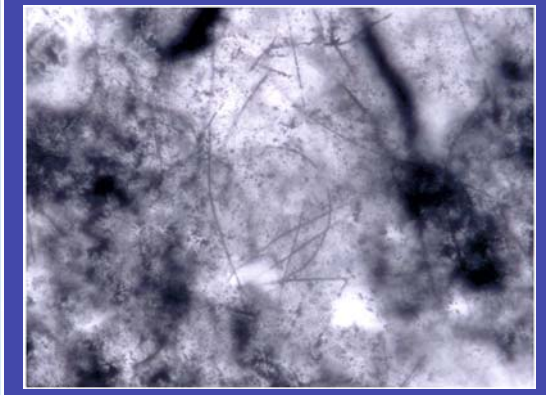
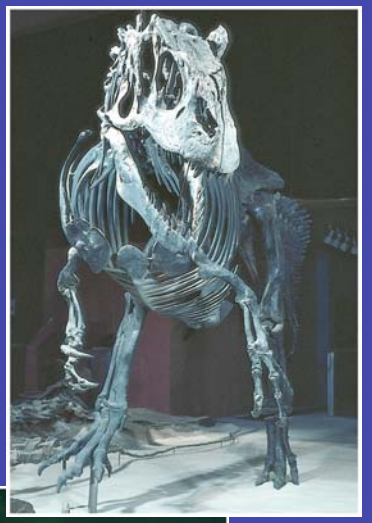
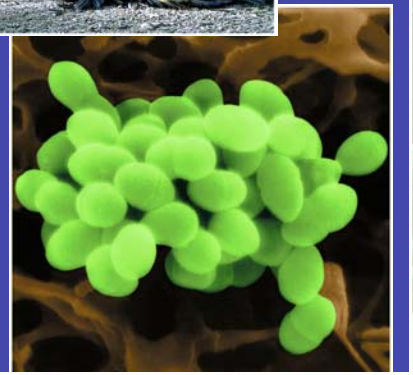








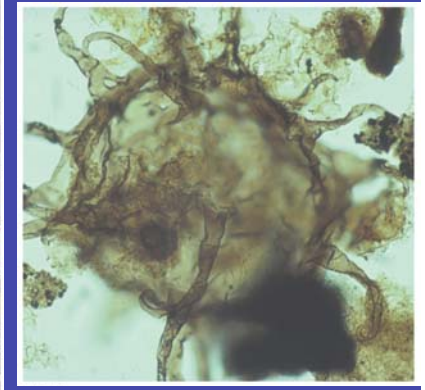










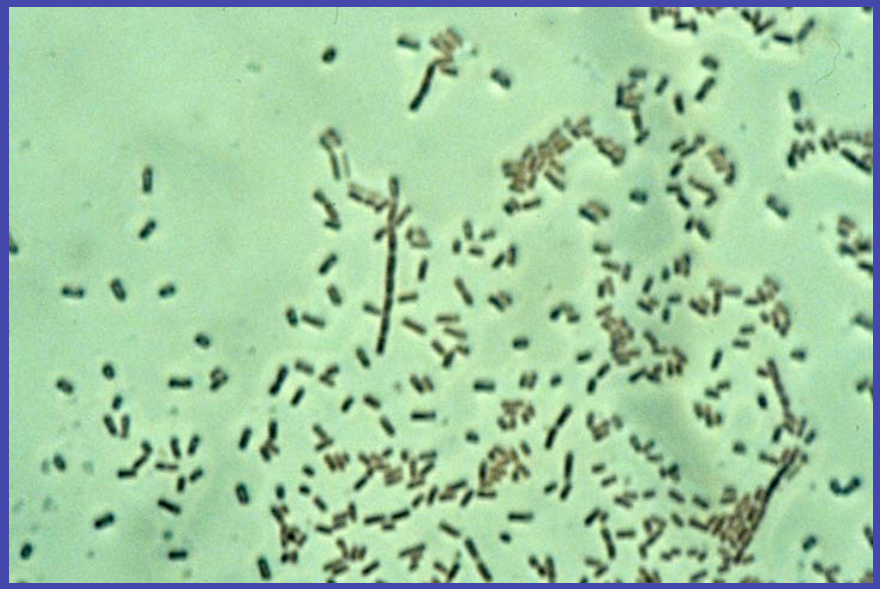


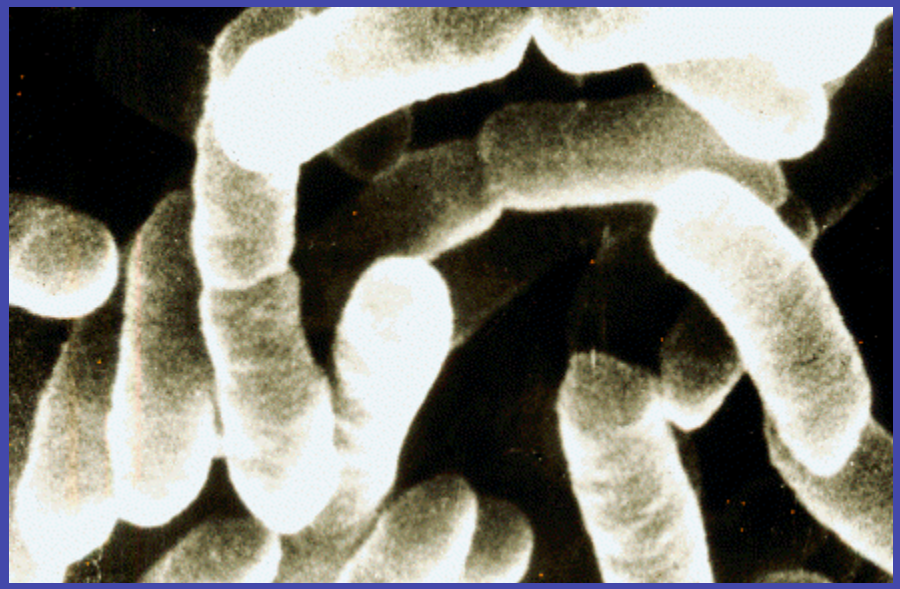
What defines

LIFE?

What defines

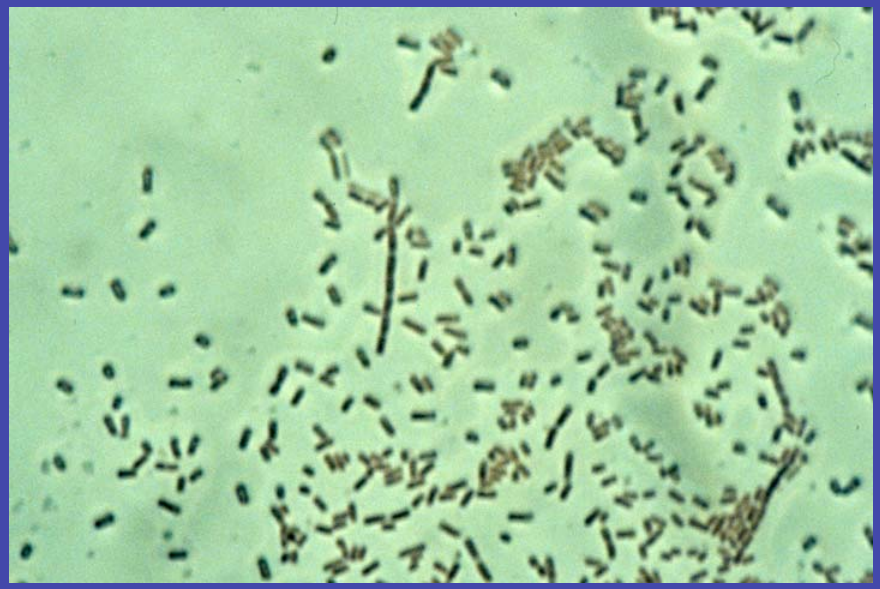
LIFE?





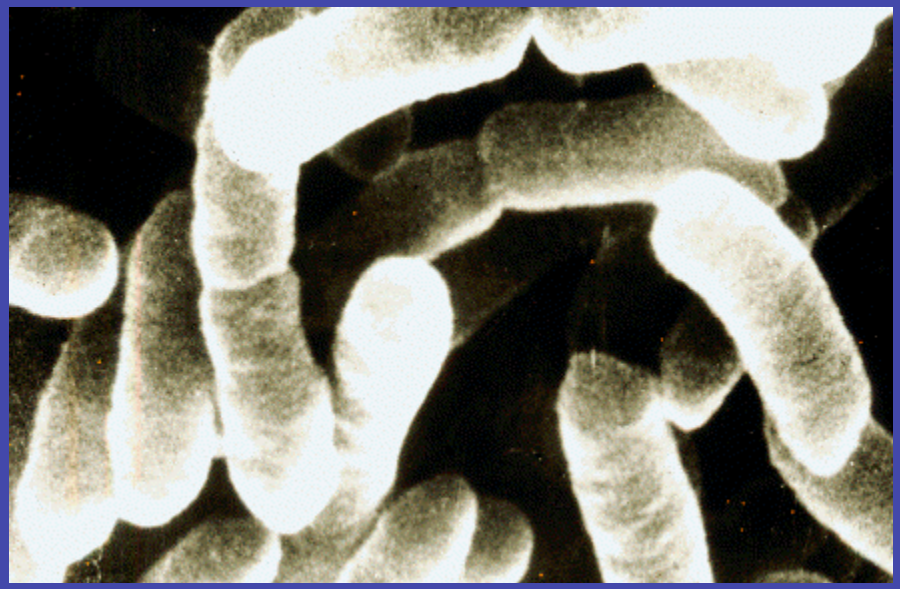
What defines

LIFE?



Bacteria

Self-replicating



Virus

Only under special circumstances









What defines

LIFE?

1) Self-replicating
2) Self-regulating
(Homeostasis)
(Metabolism)
3) Organization
4) Growth
5) Adaptation
6) Response to Stimuli





Why is Earth UNIQUE?

1. The right size

2. Right temperature

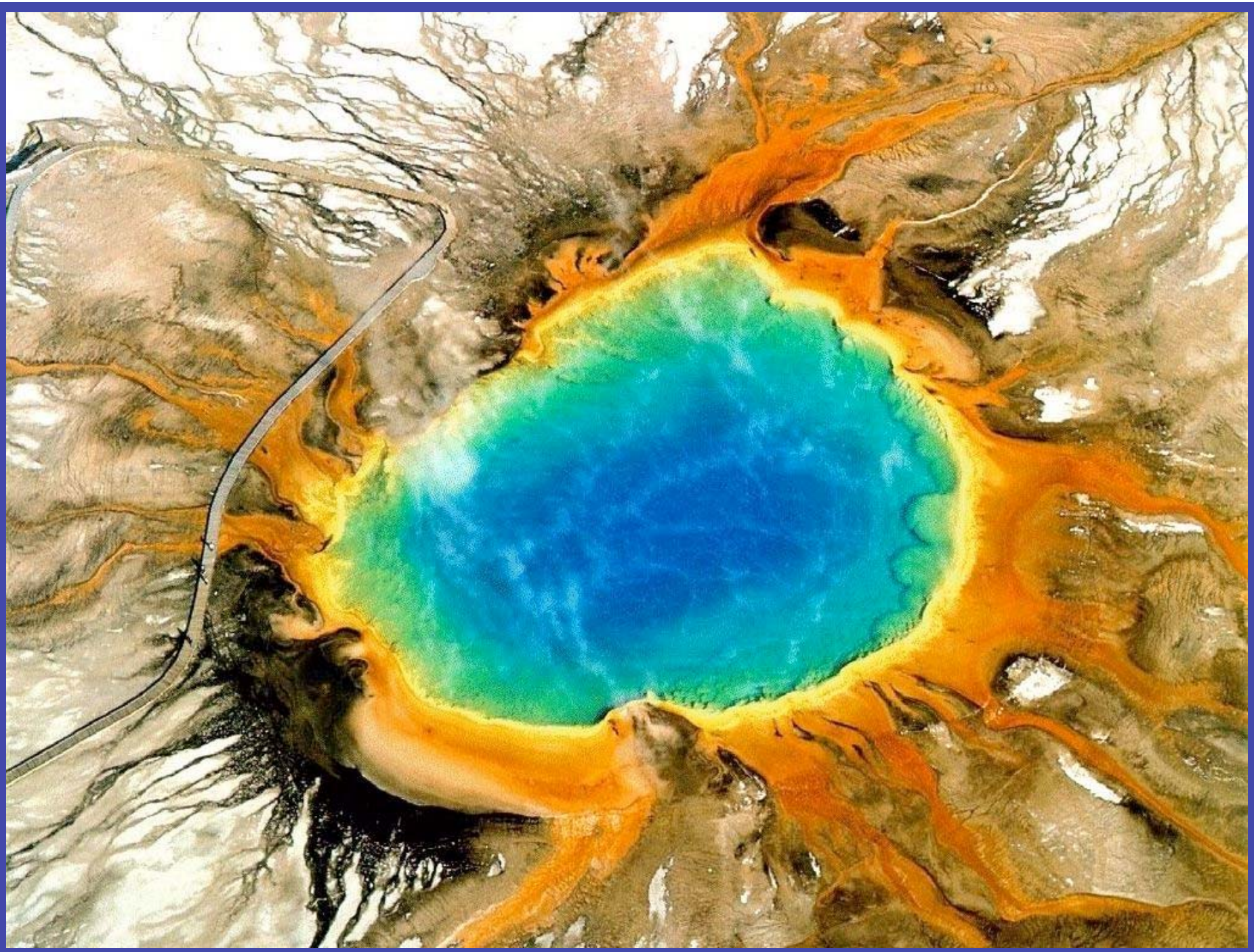
3. Water is liquid

These traits allow Earth to host LIFE

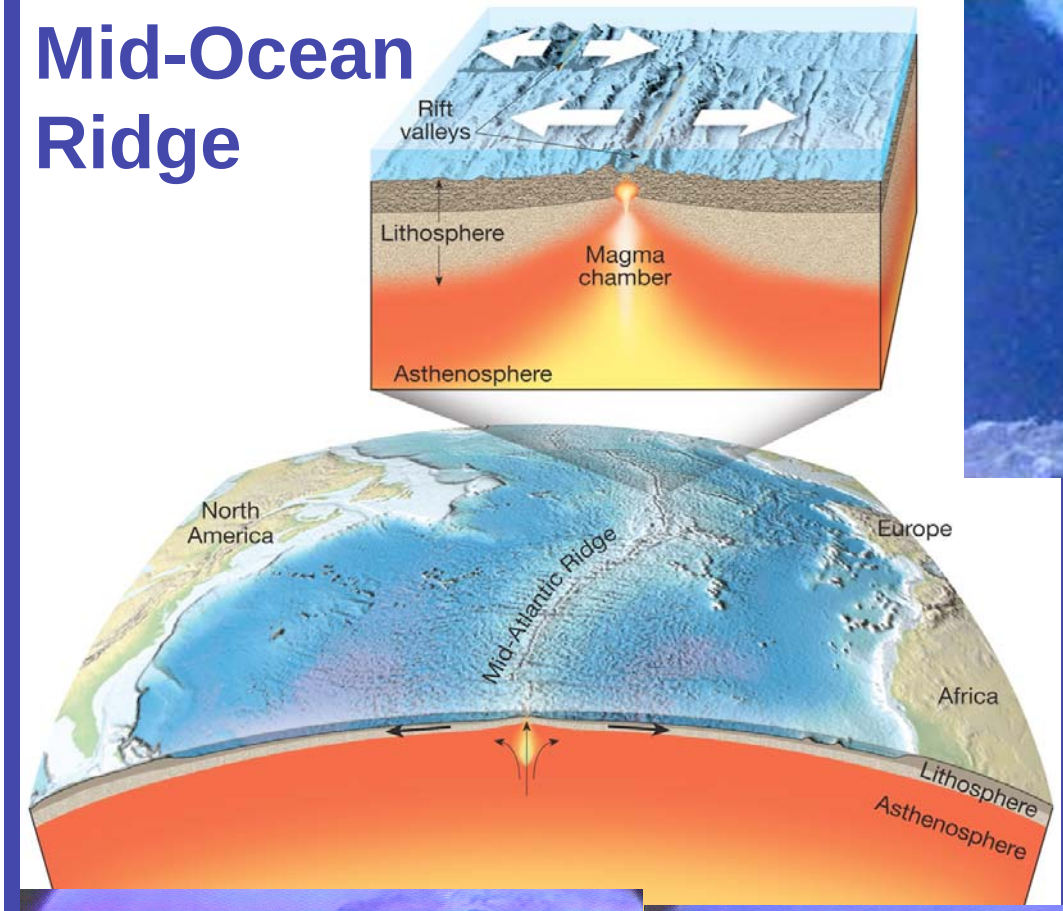
Where did life originate?

How do we know?


