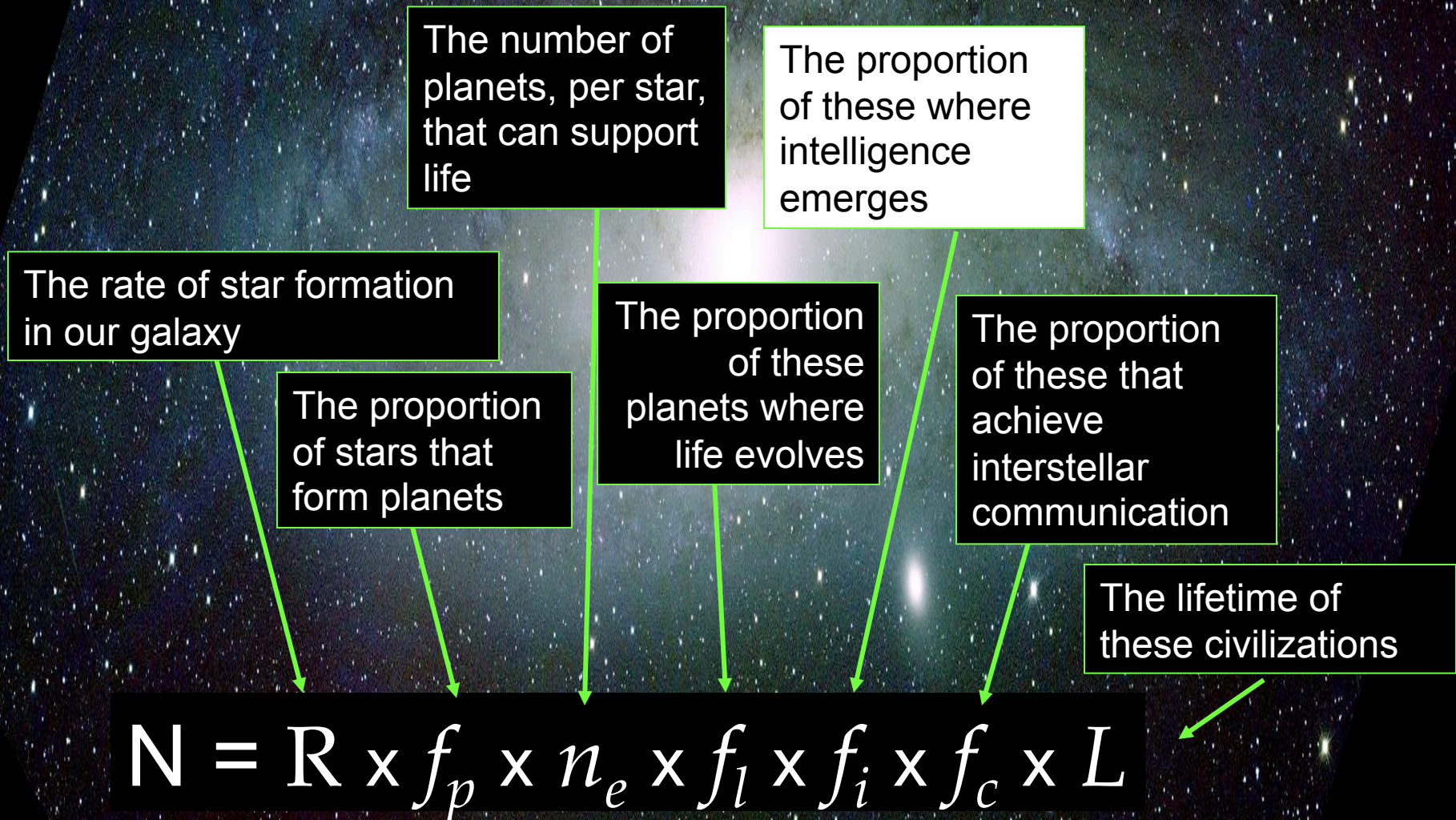
The Earth acquires 100,000 to 1,000,000 kg of extraterrestrial material each day...

Ehrenfreund P, Sephton MA, "Carbon molecules in space: from astrochemistry to astrobiology." Faraday Discuss. 2006;133:277-88; discussion 347-74, 449-52

http://www.nightskyinfo.com/maps_images/meteor_tezel.jpg

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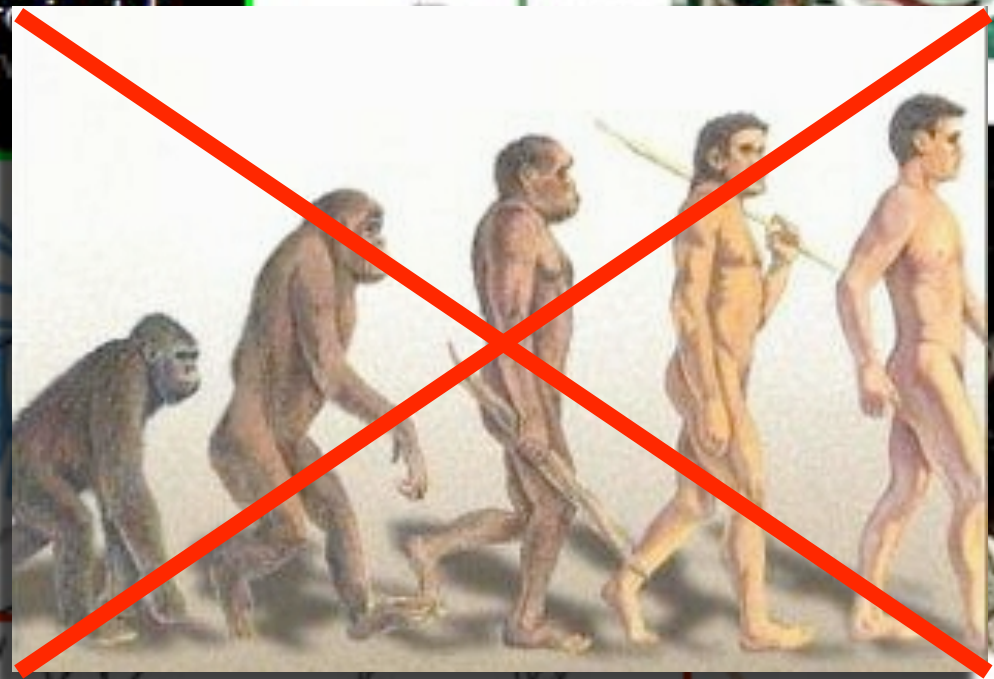
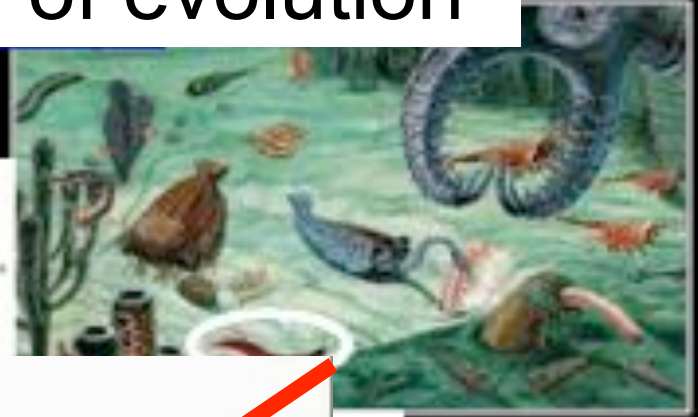


An orthodox 20th century view of evolution



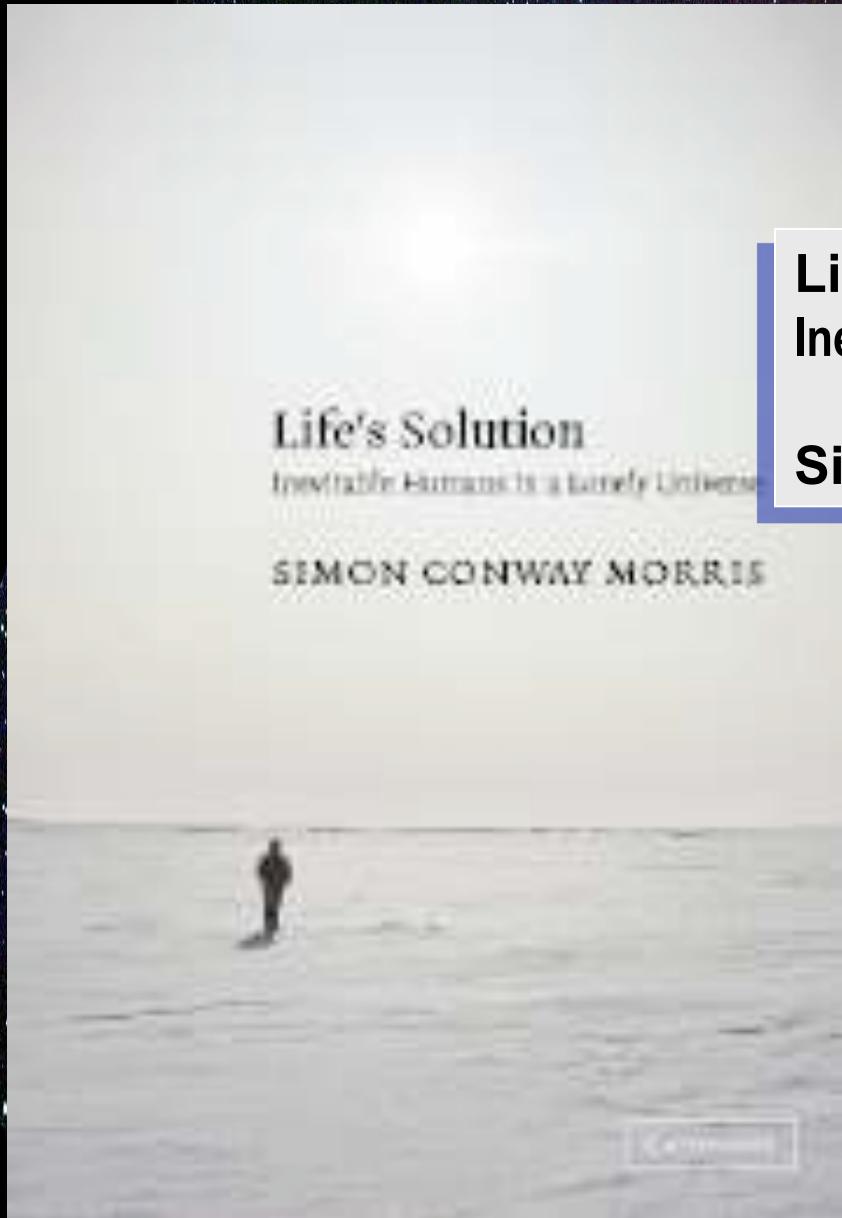
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Bacteria are single-celled organisms with no nucleus.



