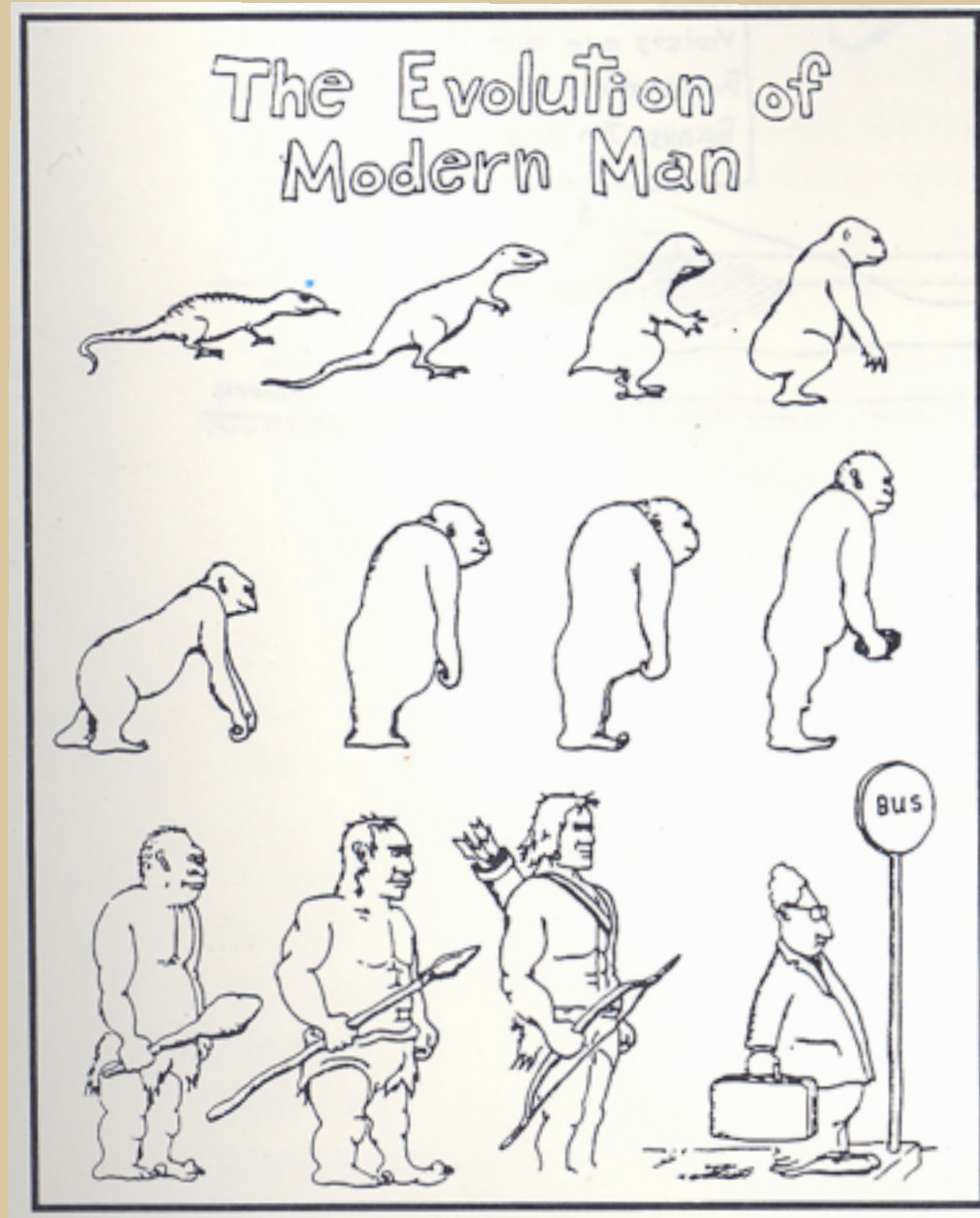


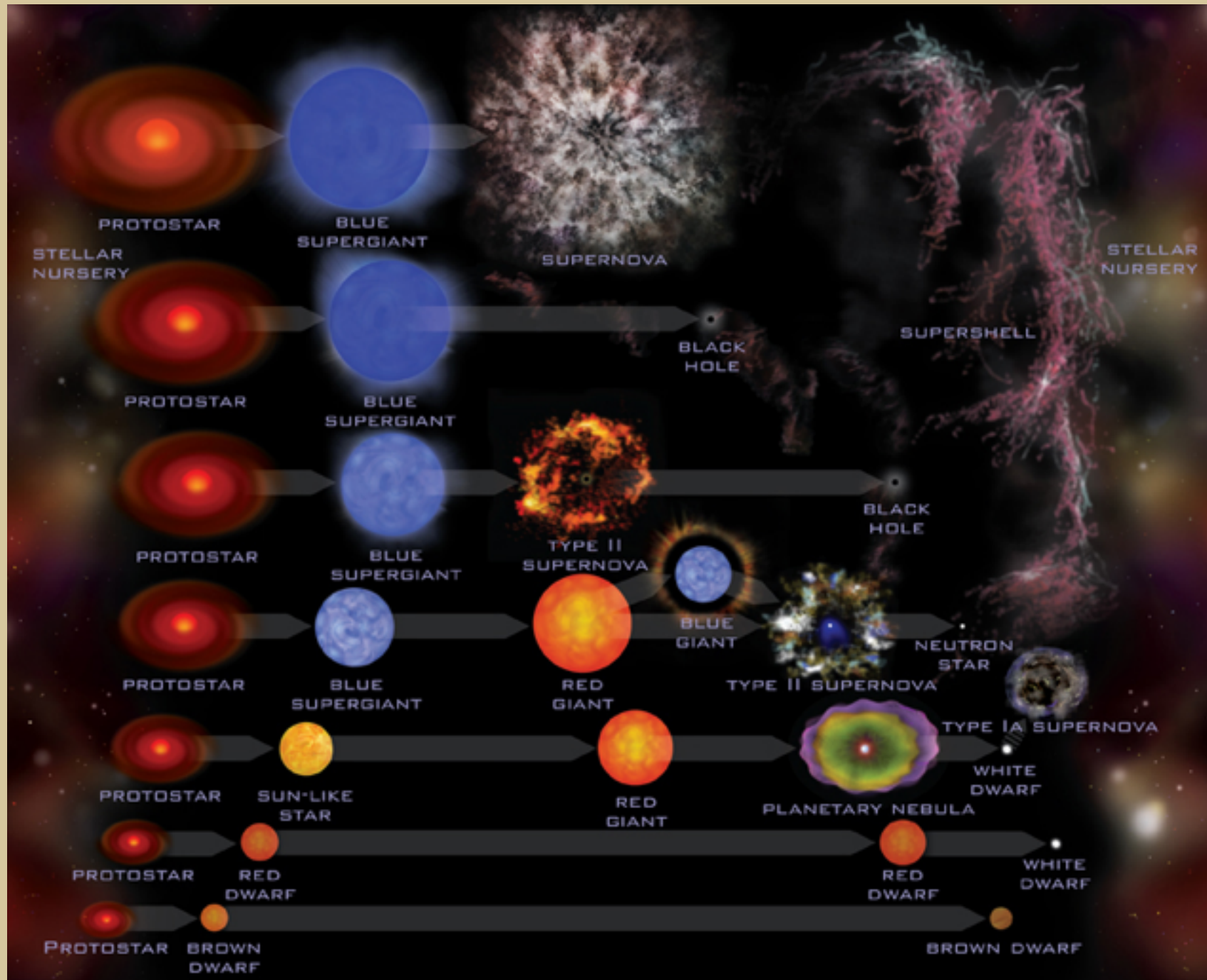
# Evolution

*Everything you wanted to know but were afraid to ask*

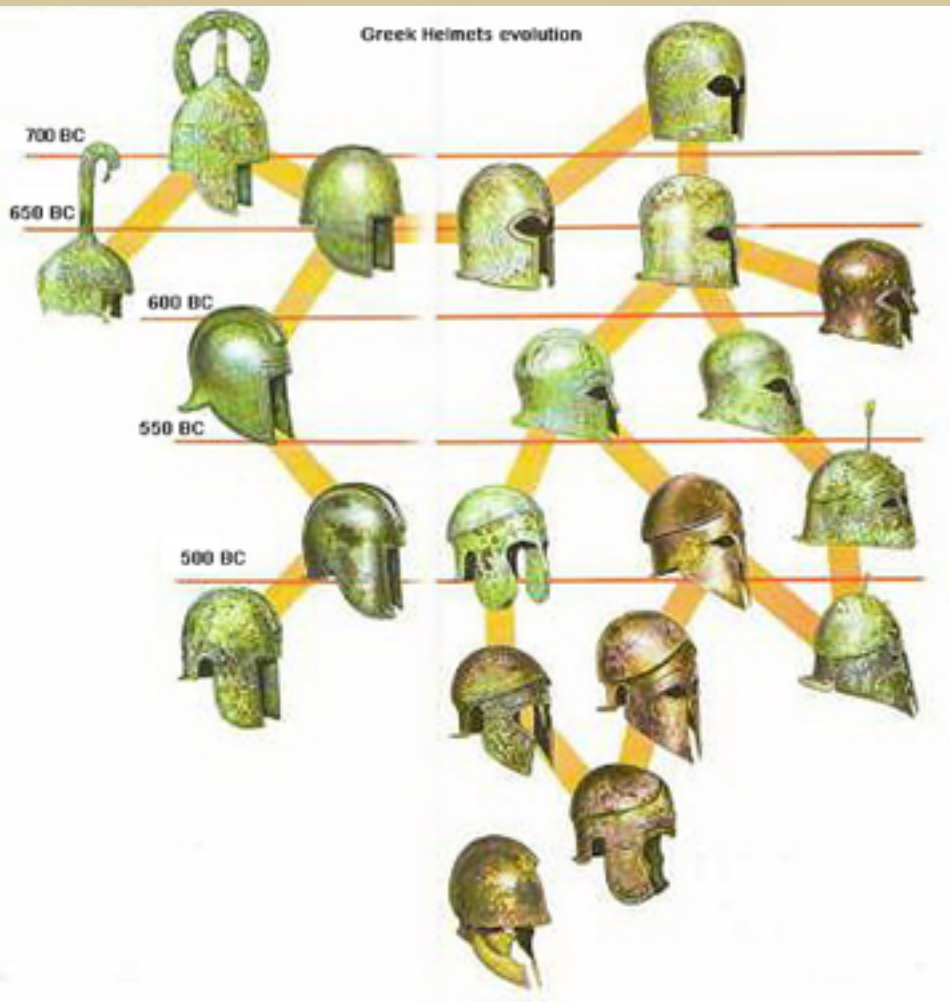


Gary Larson, 1996

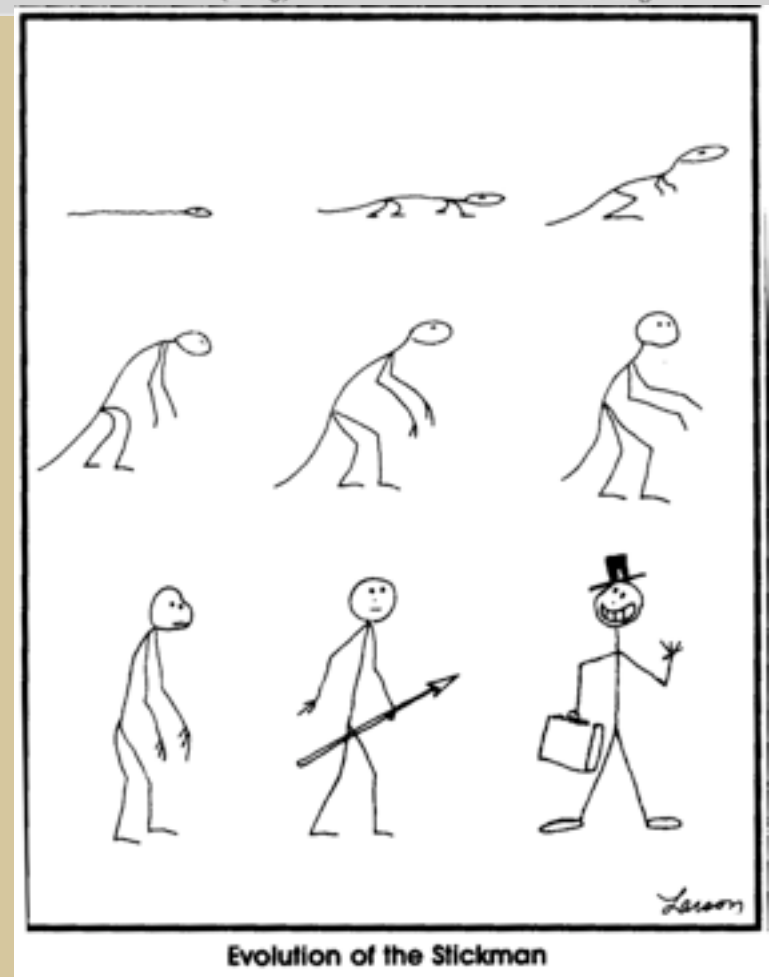
# Evolution means change through time



## Stars Evolve

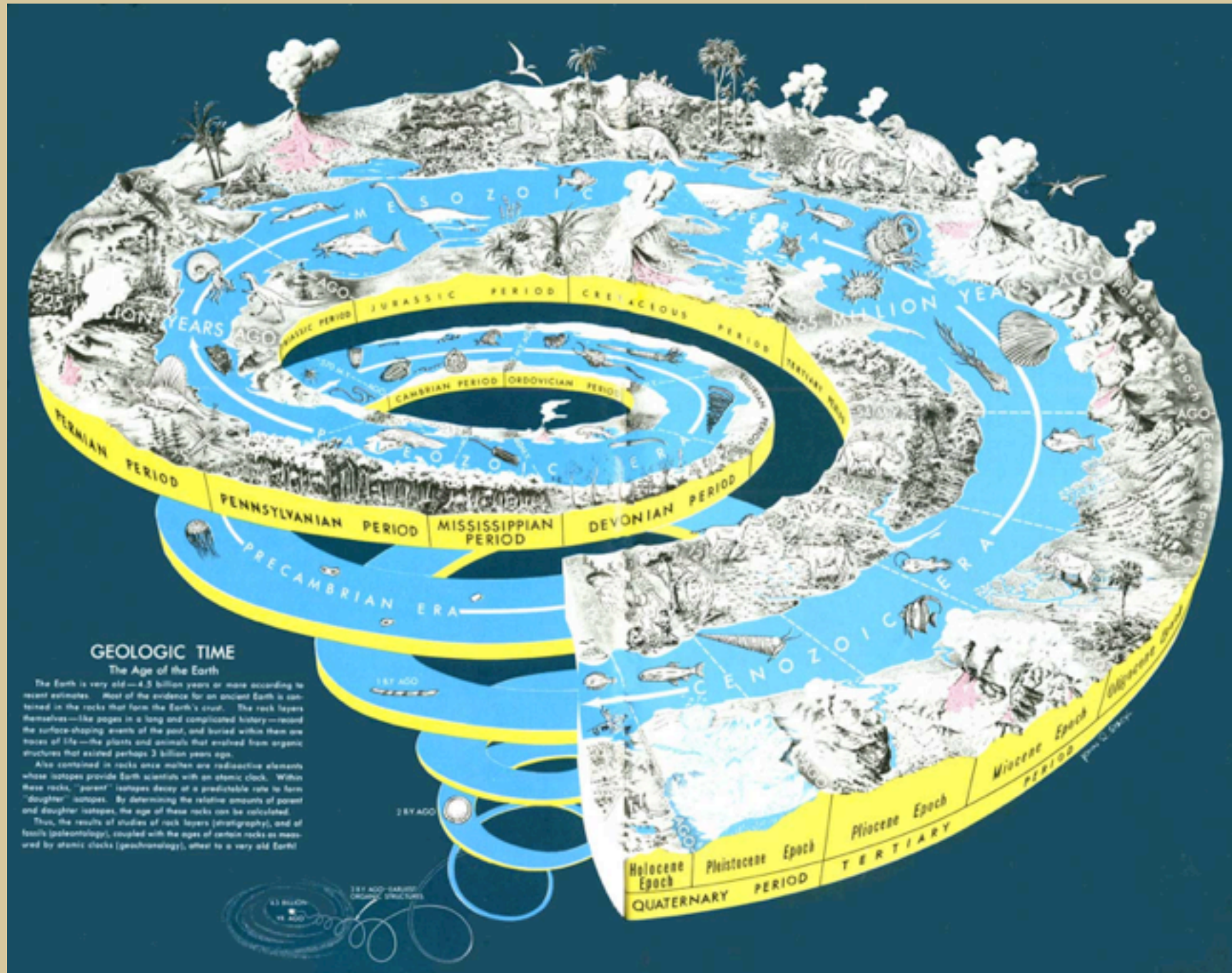


Greek helmets, the Pepsi logo,  
languages and  
the stickman have evolved





# Biological evolution refers to how life has changed through time





# U.S Attitudes About Evolution

No opinion/unsure

**6%**

Humans evolved

**16%**

God created humans pretty  
much in present form  
in the last 10,000 years

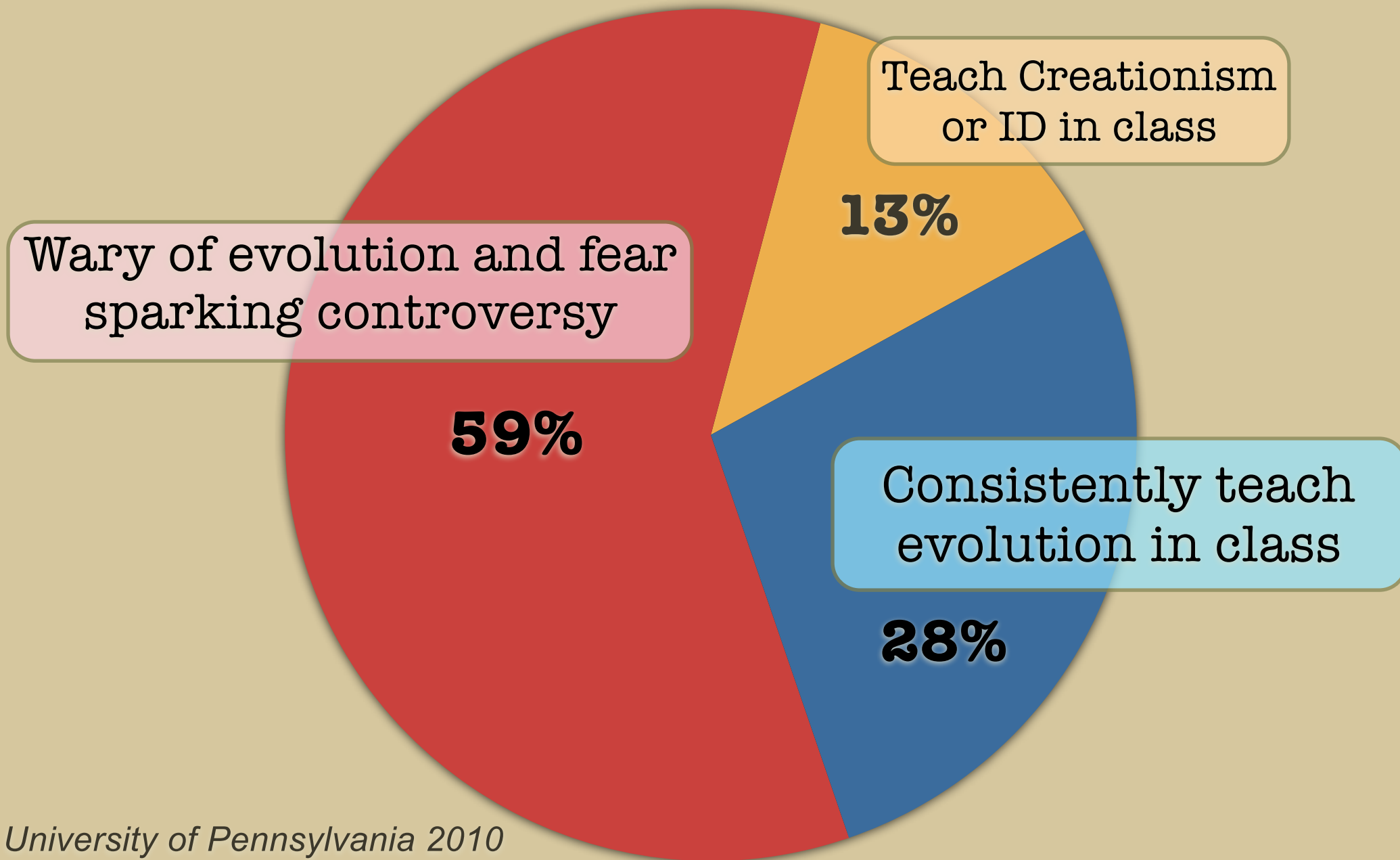
**40%**

Humans evolved  
with God guiding

**38%**

*Gallup 2010*

# U.S. High School Biology Teachers vs Teaching Evolution







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

*Natural philosophers just before Darwin  
thought Earth was old  
and life had changed through time*

James Hutton  
(1726-1797)

*Hutton found solid evidence  
of an ancient earth*

*Thought animals  
changed through time*



Erasmus Darwin  
(1731-1802)

*Grandfather of Charles Darwin*

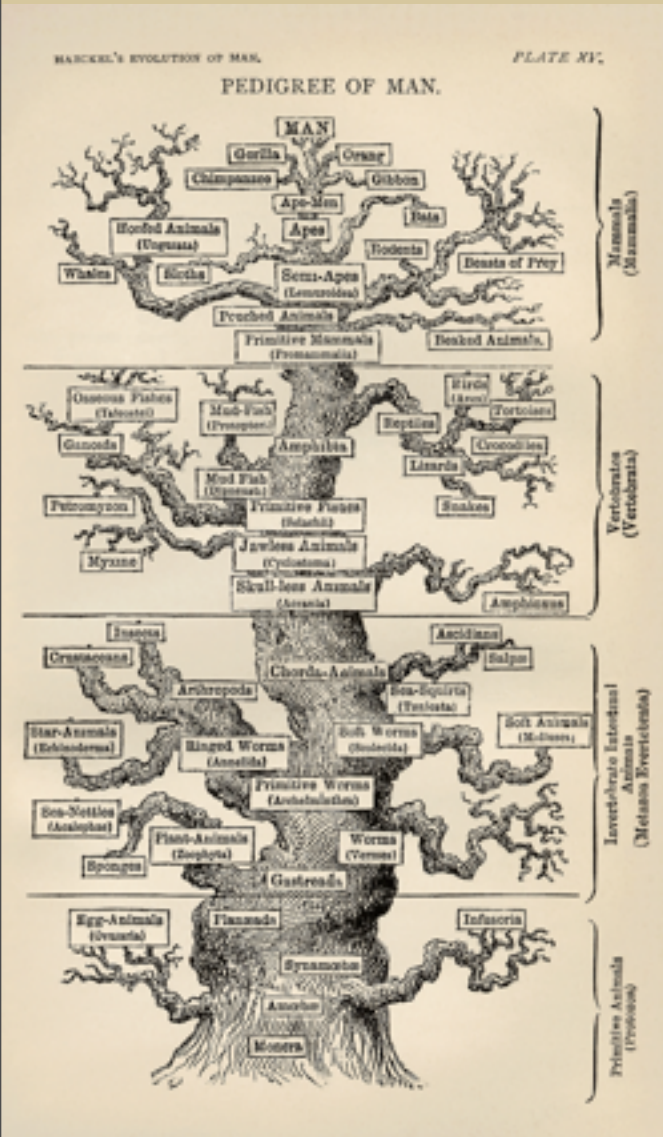
# Biological Evolution:



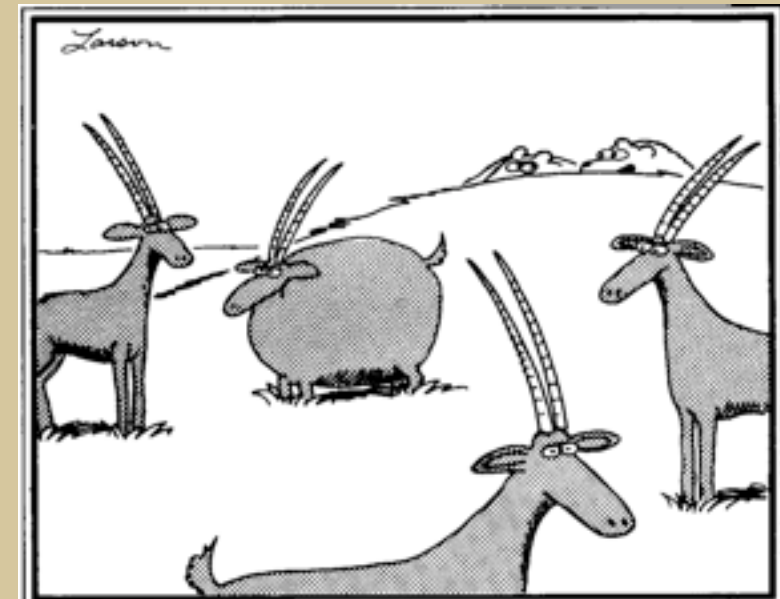
*Charles Darwin (and Alfred Russell Wallace) in 1858 first proposed a mechanism to explain how life evolved.*

All life on Earth is related by descent with modification from common ancestors.