~3.7 Bya life began



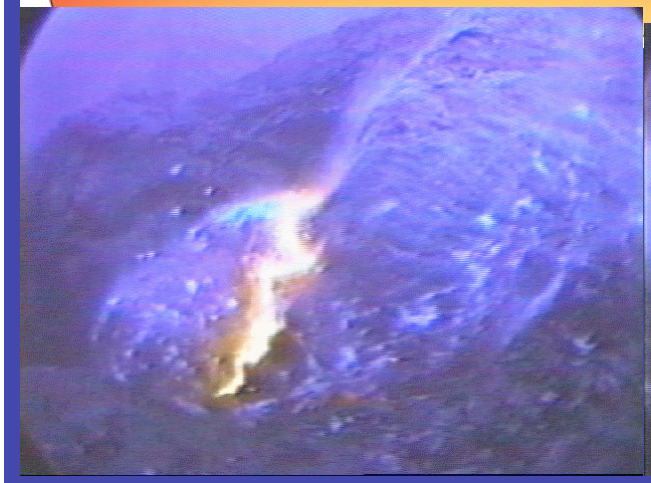
Mid-Ocean Ridge



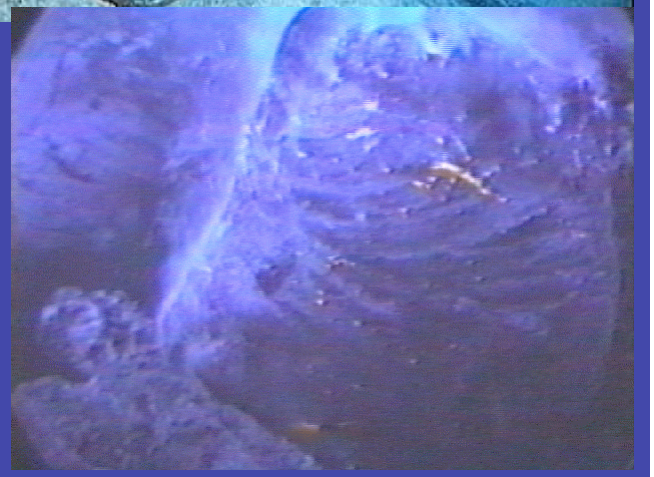














Archaebacteria tolerate extreme environments:

<u>HIGH</u>

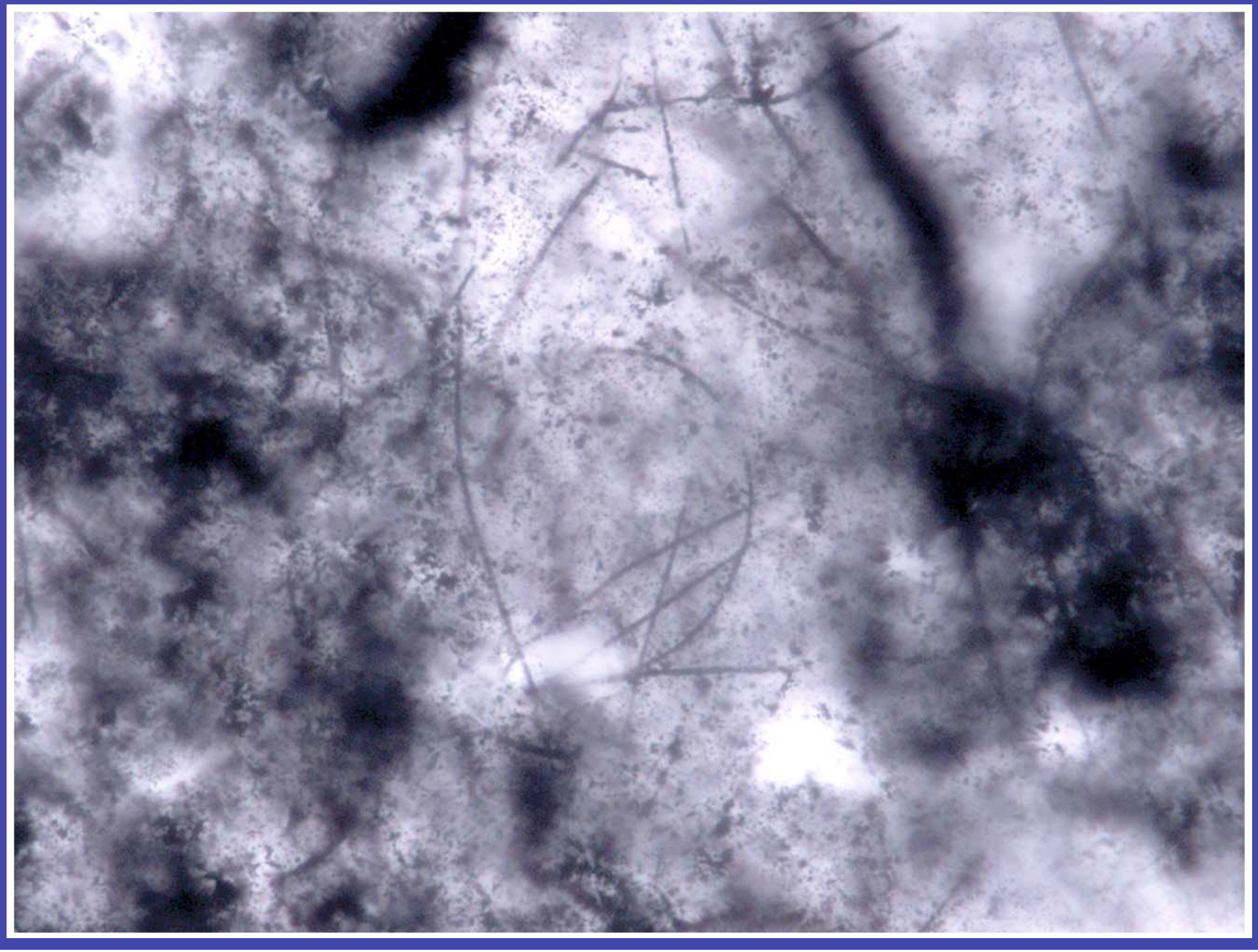
1) temperature

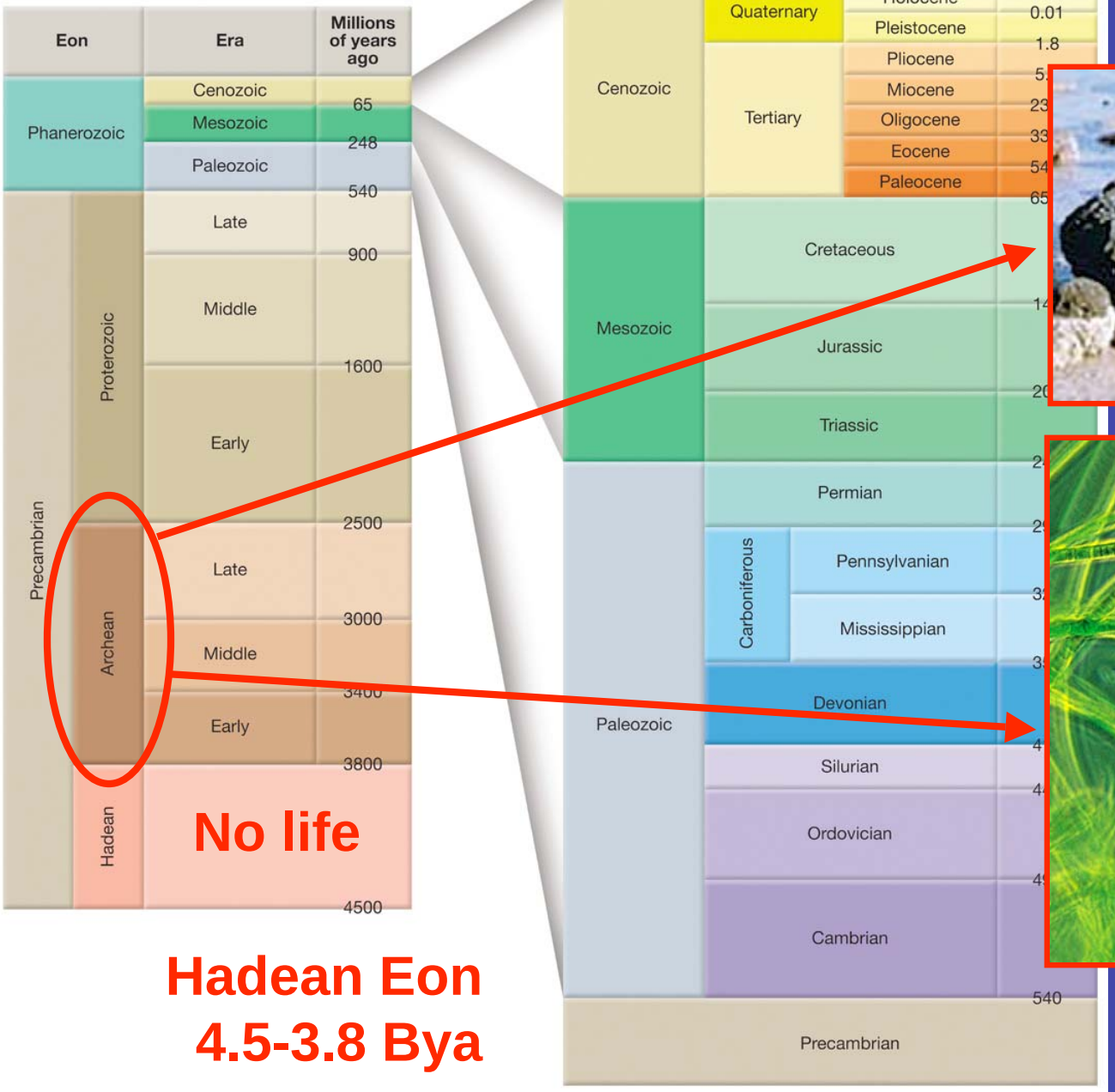
2) salinity

3) acidity



Oldest known fossil? Host rock 3.2 billion yrs old.





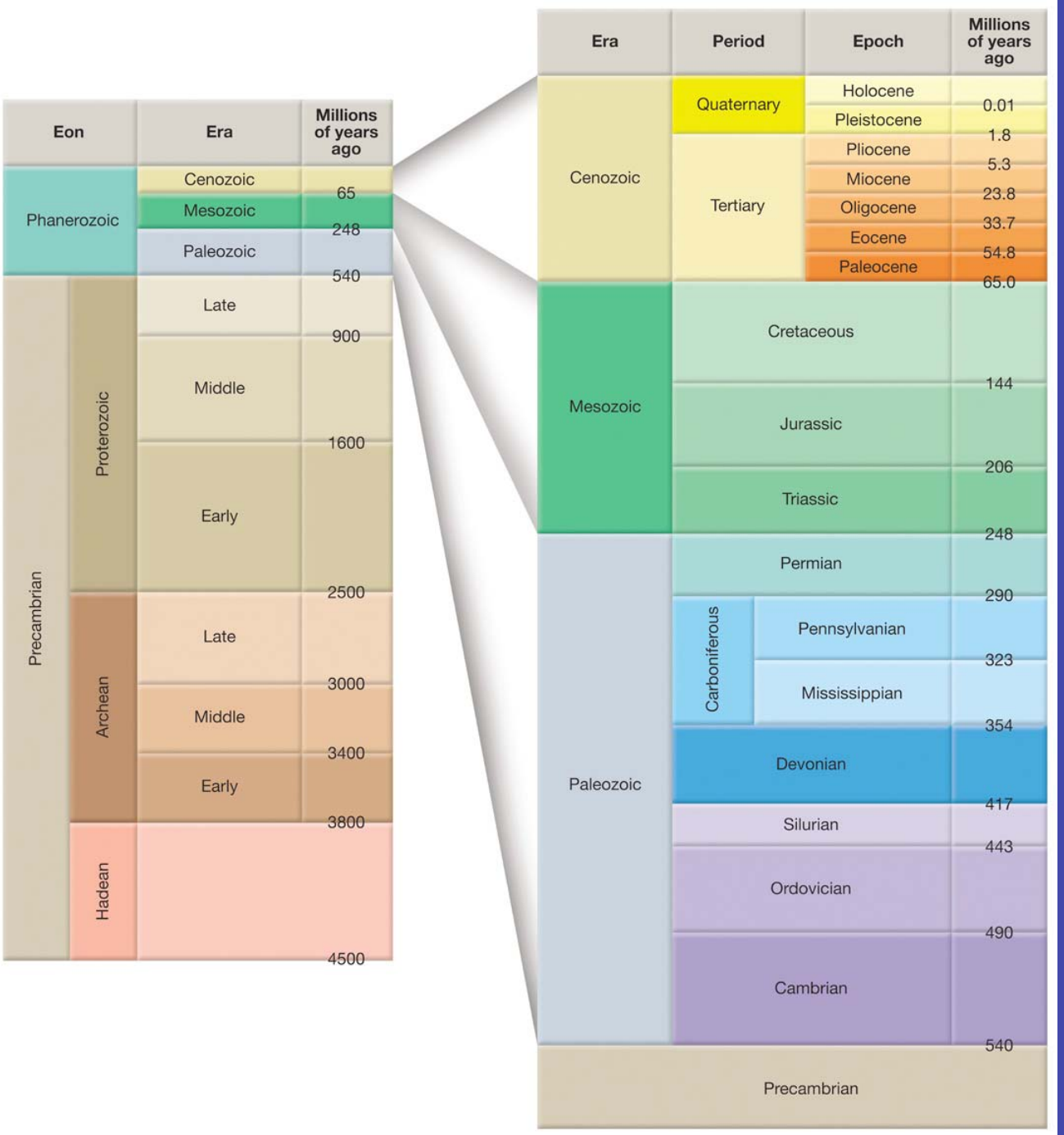
Hadean Eon
4.5-3.8 Bya

Stromatolites





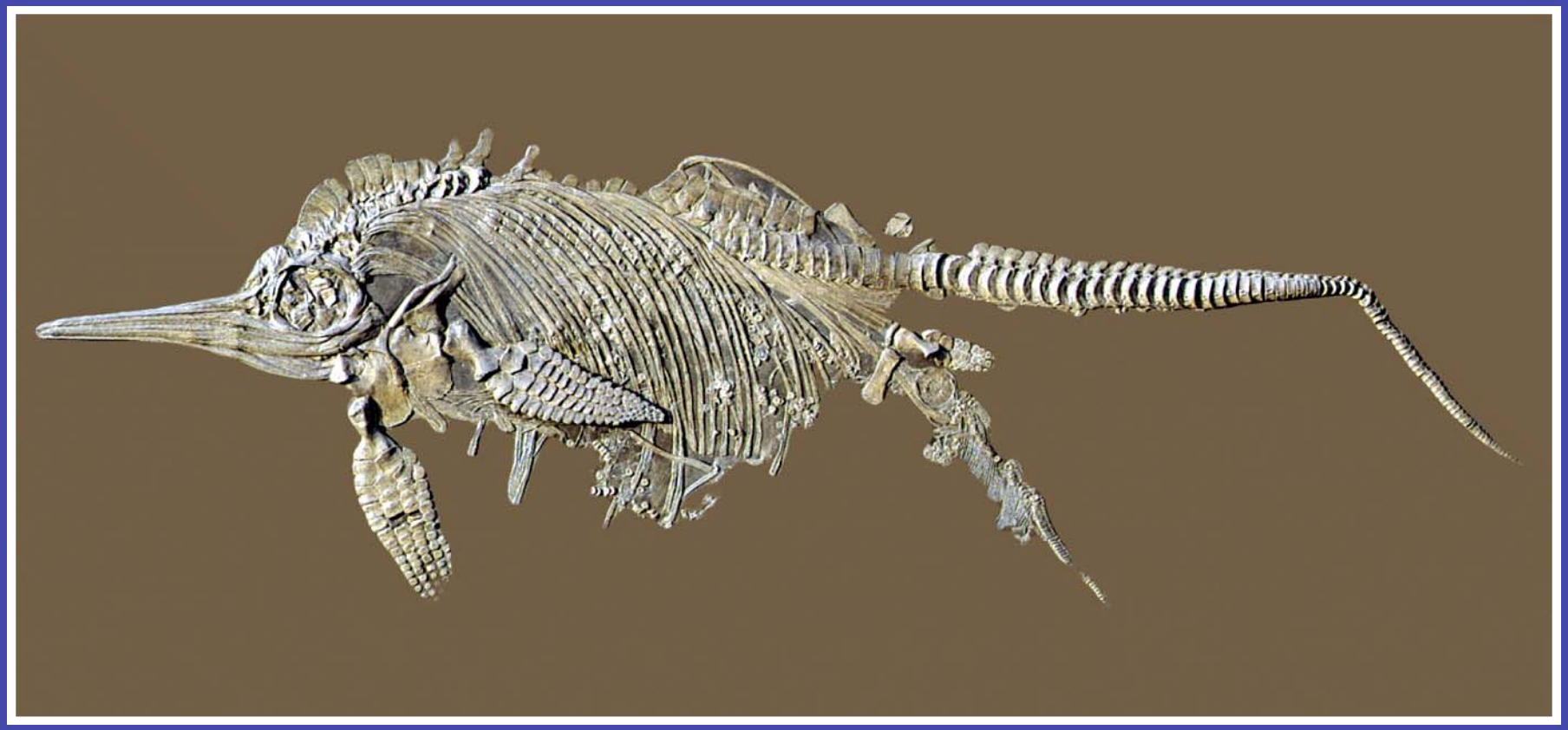
Bacteria



Fossils define the:

"Geologic Timescale"

What two factors influence fossil preservation?

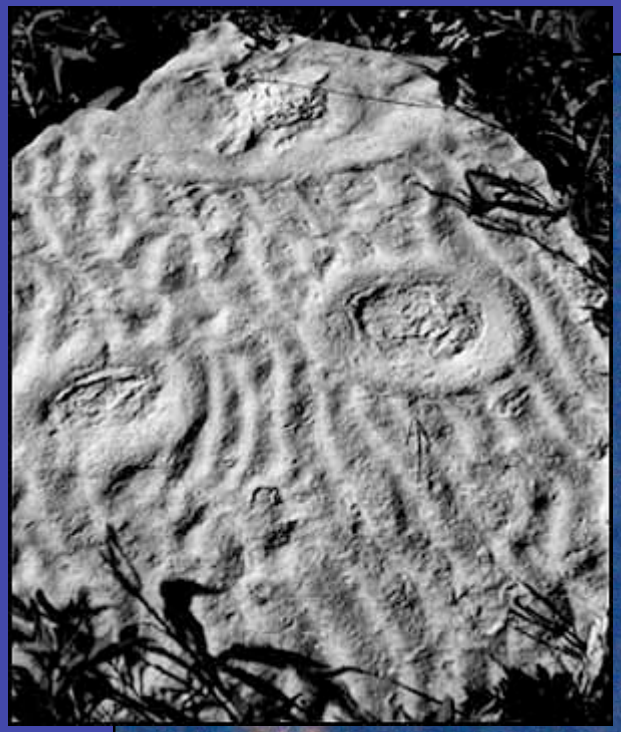


Icthyosaur (Jurassic 206-144 Mya)

What two factors influence fossil preservation?