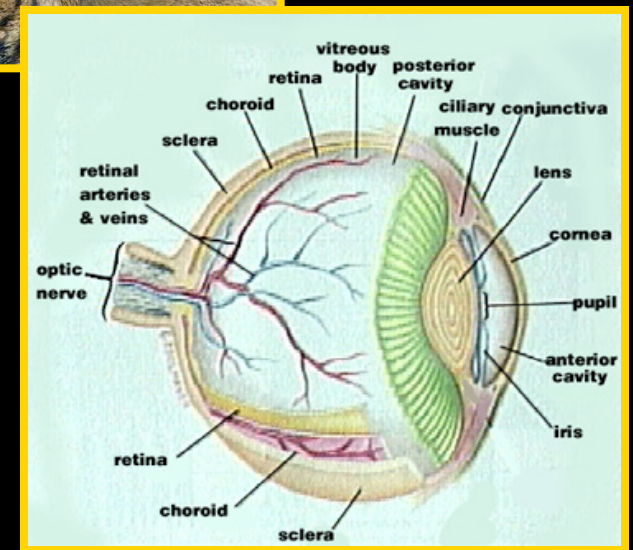
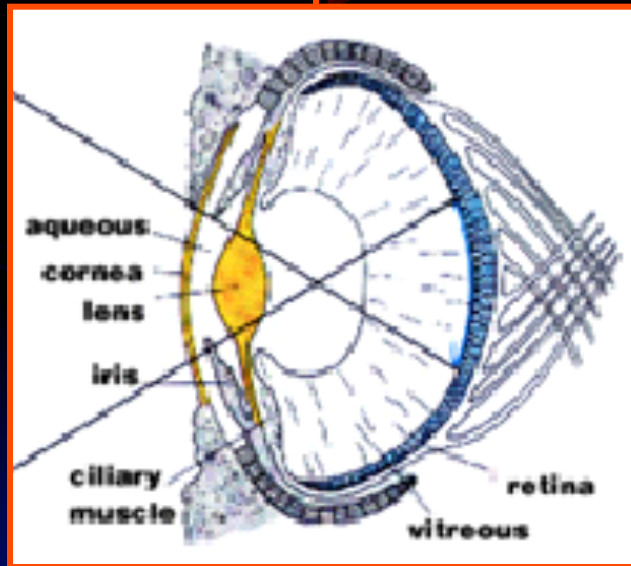
Human group 1

So what about the 21st Century?



Life's Solution
Inevitable Humans in a Lonely Universe
Simon Conway Morris

Repeating patterns of evolution?



It turns out that these eyes have essentially the same genetic basis ~ though they have evolved independently

Repeating patterns of evolution?

Years ago
0
500,000
1,000,000
1,500,000
2,000,000
2,500,000
3,000,000
3,500,000
4,000,000
4,500,000
5,000,000



Smilodon californicus



lived 1.6 mya-11,000 years ago



lived about 3 million years ago

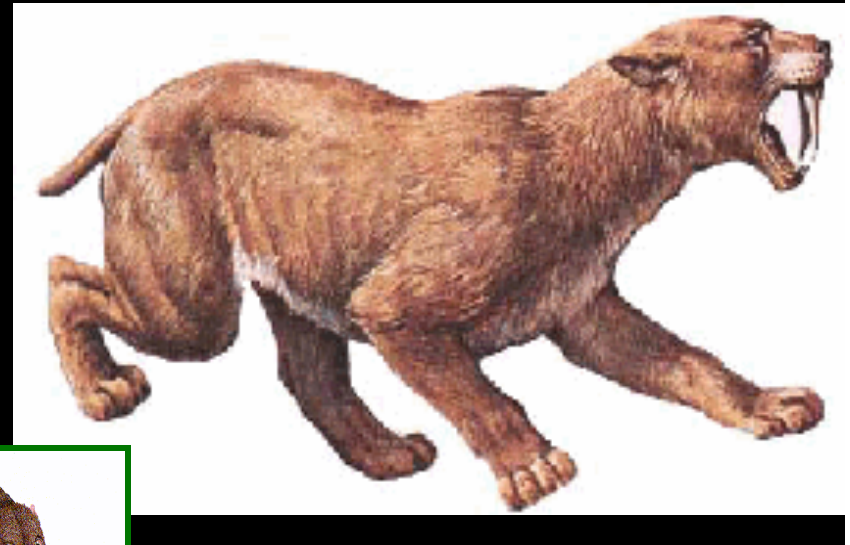
Pnylacosmilus ferox

Repeating patterns of evolution?

*Grey wolf (placental mammal):
Europe, Asia and America*



Smilodon californicus



© DK.2001

http://cas.bellarmine.edu/tietjen/images/marsupials_vertibrata.htm

*Thylacine 'wolf' (marsupial mammal,
related to kangaroos): Australasia*

Thylacosmilus ferox

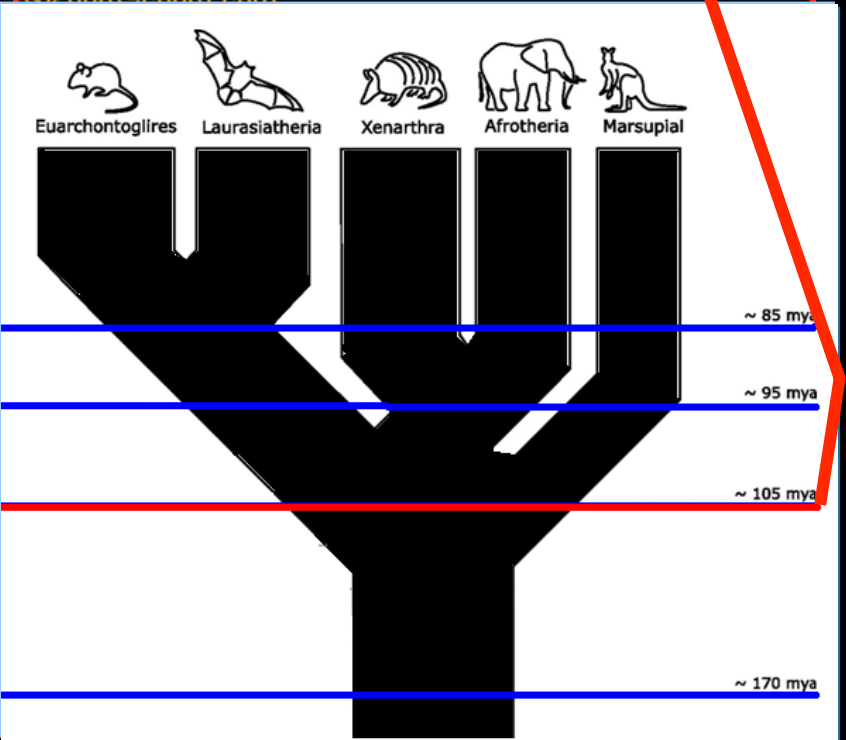
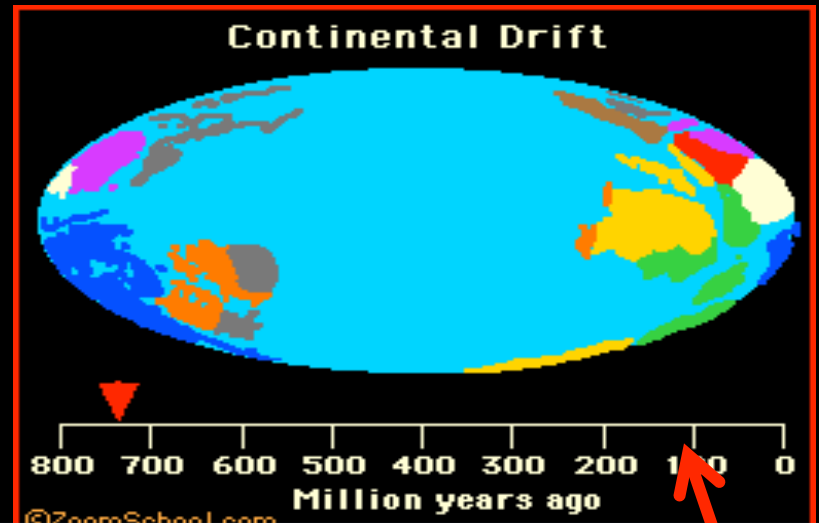
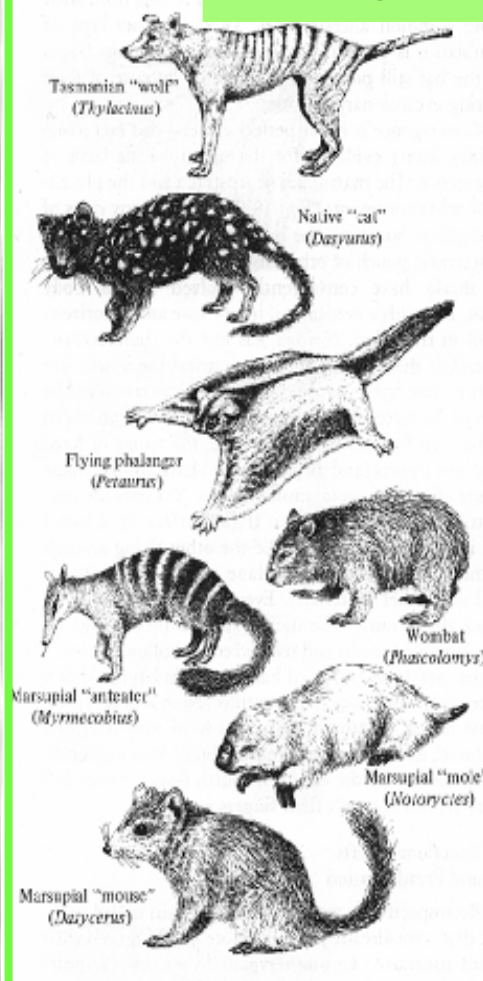
◆ Plate Tectonics (used to be called “Continental Drift”)

explains things like Australia contains marsupial counterparts to placental mammals...