*First of two main conclusions of evolution*



Modification through time takes place mostly through natural selection

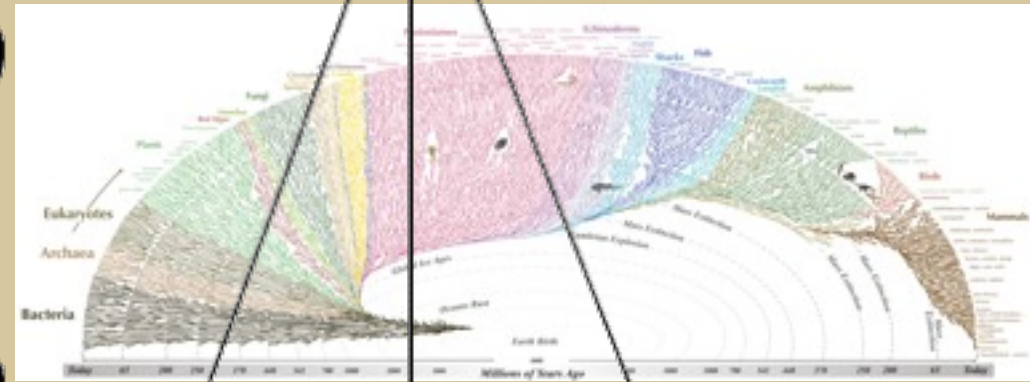


Dibs



# Life on Earth is One Big Extended Family

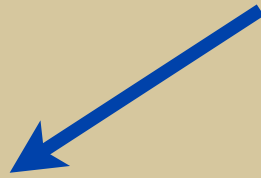
Earth is round, orbits  
the sun, and is  
billions of years old



*The common ancestry of life on Earth, is as well established as our knowledge that  
the Earth is round, orbits the Sun and is billions of years old.*



**Grandmother**



*Common ancestry can be expressed through a standard genealogy*



Mother



Brother



Sister





Grandmother

Brother



Sister



First cousins



Two generations to the common ancestor

Brother



Grandmother



Sister



First cousins



First cousin,  
once removed





Great grandmother

Brother

Sister

First cousins

Second cousins

G

G

G

Three generations to the  
common ancestor

Great great great great great great great great  
great great great great grandmother



Great great great great great great great great  
Great great great great great great great great  
Great great great great great great great great  
Great great great great great great great great  
Great great great great great great great great

Great great great great great great great great  
Great great great great great great great grandmother

Great great great great great great great grandmother

Great great great great great great grandmother

Great great great great great grandmother

Great great great great grandmother

Great great great grandmother

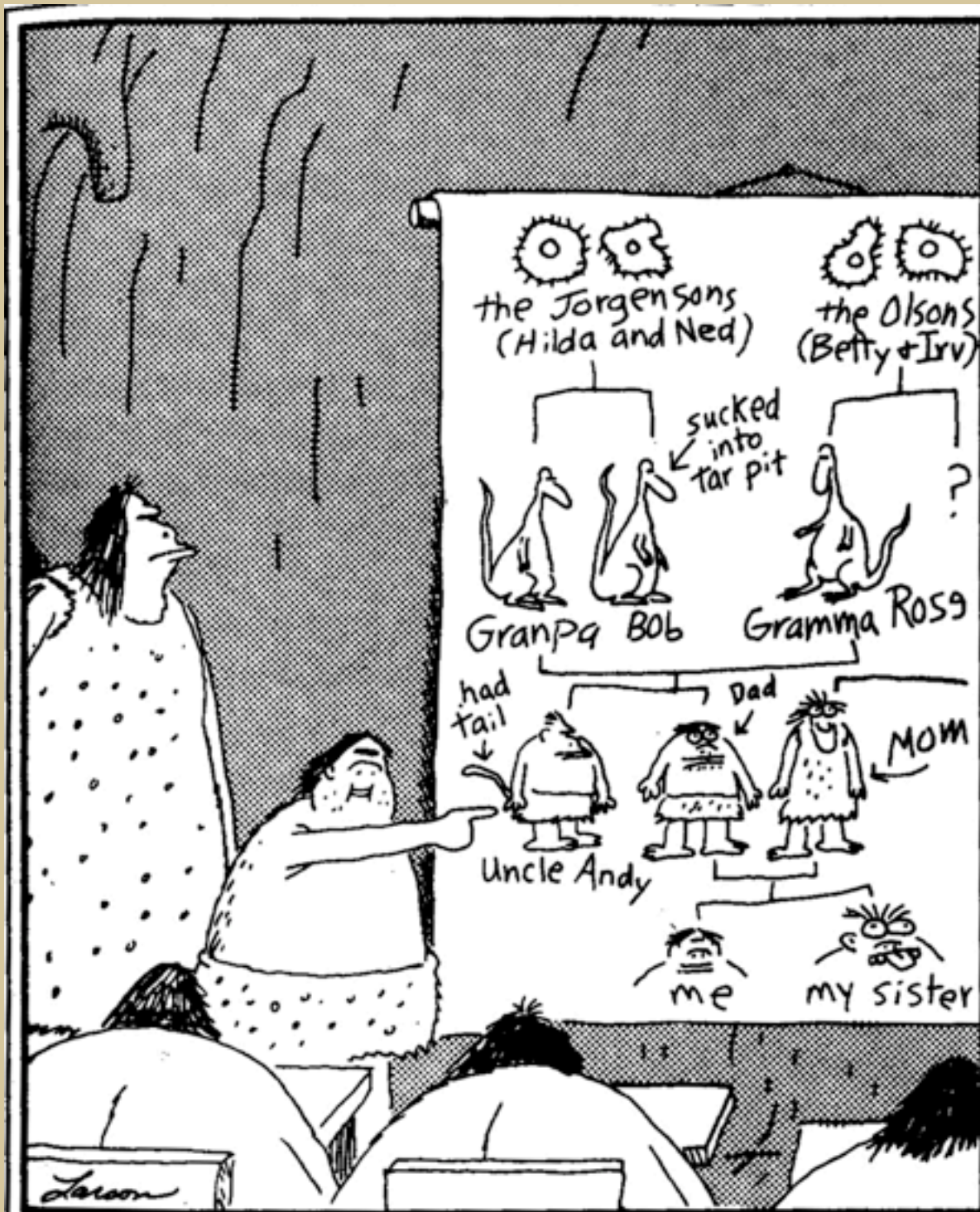
Great great grandmother

Great grandmother

Grandmother

*The human connection to all of life extends  
all the way back to the beginning of  
life on Earth*





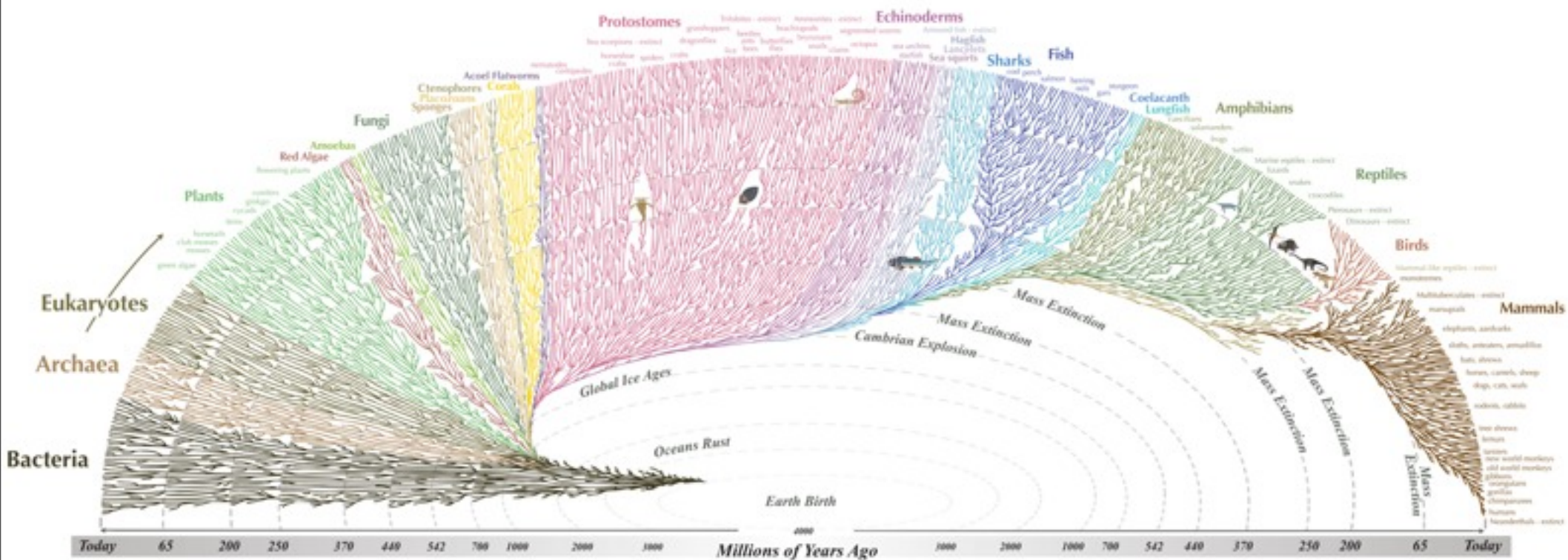
Dirk brings his family tree to class.

*In reality, many billions of generations,  
and mote than 3 billion years  
separate early life on Earth  
from modern humans*

*Garry Larson 1994*



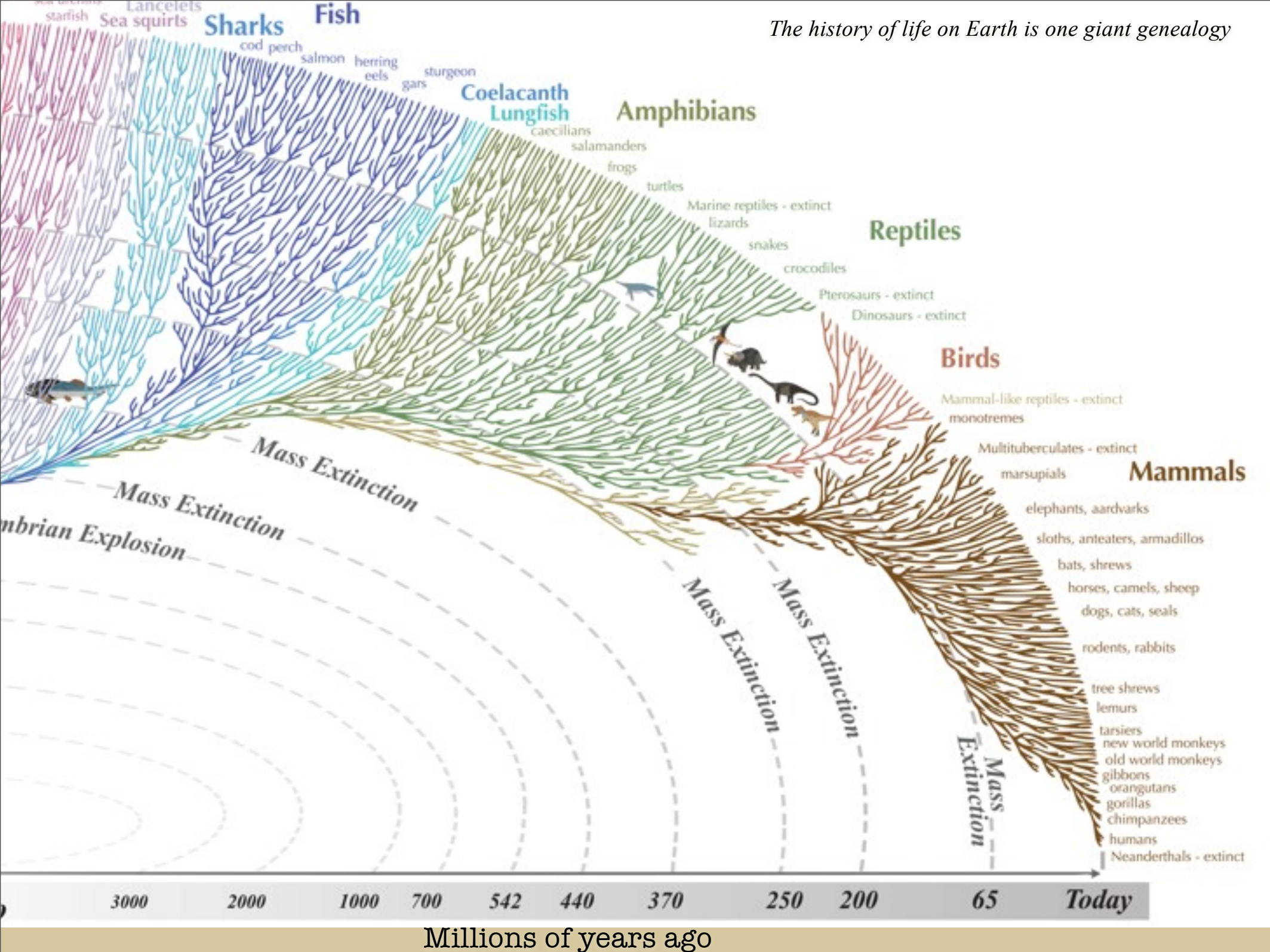
# Evolution



The Tree of Life is a family genealogy

All life on Earth is related by common ancestry,  
not only with every other living thing,  
but with every thing that has ever lived.

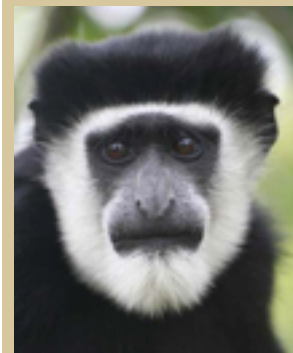
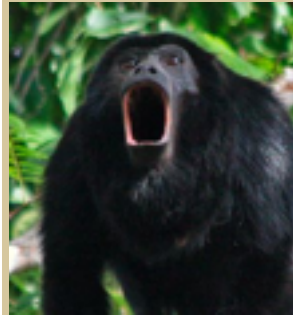
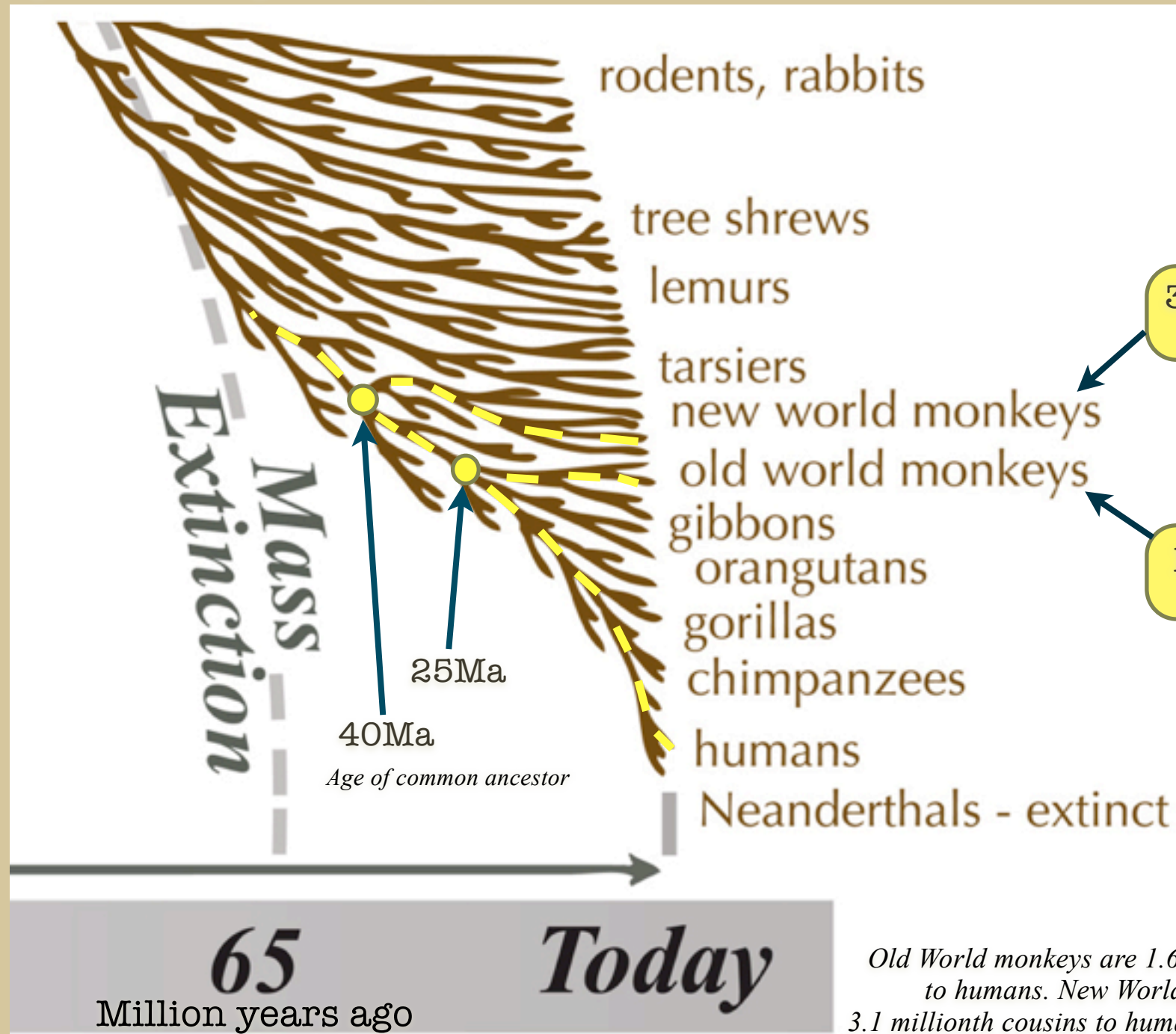
*The history of life on Earth is one giant genealogy*





All life on Earth is related by descent with modification from common ancestors.  
All living things are cousins.

*Count generations along both lines of descent to a common ancestor to reveal the cousin relationship*

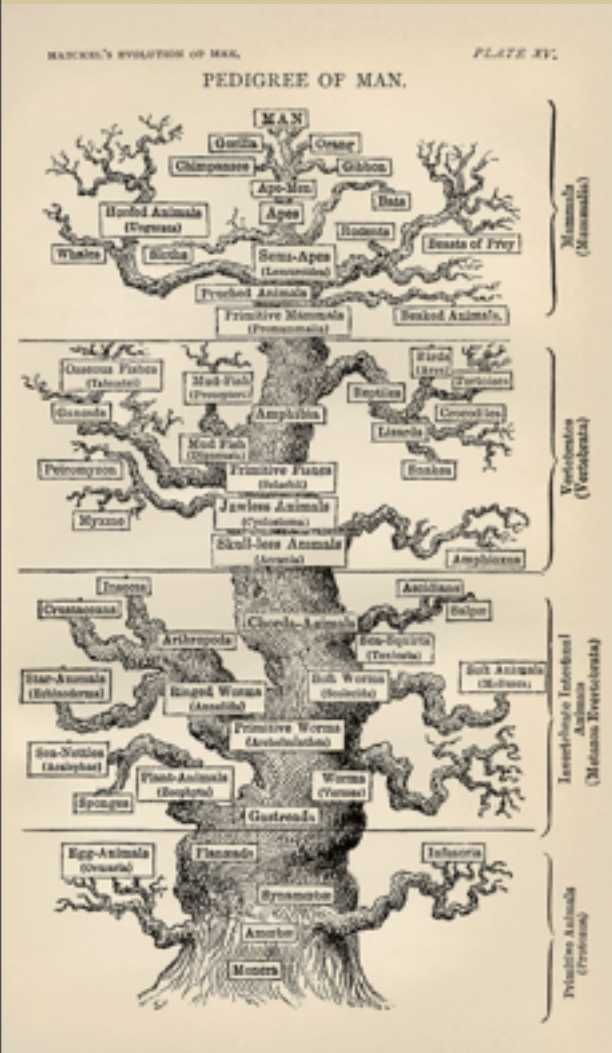




# Biological Evolution:

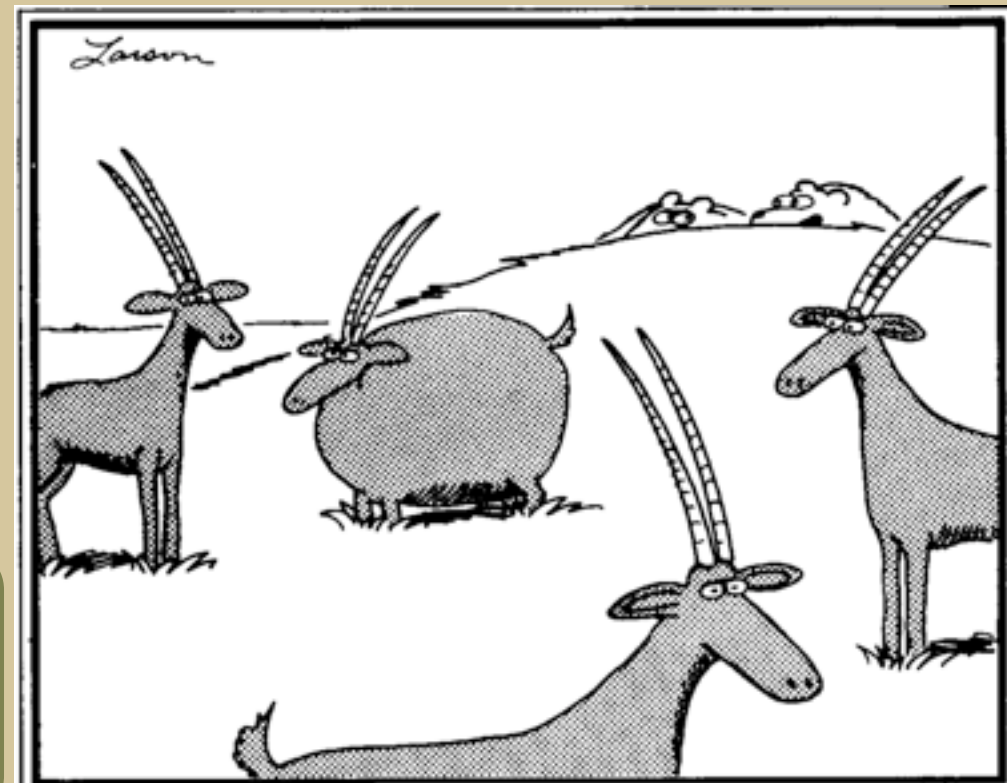


All life on Earth is related by descent with modification from common ancestors.