1) Hard parts

2) Rapid burial



Cambrian (525 Mya)

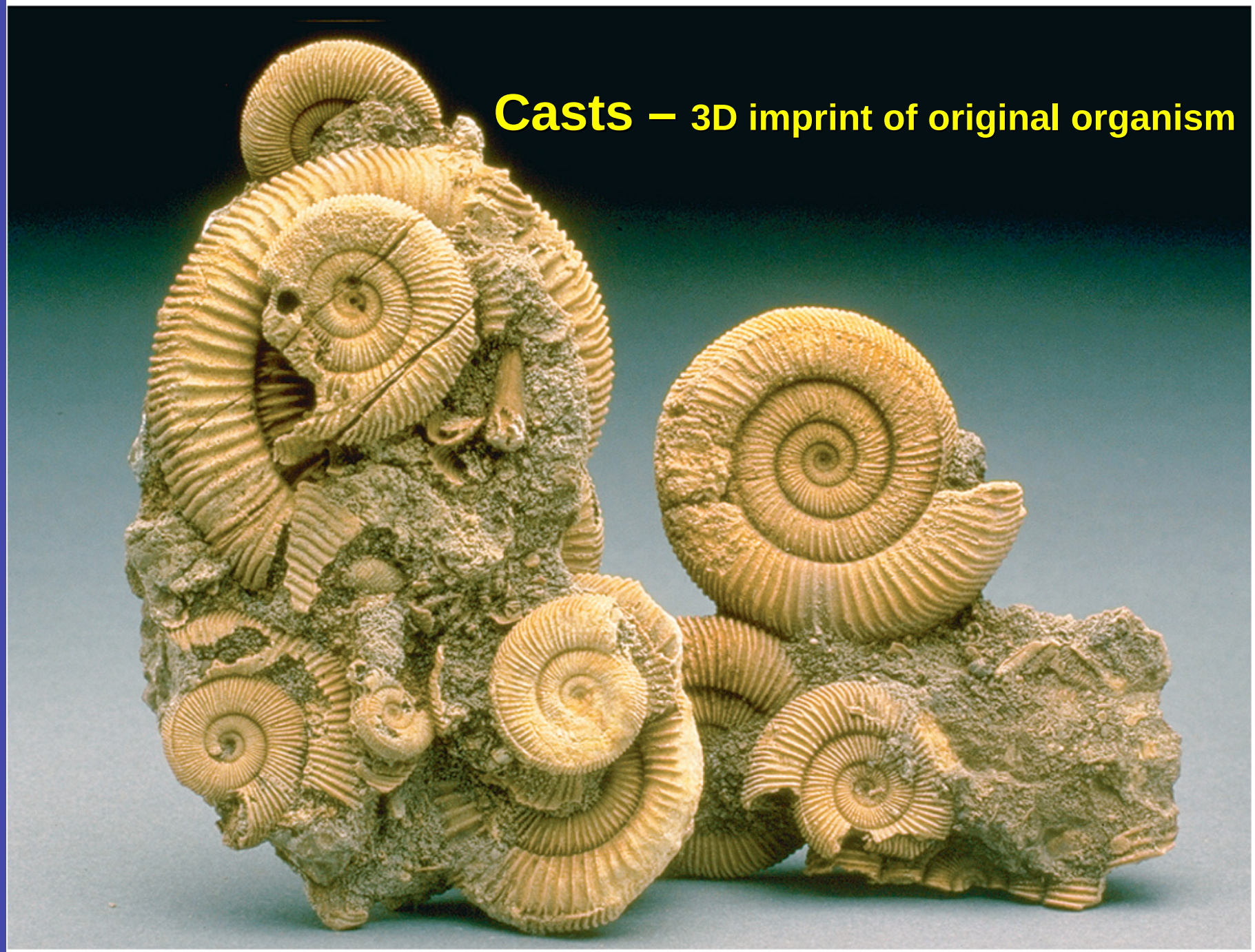


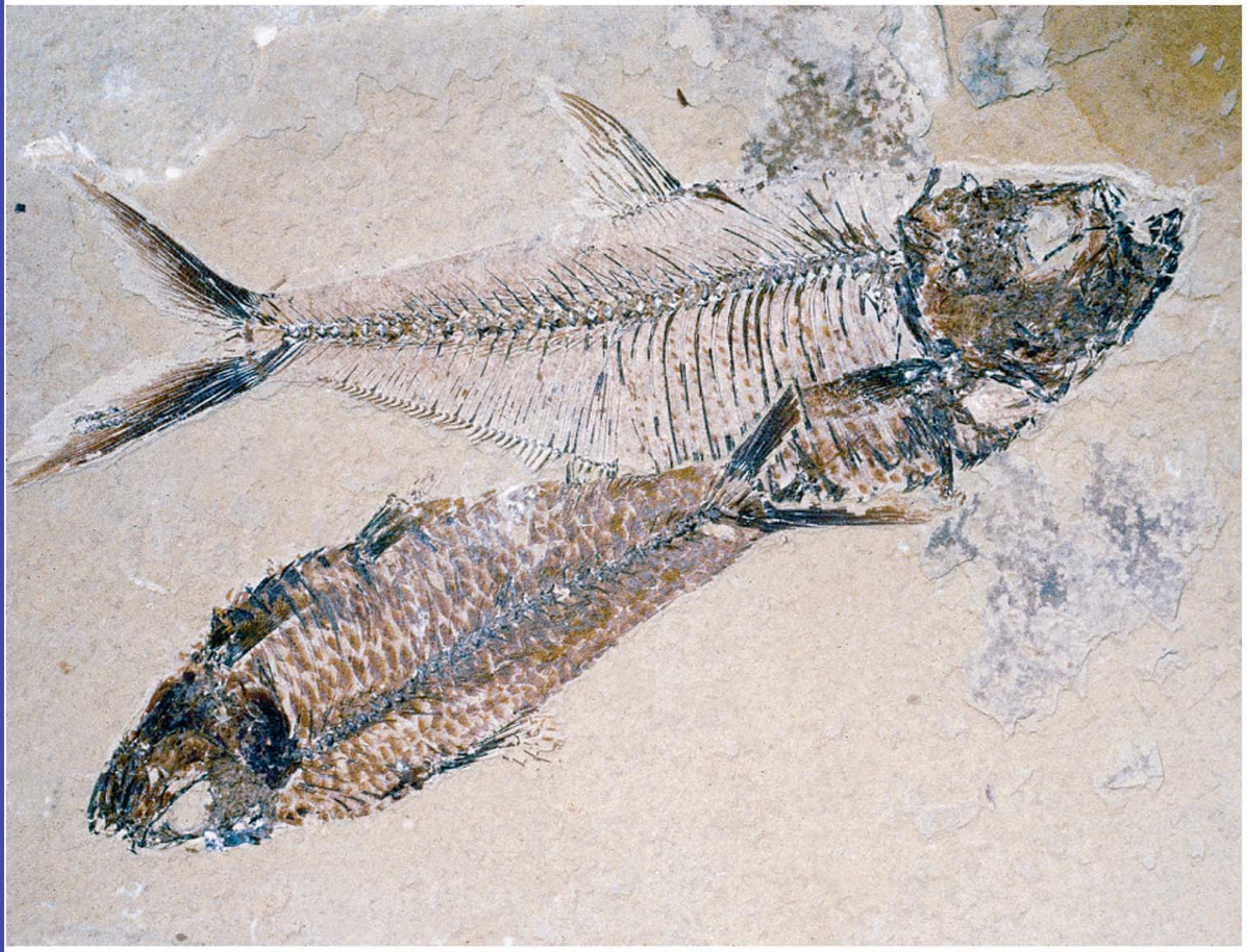
Eocene Mammal (54.8-33.7 Mya)

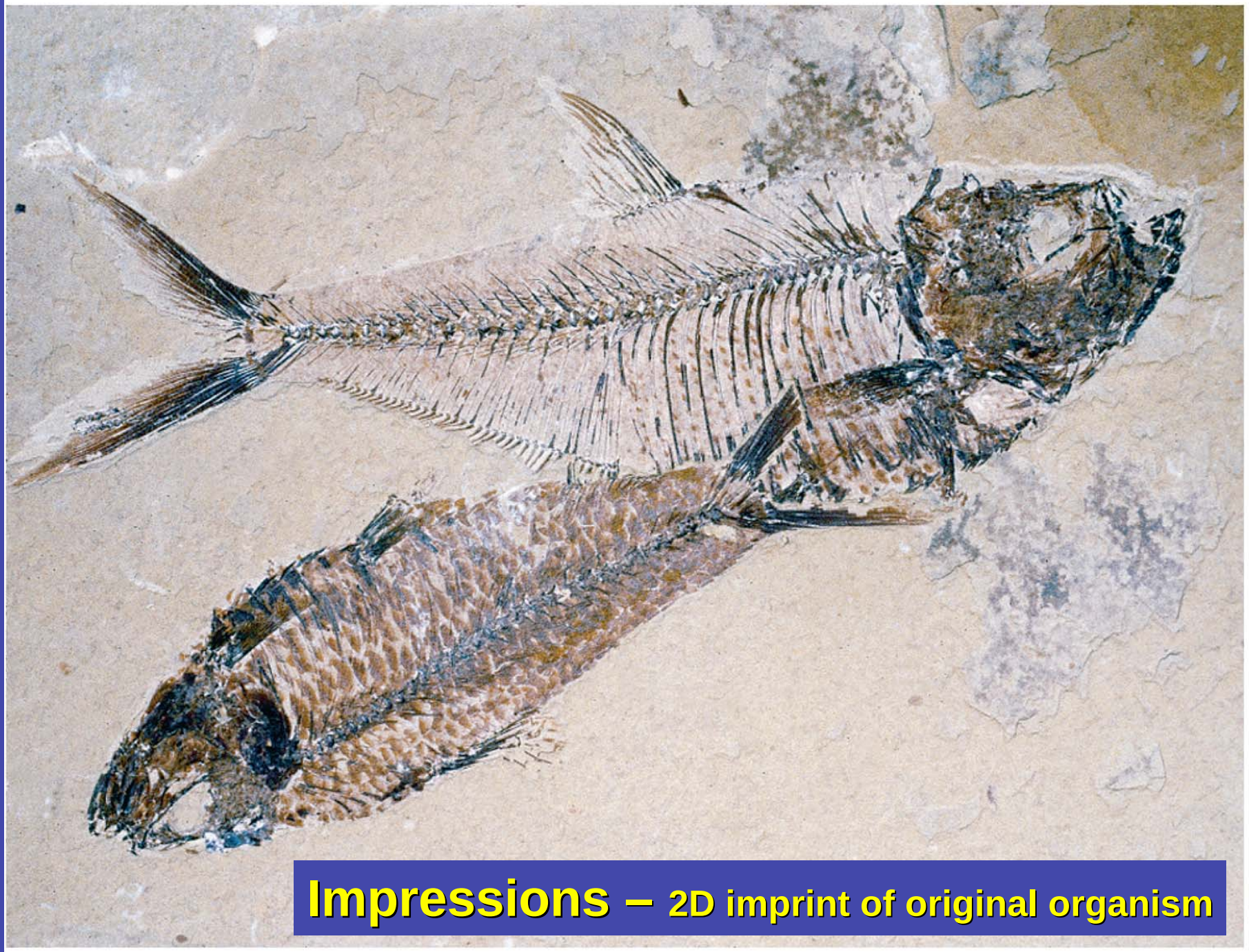



Petrified Wood – organic materials replaced with minerals




Casts – 3D imprint of original organism





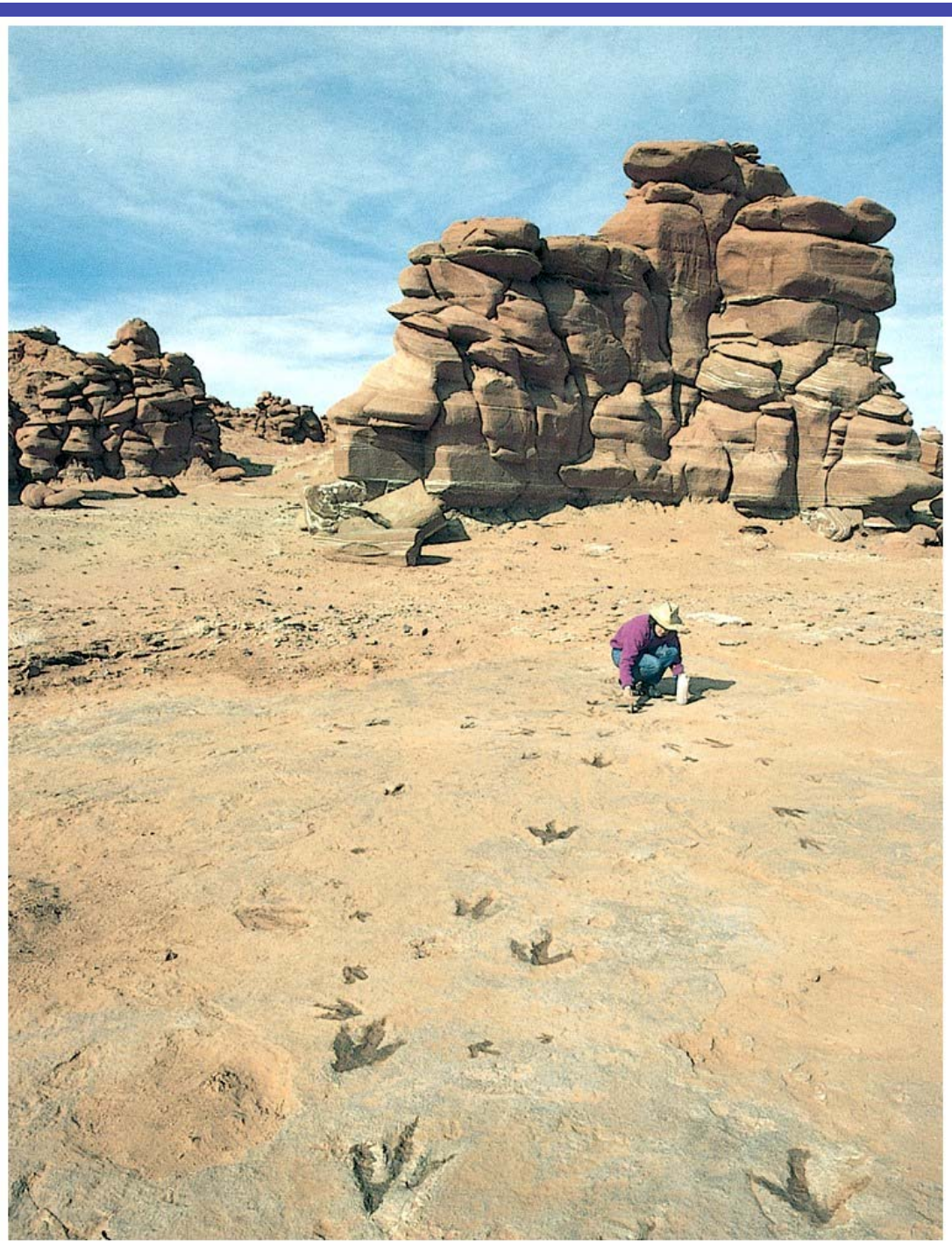
Impressions – 2D imprint of original organism



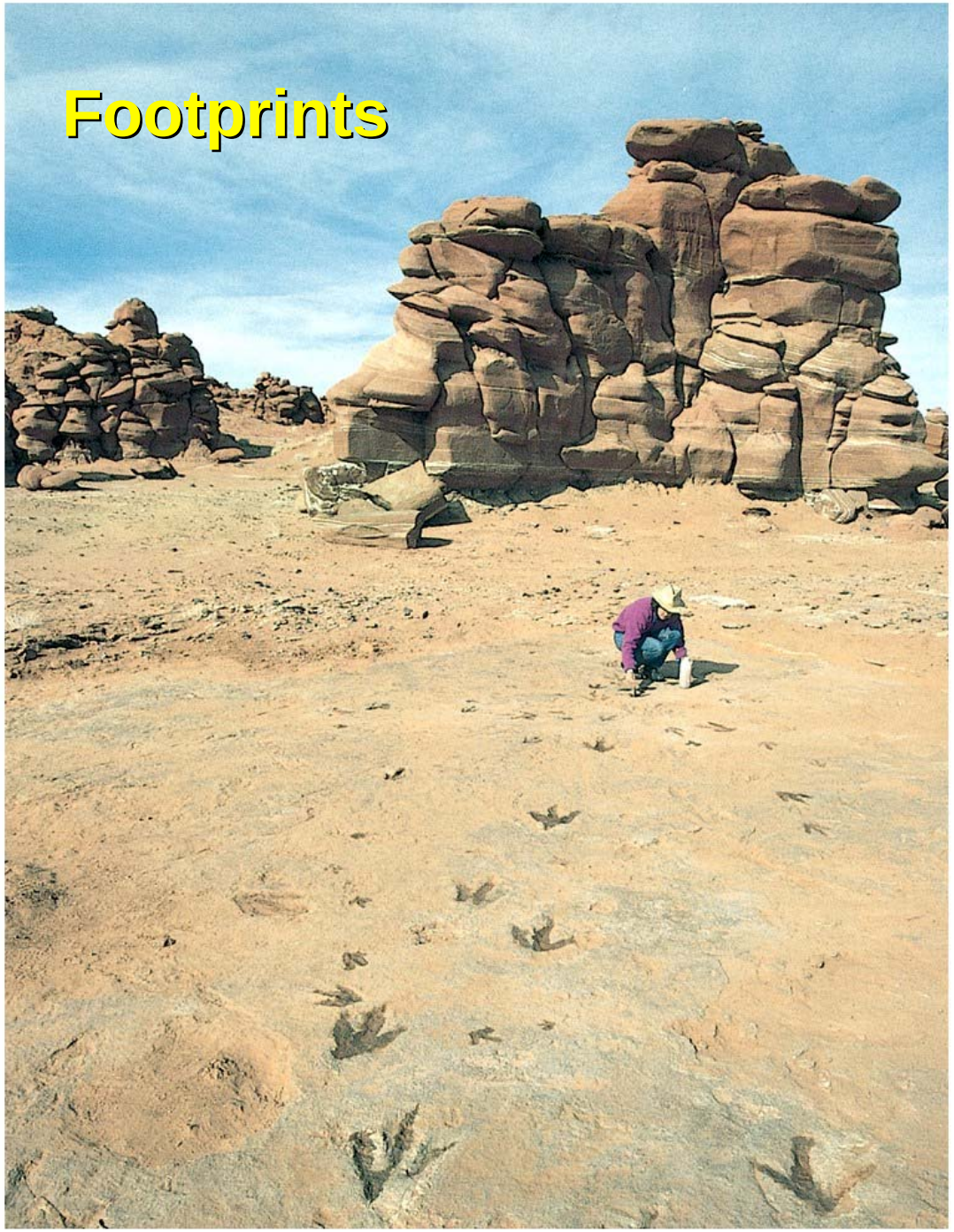

Carbon films –
anoxic burial preserves carbon residue




Amber – fossil tree resin



Footprints







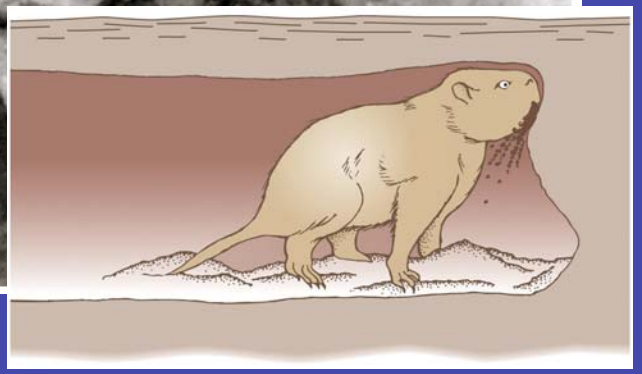
Coprolites (feces)