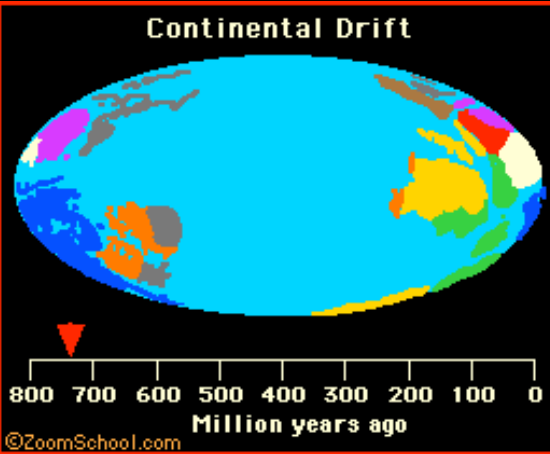
Placentals



Marsupials

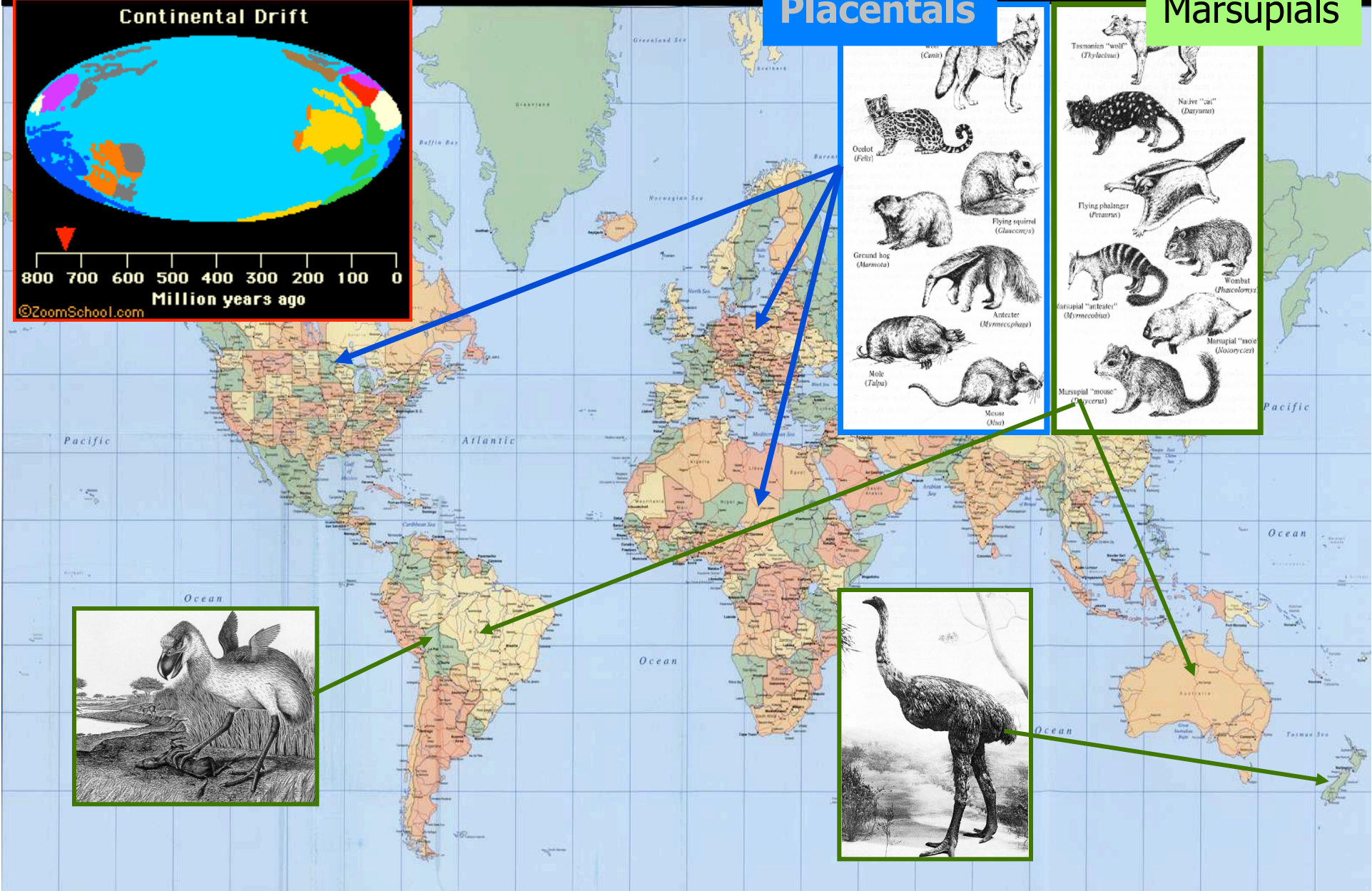
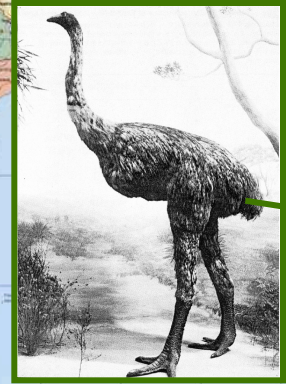
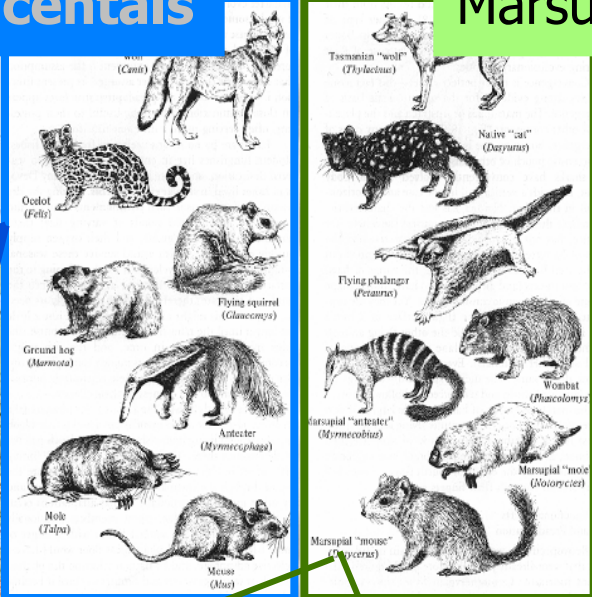


Gould points out that in Australasia and South America, separate of landmasses meant that birds and marsupial mammals became top predators and largest animals (rather than placental mammals)



Placentals

Marsupials



But 3 million years ago, a land bridge rejoined north and south America...in general, placentals out-competed birds and marsupials

Placentals

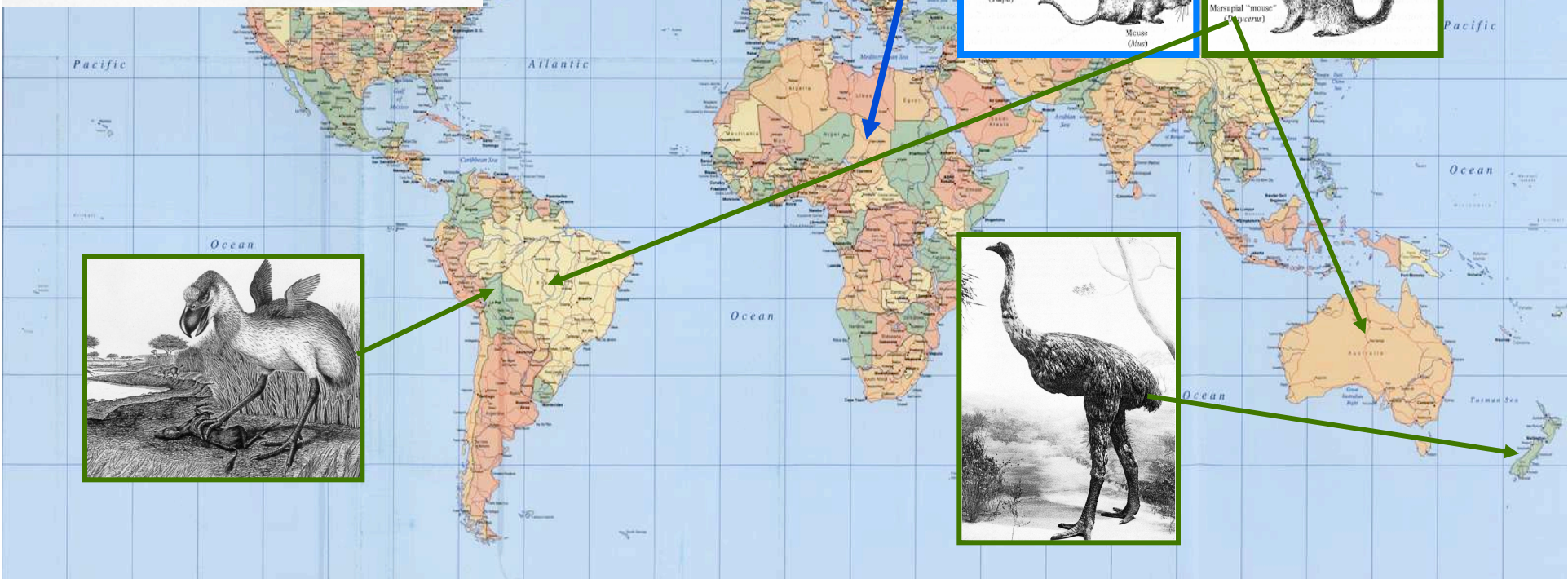
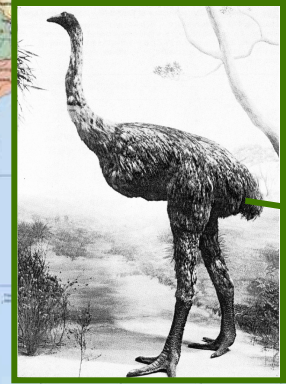
Marsupials

North America:
 Bears
 Camels
 Cats
 Deer
 Dogs
 Elephants
 Horses
 Peccaries
 Rabbits
 Raccoons
 Skunks
 Tapirs
 Weasels

South America:
 Anteaters
 Armadillos
 Capybaras
 Glyptodonts
 Monkeys
 Opossums
 Porcupines
 Phorusrhacids
 Sloths
 Teratorns
 Toxodonts

Canine (Canis)
 Ocelot (Felis)
 Ground hog (Marmota)
 Anteater (Myrmecophaga)
 Mole (Talpa)
 Mouse (Mus)

Tasmanian "wolf" (Thylacynus)
 Native "cat" (Dasyurus)
 Flying phalanger (Petaurus)
 Wombat (Phacelomys)
 Marsupial "anteater" (Myrmecobius)
 Marsupial "mouse" (Murexia)



~ Round #2 to the placentals?