Modification through time takes place mostly through natural selection

*Second of two main conclusions of evolution*



Dibs

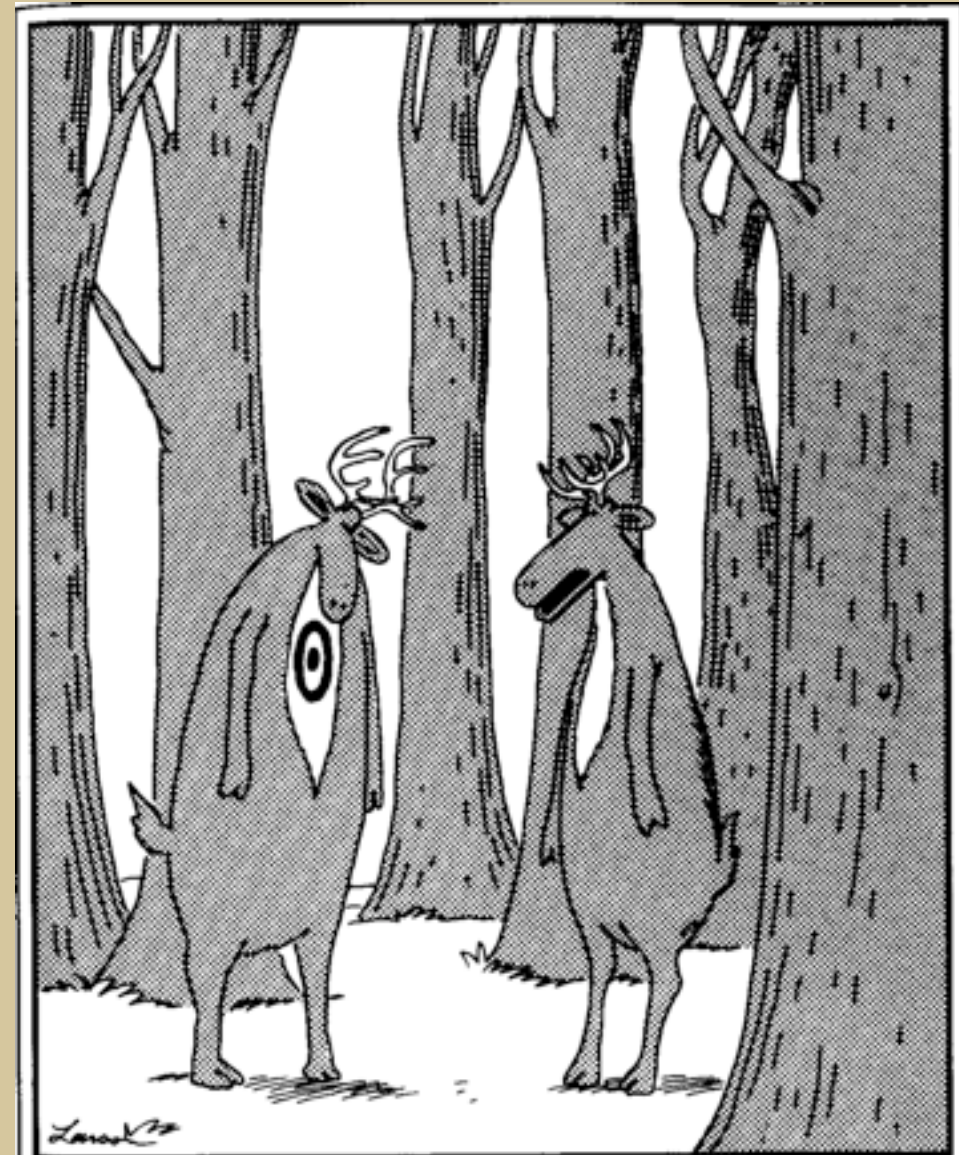
# Natural Selection

Characteristics vary within a population



Embarrassing moments at gene parties

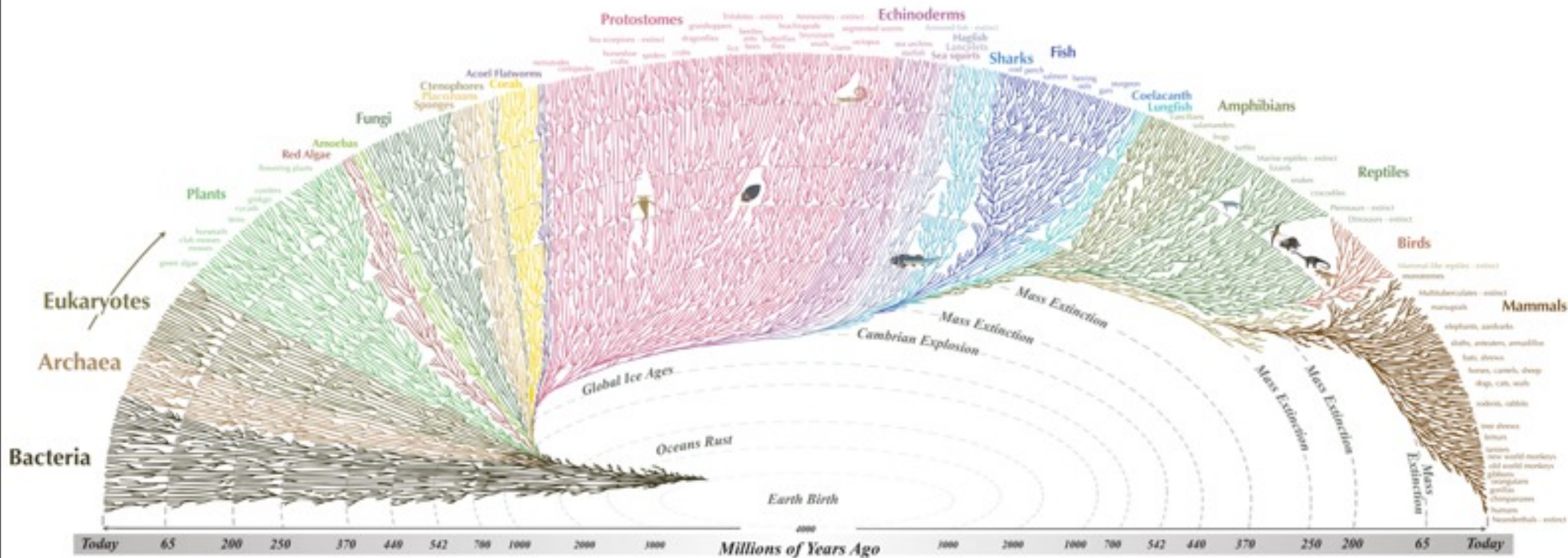
Variations that improve reproductive success increase in the population



"Bummer of a birthmark, Hal."



# Evolution



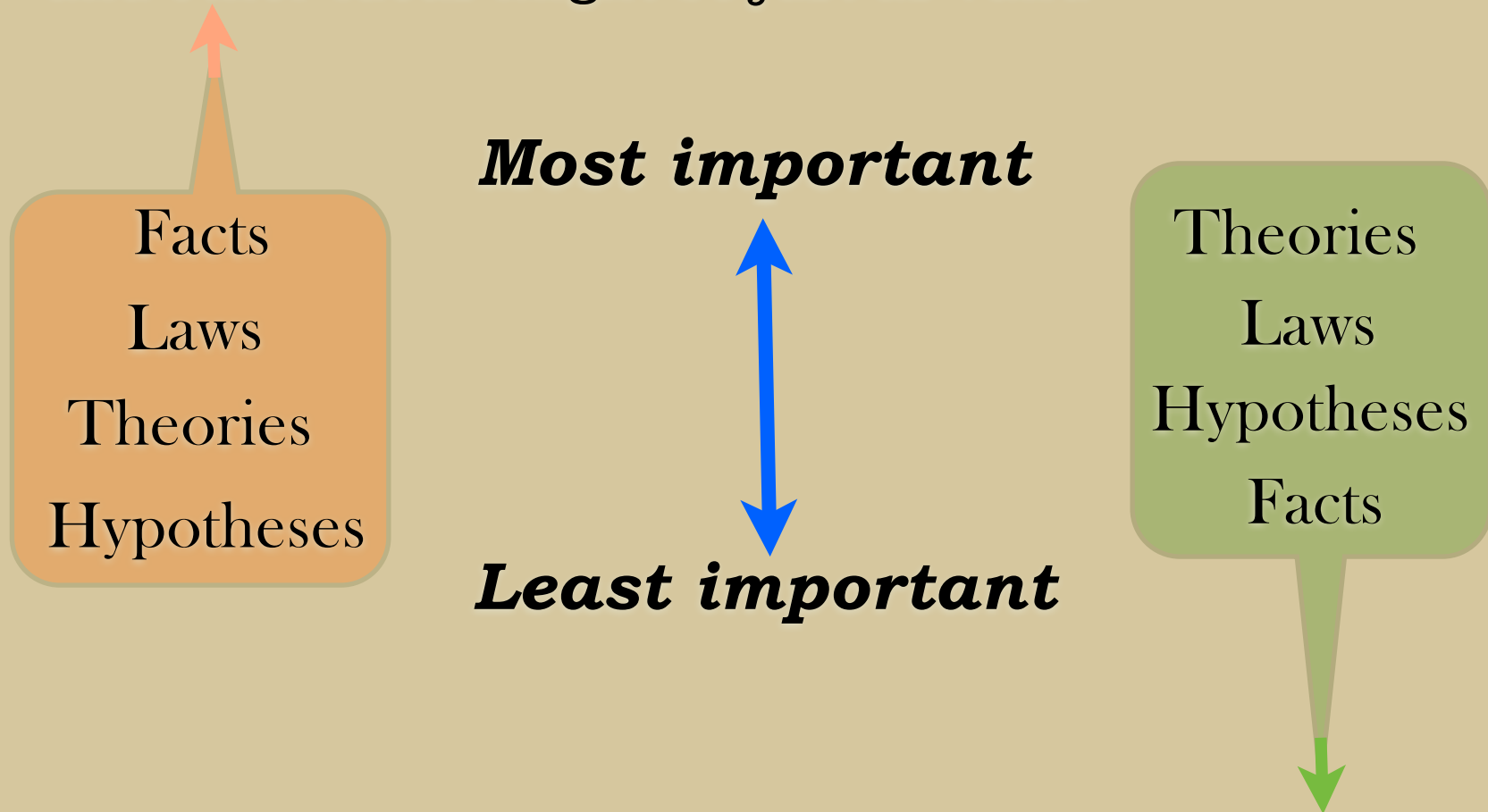
★ All life on Earth is related by descent with modification from common ancestors.

★ Modification through time takes place mostly through natural selection



# “Evolution is just a theory”

**Everyday usage** of ‘theory’ = guess or hunch,  
and other ideas might be just as valid



**Scientific usage** of ‘theory’ is very different =  
well-substantiated explanation of a set of facts and laws in  
the natural world

# “Acceptance of evolution is incompatible with religious belief”



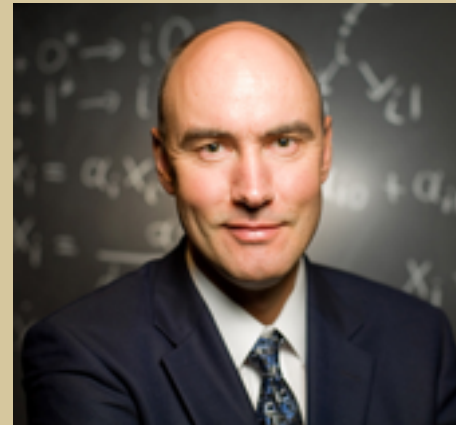
Francis Collins  
Professor Internal Medicine  
and Human Genetics  
Director; Human Genome Project  
Director; National Institutes of Health

Ken Miller  
Biology Professor  
Brown University



*Many prominent defenders of evolution  
have strong religious faith*

Karl Giberson  
Physics Professor  
Eastern Nazarene College



Martin Nowak  
Director, Program for  
Evolutionary Dynamics  
Harvard University



Currently, I see ... fierce debate raging between so-called “creationism” and evolutionism, presented as though they were mutually exclusive alternatives: .... This antithesis is absurd because, ..., there are so many scientific proofs in favor of evolution which appears to be a reality we can see and which enriches our knowledge of life ...

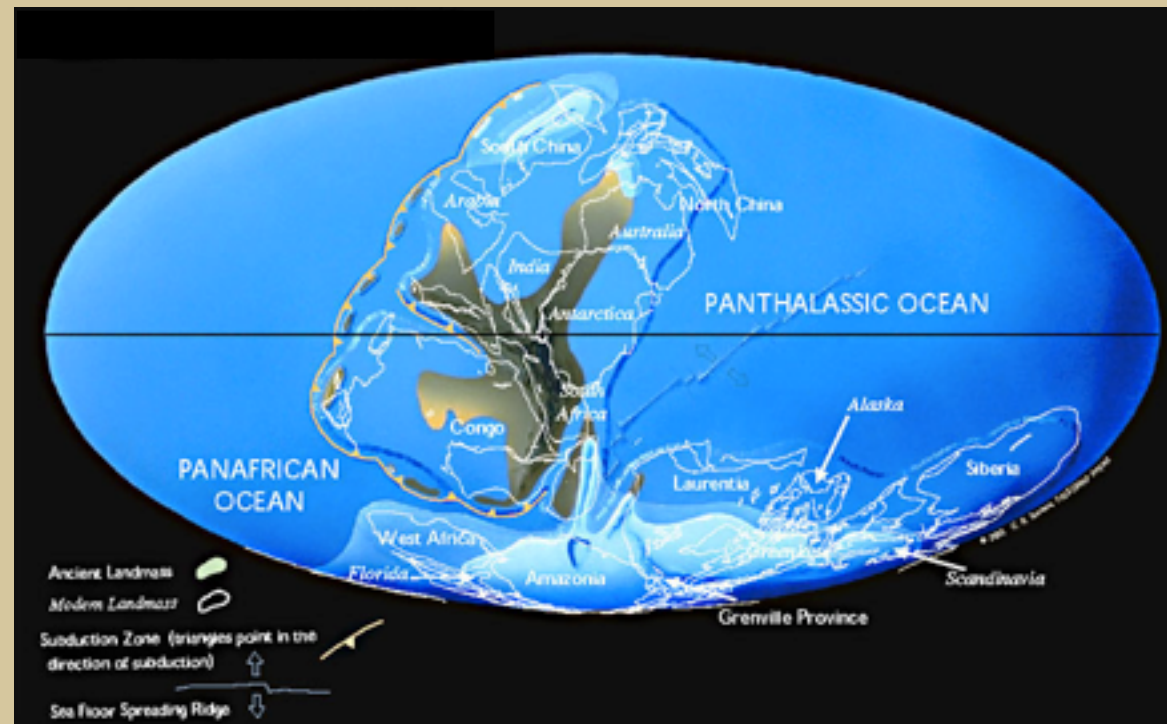
Pope Benedict XVI, 2007

“Evolution claims life came from mud all by itself”

“There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that...from so simple a beginning, endless forms most beautiful and most wonderful have been, and are being, evolved.”

Charles Darwin, *On the Origin of Species* 1859

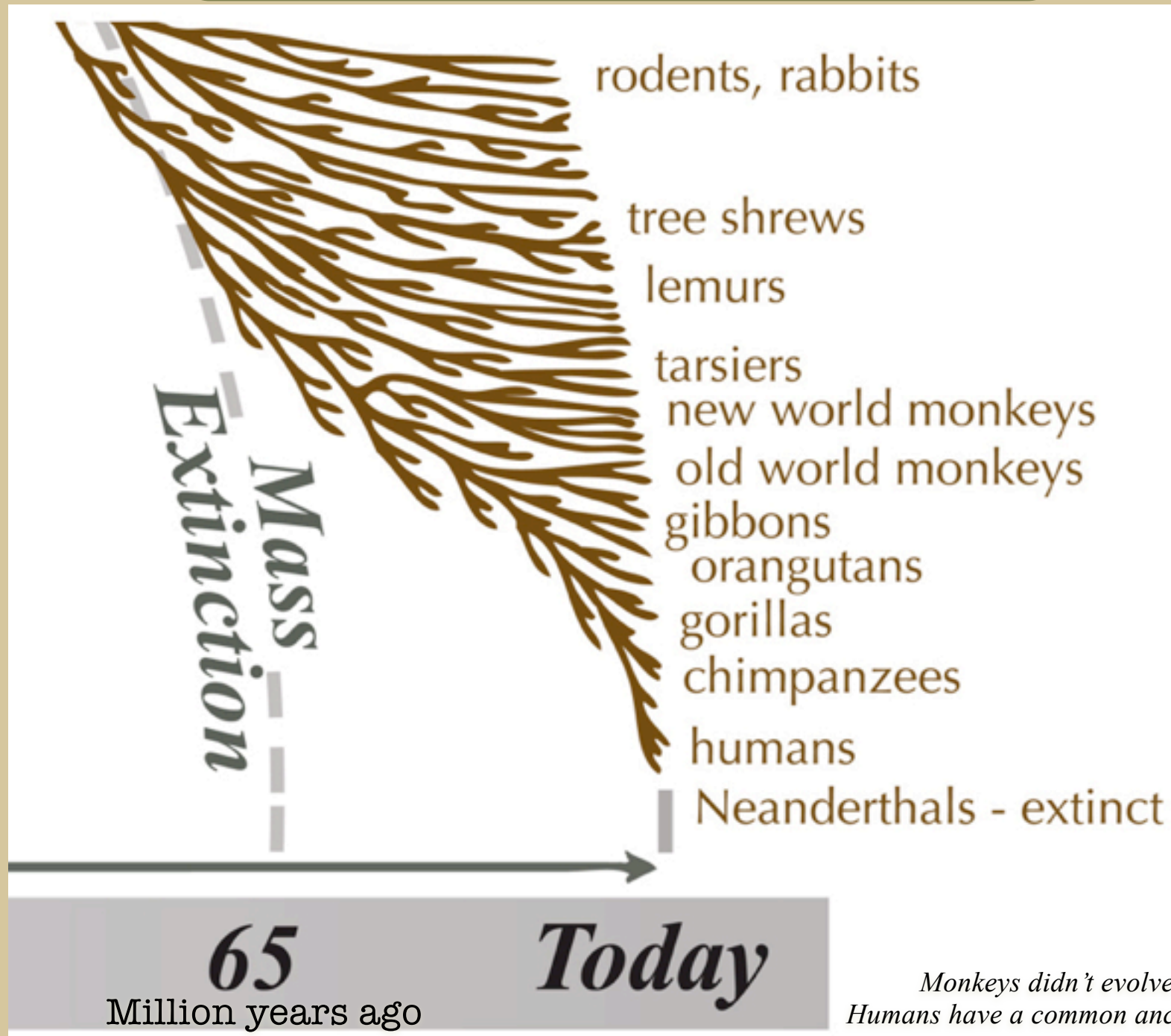
*Earth about 650 million years ago*



The theory of evolution says nothing about how life first began on Earth



“If people come from monkeys,  
why are there still monkeys?”



# “Humans and dinosaurs lived together before the Flood”

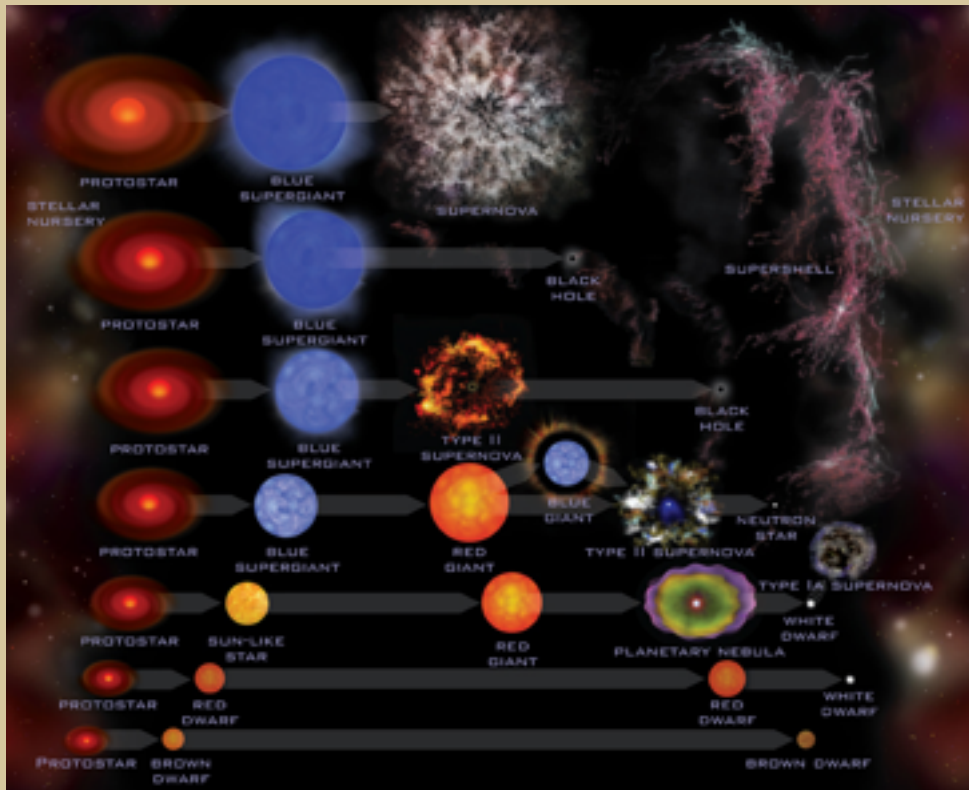


“What a find, Williams! The fossilized footprint of a brachiosaurus! . . . And a Homo habilis thrown in to boot!”

*Dinosaurs went extinct 65 million years before modern humans evolved.  
The geologic theory of ancient earth is the foundation for mining and oil exploration.*

*Multiple, independent lines of evidence confirm Earth is about 4.6 billion years old, life began more than 3.5 billion years ago, life moved onto land from the sea more than 400 million years ago, dinosaurs and mammals evolved about 230 million years ago, and modern humans evolved about 200,000 years ago.*

“We’ve never seen a new species evolve, therefore evolution can’t be true”



Stars and Language evolve

Biological evolution uses the same  
historical methods



“Evolution doesn’t make accurate predictions”

Biological evolution has made numerous accurate predictions!!