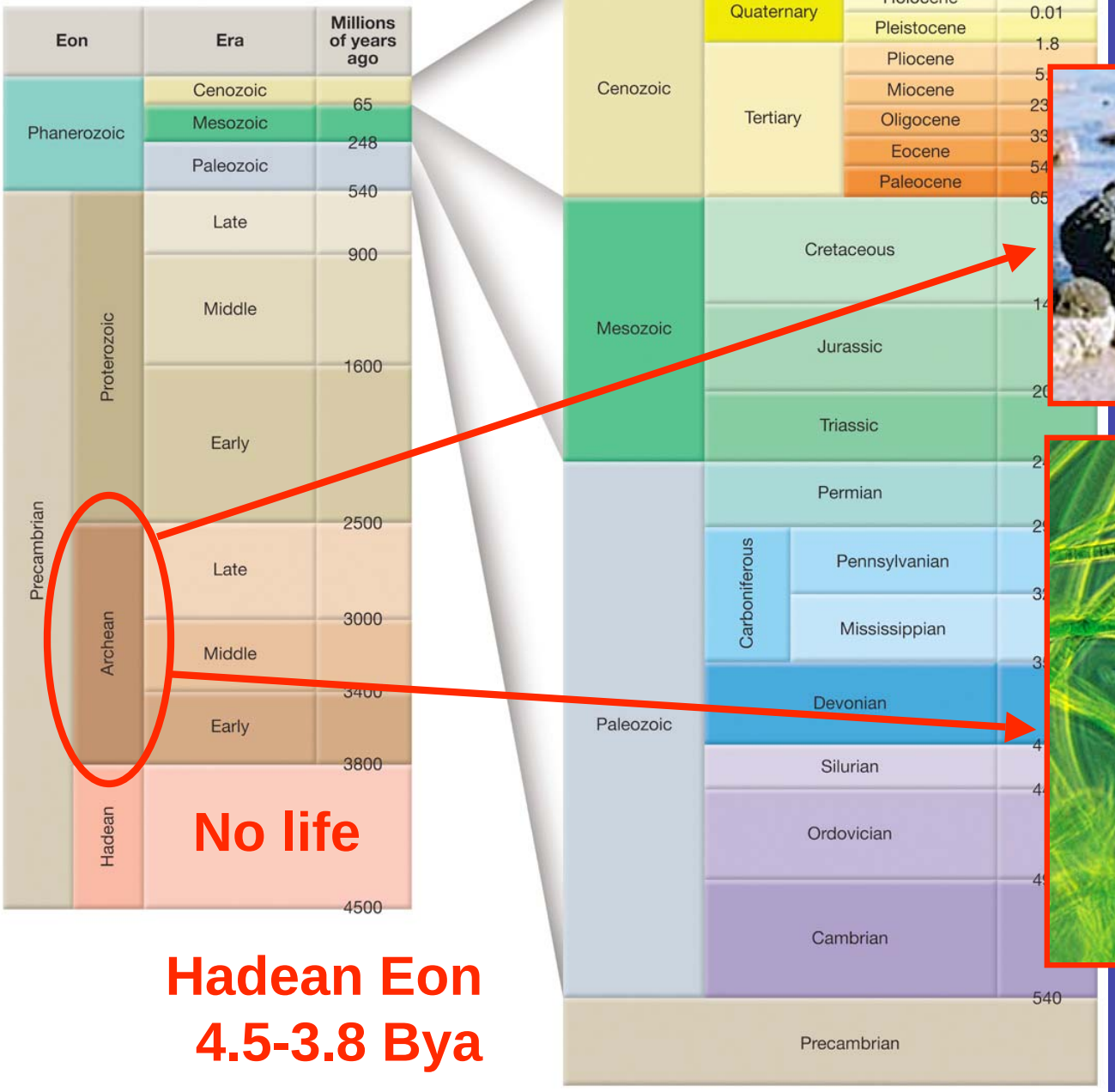






Burrows





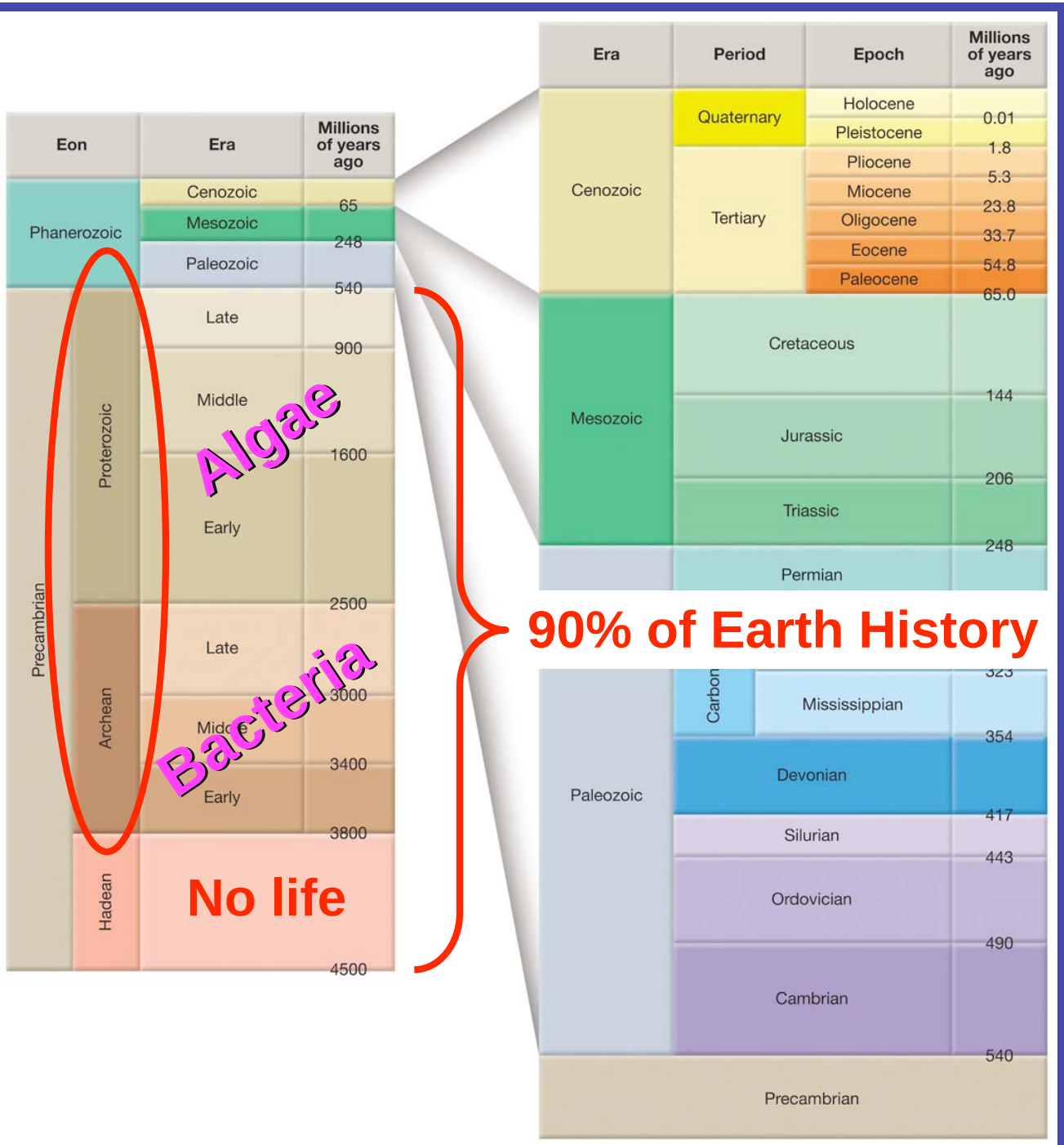
Hadean Eon
4.5-3.8 Bya

Stromatolites



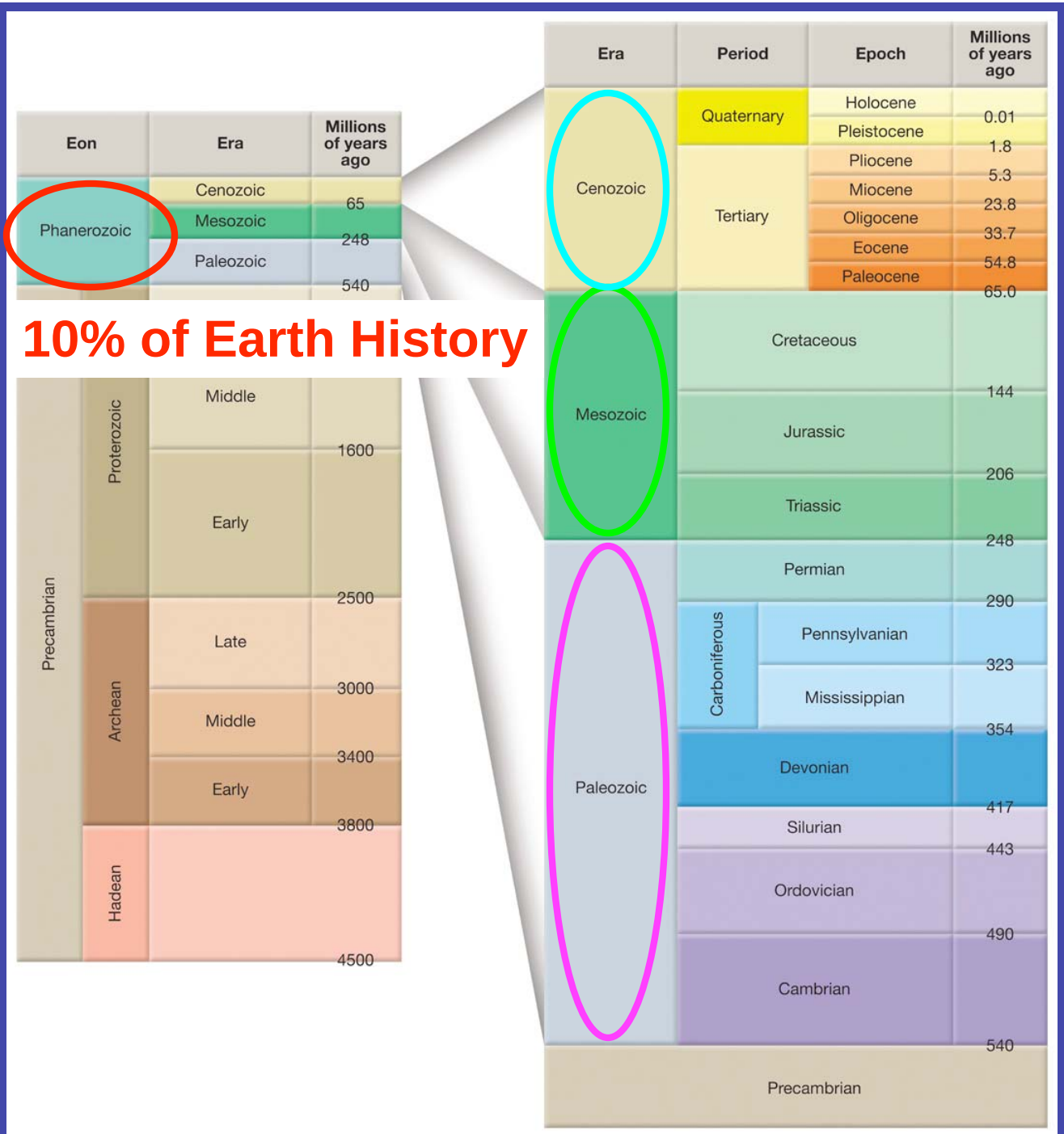


Bacteria



Fossils
define the:

Geologic Timescale



Phanerozoic

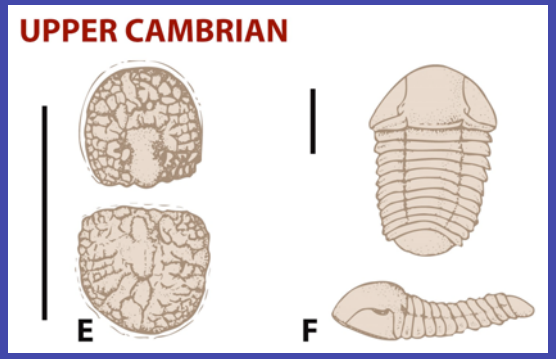
“Visible life”