Placentals

Marsupials

North America:

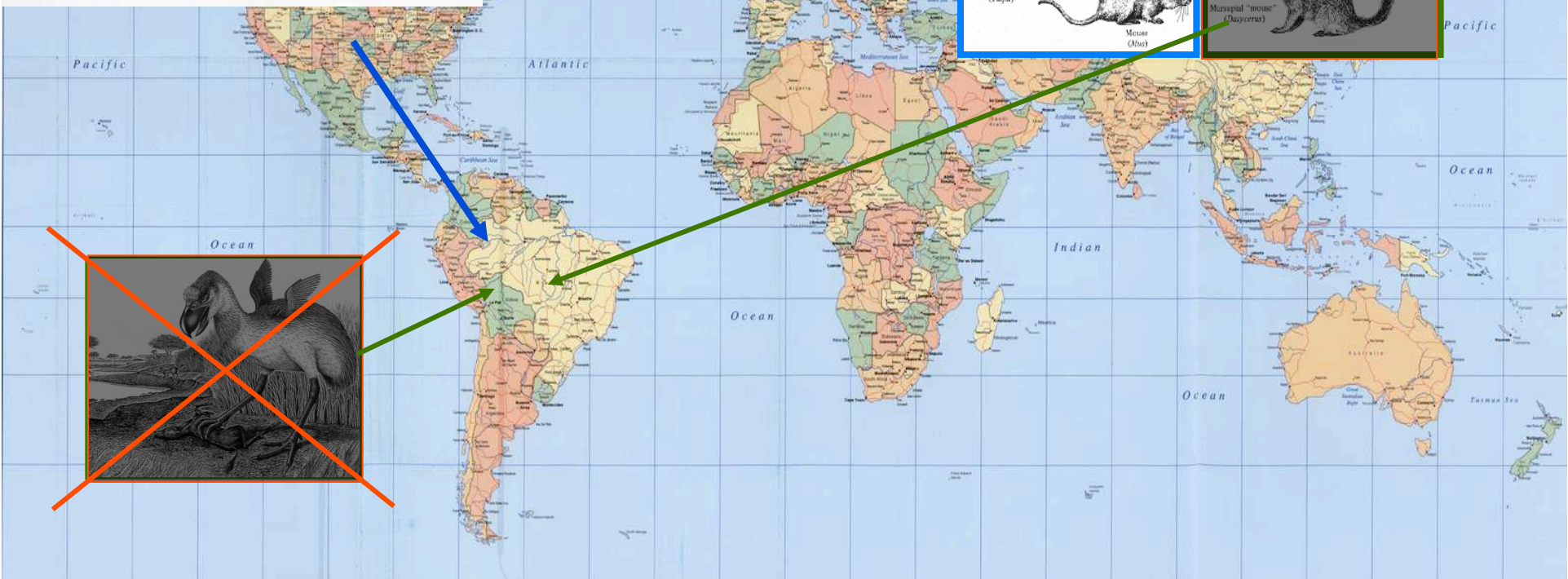
- Bears
- Camels
- Cats
- Deer
- Dogs
- Elephants
- Horses
- Peccaries
- Rabbits
- Raccoons
- Skunks
- Tapirs
- Weasels

South America:

- Anteaters
- Armadillos
- Capybaras
- Glyptodonts
- Monkeys
- Opossums
- Porcupines
- Phorusrhacids
- Sloths
- Teratorns
- Toxodonts

- Canine (Canis)
- Ocelot (Felis)
- Ground hog (Marmota)
- Mole (Talpa)
- Mouse (Mus)
- Flying squirrel (Glaucomys)
- Anteater (Myrmecophaga)

- Tasmanian "wolf" (Thylacynus)
- Native "cat" (Dasyurus)
- Flying phalanger (Perameles)
- Wombat (Phalanger)
- Marsupial "antelope" (Myrmecobius)
- Marsupial "mouse" (Marsupialia)



~ Round #3 to the placentals

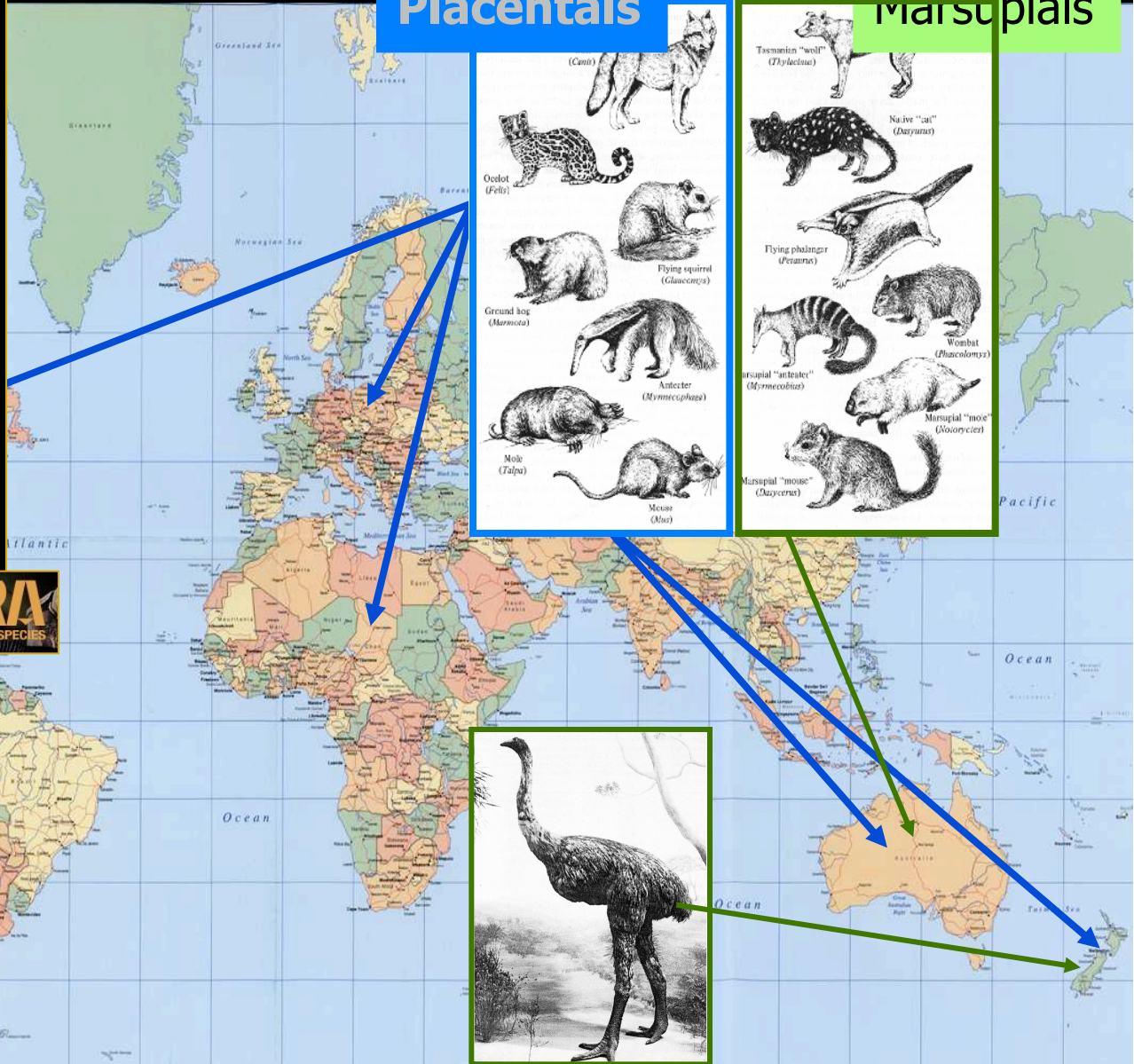
“...moas developed on isolated islands with limited contact with mammals and other terrestrial (land dwelling) vertebrates...

...While it is possible that moa populations were already in decline due to natural causes...the most likely explanation for their extinction is overexploitation by humans ...[and]... predation of young chicks by dogs and rats that came to the islands with the first humans...

BAGHEERA
A WEBSITE FOR OUR ENDANGERED SPECIES

Placentals

Marsupials



~ Round #3 to the placentals

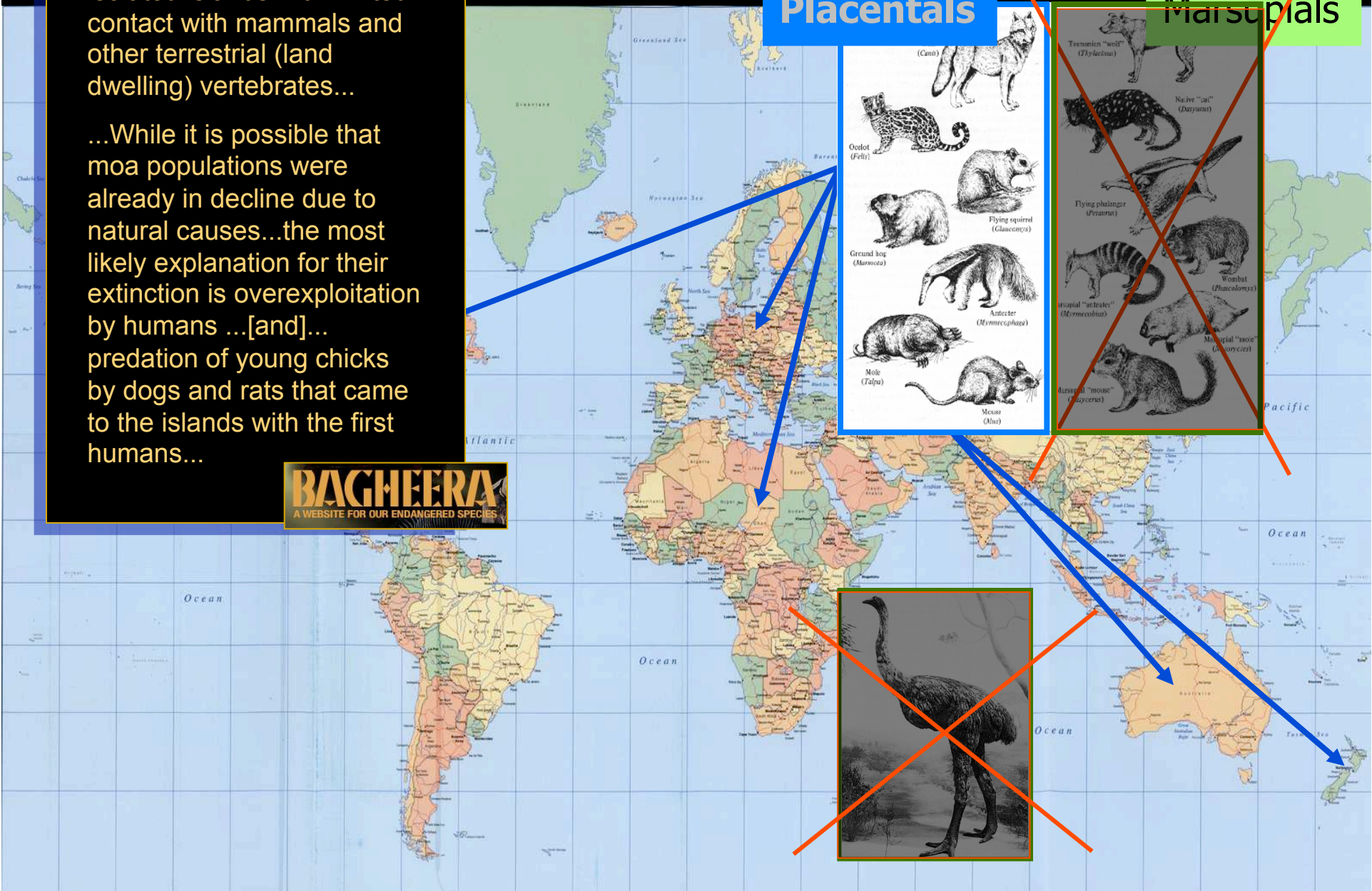
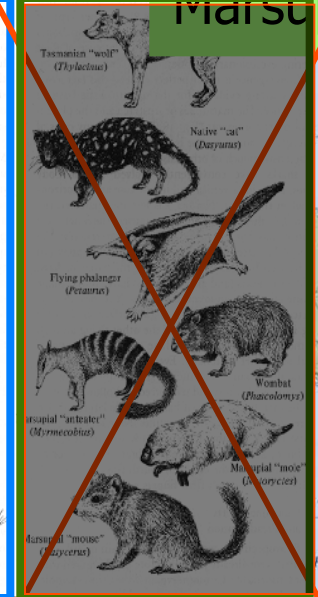
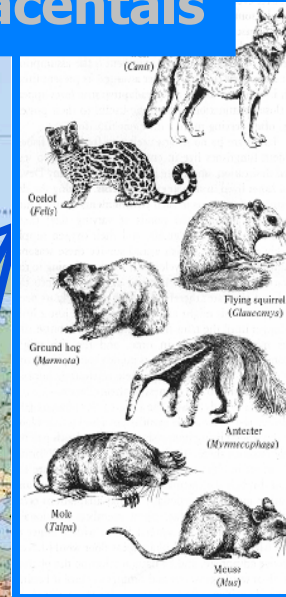
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BAGHEERA
A WEBSITE FOR OUR ENDANGERED SPECIES