PreCambrian fossils

Transitional fossils

Mechanism for mutation  
and inheritance

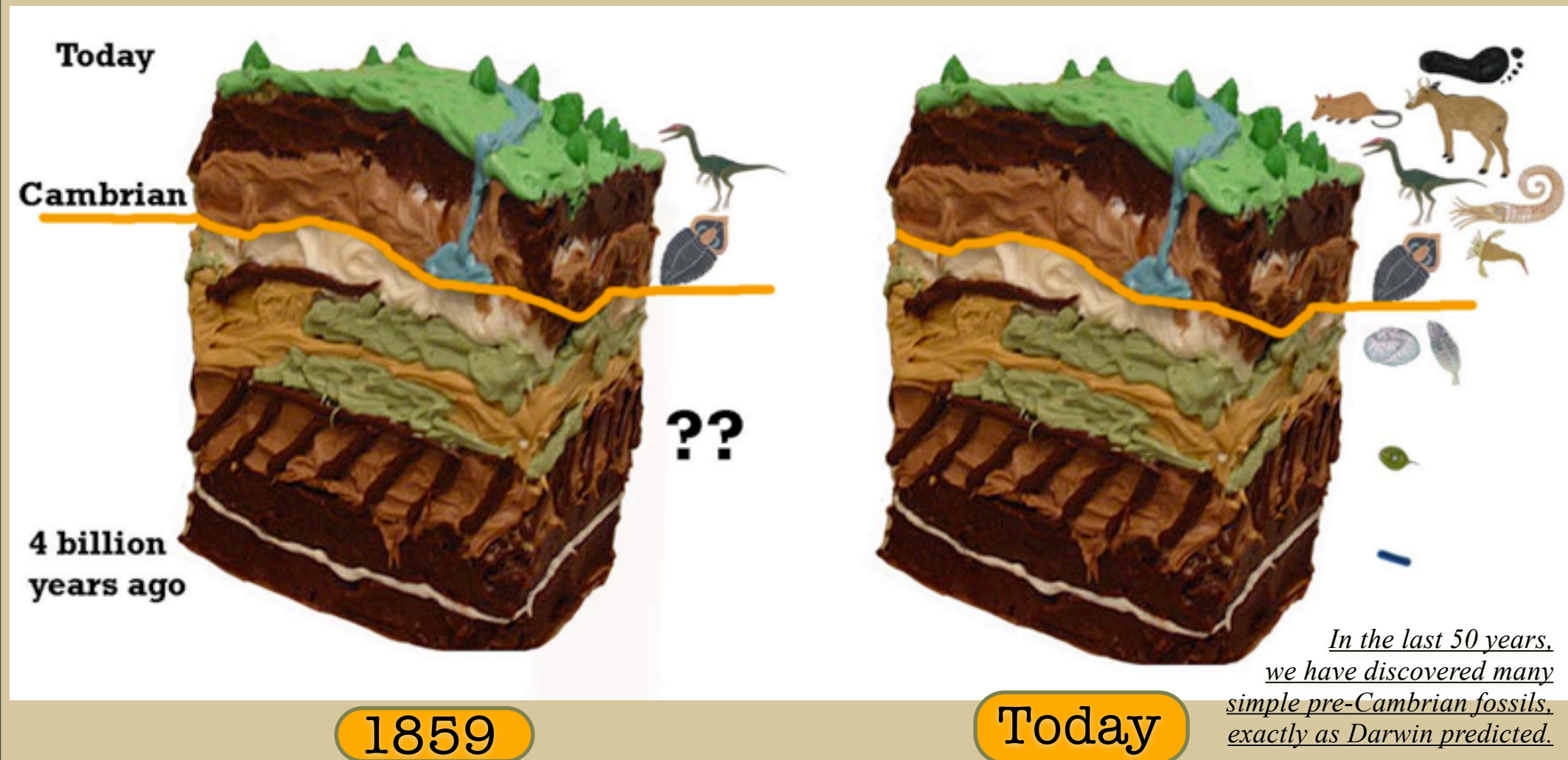
Geographical distribution  
of species

Evolution vs  
Gravitational theory



*“...if my theory be true, it is indisputable that before the the lowest Silurian (Cambrian) stratum was deposited, long periods elapsed,...and during these vast, yet quite unknown, periods of time, the world swarmed with living creatures. To the question why we do not find records of these vast primordial periods, I can give no satisfactory answer.”*

*On the Origin of Species, 1859*





“Evolution doesn’t make accurate predictions”

Biological evolution has made numerous accurate predictions!!

PreCambrian fossils

Transitional fossils

Mechanism for mutation  
and inheritance

Geographical distribution  
of species

Evolution vs  
Gravitational theory







*Ichthyostega*



*Acanthostega*



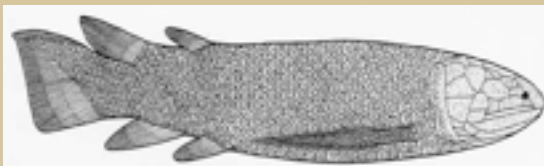
*Tiktaalik*



*Panderichthys*

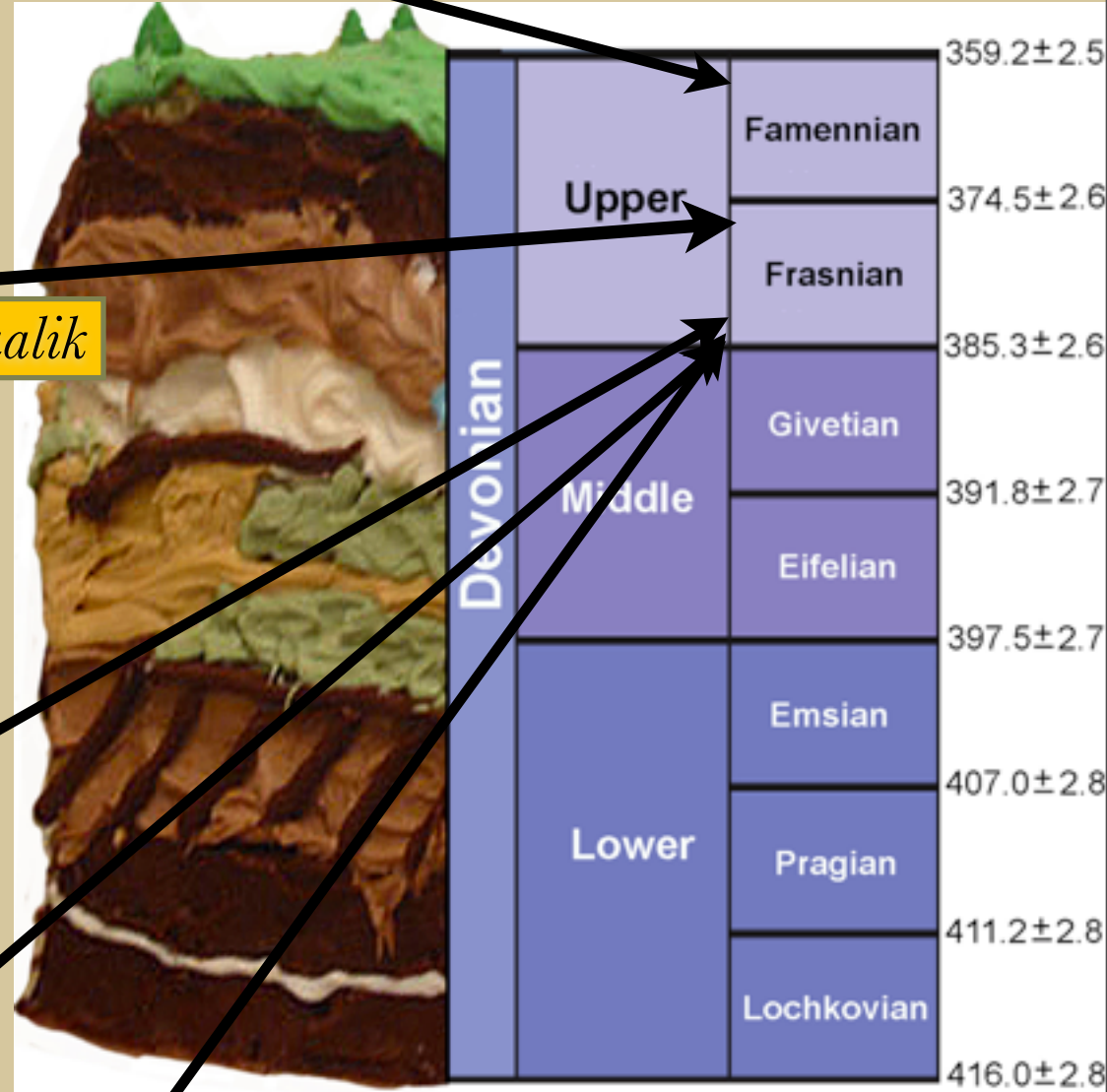


*Eusthenopteron*

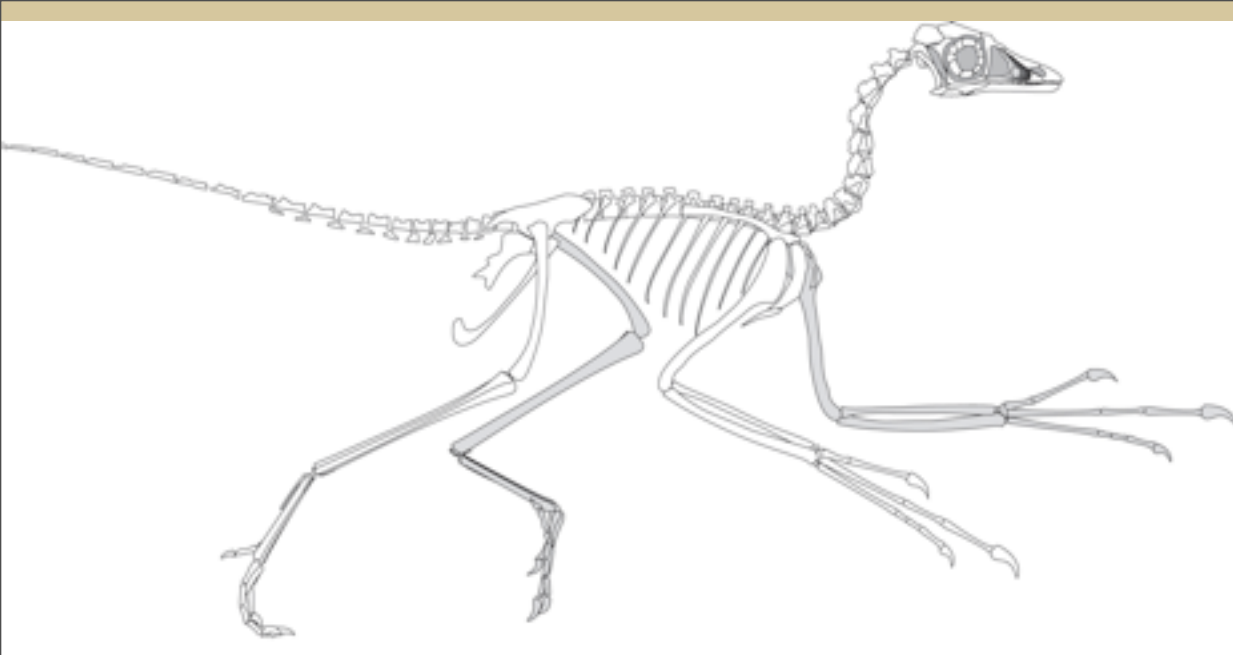


*Glyptolepis*

A transitional form between fish and amphibians was predicted to have lived about 375 million years ago. In 2004 fossils of exactly this age and this sort of animal were found in northern Canada, on Baffin Island.



*The transition of one branch of dinosaurs to birds is one of the best documented cases in evolution*

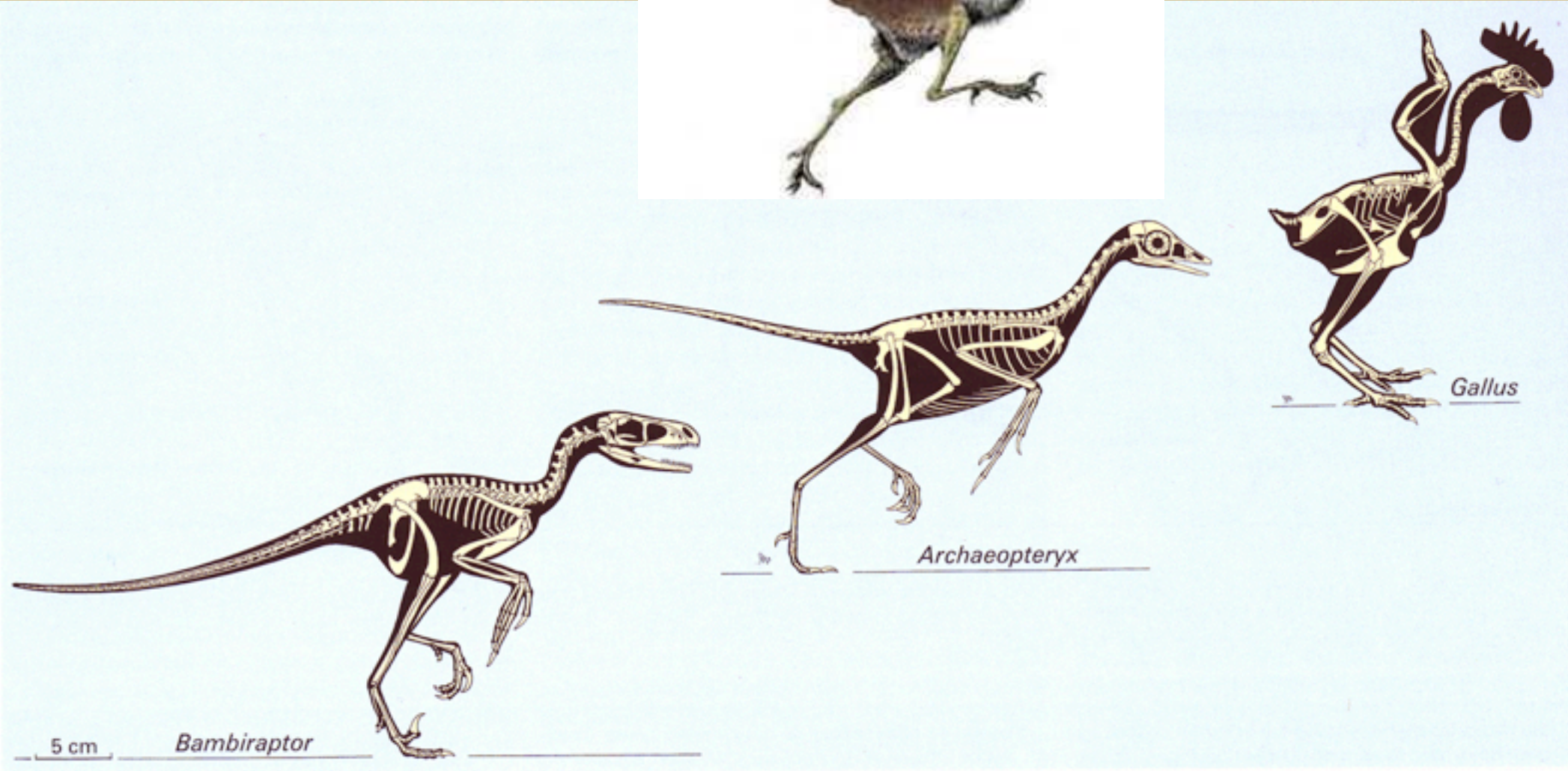


*Archaeopteryx lithographica*



*Archaeopteryx is a prime example of a transitional fossil, having characteristics of both a bird and dinosaur*

Older —————> Younger

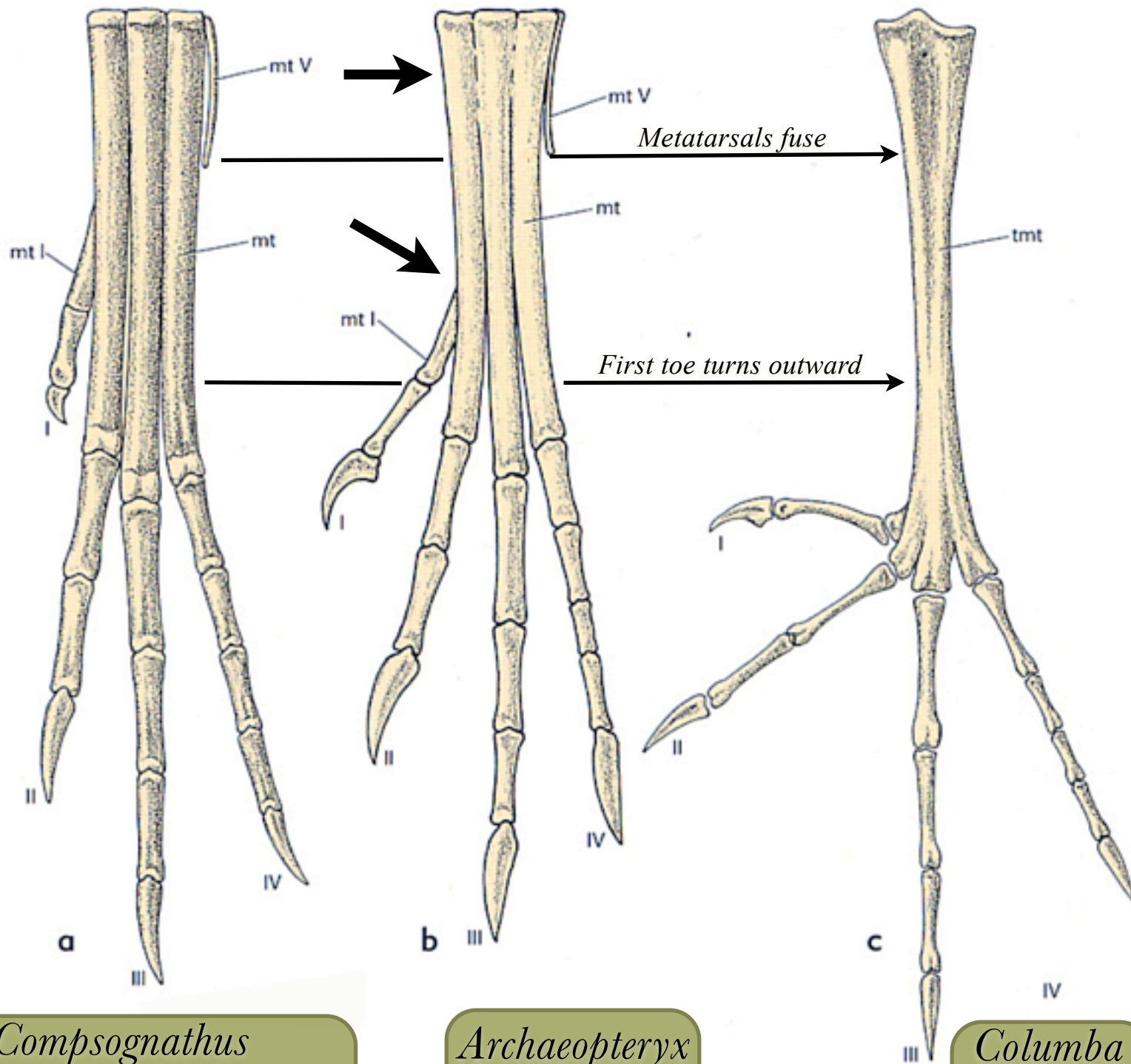


Theropod dinosaur —————> Urvogel —————> Modern Bird

*Urvogel is German for early bird*

*The next several slides show the transition of dinosaur to bird features, as recorded in the fossil record.*