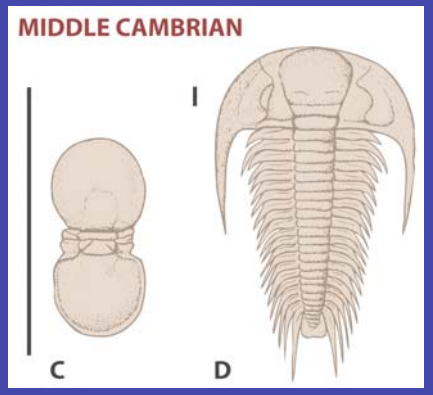
Recent life

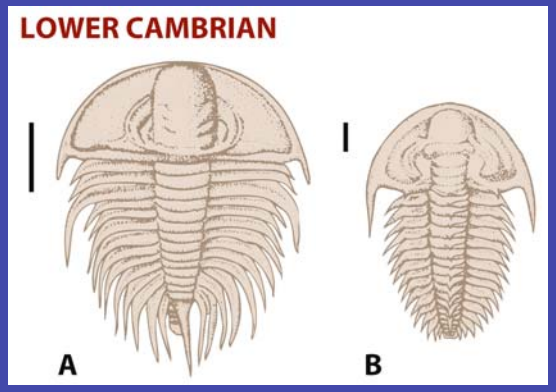
Middle life

Ancient life

Early Paleozoic (Ancient Life) – Trilobites: arthropods, 15k species









Middle Paleozoic (A.L.) – Jawed Fish: vertebrate predator; Seed Plants

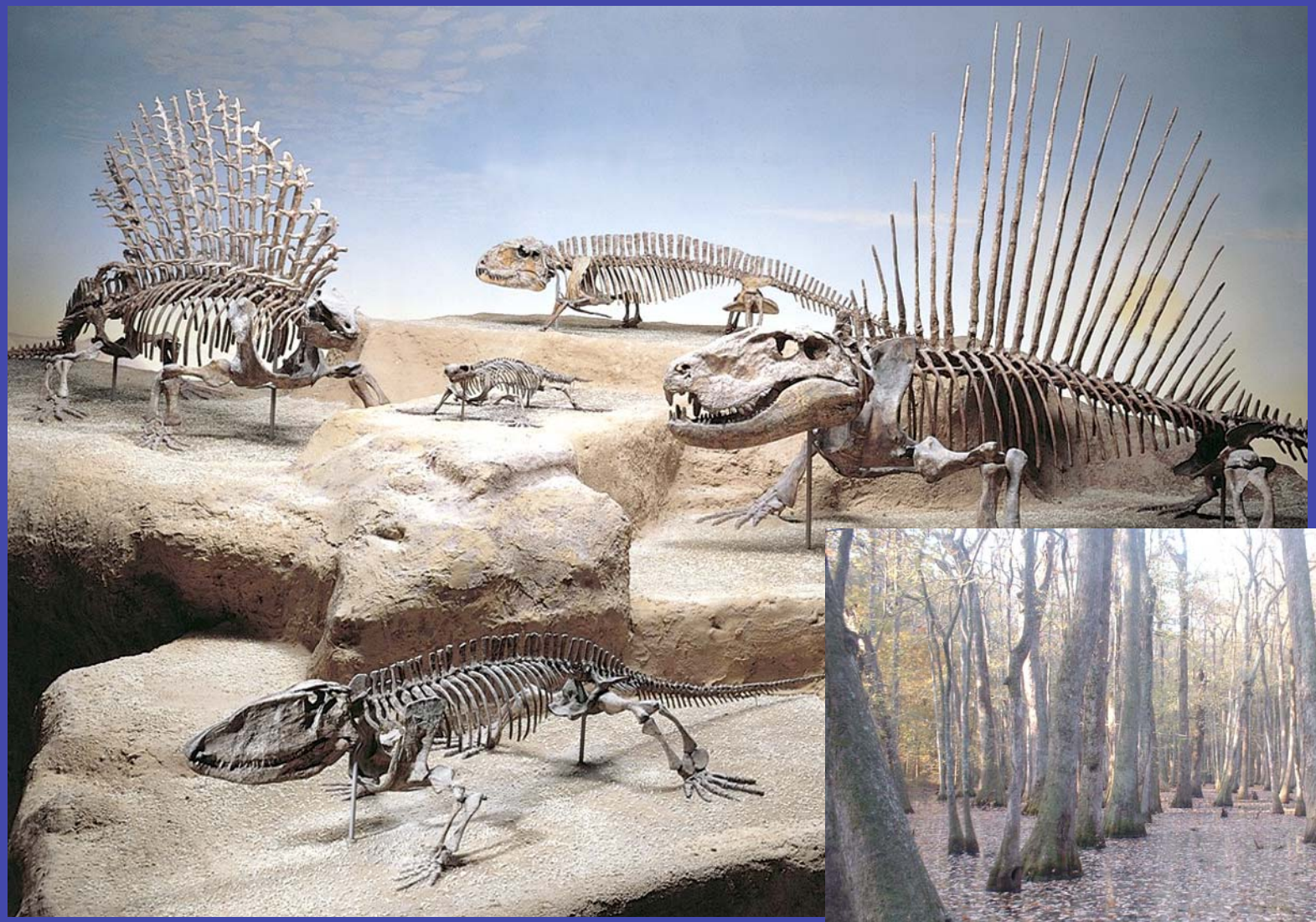


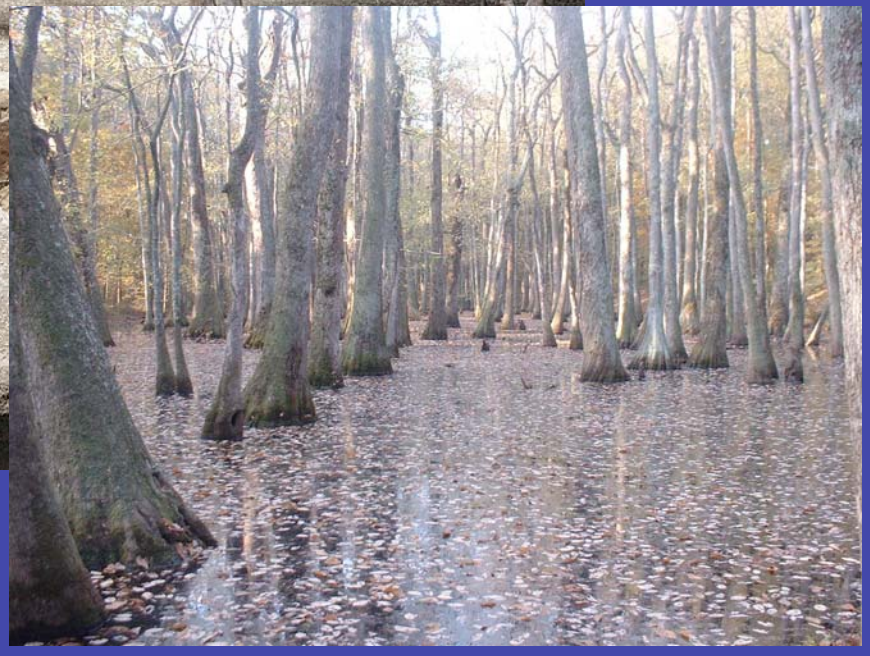




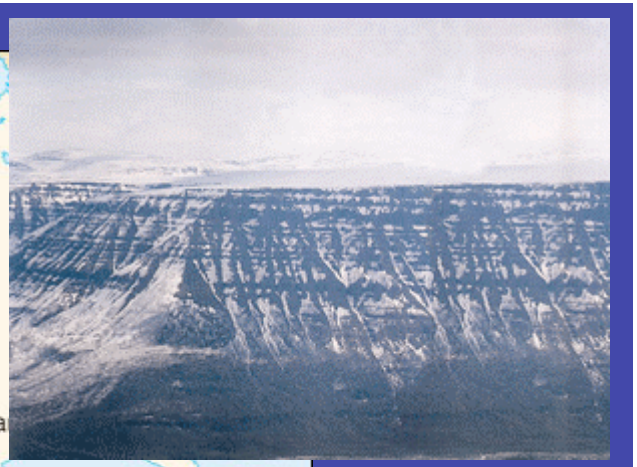


Late Paleozoic (A.L.) – Reptiles such as Dimetrodon, Coal Swamps









Permian Extinction

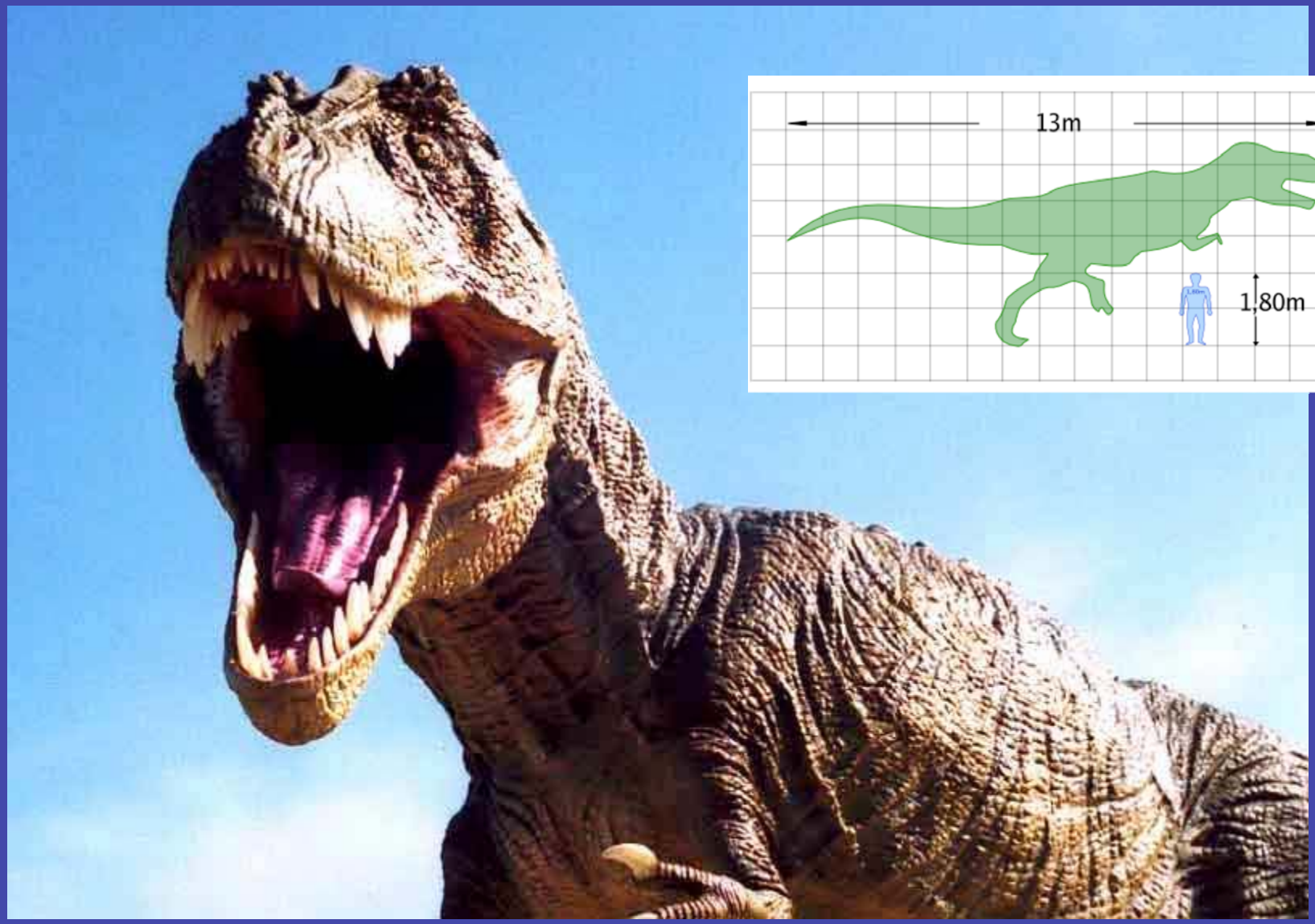
96% marine

70% terrestrial

Siberian Flood basalts: 251-250 Mya, 1-4 million km^3

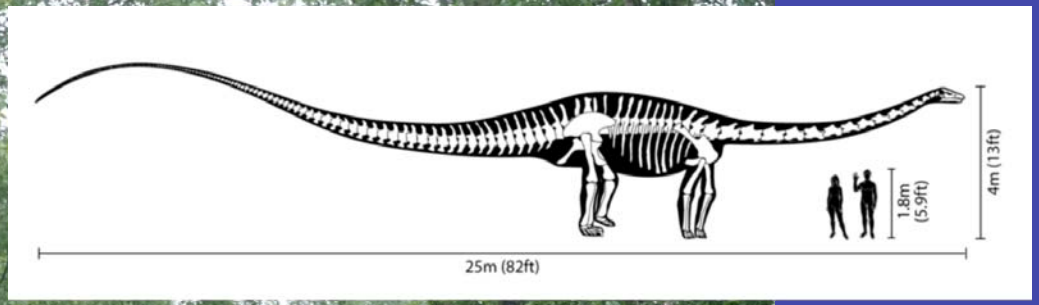


Early Mesozoic (Middle Life) – DINOSAURS!



T-rex: bipedal predator 13m long, 7.5 tons, hollow bones

Early Mesozoic (Middle Life) – DINOSAURS!



Sauropods: largest animals ever by an order of magnitude
40m long, 18m high, 90-110 tons

Early Mesozoic (Middle Life) – DINOSAURS!