Placentals

Marsupials



◆ Mammal species evolve to fill a void...

A worldwide layer of compressed ash from 65 mya



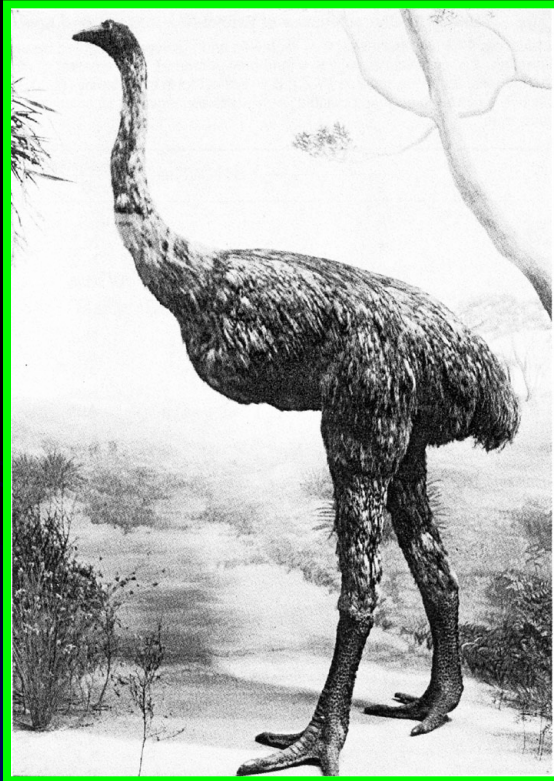
Eon Era

Phanerozoic
Cenozoic
Mesozoic
Paleozoic

Tertiary
Cretaceous 65 mya



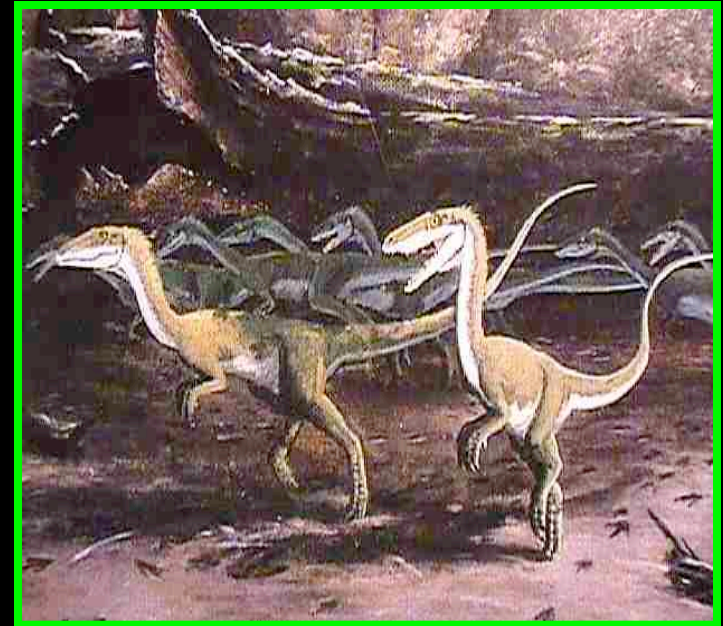
Let us remember that birds really are dinosaurs!



Canada goose gosling

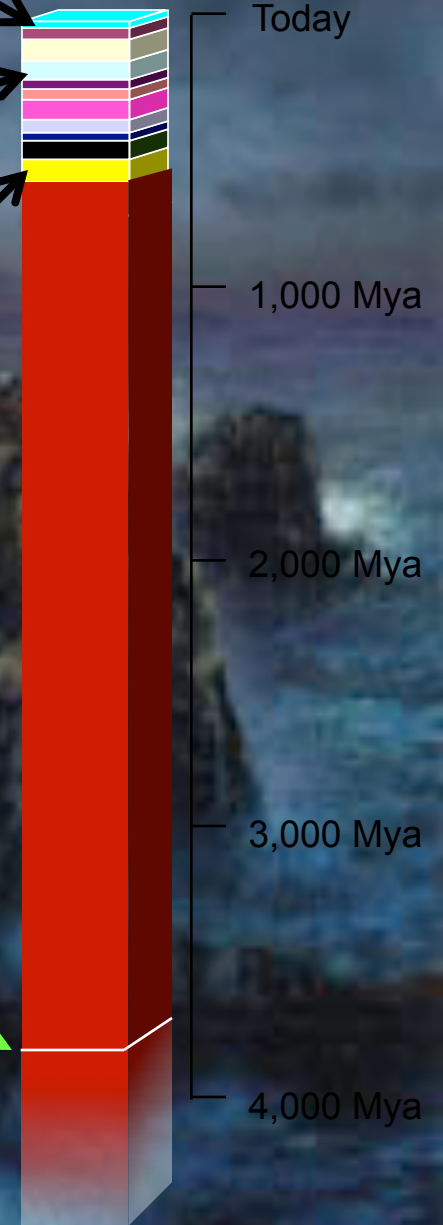
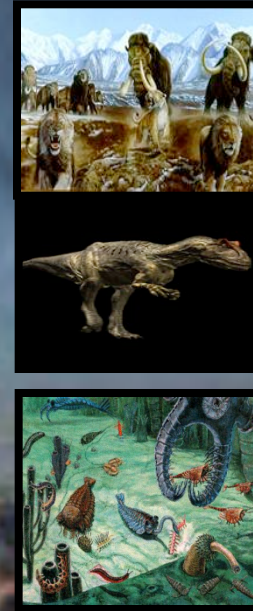


Falcarius utahensis



So perhaps mammals are just plain likely to outcompete ground-based birds/reptiles as top predators?

◆ Life on earth to scale...

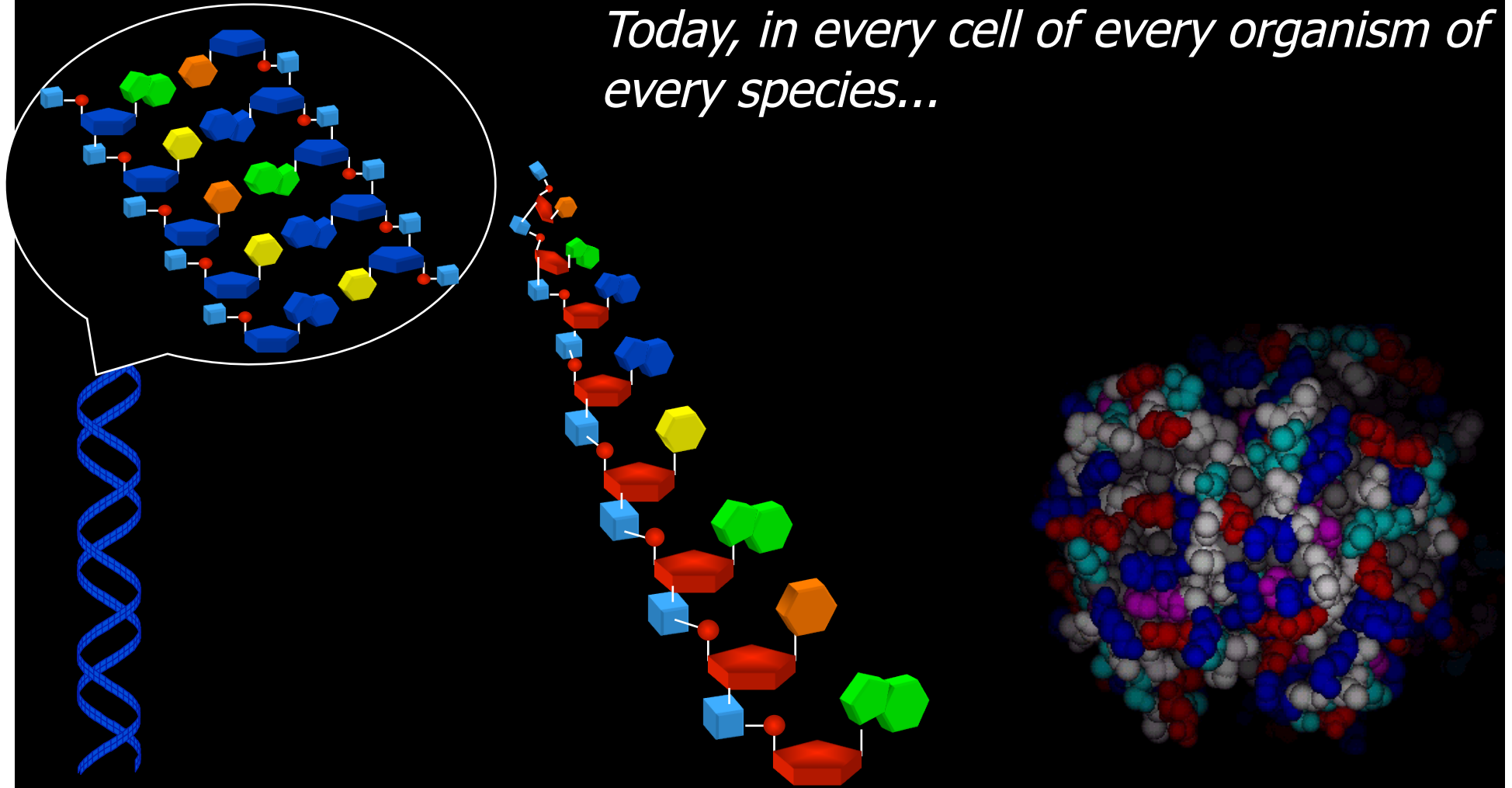


Nature (1996) 384:55-9. "Evidence for life on Earth before 3,800 million years ago", *Eiler JM, Mojzsis SJ, Arrhenius G.*

"It is unknown when life first appeared on Earth...Here we ... provide evidence for the emergence of life on Earth by at least 3,800 Myr before present."