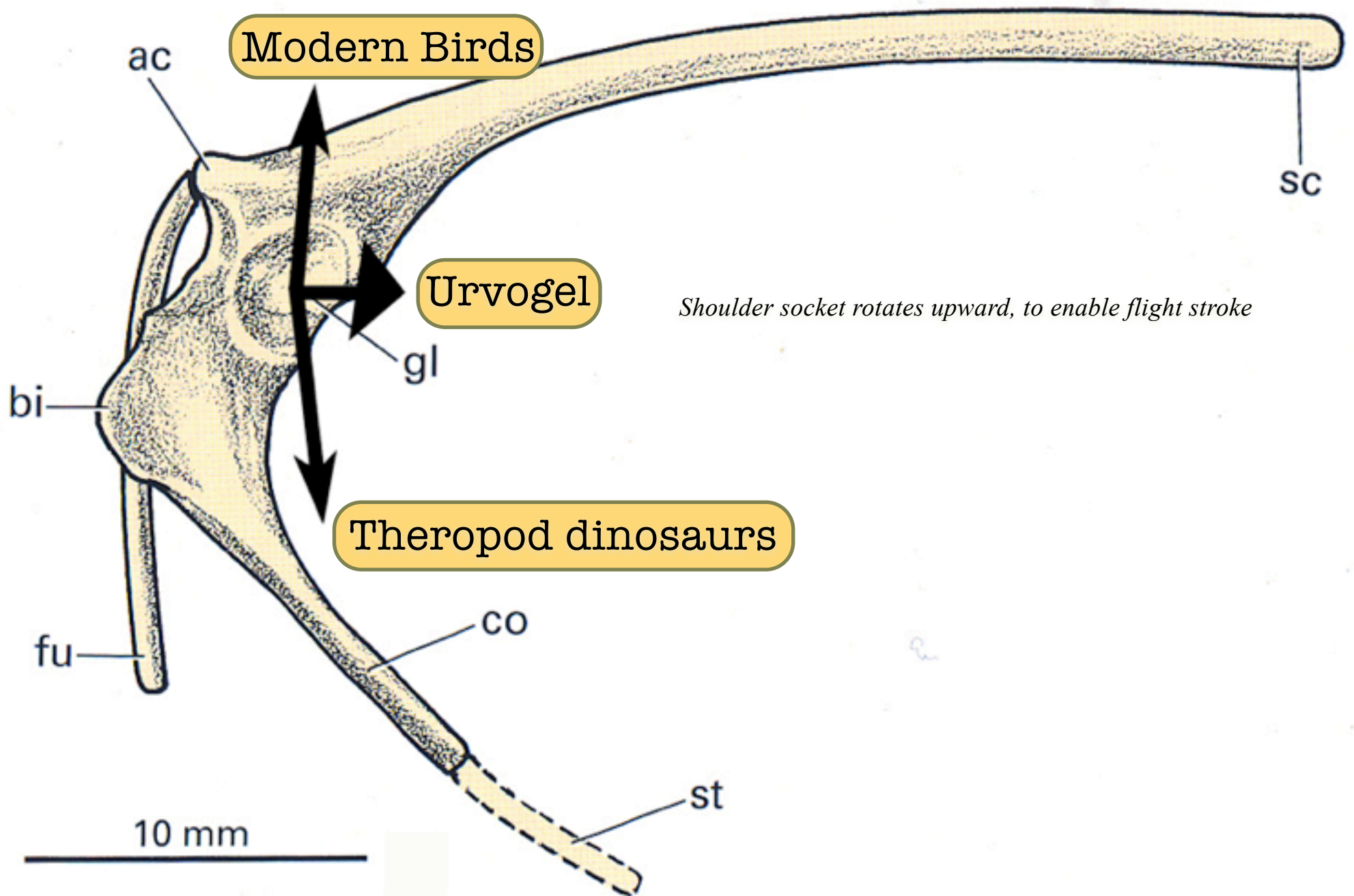
Older

*Compsognathus*  
Theropod dinosaur

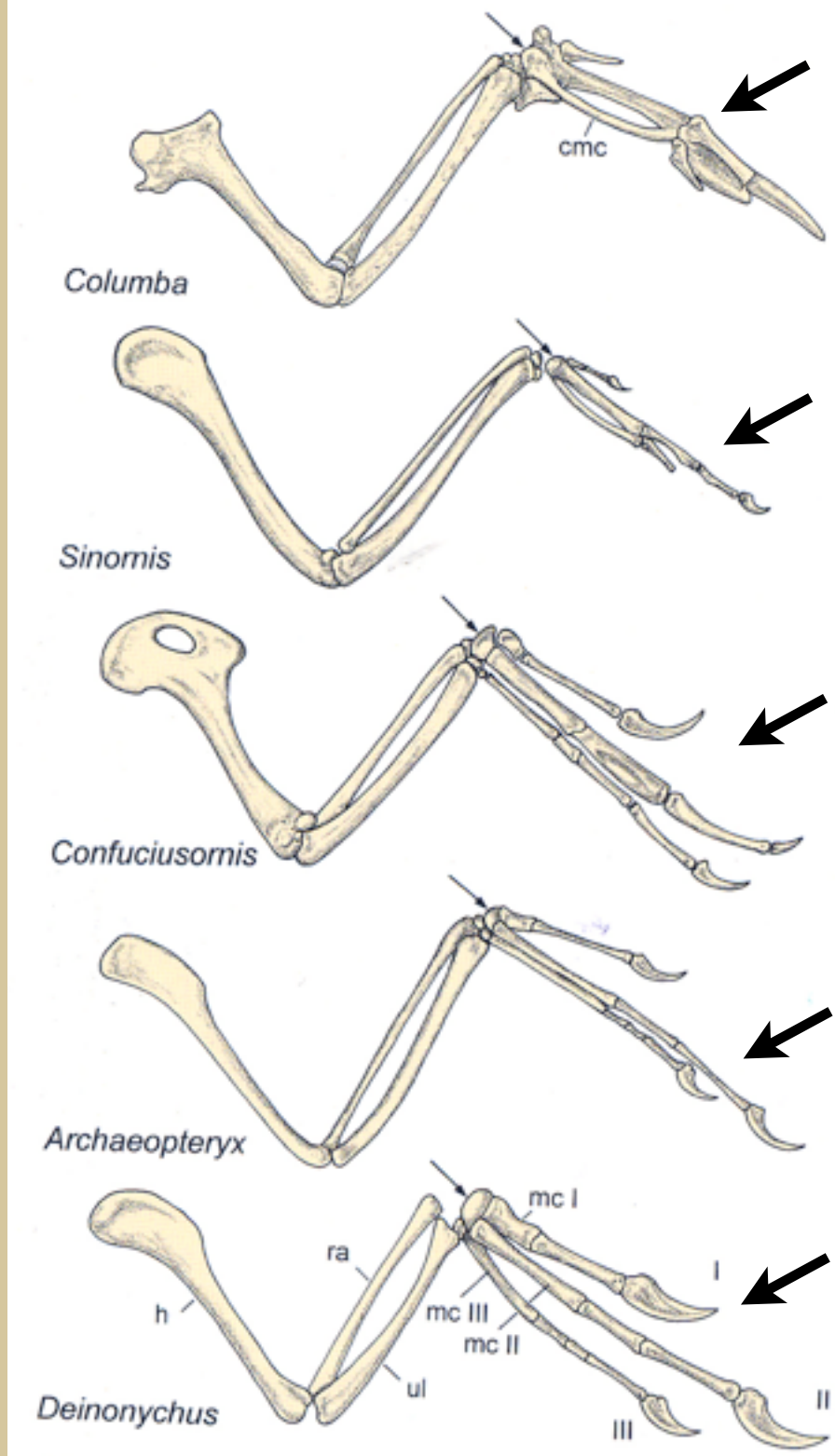
*Archaeopteryx*  
Urvogel

*Columba*  
Dove

Younger







Modern Bird

More Modern Bird

Early Bird

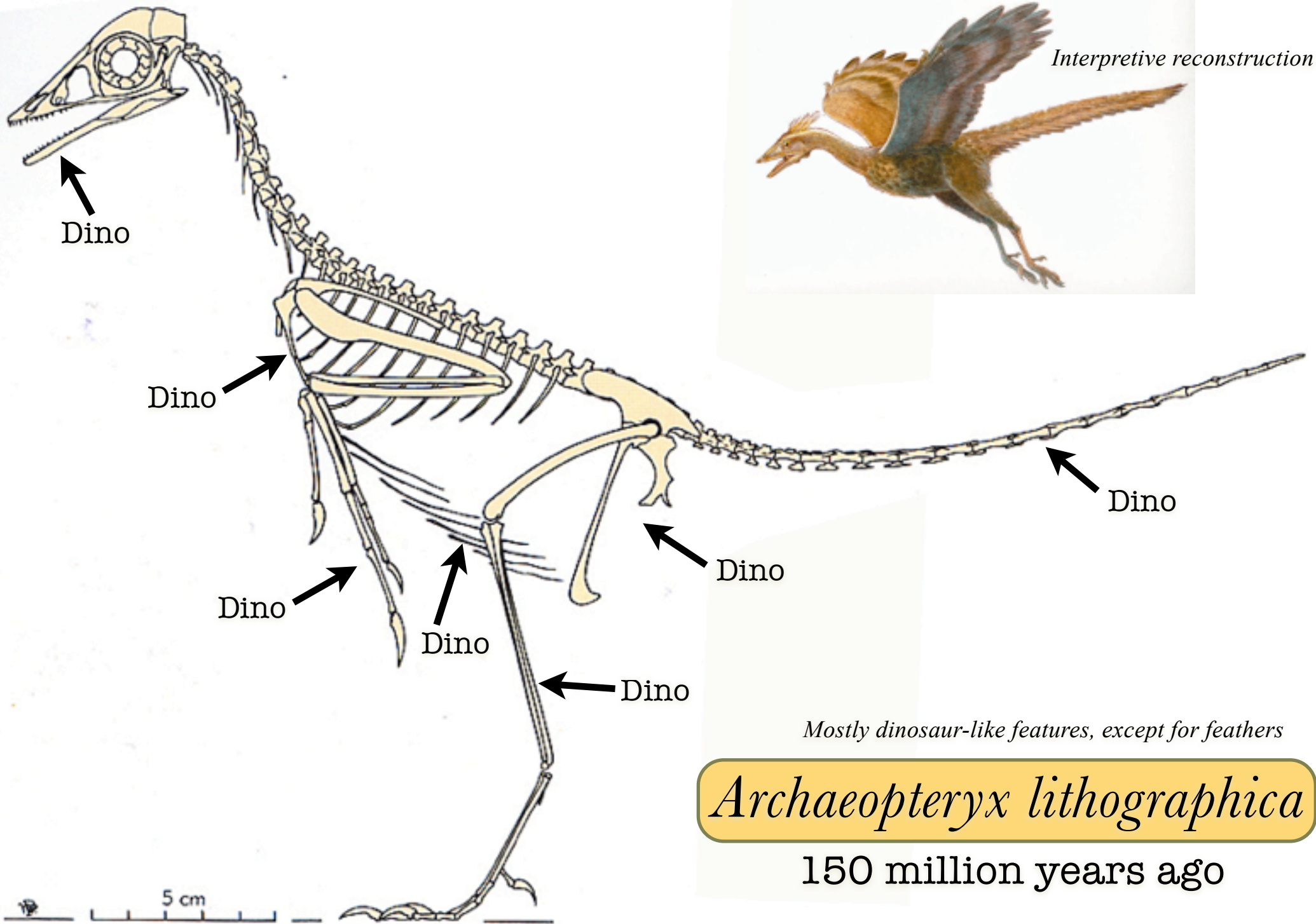
Urvogel

Theropod dinosaur

Younger

*Fingers fuse*

Older



*Interpretive reconstruction*

Dino

Dino

Dino

Dino

Dino

Dino

*Mostly dinosaur-like features, except for feathers*

*Archaeopteryx lithographica*

150 million years ago

5 cm



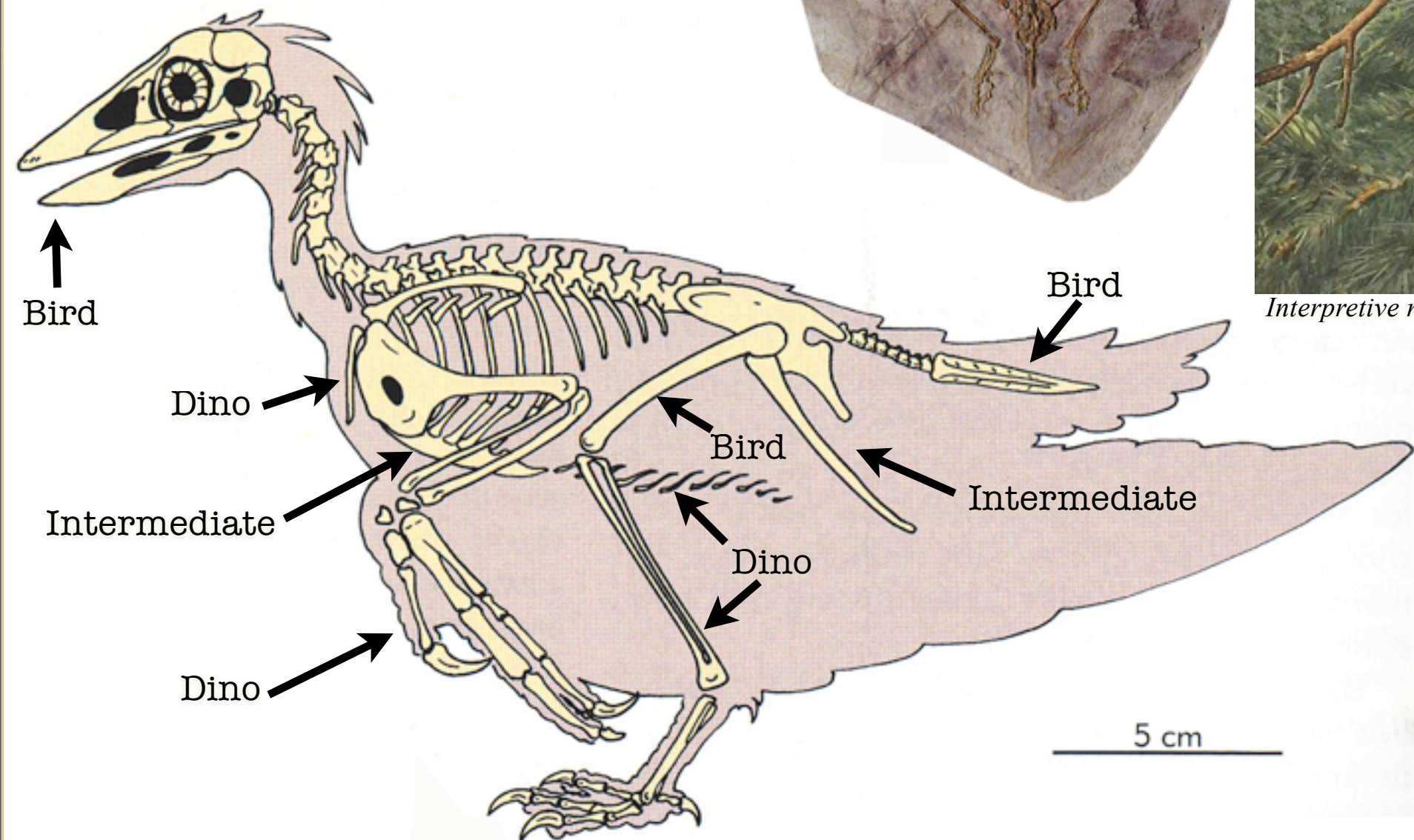
# Confuciusornis

125 Million years ago

Mix of dinosaur and bird features



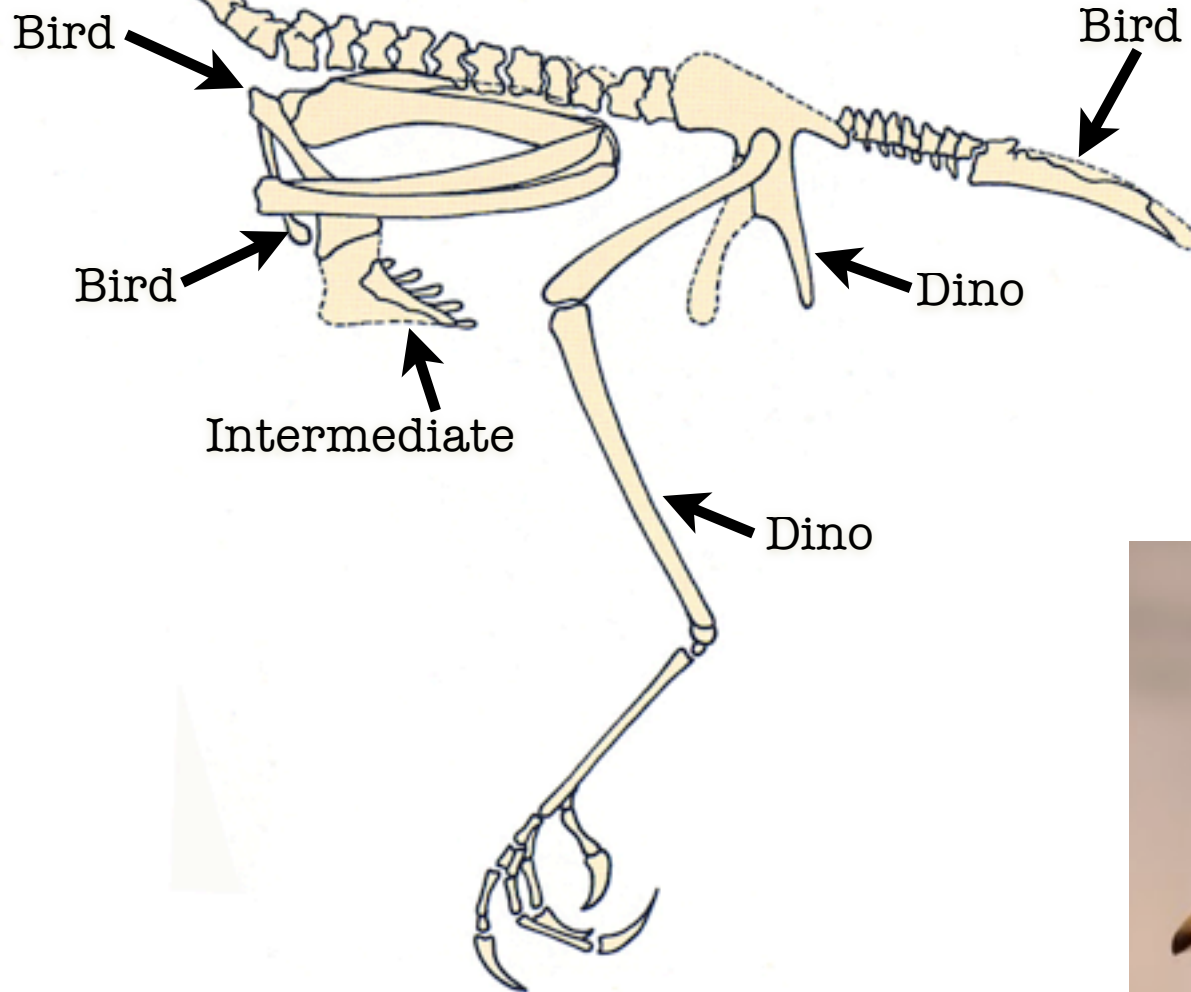
Interpretive reconstruction



## *Iberomesornis*

125 million years ago

*Mix of dinosaur and bird features*



*Interpretive reconstruction*

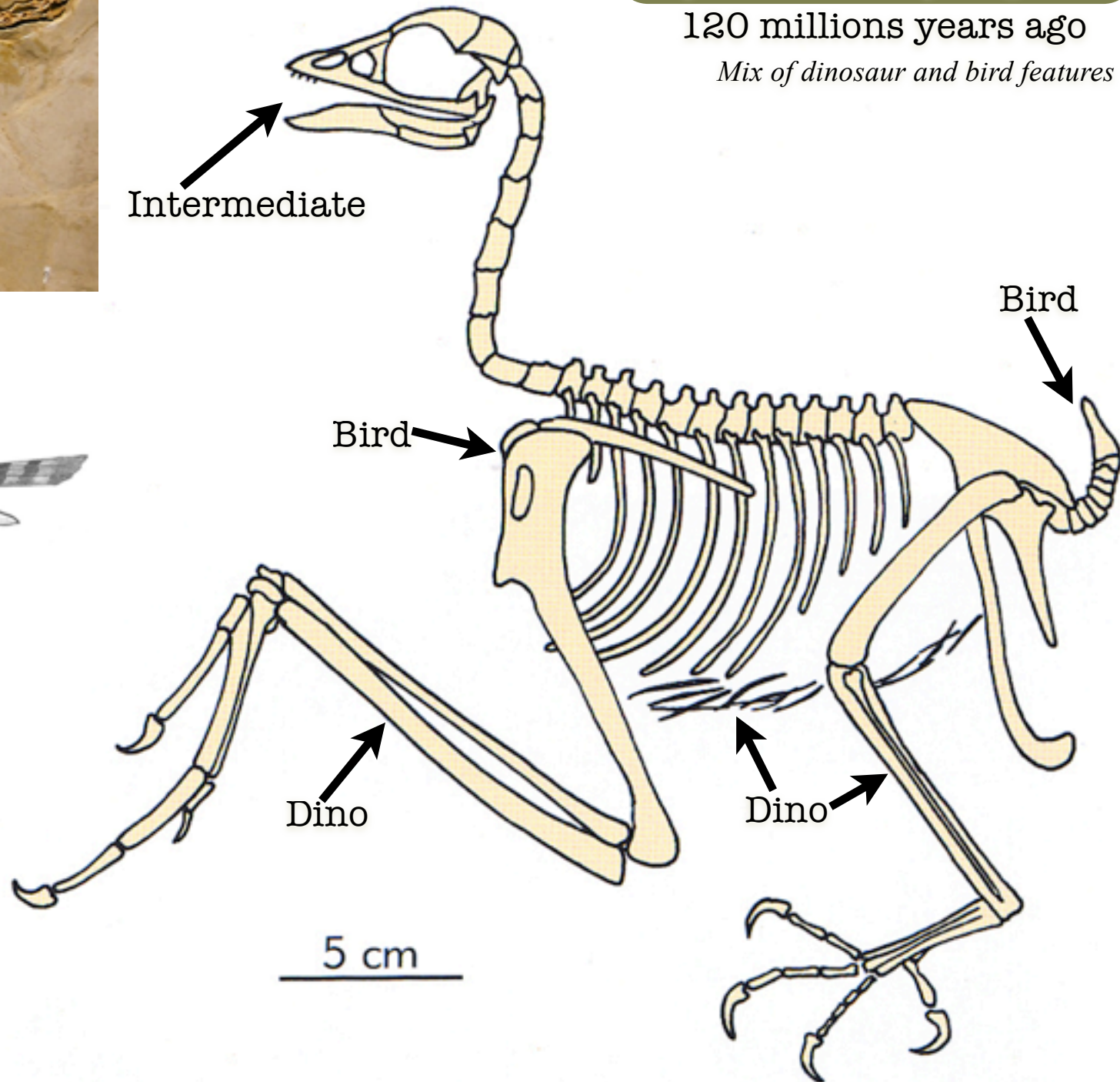


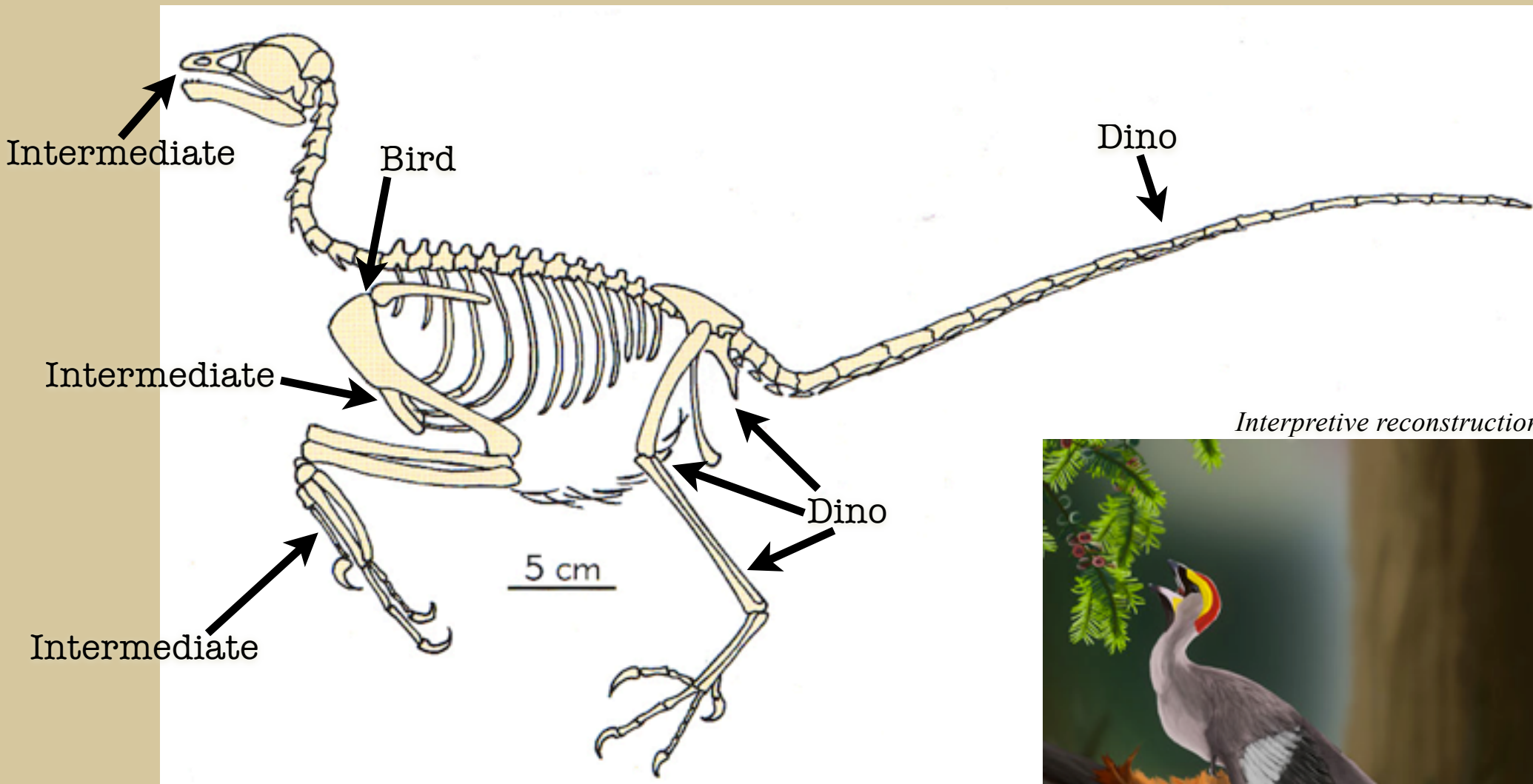


# *Sapeornis chaoyangensis*

120 millions years ago

*Mix of dinosaur and bird features*





*Interpretive reconstruction*



*Jeholornis prima*

120 million years ago

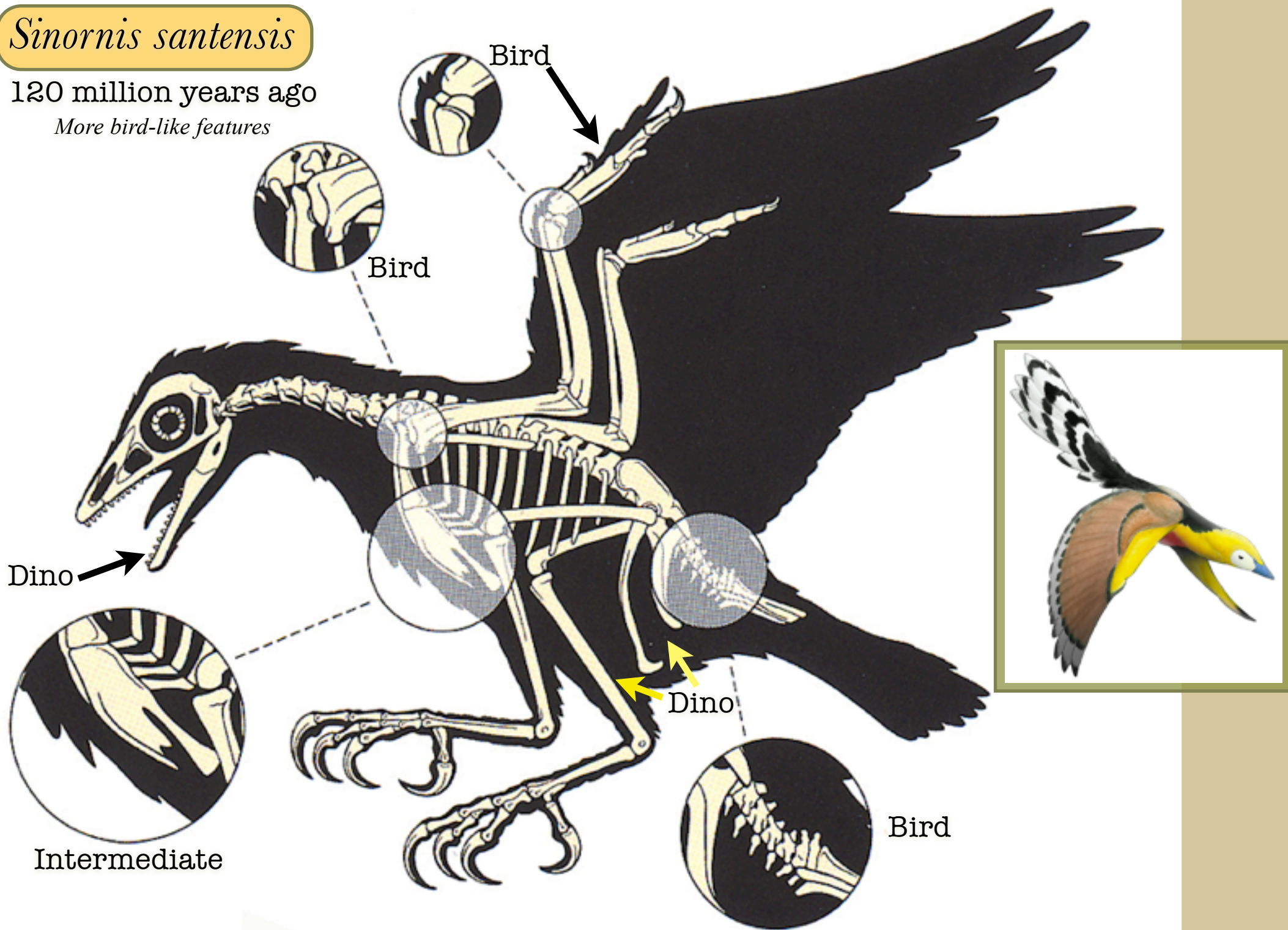
*More bird-like features*



*Sinornis santensis*

120 million years ago  
*More bird-like features*

### *More bird-like features*



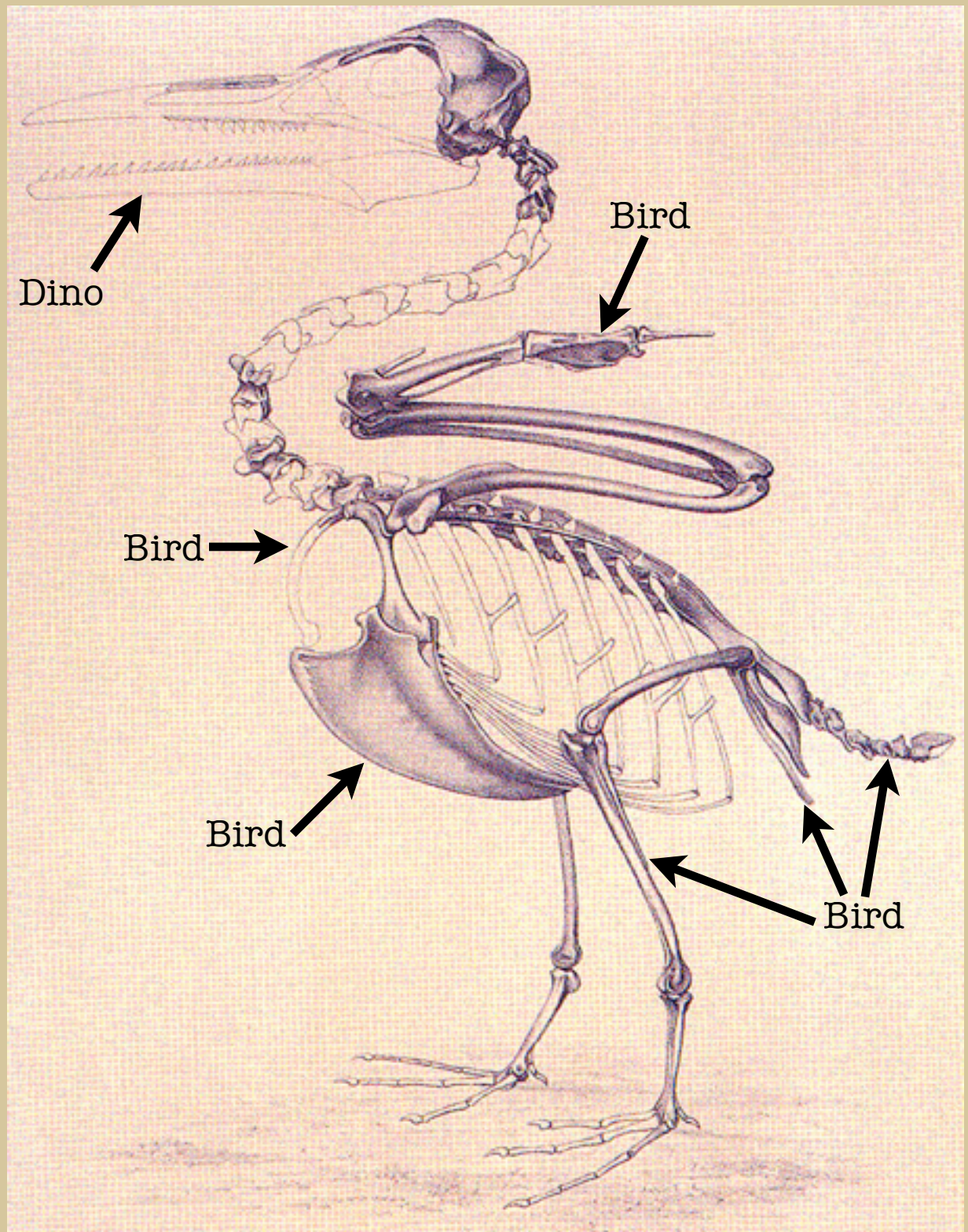


# *Ichthyornis dispar*

85 million years ago

*Almost all bird-like features, except for teeth*