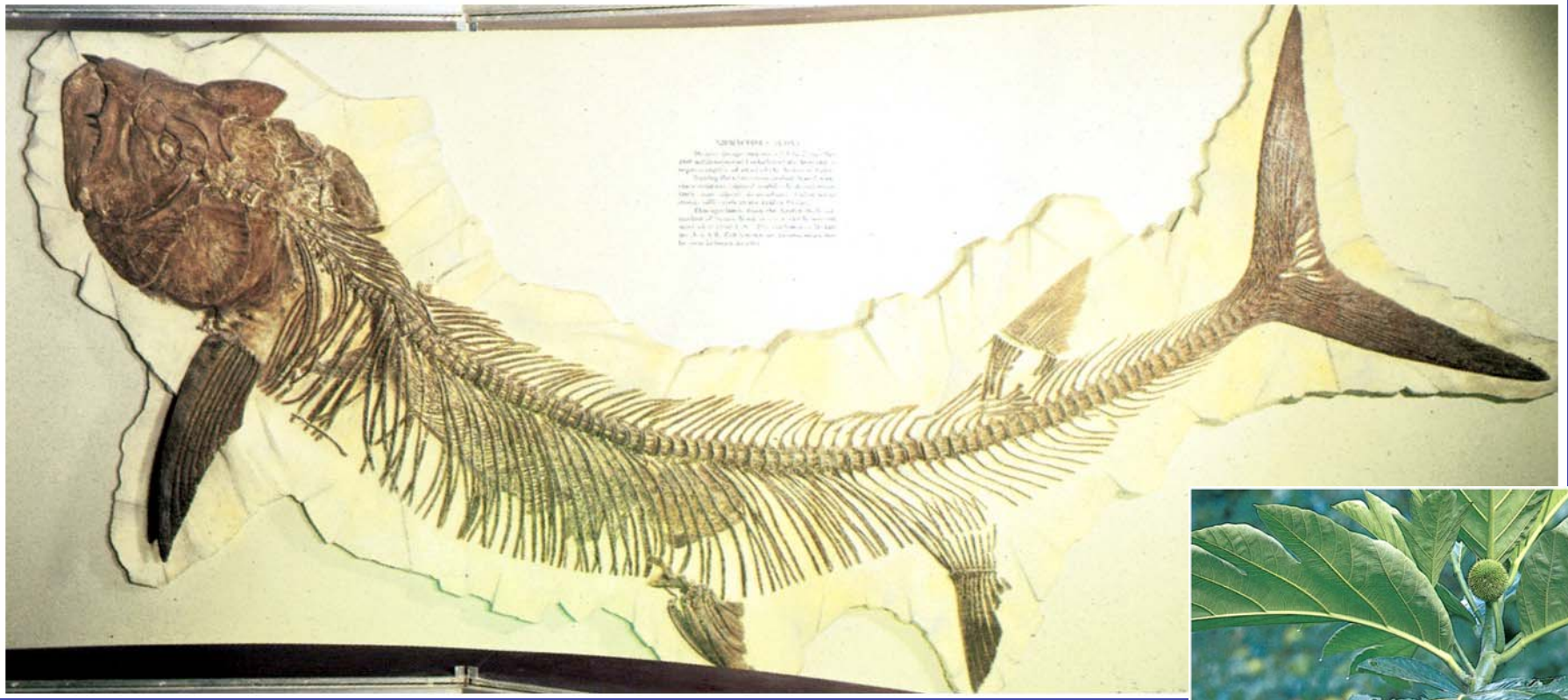




Median dinosaur weight 2 tons

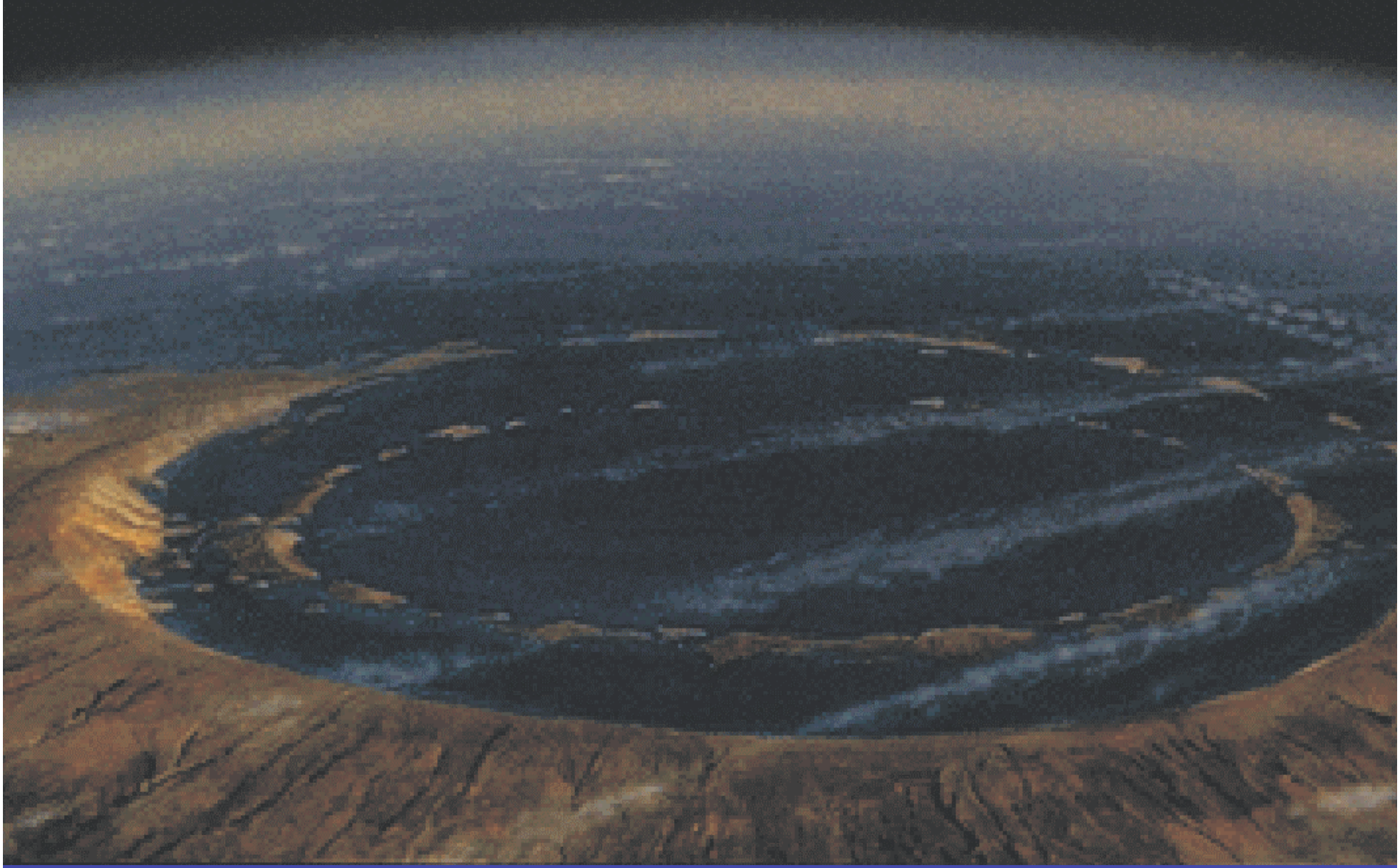


Late Mesozoic (Middle Life) – Chalk (Cretaceous), modern fish



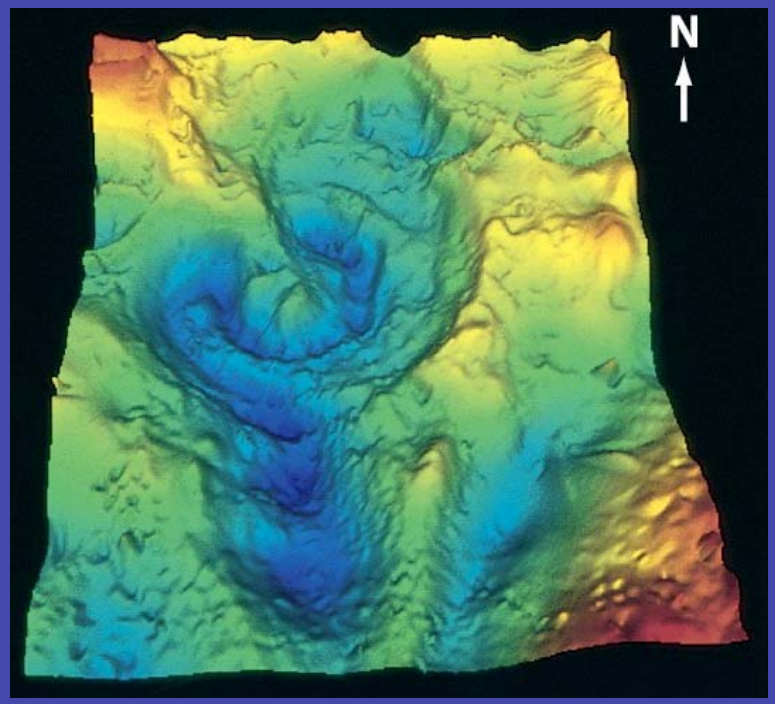


End of the Dinosaurs

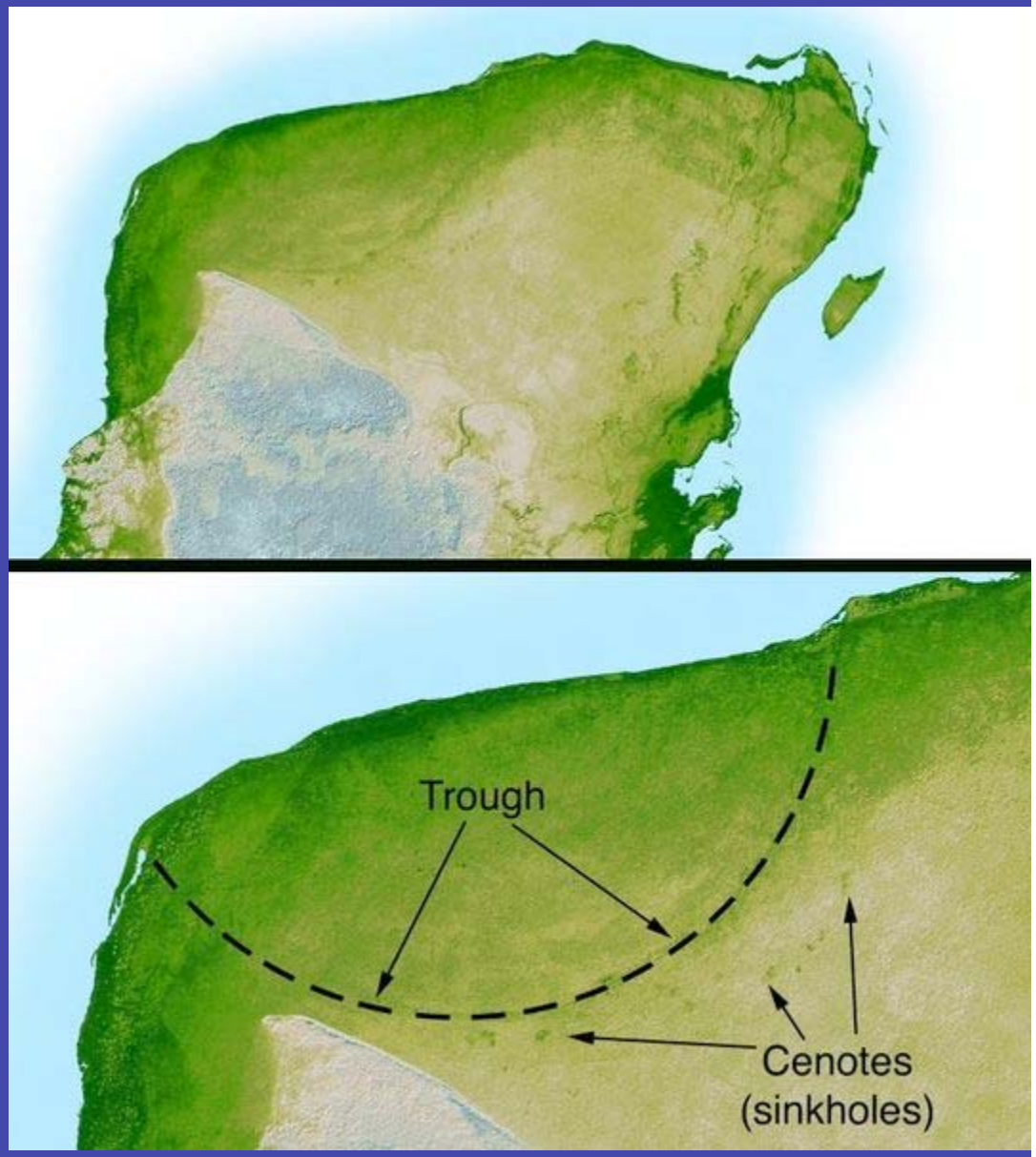


Chicxulub Crater – >180km across





Andesite layer 1.3km down



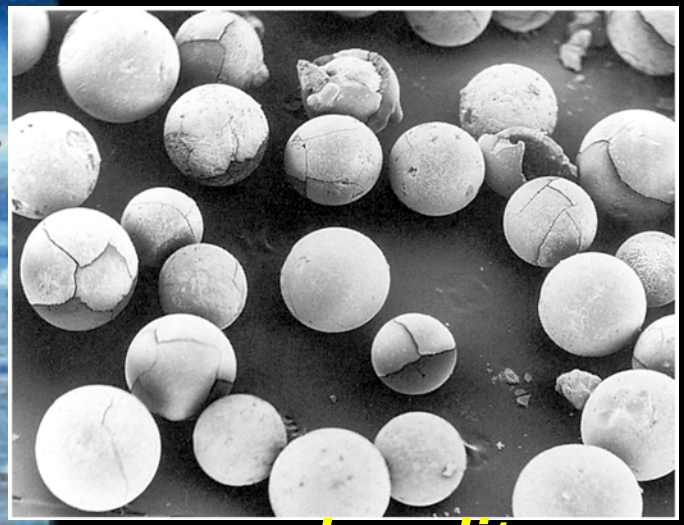
10 km across ***(not to scale!)***



2 million times more powerful than largest nuclear explosion

K/T Boundary

65 Mya



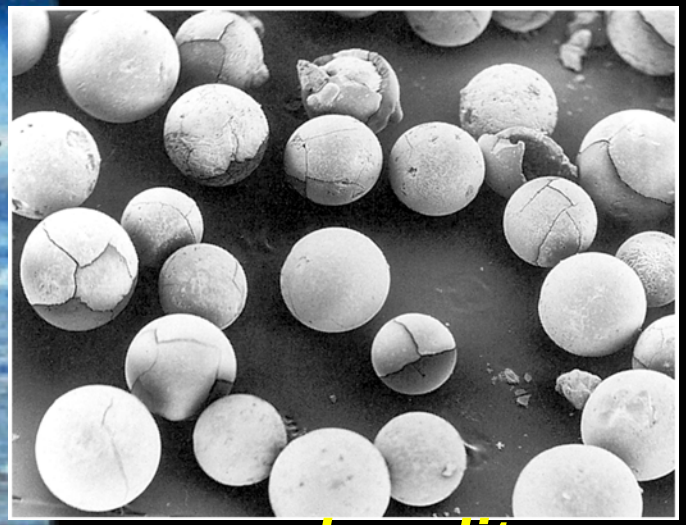
spherulites

10 km across ***(not to scale!)***

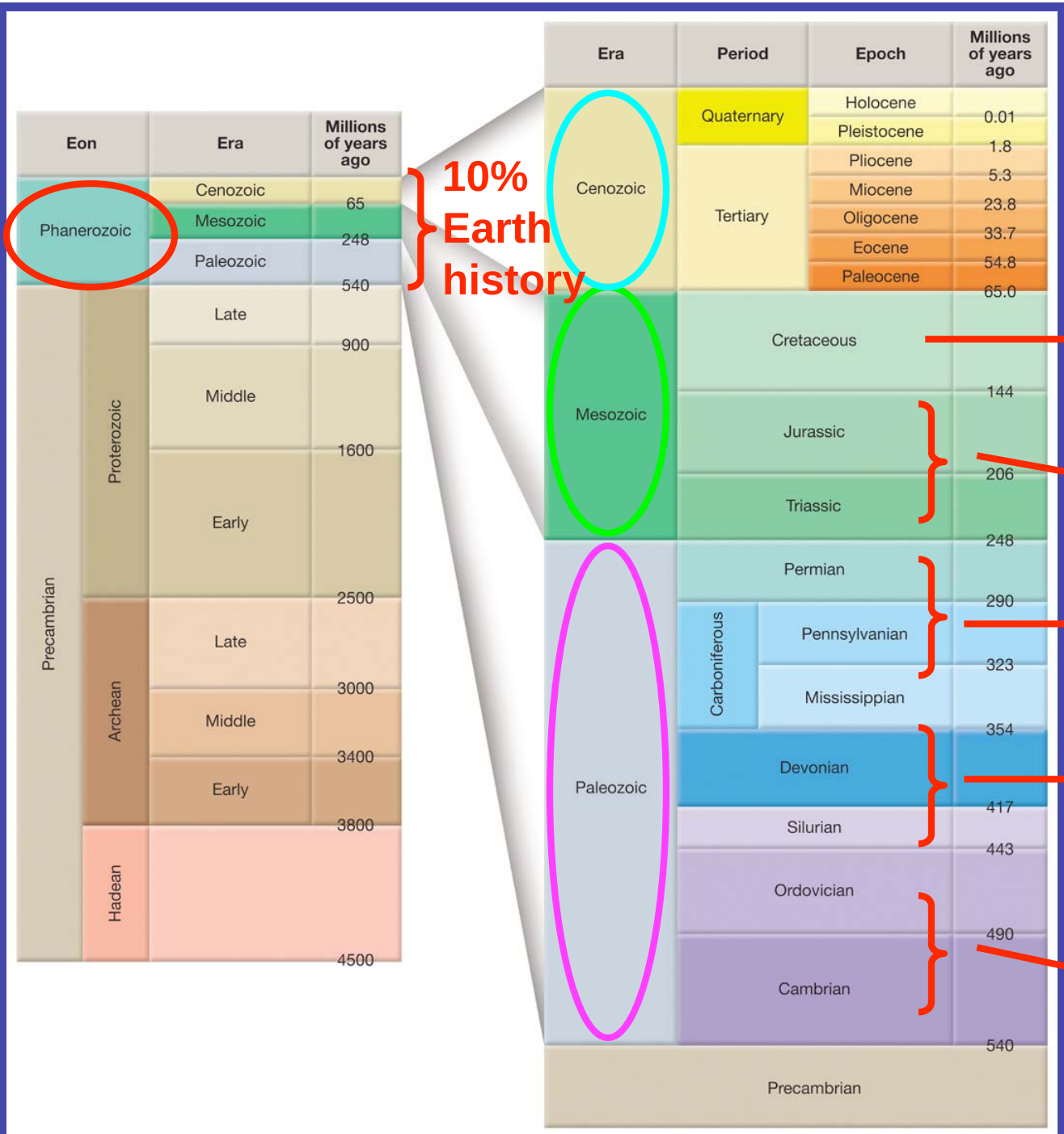


1) Mega-tsunami kilometers high

2) Nuclear winter from atmospheric debris

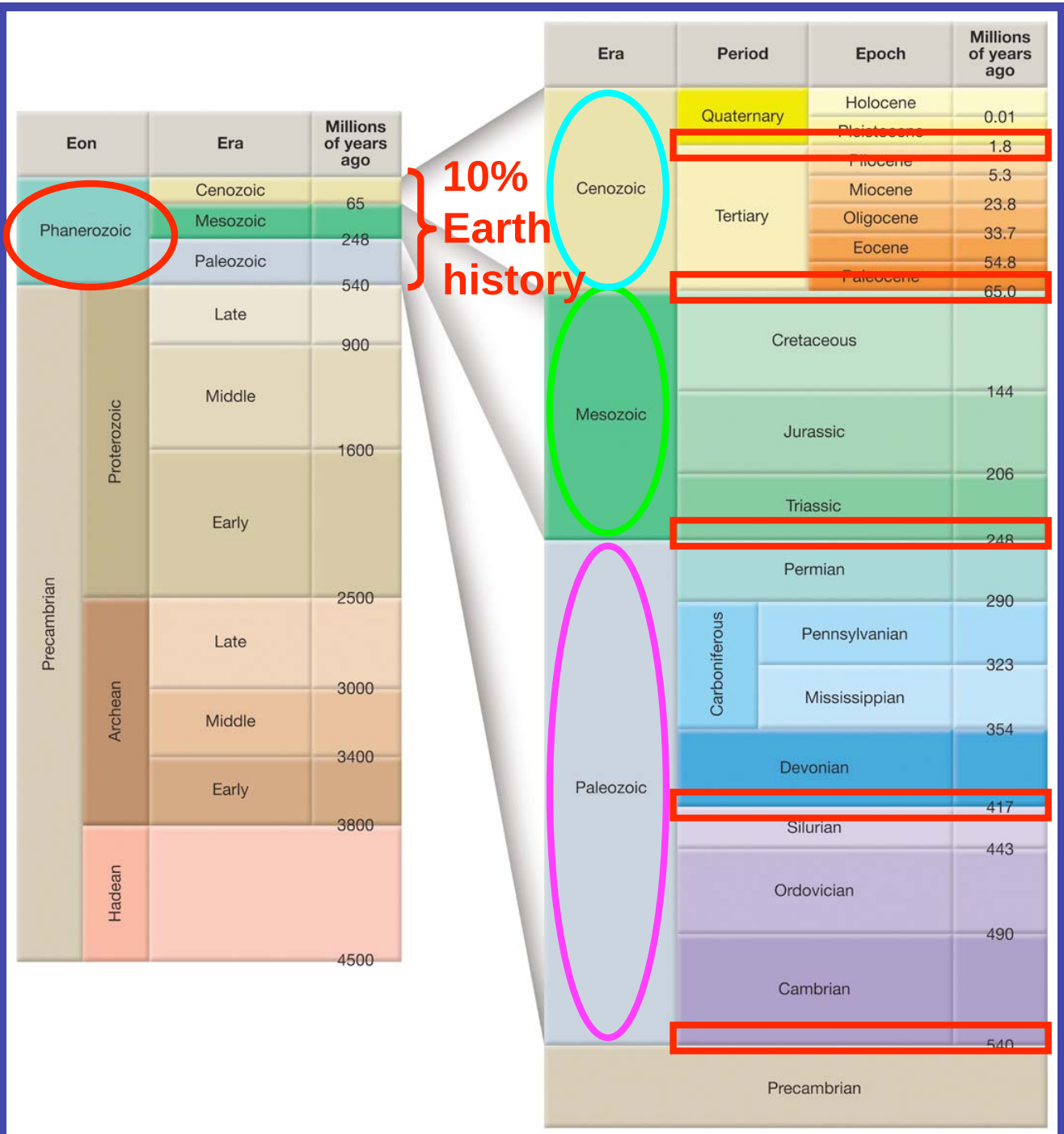


spherulites


Eon
Era
Millions of years ago
Phanerozoic
Cenozoic
Mesozoic
Paleozoic
65
248
540
Precambrian
Proterozoic
Late
Middle
Early
900
1600
2500
Archean
Late
Middle
Early
3000
3400
3800
Hadean
4500
10% Earth history
Era
Period
Epoch
Millions of years ago
Cenozoic
Quaternary
Holocene
Pleistocene
0.01
1.8
Tertiary
Pliocene
Miocene
Oligocene
Eocene
Paleocene
5.3
23.8
33.7
54.8
65.0
Mesozoic
Cretaceous
Jurassic
Triassic
144
206
248
Paleozoic
Permian
Carboniferous
Pennsylvanian
Mississippian
290
323
354
Devonian
Silurian
417
443
Ordovician
Cambrian
490
540
Precambrian
Evolutionary Highlights:
Modern fish
Dinosaurs
Reptiles
First jawed fish
Trilobites



The sensor is a Geiger-Müller tube, an inert gas-filled tube (usually Helium, Neon or Argon with Halogens added) that briefly conducts electricity when a particle or photon of radiation temporarily makes the gas conductive. The tube amplifies this conduction by a cascade effect and outputs a current pulse, which is then often displayed by a needle or lamp and/or audible clicks. Modern instruments can report radioactivity over several orders of magnitude.



Extinctions define boundaries on geologic timescale:

1) Meteorite Impacts
2) Plate Reorganization
3) Volcanism
4) Astronomical Events
5) Etc…

Result:

Climate change

Early Cenozoic (Recent Life) – Radiation of mammals





Paraceratherium:
gigantic hornless rhinoceros

Where do you find palm fronds today?



Fossil palm frond



Bahamas



Hawaii

Wyoming?



Where would you expect to find alligators today?

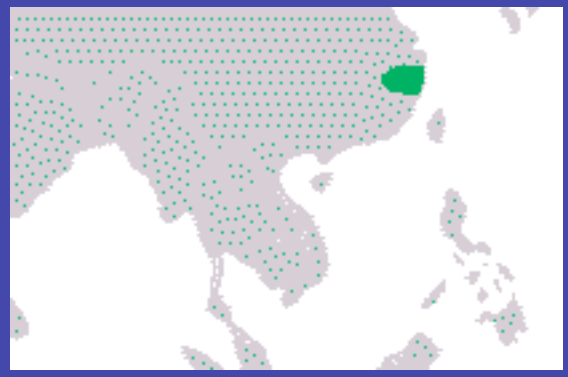


Where would you expect to find alligators today?



Everglades

China





Where would you expect to find alligators today?