◆ Standards and Universals

Today, in every cell of every organism of every species...



DNA (information) → RNA ('temporary' gene) → Protein (phenotype)

DNA genes are translated into RNA "messages" that are then translated into proteins

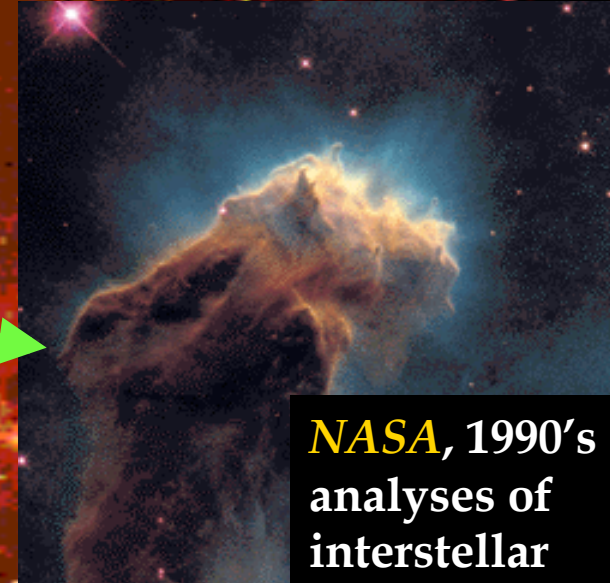
Validated by space research...



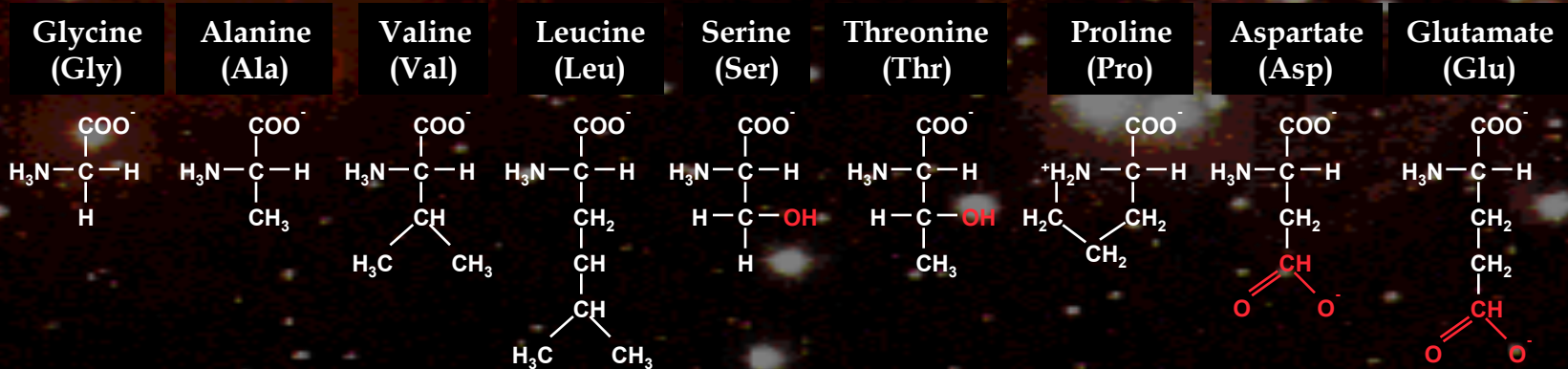
Stanley Miller – 1950's
'spark tube' experiments



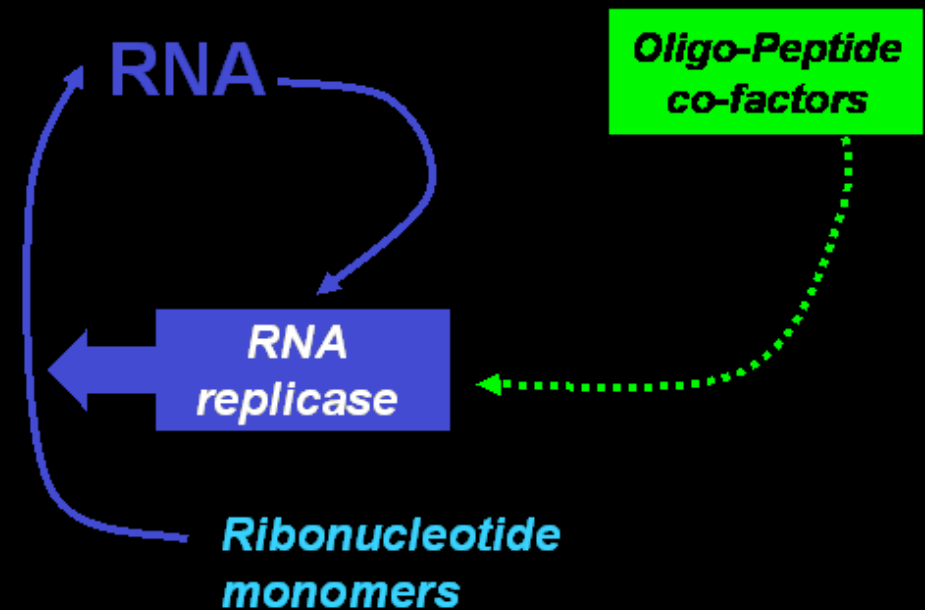
Kvenvolden, 1970's analyses
of the Murchison Meteorite



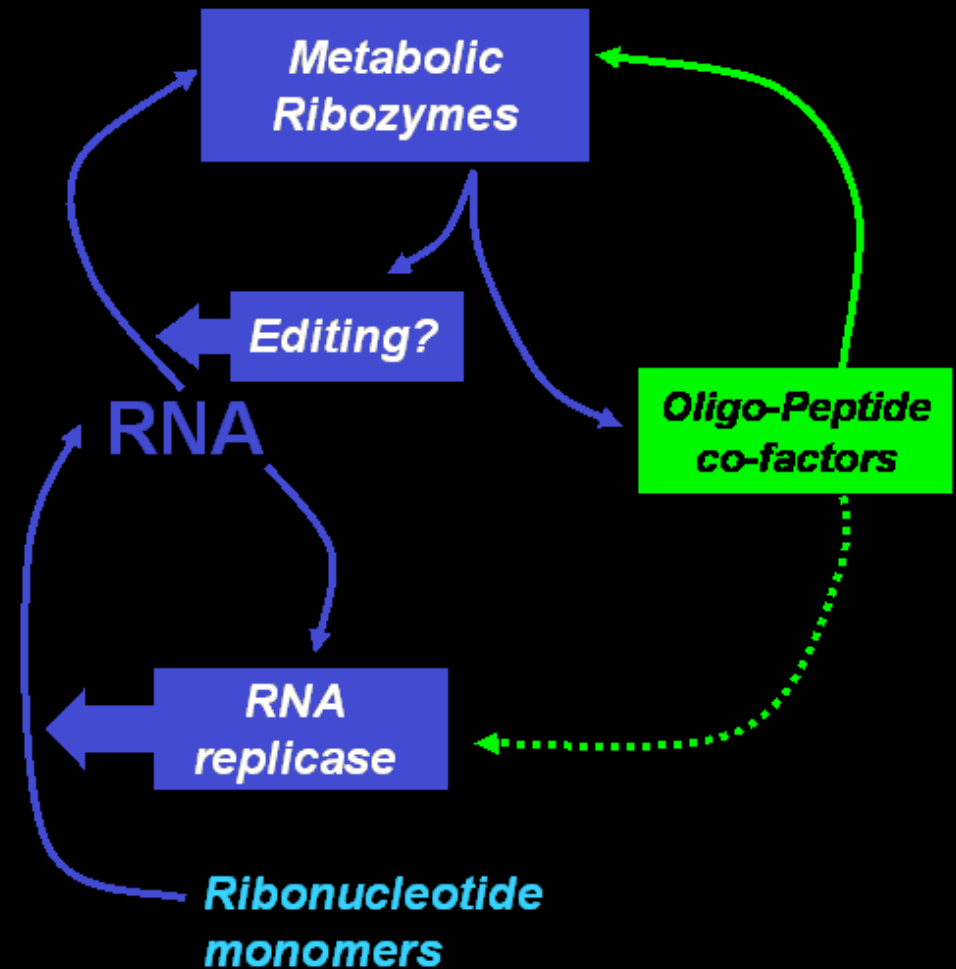
NASA, 1990's
analyses of
interstellar
'space dust'



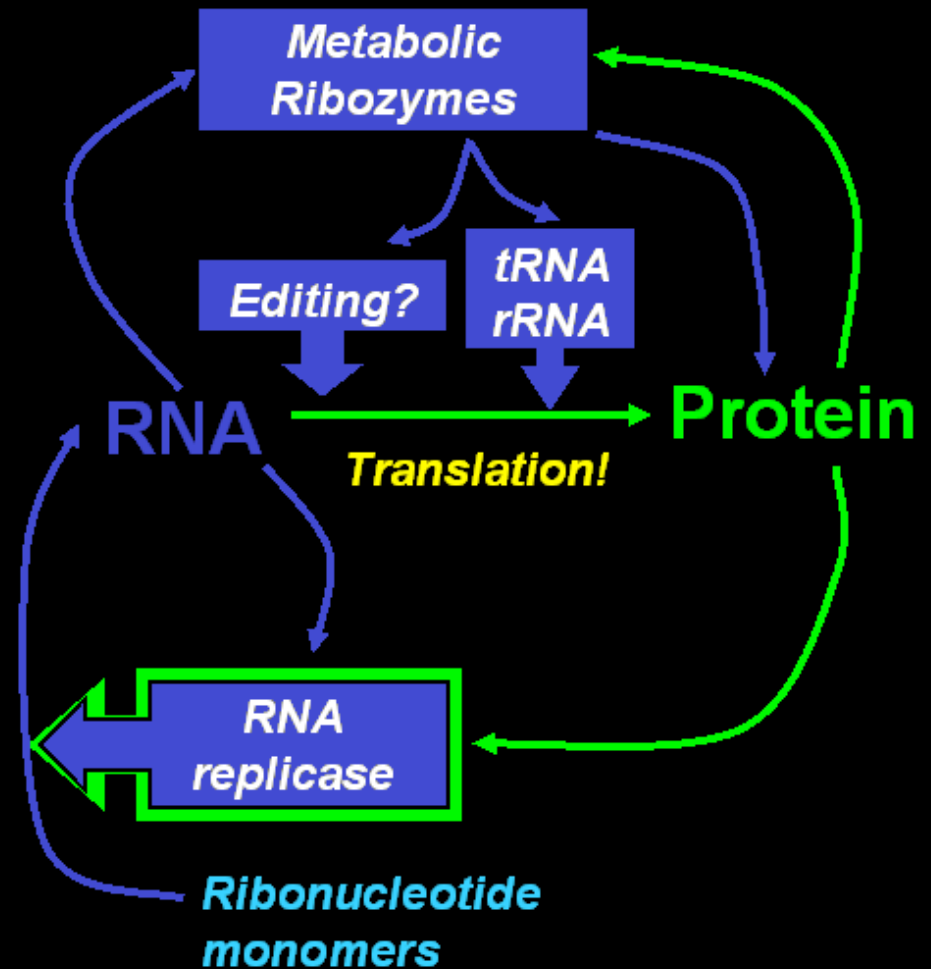
Solving the Puzzle of Primordial Self-Replication