*Interpretive reconstruction*

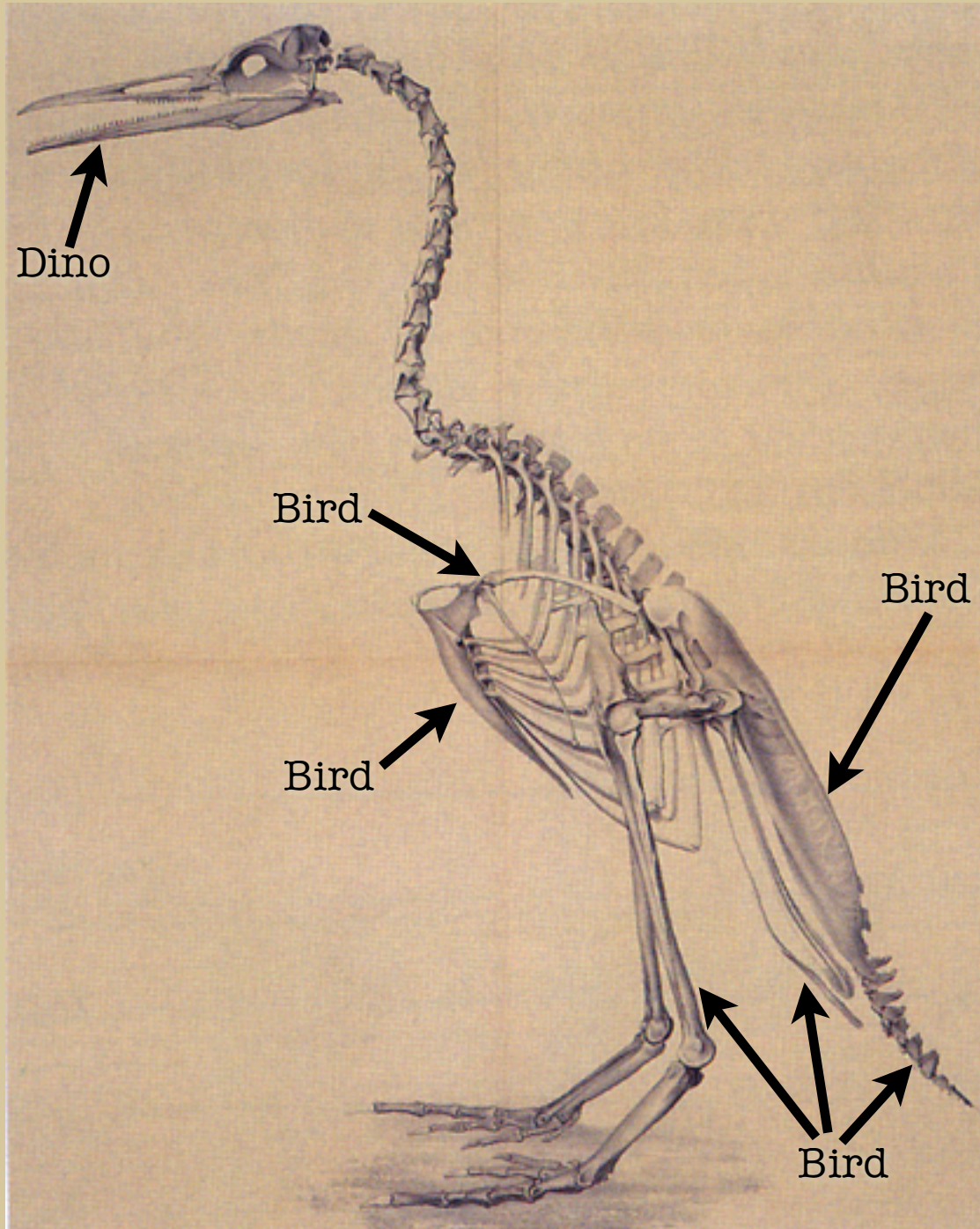




# *Hesperornis regalis*

80 million years ago

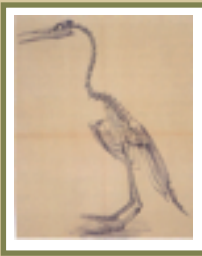
*Almost all bird-like features, except for teeth*



*Interpretive reconstruction*



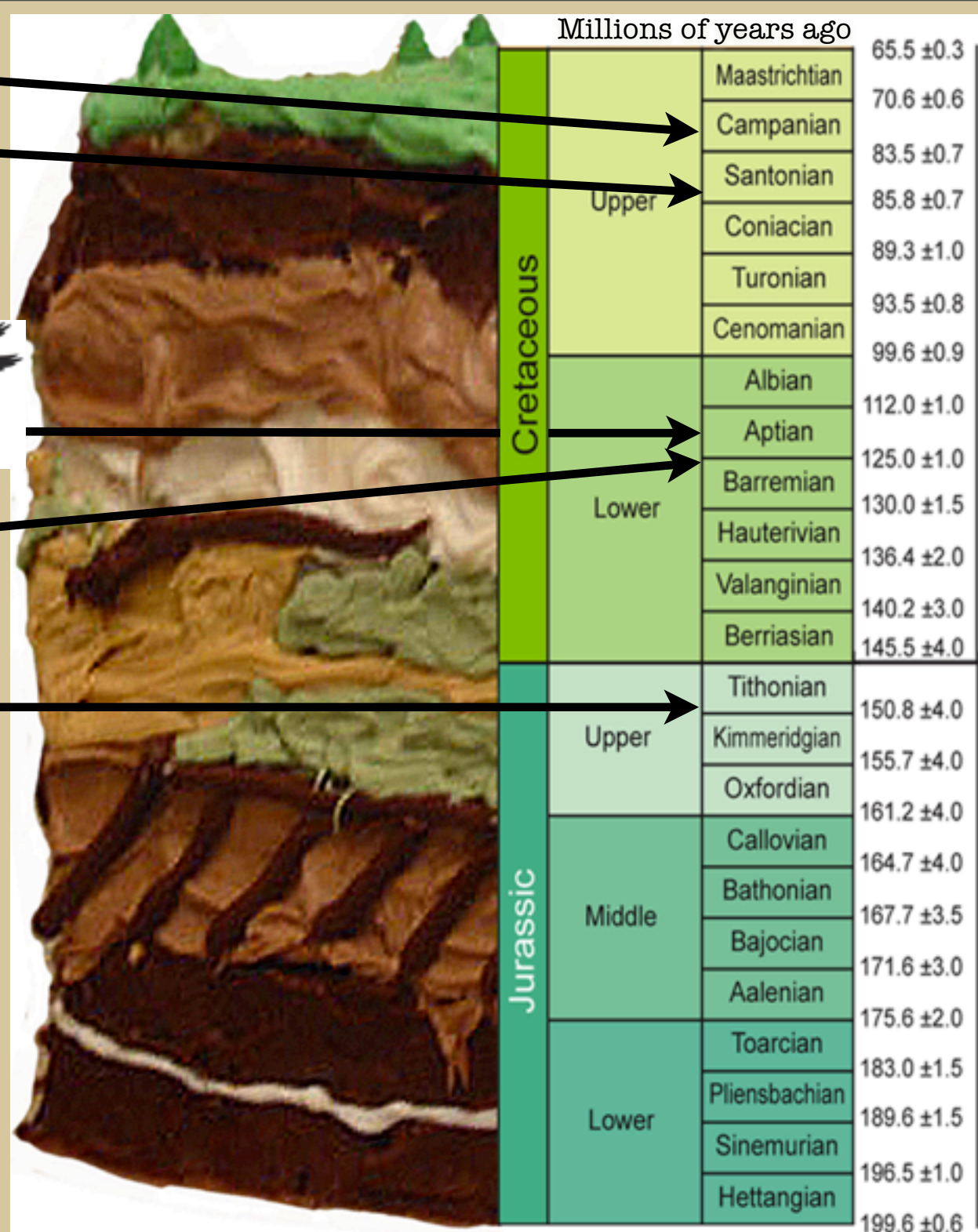
*Mostly bird-like*



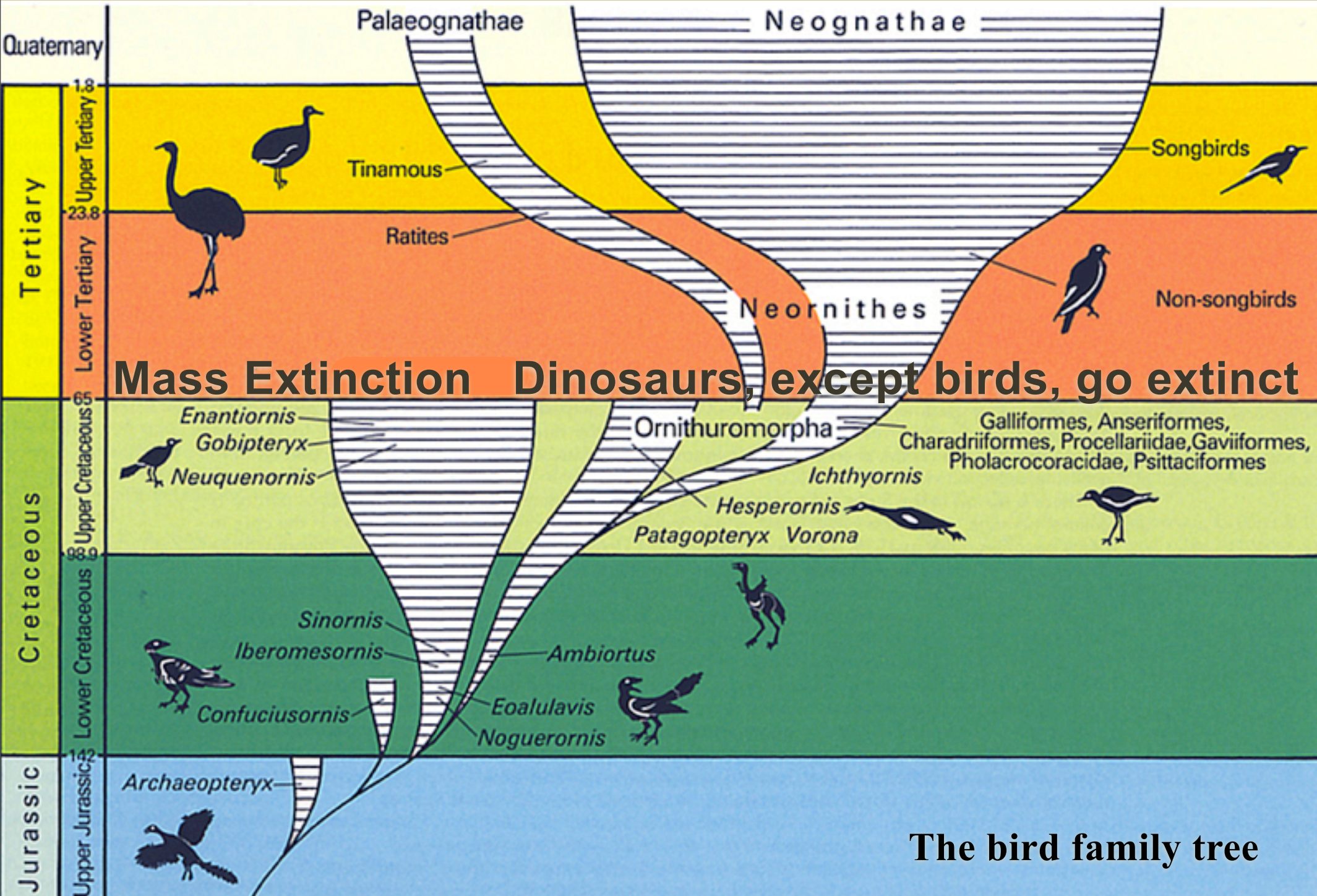
*Archaeopteryx*

*Mostly dinosaur-like*

*The anatomical transition from dinosaurs to birds is well recorded in the fossil record.*







The bird family tree



“Evolution doesn’t make accurate predictions”

Biological evolution has made numerous accurate predictions!!

PreCambrian fossils

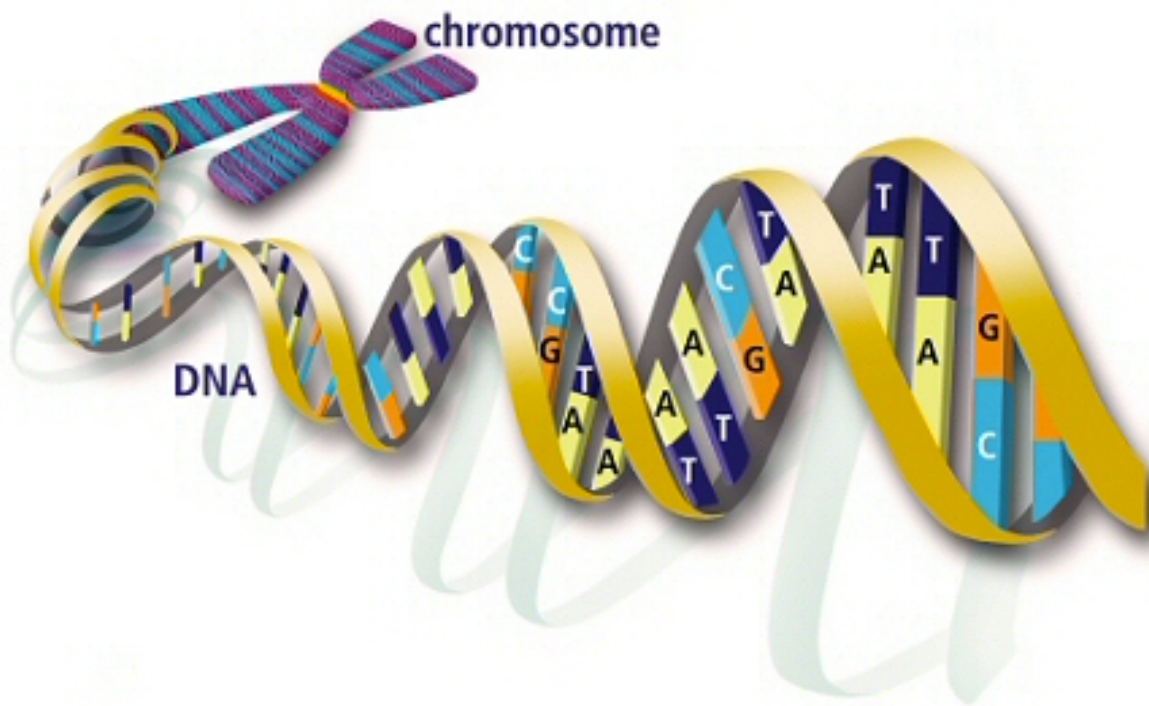
Transitional fossils

Mechanism for variation  
and inheritance

Geographical distribution  
of species

Evolution vs  
Gravitational theory





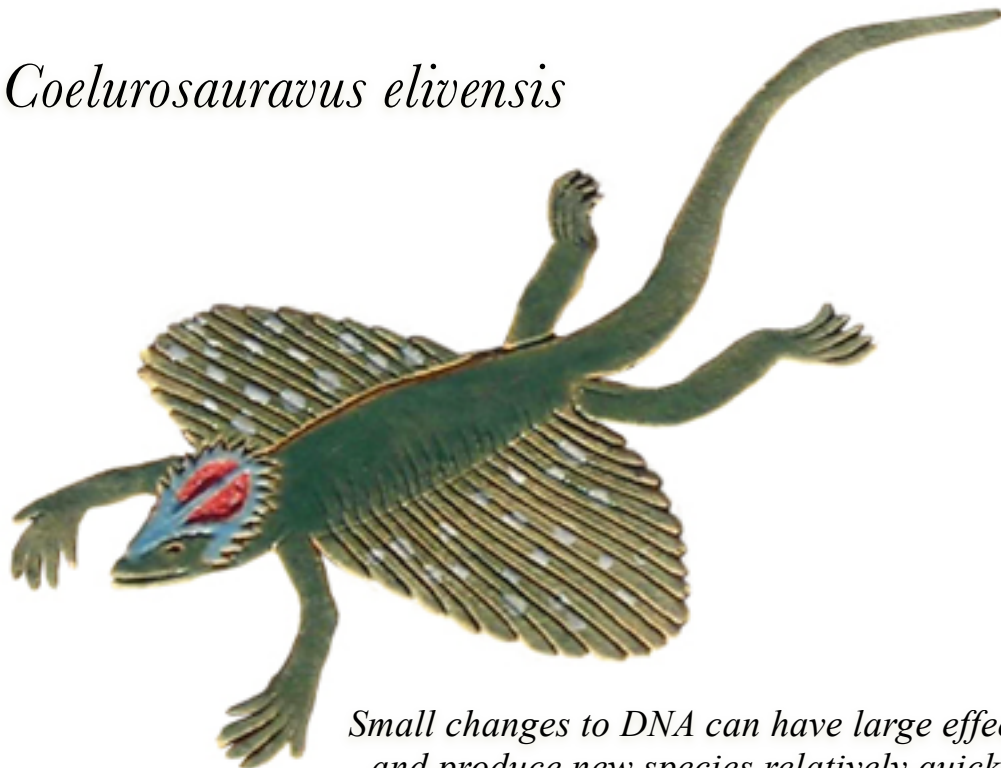
# DNA discoveries spectacularly confirm evolutionary theory

*Darwin had no idea what the biological mechanism of modification and inheritance would be.*

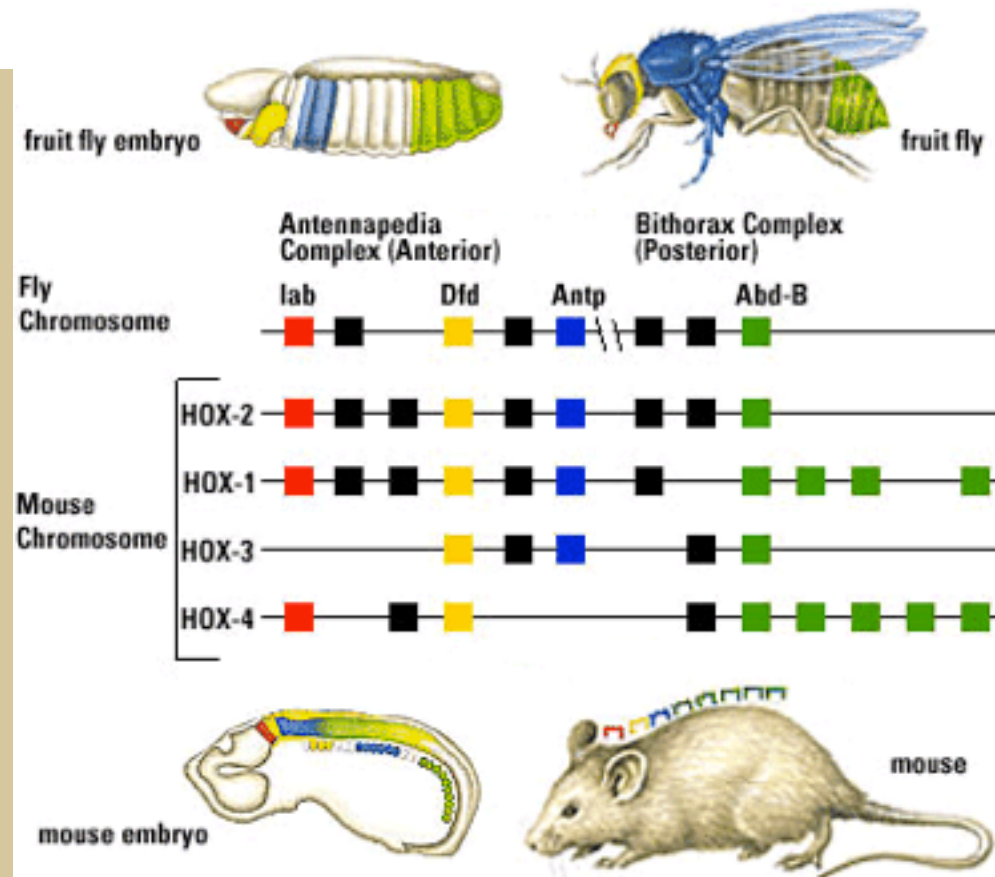
*150 years after Darwin....*

*Everything we have learned about DNA is consistent with evolutionary theory*

*Coelurosauravus elivensis*



*Small changes to DNA can have large effects,  
and produce new species relatively quickly*





“Evolution doesn’t make accurate predictions”

Biological evolution has made numerous accurate predictions!!