Alligator fossils found on Ellesmere Island

78° North
(north of Greenland)
54.8-33.7 Mya
Eocene

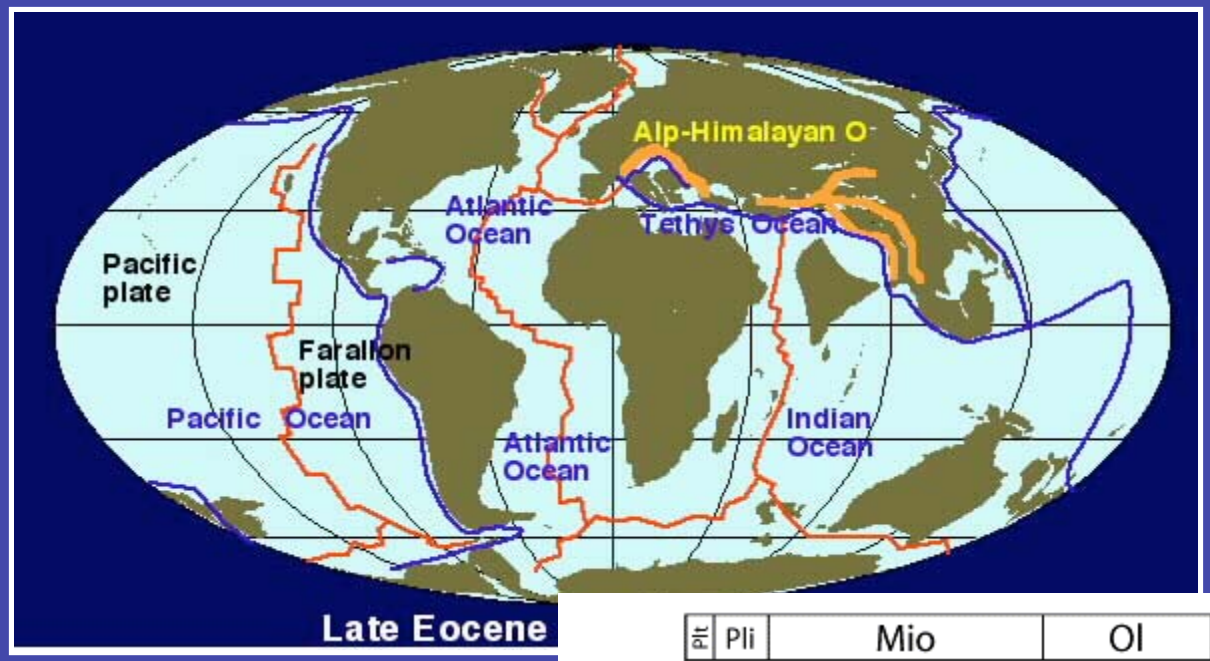






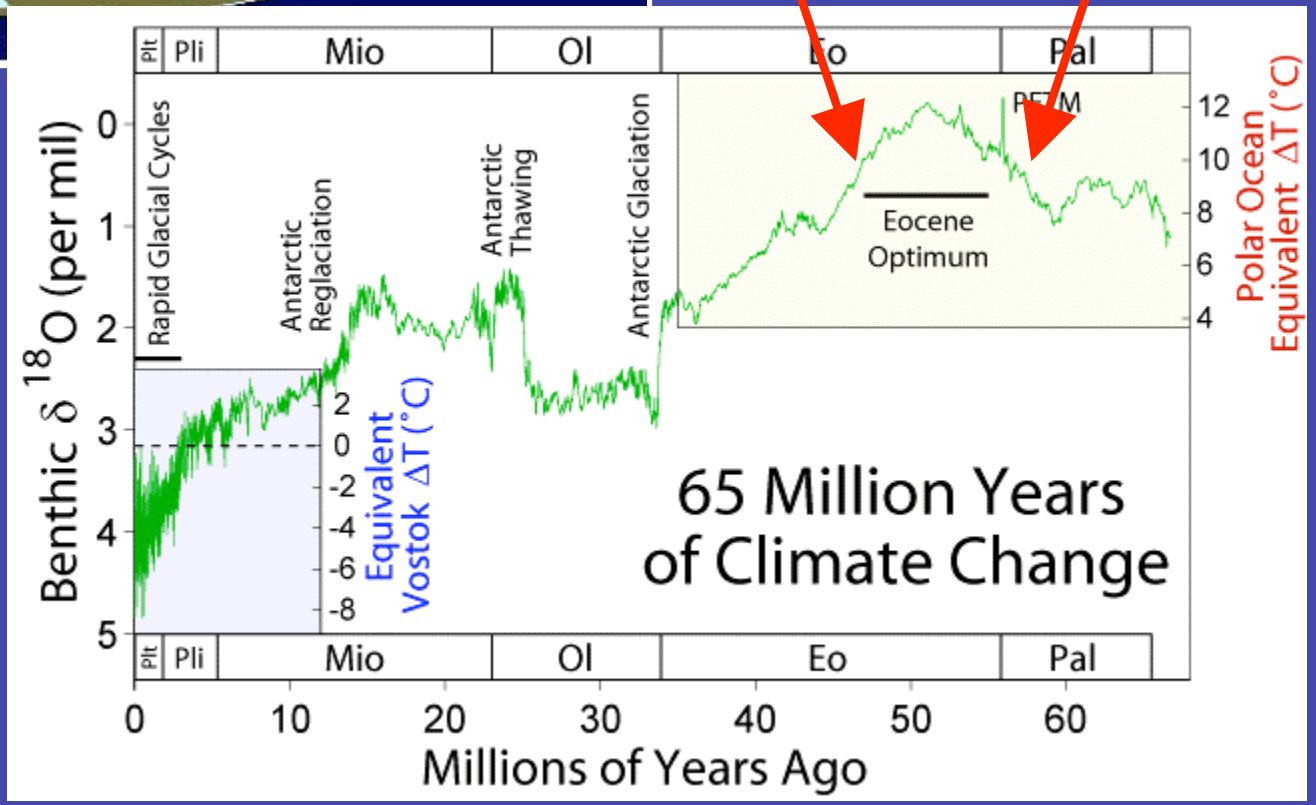
Why was Eocene climate so different from today?

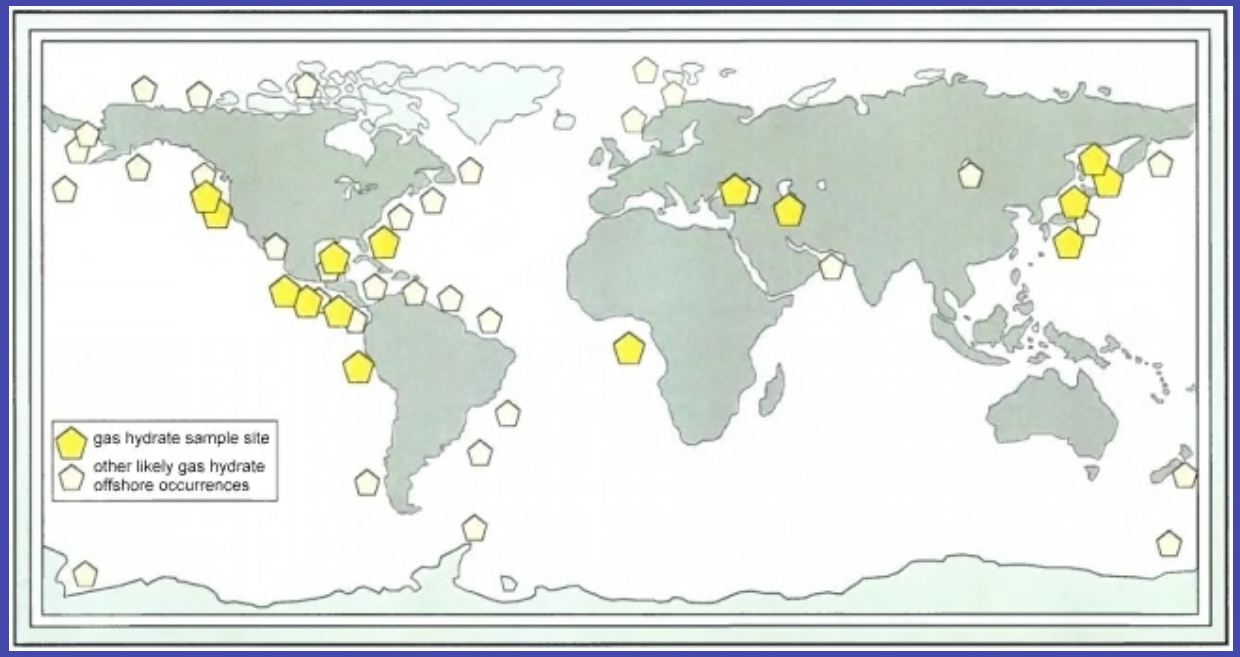


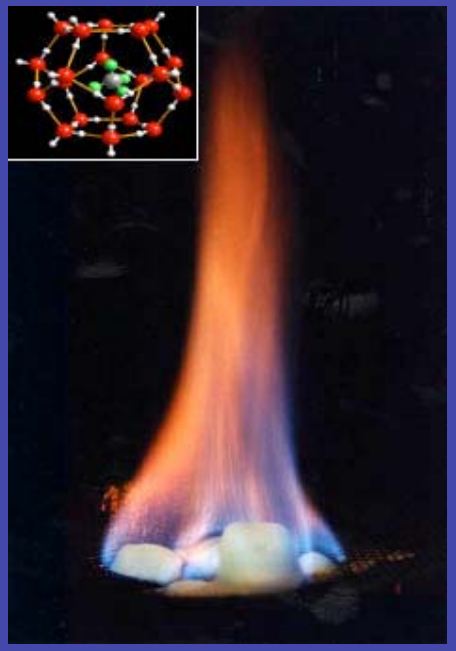


What was going on here to change global temperature?

Paleocene-Eocene Thermal Maximum



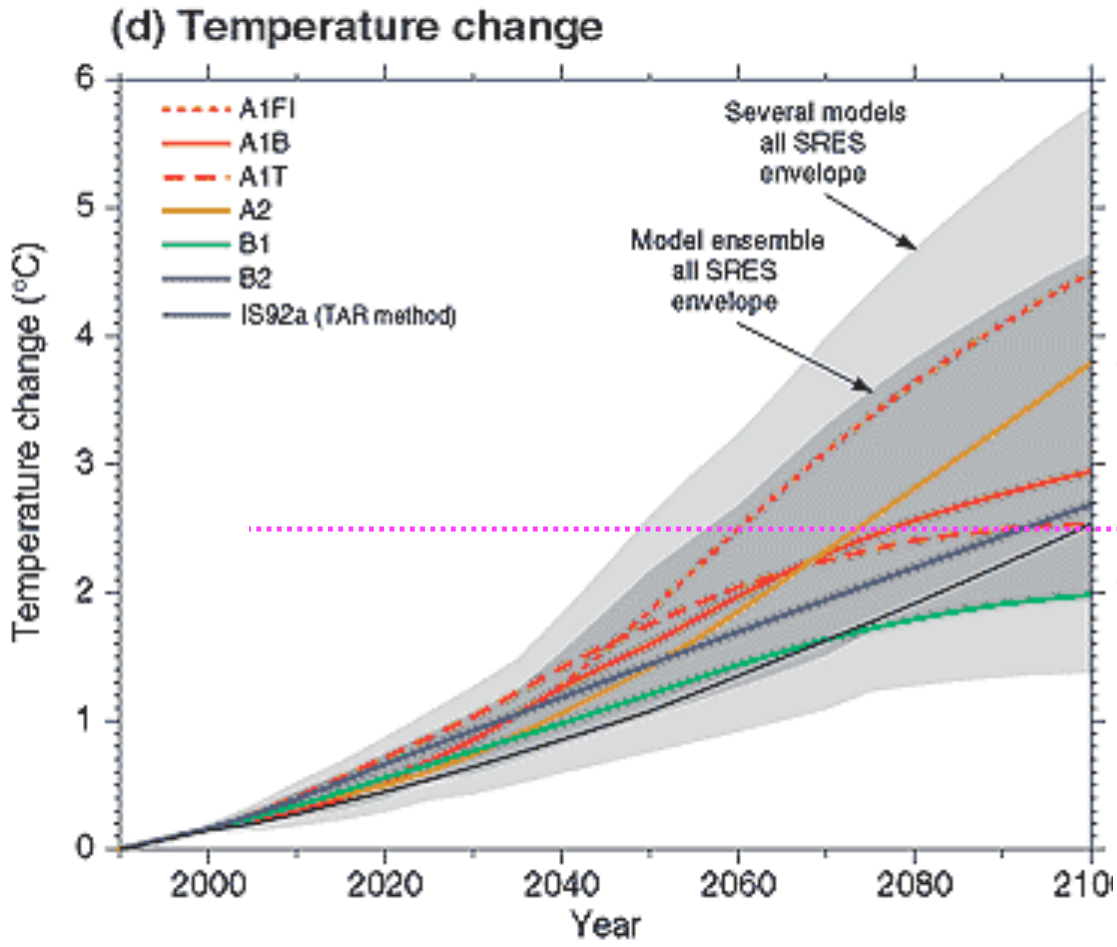


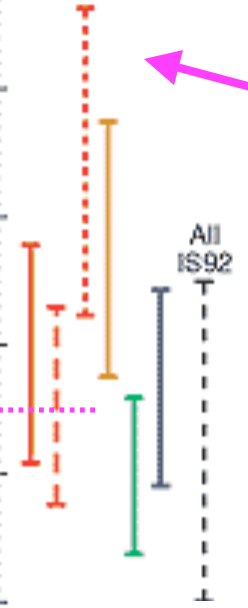


Sea surface temperatures rose 5-8ºC
Arctic Ocean sea surface temperatures were 23ºC
Drastic changes in ocean chemistry
Massive worldwide extinctions

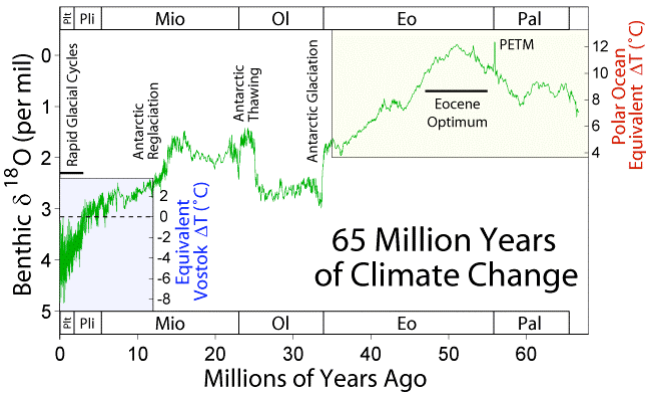
Sudden “global warming” caused by methane?

How is temperature projected to change in our lifetimes?



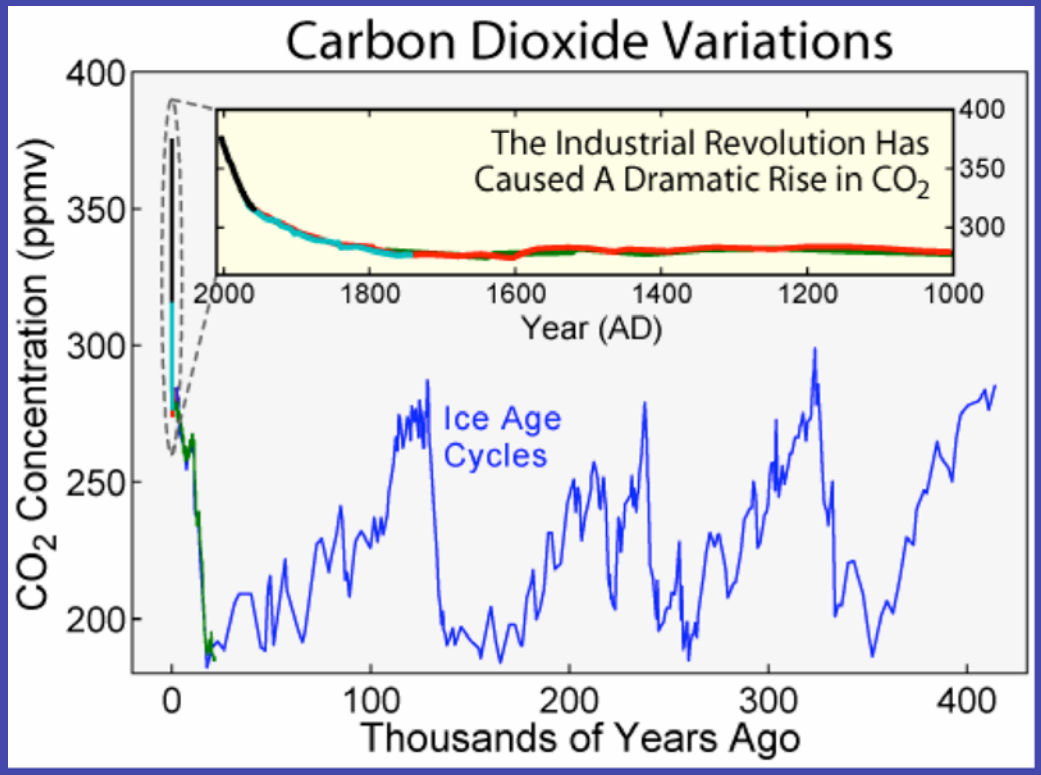


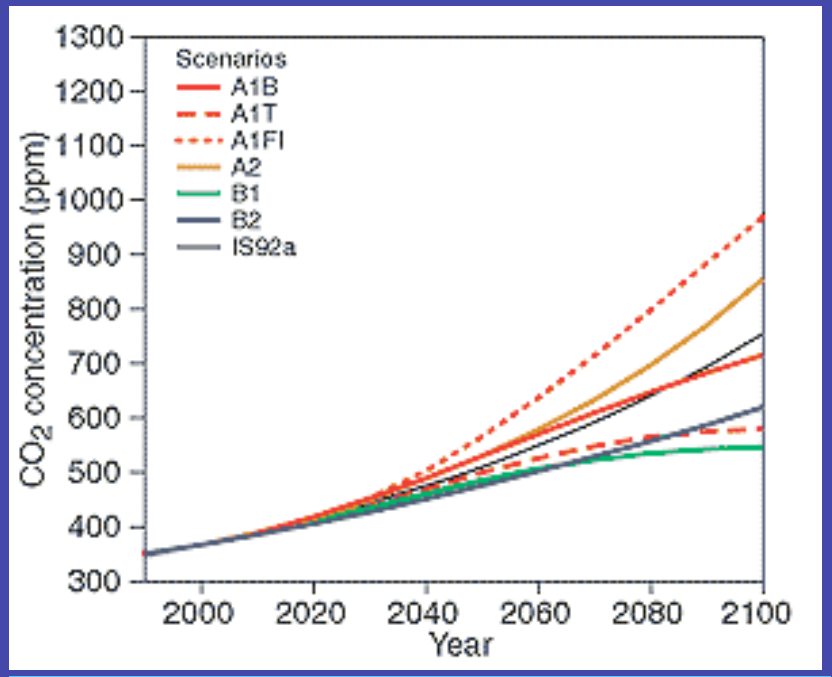
Similar?