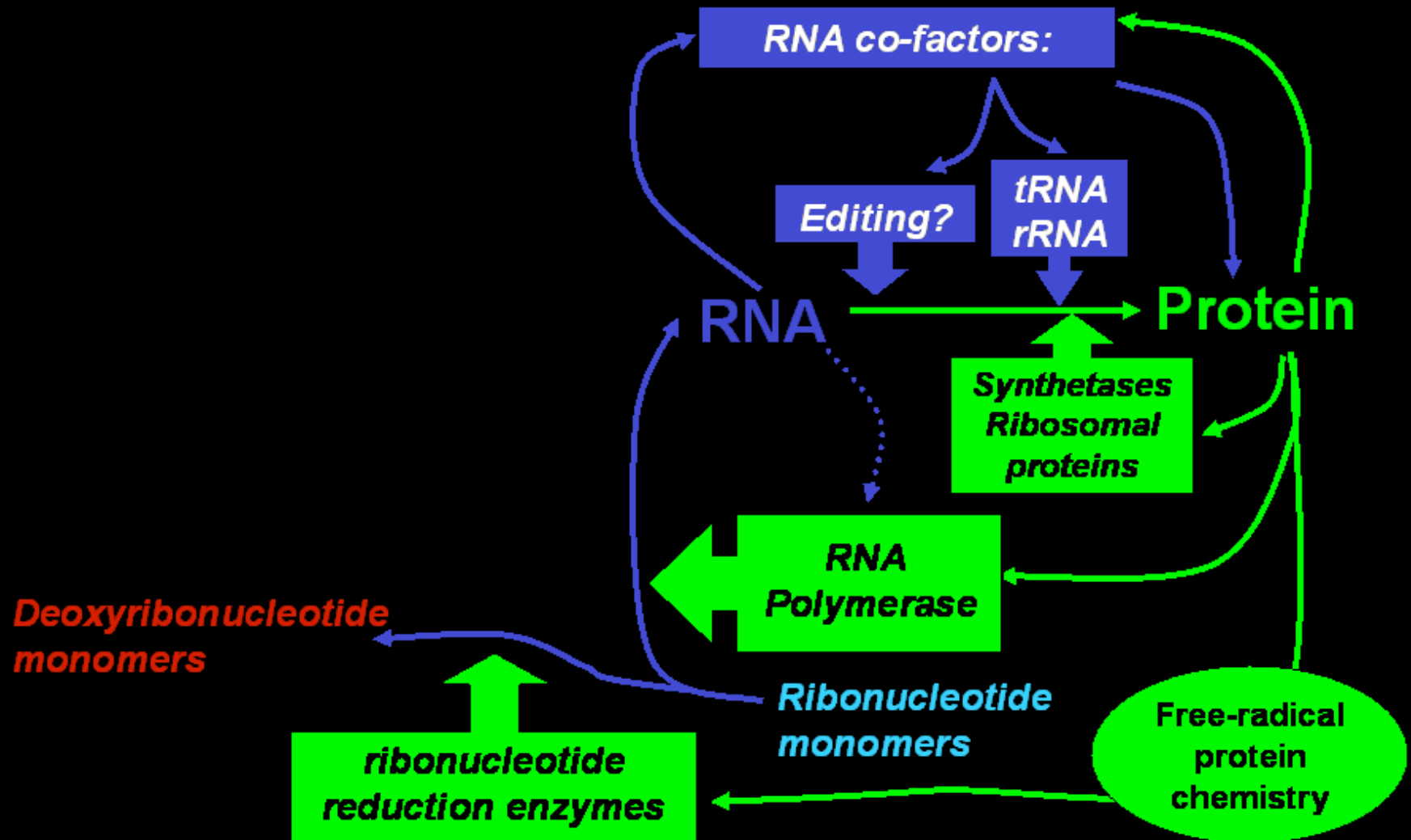
Solving the Puzzle of Primordial Self-Replication



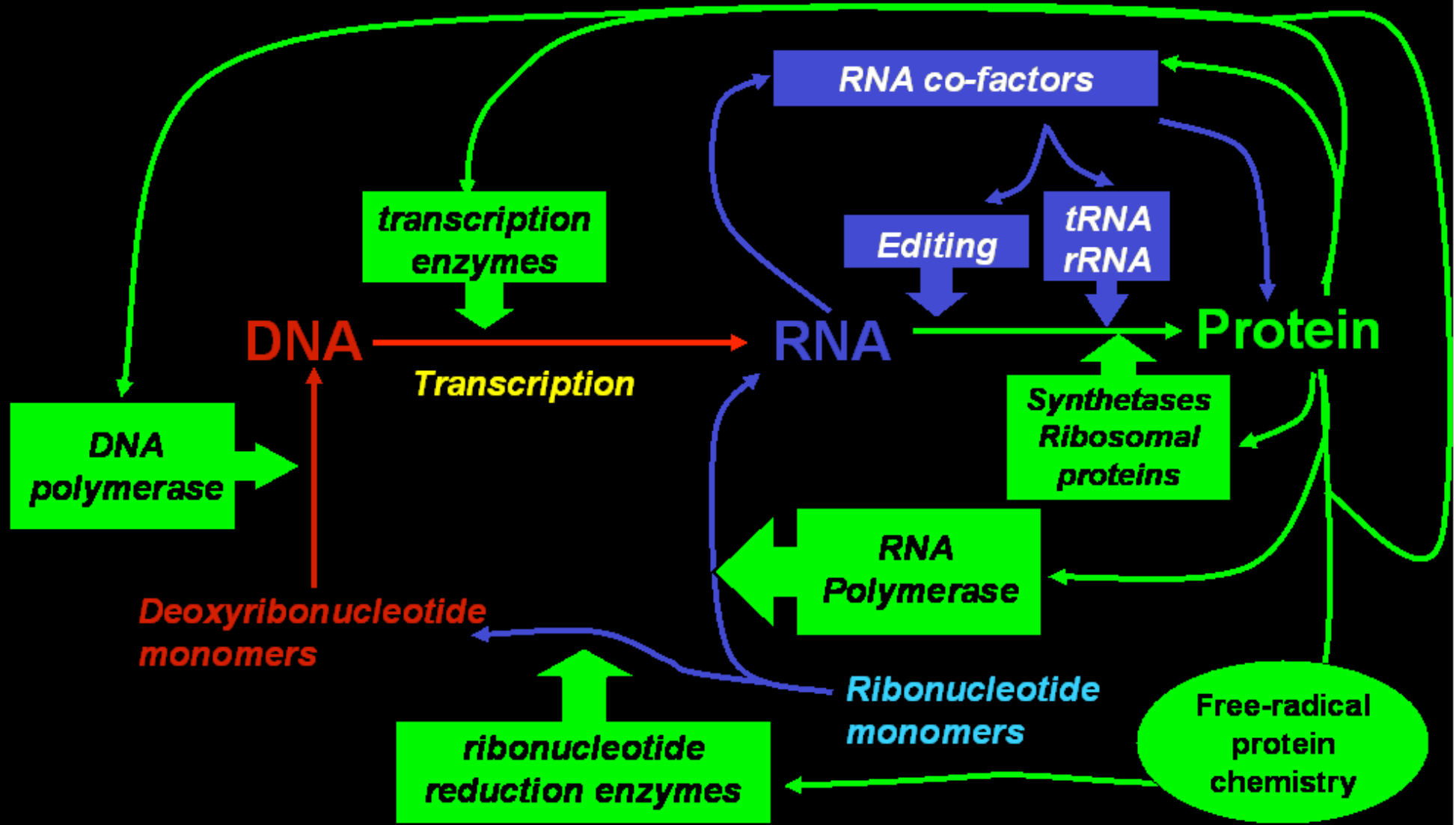
Solving the Puzzle of Primordial Self-Replication



Solving the Puzzle of Primordial Self-Replication

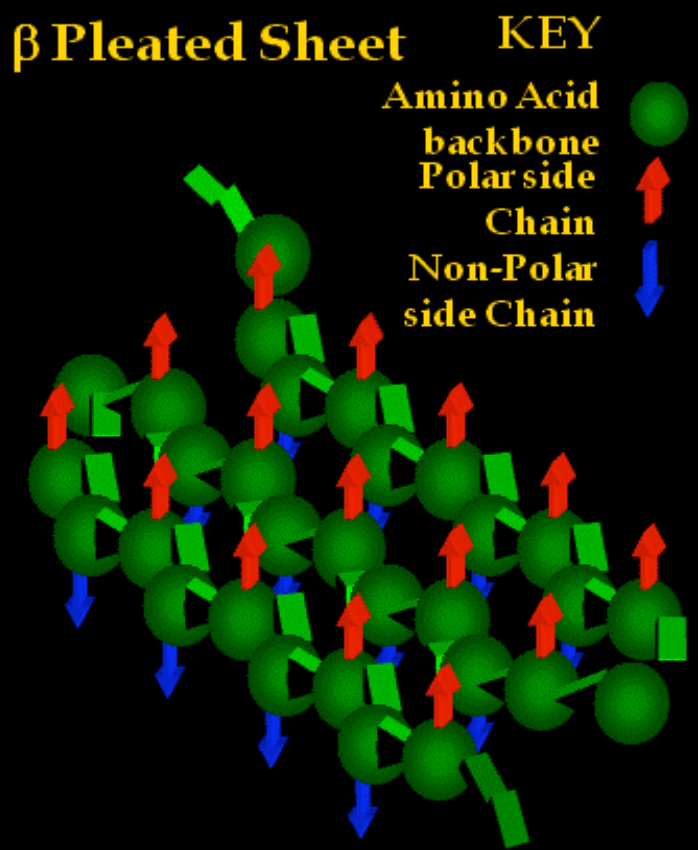


Solving the Puzzle of Primordial Self-Replication



A Non-Random Genetic Code?