PreCambrian fossils

Transitional fossils

Mechanism for mutation  
and inheritance

Geographical distribution  
of species



Evolution vs  
Gravitational theory

# Biogeography

Darwin correctly predicted in *The Descent of Man* (1871) that man's ancestors would be found in Africa



*Australopithecus  
afarensis*



*Homo habilis*



*Homo erectus*



*Australopithecus africanus*



“Evolution doesn’t make accurate predictions”

Biological evolution has made numerous accurate predictions!!

PreCambrian fossils

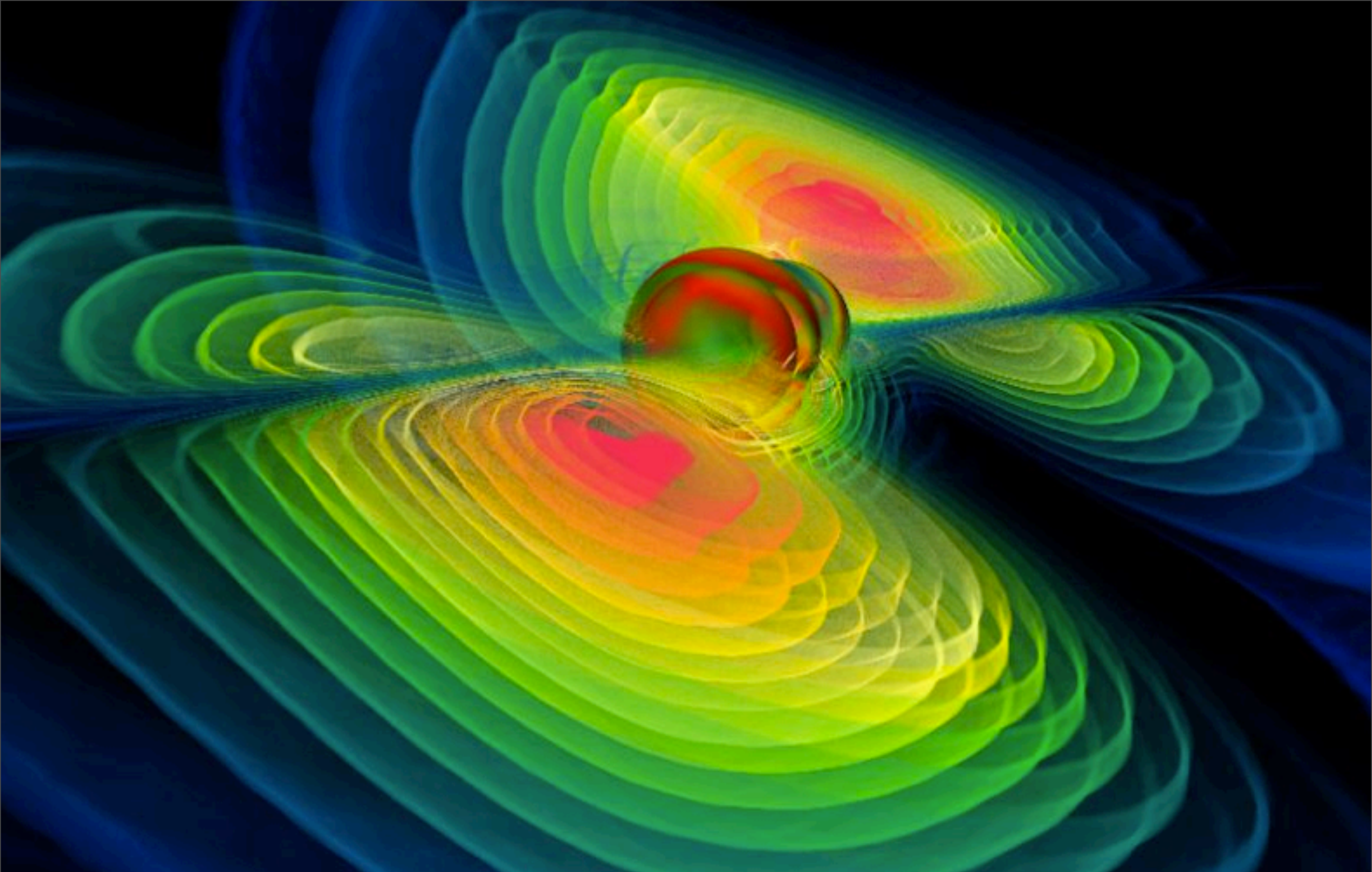
Transitional fossils

Mechanism for mutation  
and inheritance

Geographical distribution  
of species



Evolution vs  
Gravitational theory



Gravitational theory predicts gravity waves.  
Gravity waves have not been detected!

*Biological evolution is better supported than current gravitational theory*



“Evolution claims a monkey could randomly type out a Shakespeare play”

130,000 letters in Hamlet

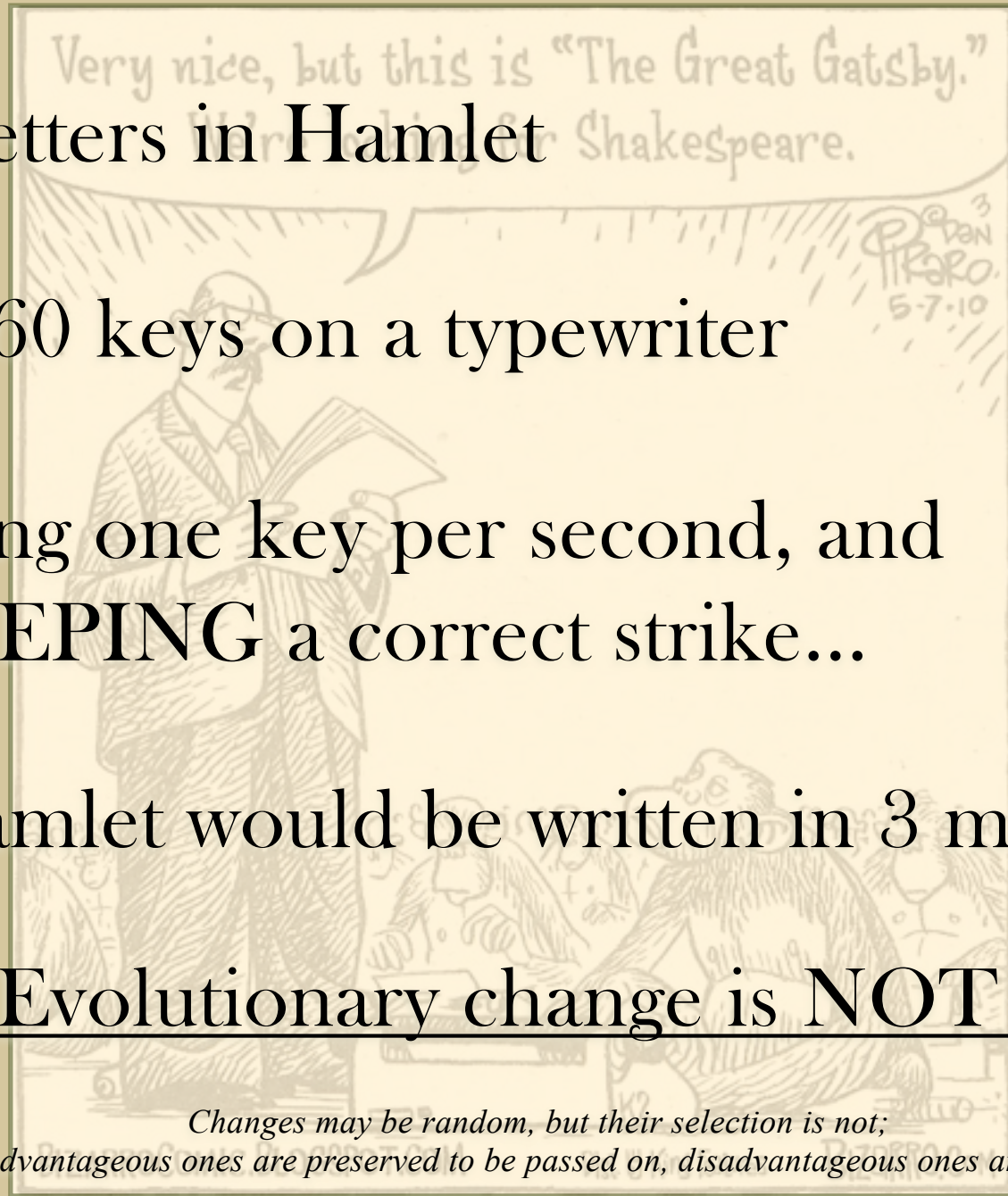
About 60 keys on a typewriter

Striking one key per second, and  
**KEEPING** a correct strike...

Hamlet would be written in 3 months

Evolutionary change is NOT random

*Changes may be random, but their selection is not;  
advantageous ones are preserved to be passed on, disadvantageous ones are not.*



# “Evolution couldn’t have made an eye”

*Intermediate stages in inferred evolution of eyes are found in nature.  
Light-sensitive organ independently evolved more than twenty times.*

Flatworm



Limpet



Nautilus



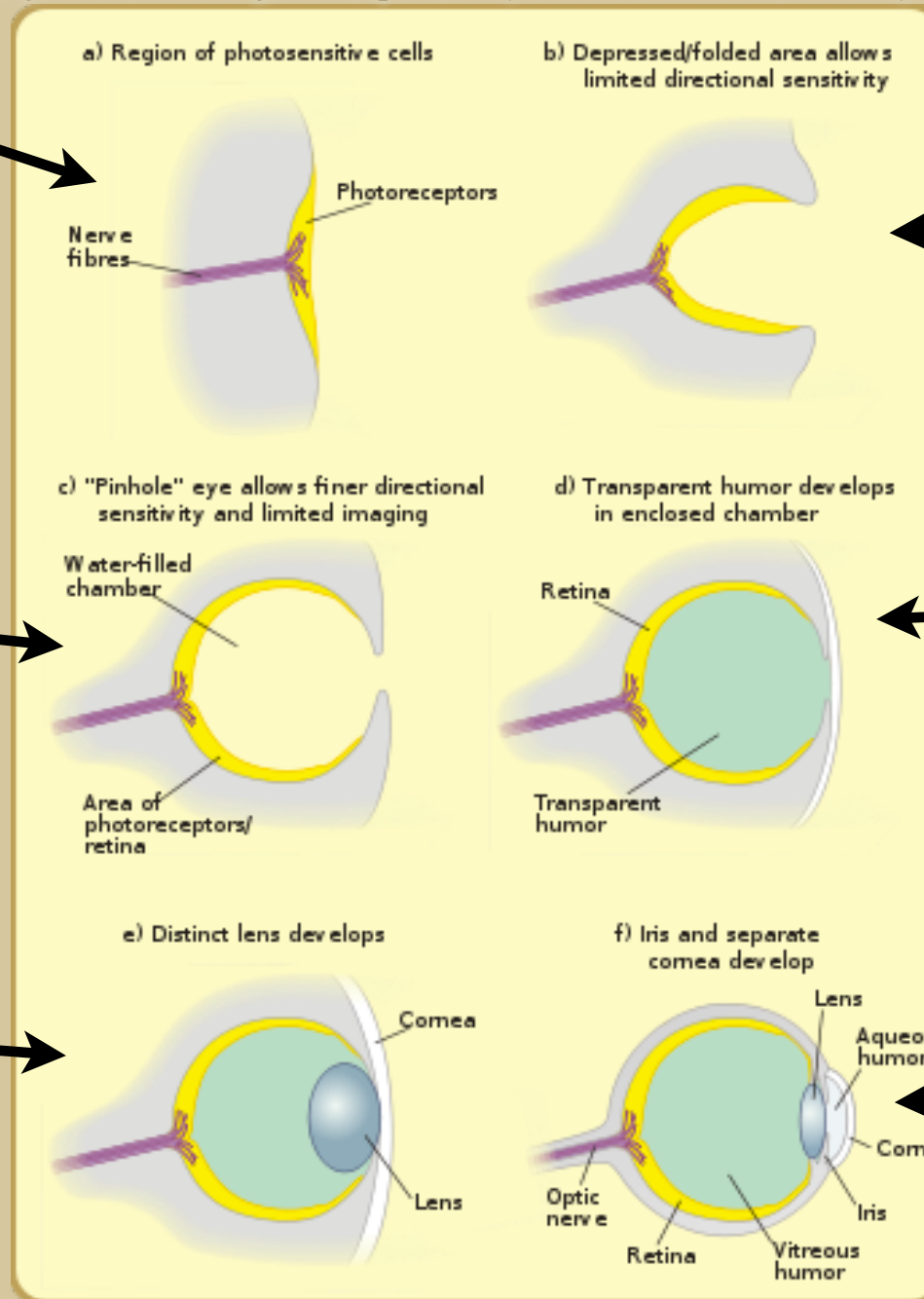
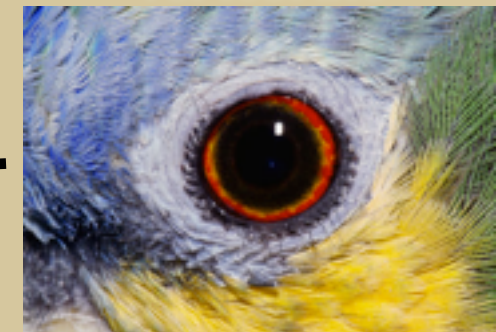
Ragworm



Abalone

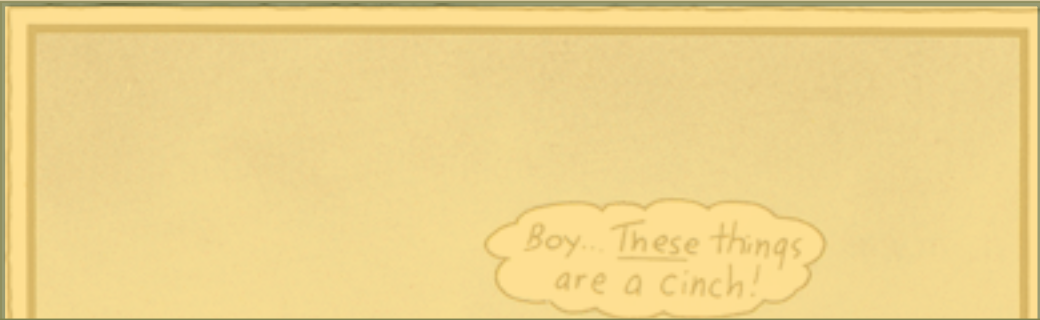


Vertebrate






“To be fair, Creationism/Intelligent Design should be taught alongside evolution”



99.9% of species that ever lived  
have gone extinct

*Eventual extinction of all species casts doubt  
on their being intelligently designed*



If intelligent design is taught alongside evolution,  
astrology would be taught with astronomy,  
and alchemy with chemistry

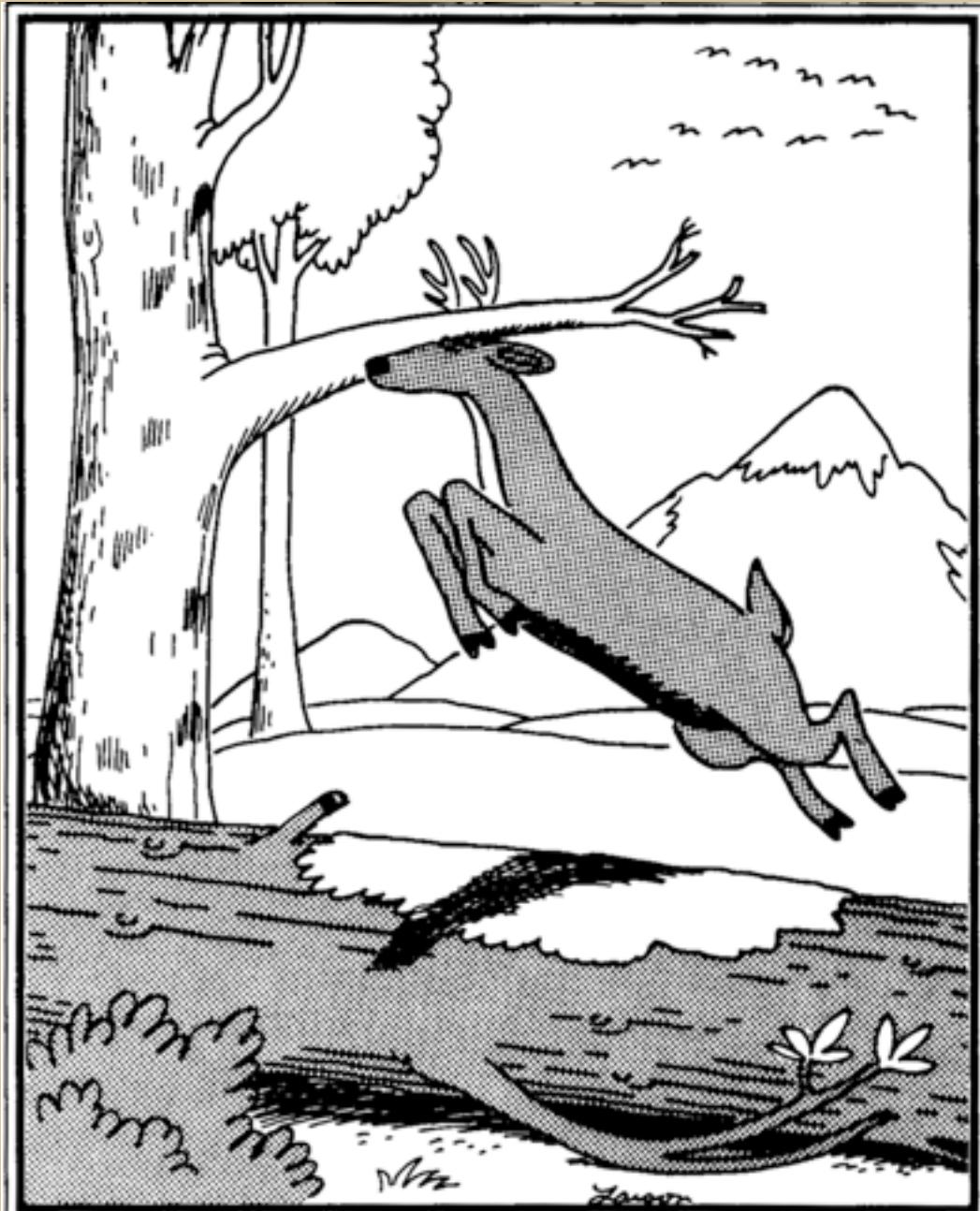
*Testimony of intelligent design proponent  
in 2005 Federal trial Kitzmiller v Dover*



God makes the snake

*Gary Larson 1998*

# “Nature’s perfect balance shows intelligent design”



Gary Larson

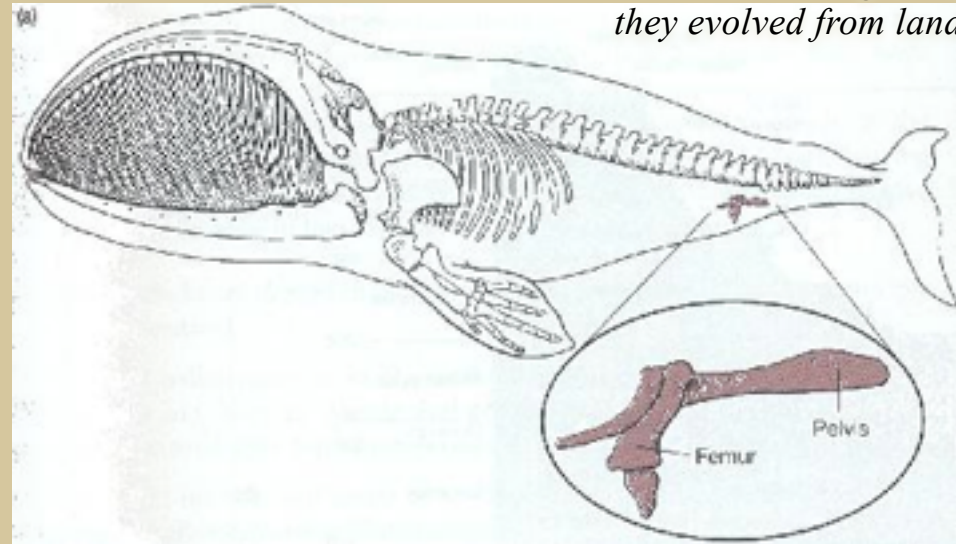
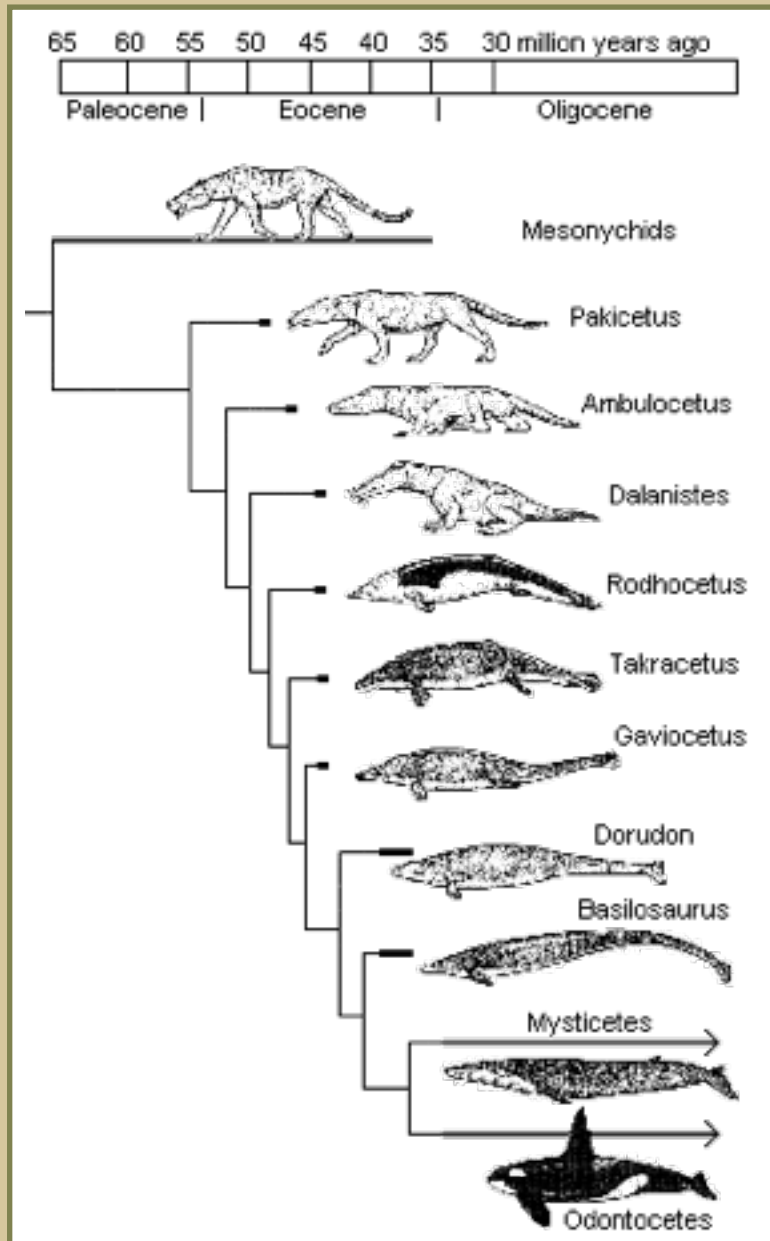
Nature scenes we rarely see

*Forms in nature are never perfect.  
Disease, famine, birth defects and inevitable  
extinction suggest instead that evolution  
results in what is good enough to survive*



# Nature is not perfect

Vestigial features, atavisms and bad design are consistent with evolution



*Whales have vestigial legs because they evolved from land animals*

Flightless wings      Sightless eyes

Snake pelvis

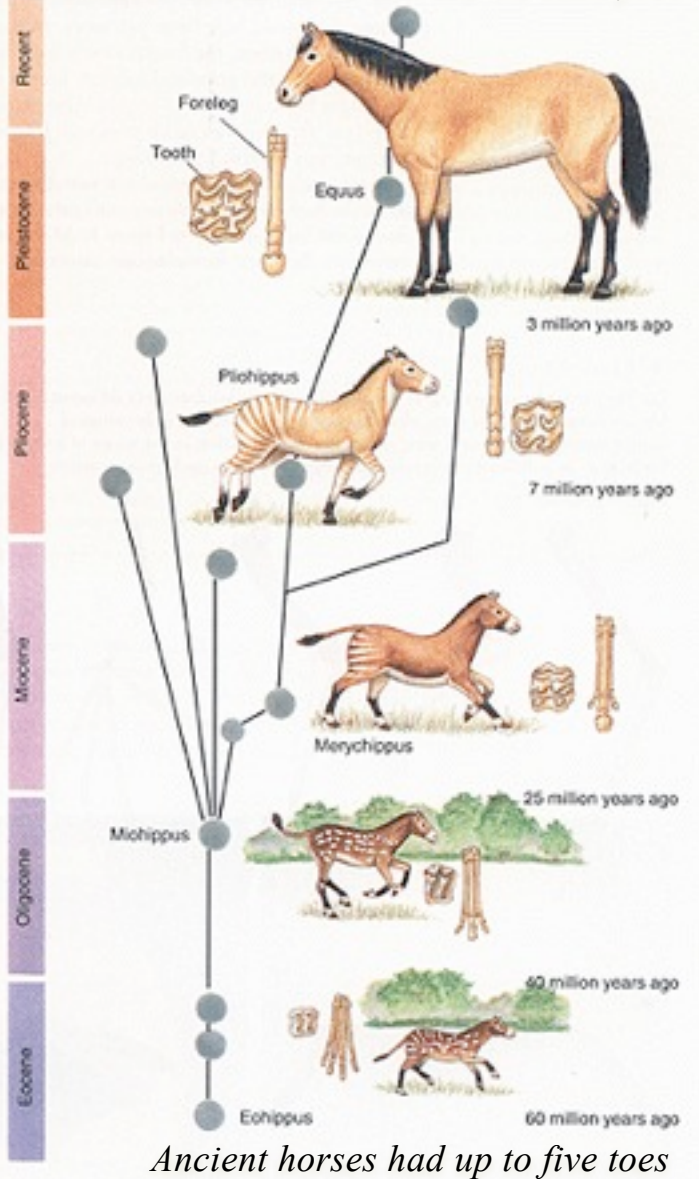
Wisdom teeth      Coccyx (tail bone)

*Vestigial features are nonfunctioning remnants of what were functional features in ancestors*

*The evolution of whales from land to sea is one of the best documented evolutionary transitions*

# Vestigial features, atavisms and bad design

Modern horses have one toe on each foot



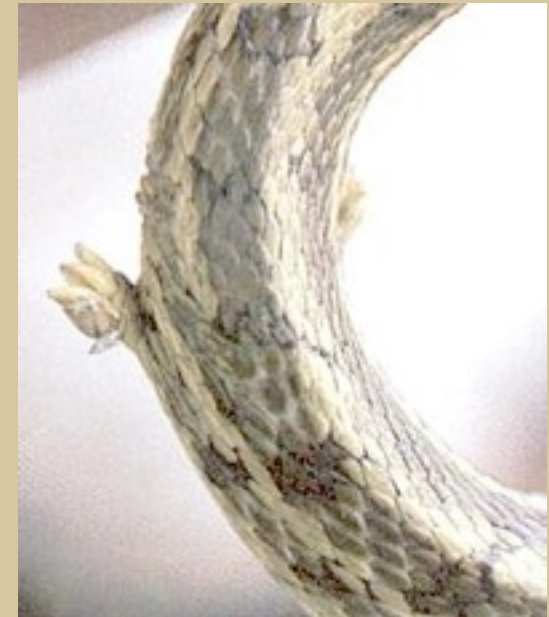
Ancient horses had up to five toes

Atavisms are features useful in direct ancestors that reappear (rarely) when genetic mutation turns on DNA machinery to make the feature. Normally DNA instruction to make the feature is turned off.

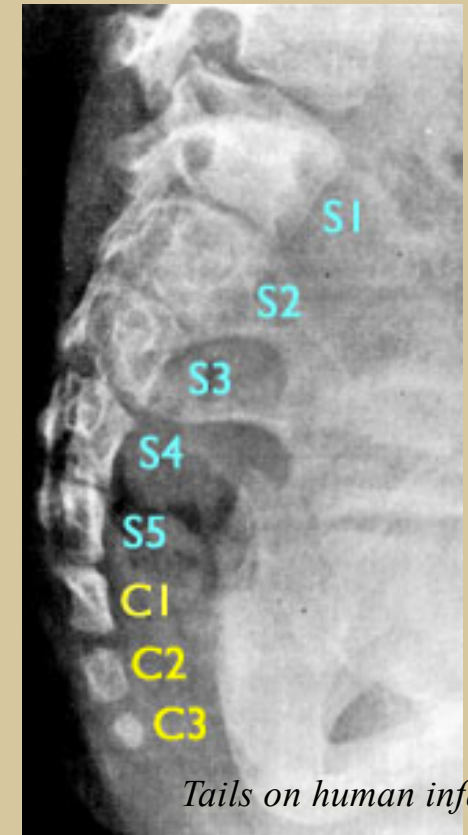
Extra toes in horses



Legs on snakes



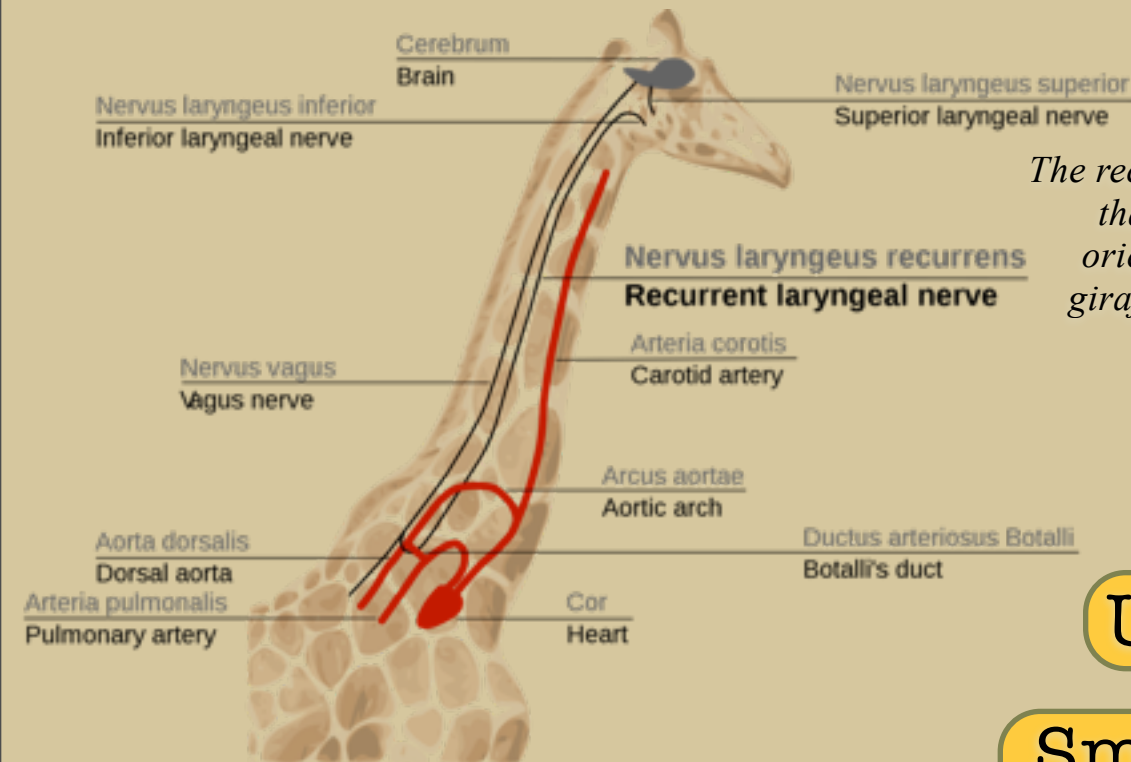
Legs on dolphins



Tails on human infants



# Vestigial features, atavisms and bad design are consistent with evolution



*The recurrent laryngeal nerve is much longer than necessary, because the original orientation was maintained even as the giraffe's neck evolved longer and longer*

Hernias

Urethra and prostate gland

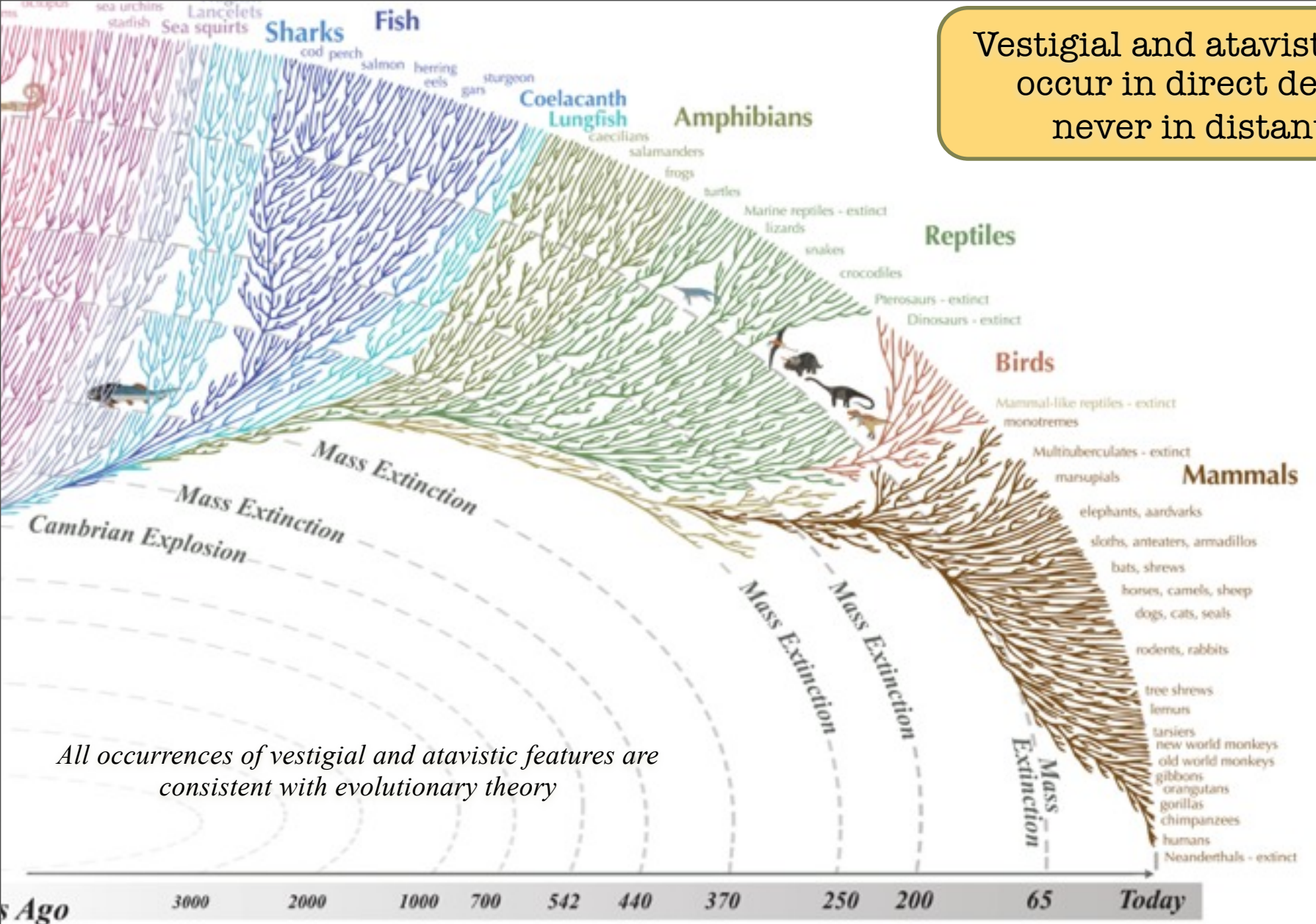
Small pelvic birth canal

Fallopian gap

Lower back structure

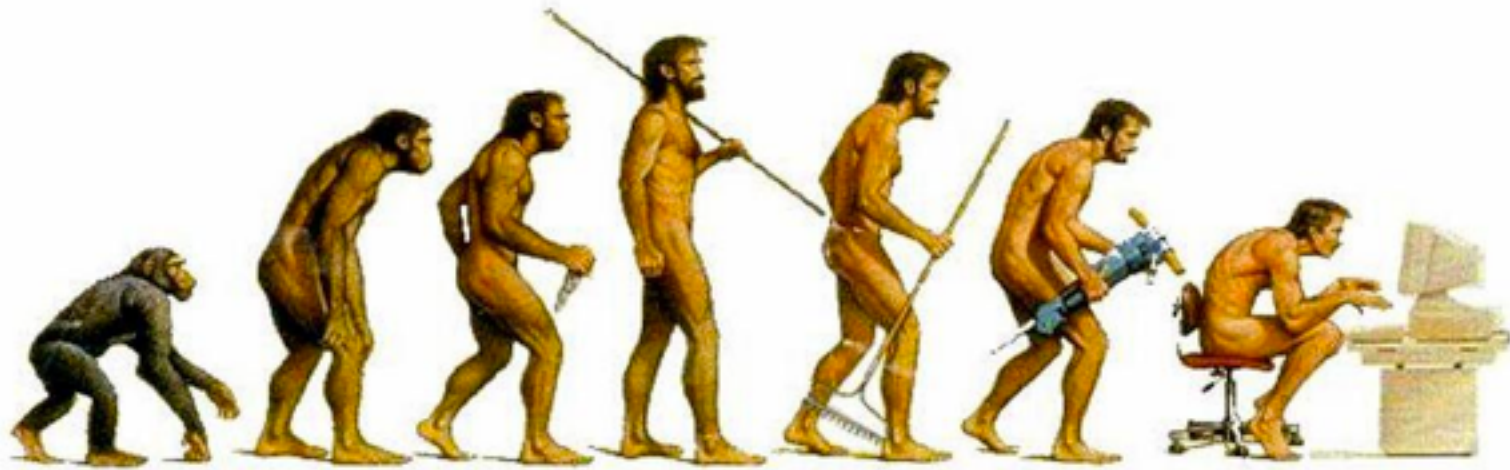
All can be traced back to features of our ancestors

Vestigial and atavistic structures occur in direct descendants, never in distant cousins

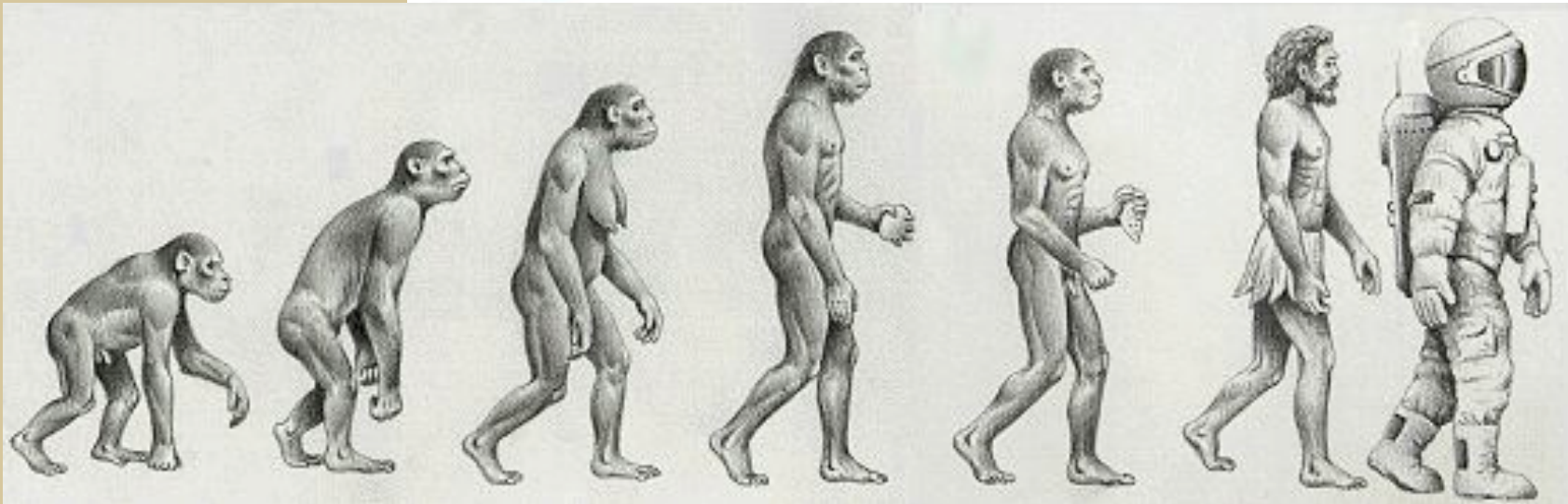
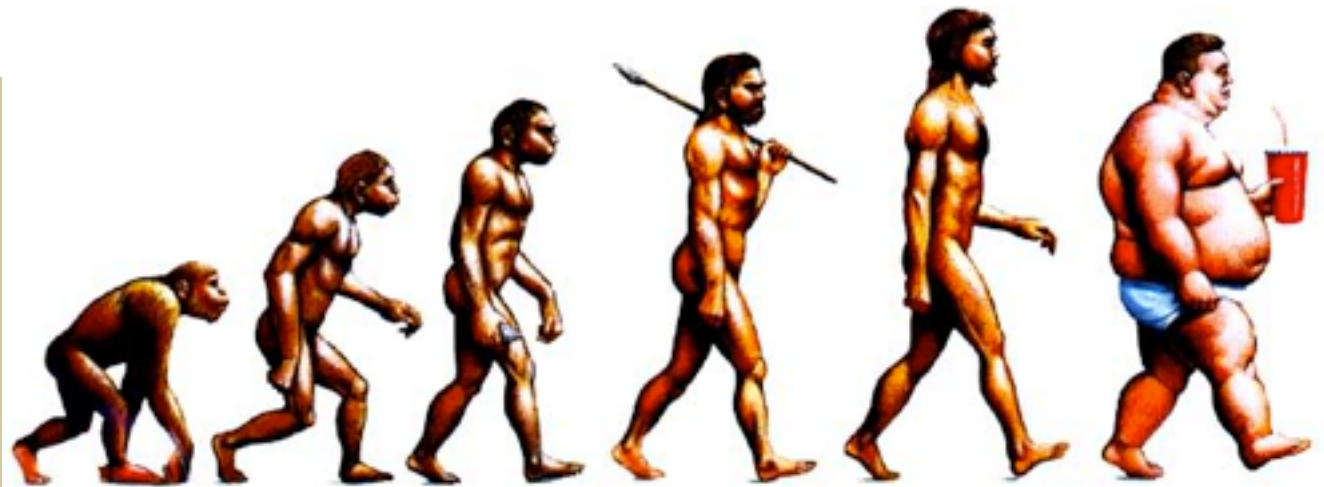


Evolution would be falsified if vestigial or atavistic feathers or wings appeared in mammals; hair or nipples in fish, amphibians or reptiles; arthropods with backbones; legs in sharks.





“The Ladder of Progress?”







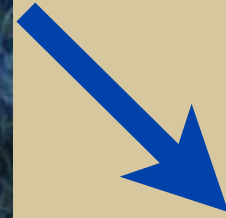
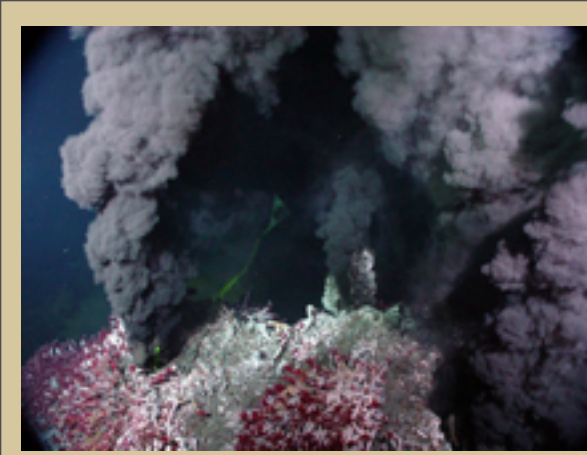
*Evolution is contingent on current conditions.  
If conditions change, the course of evolution adapts.*

*If the asteroid (or comet) missed the Earth ,  
perhaps the space-faring species  
on Earth today would be a dinosaur.*

What if the  
asteroid  
that killed  
off the  
dinosaurs  
had missed  
65 Ma?







## Life's trajectory?

*Evolution does not follow a predestined path but, given stable enough conditions, life will arise in water, move onto land, and perhaps leave its home planet.*