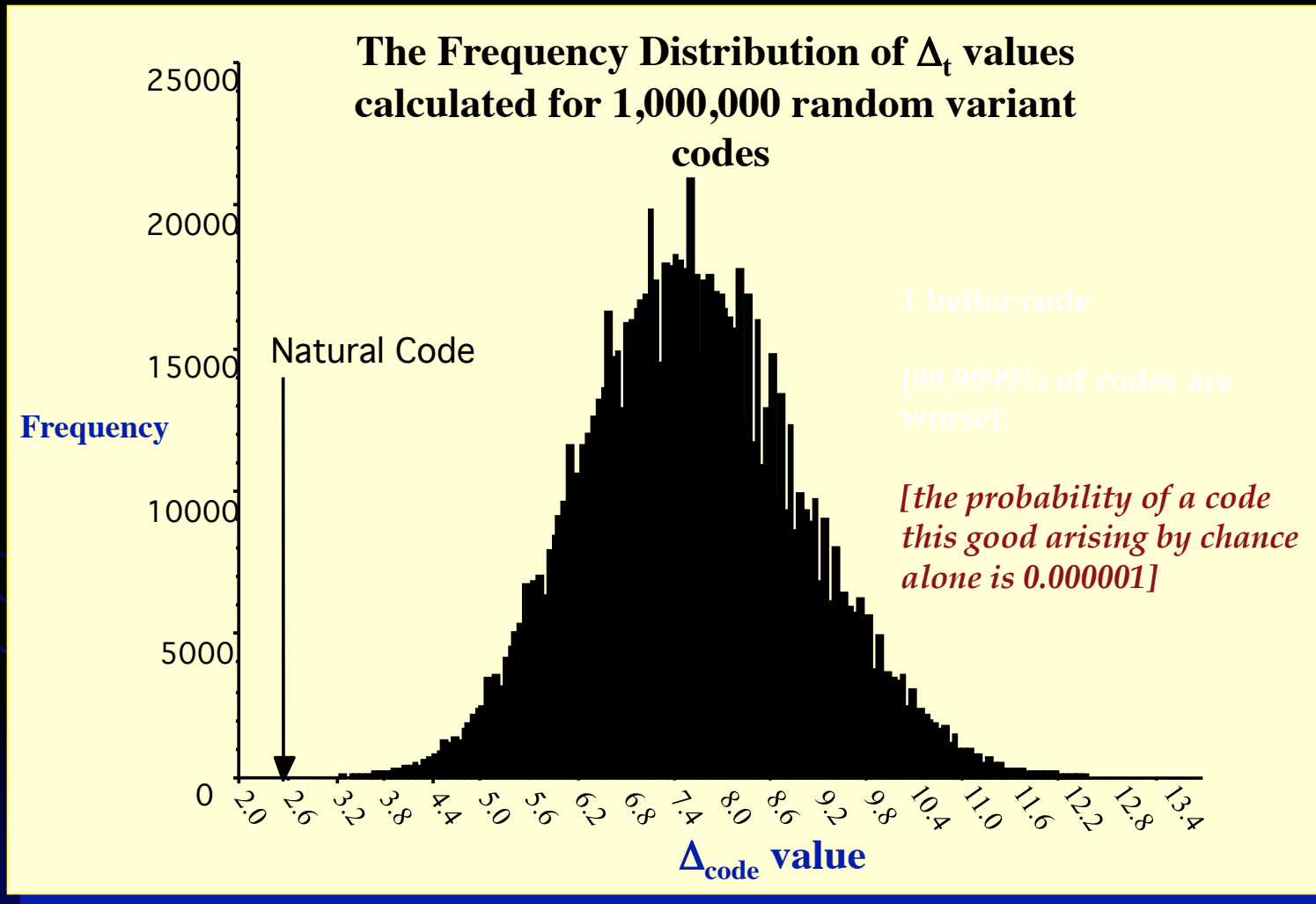
	-U-	-C-	-A-	-G-
U--	UUU Phe UUC UUA Leu UUG	UCU UCC Ser UCA UCG	UAU Tyr UAC UAA UAG	UGU Cys UGC UGA UGG Trp
C--	CUU Leu CUC CUA CUG	CCU CCC Pro CCA CCG	CAU His CAC CAA Gln CAG	CGU Arg CGC CGA CGG
A--	AUU Ile AUC AUA AUG Met	ACU ACC Thr ACA ACG	AAU Asn AAC AAA Lys AAG	AGU Ser AGC AGA Arg AGG
G--	GUU Val GUC GUA GUG	GCU Ala GCC GCA GCG	CAU Asp CAC CAA Gln CAG	GGU GGC Gly GGA GGG



“Polar Requirement” (hydrophobicity)

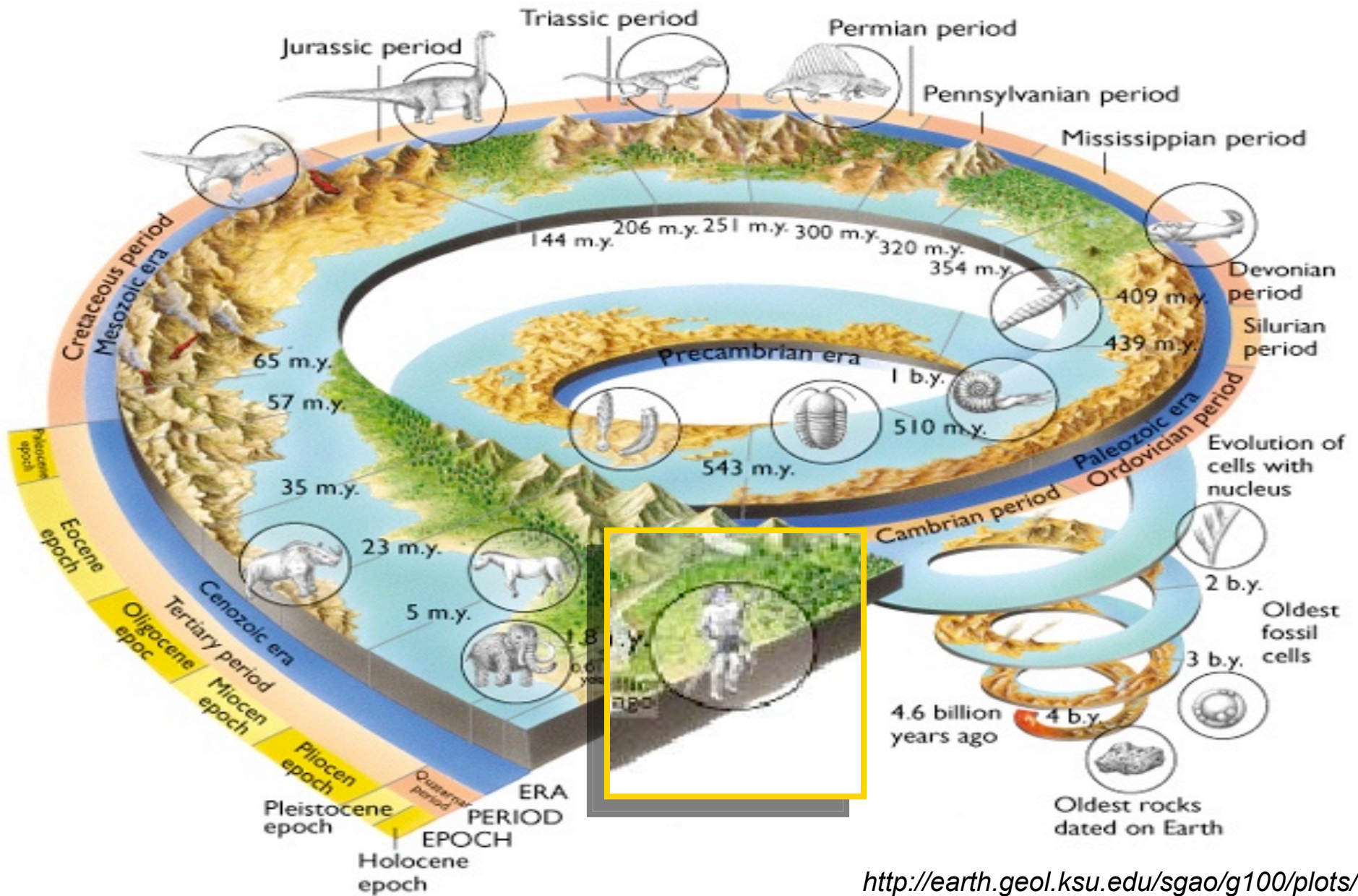


The 'natural' code compared to 1,000,000 random alternatives
[incorporating patterns of translation error into Δ value calculations]



"The Genetic Code is 1 in a Million", Freeland & Hurst (1998) JME 47: 238-248

Would evolution lead to something like us?



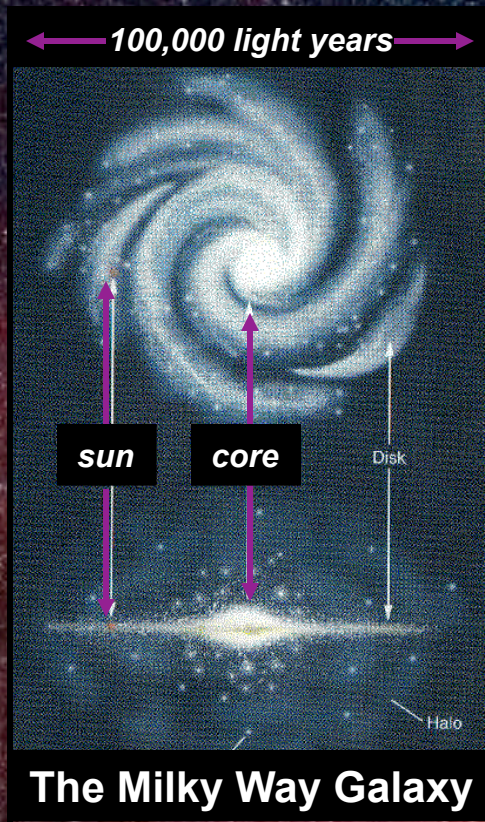
Science versus philosophy...

"The scientific method requires that an hypothesis be ruled out or modified if its predictions are clearly incompatible with experimental tests ... Note this also implies that a theory must be testable. Theories which cannot be tested...do not qualify as scientific theories..."

Wolfs, "Introduction to the Scientific Method"

"Aristotle maintained that women have fewer teeth than men; although he was twice married, it never occurred to him to verify this statement by examining his wives' mouths." *Bertrand Russell*

in just another star system...



“This ... image from NASA's Spitzer Space Telescope shows hundreds of thousands of stars crowded into the swirling core of our spiral Milky Way galaxy”

NASA mission news 01.10.06
<http://www.nasa.gov/vision/universe/starsgalaxies/spitzer-20060110.html>