Intergovernmental Panel on Climate Change

IS92a = "business as usual"





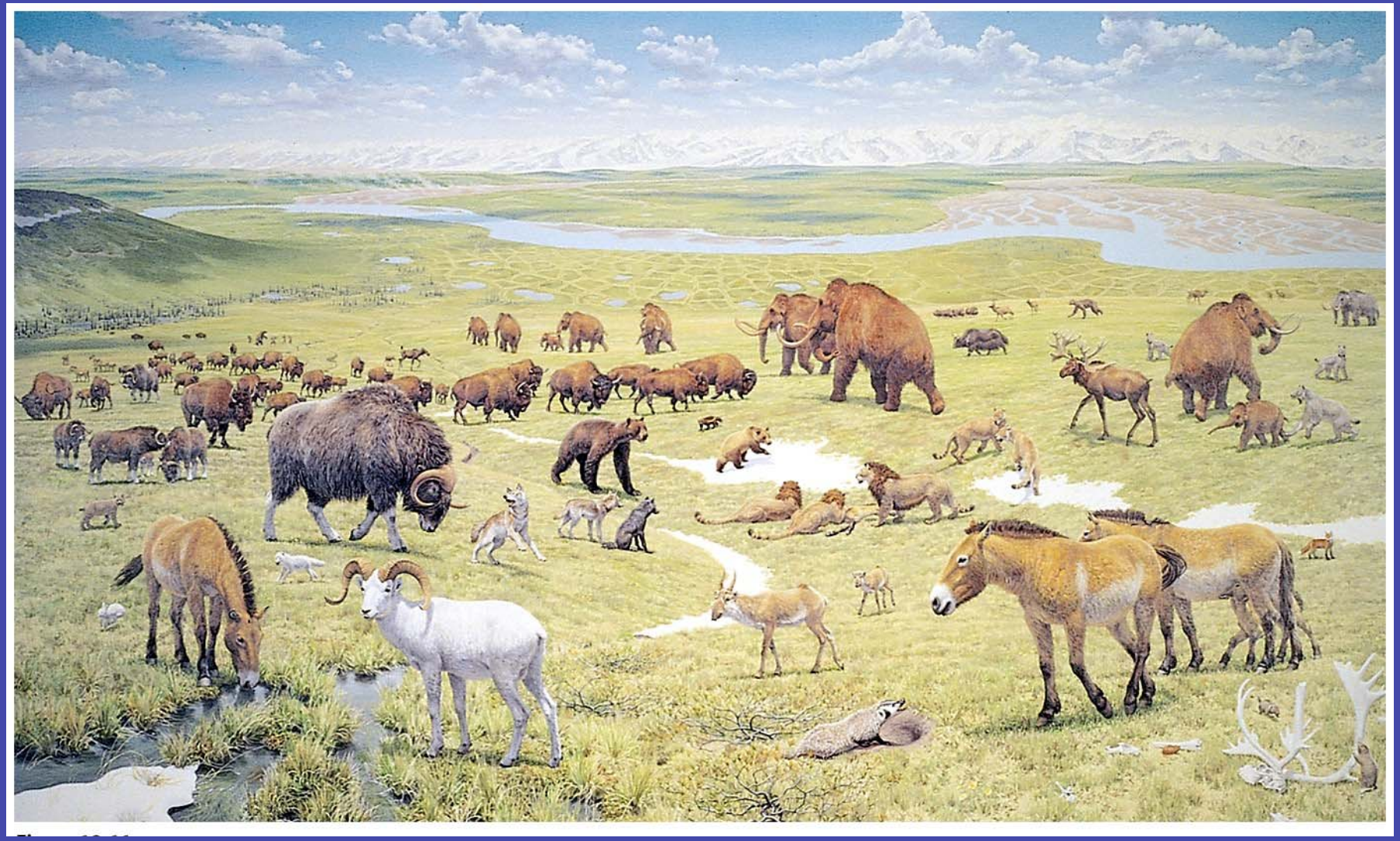


Could we have alligators in the Arctic again?

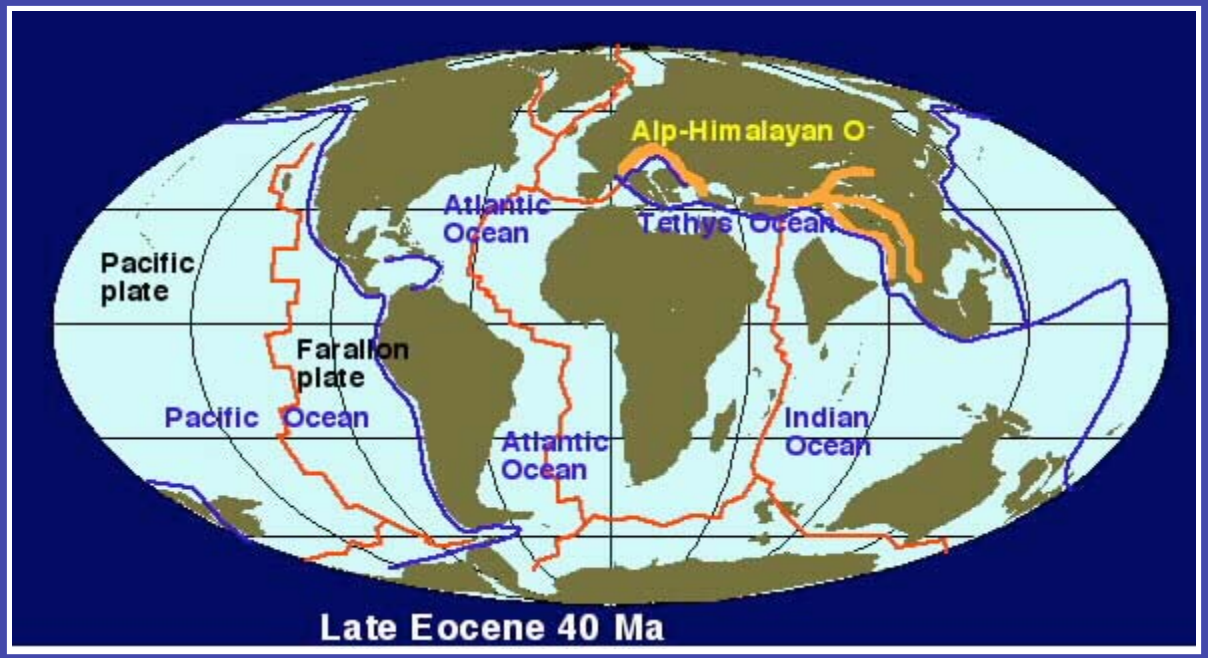


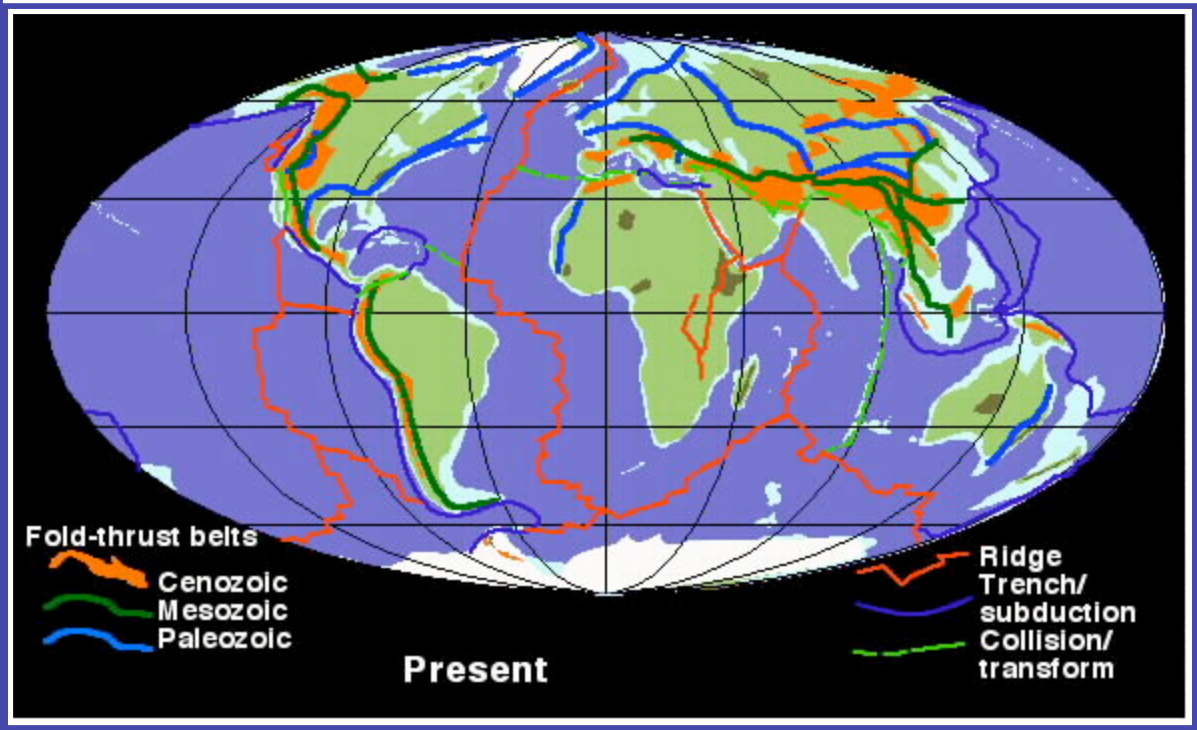


Late Cenozoic (Recent Life) – Diversification of mammals



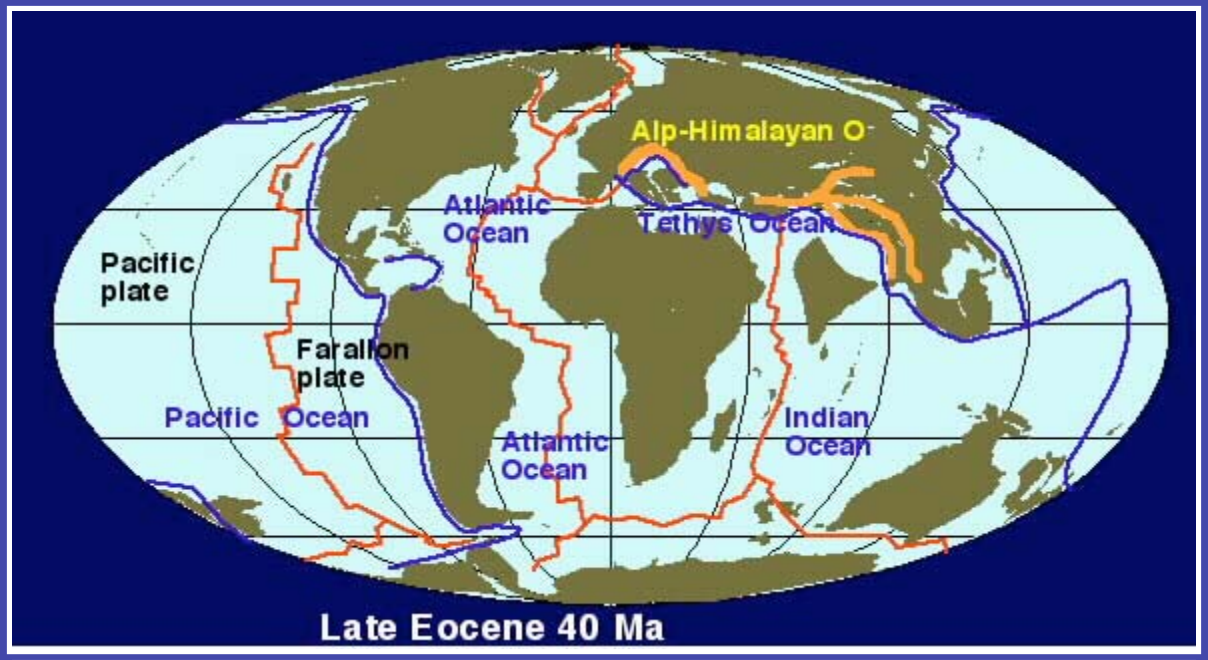
Grassland species thrive

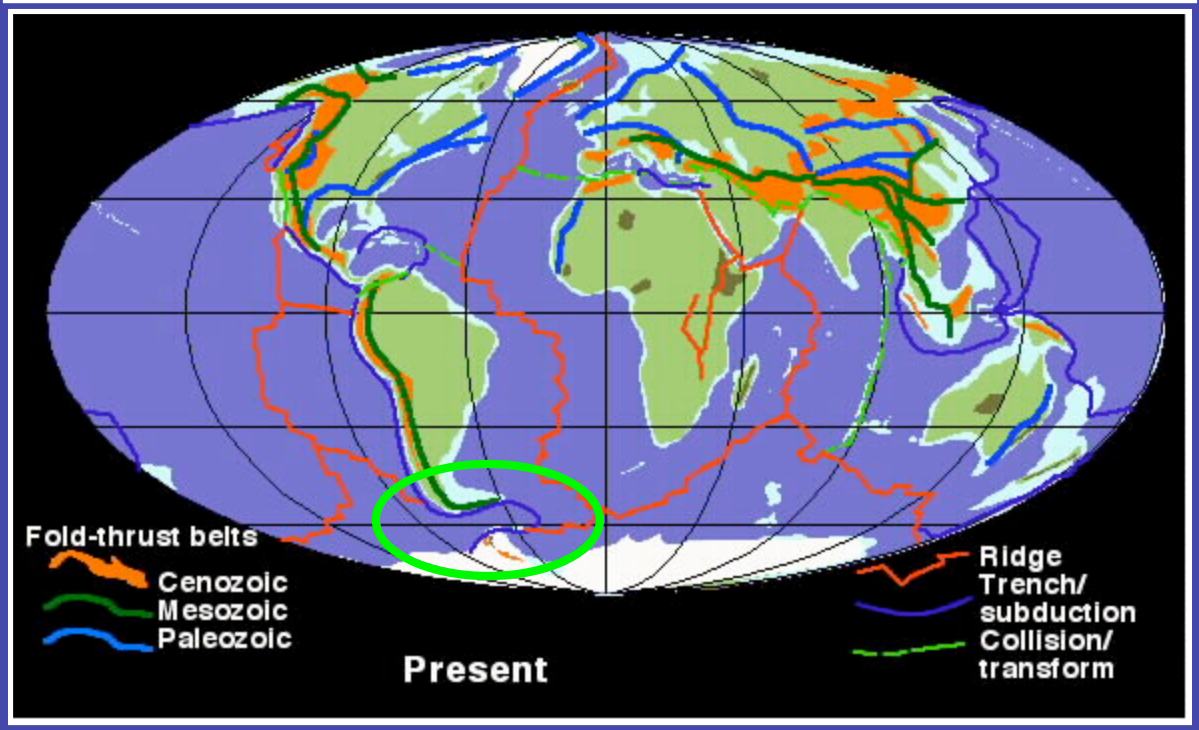




What happened between Eocene and Oligocene?

Have the positions of Wyoming and Ellesmere changed much over the last 40 Mya?



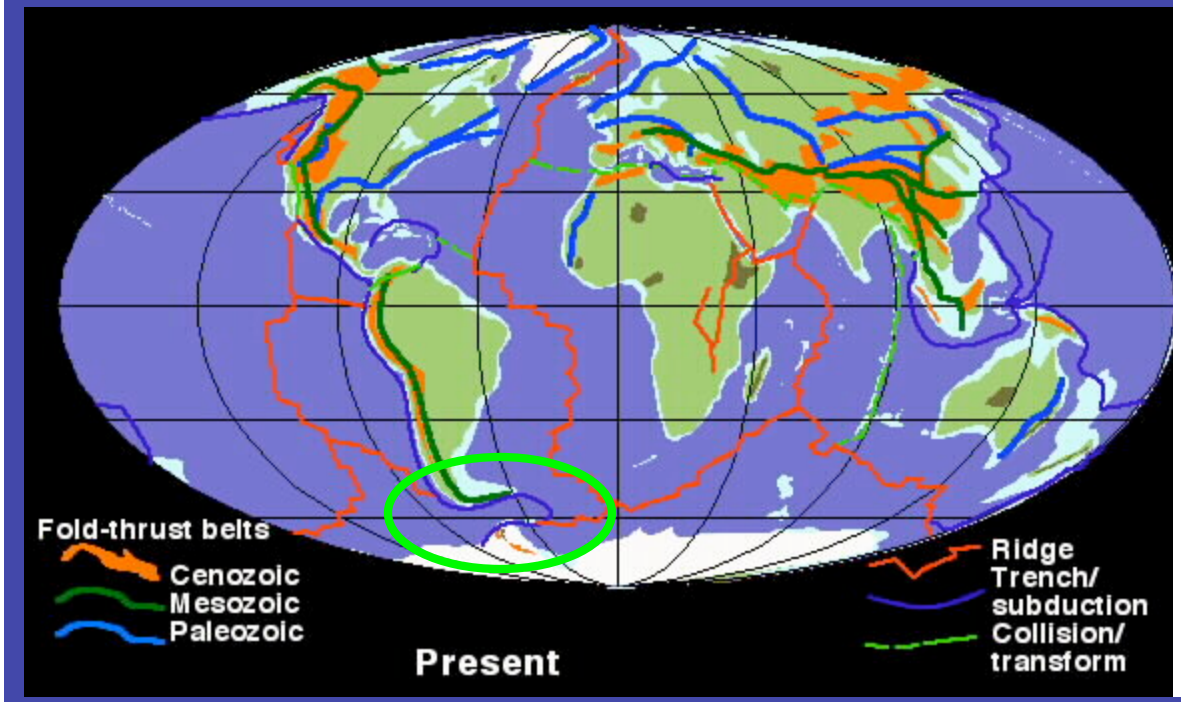


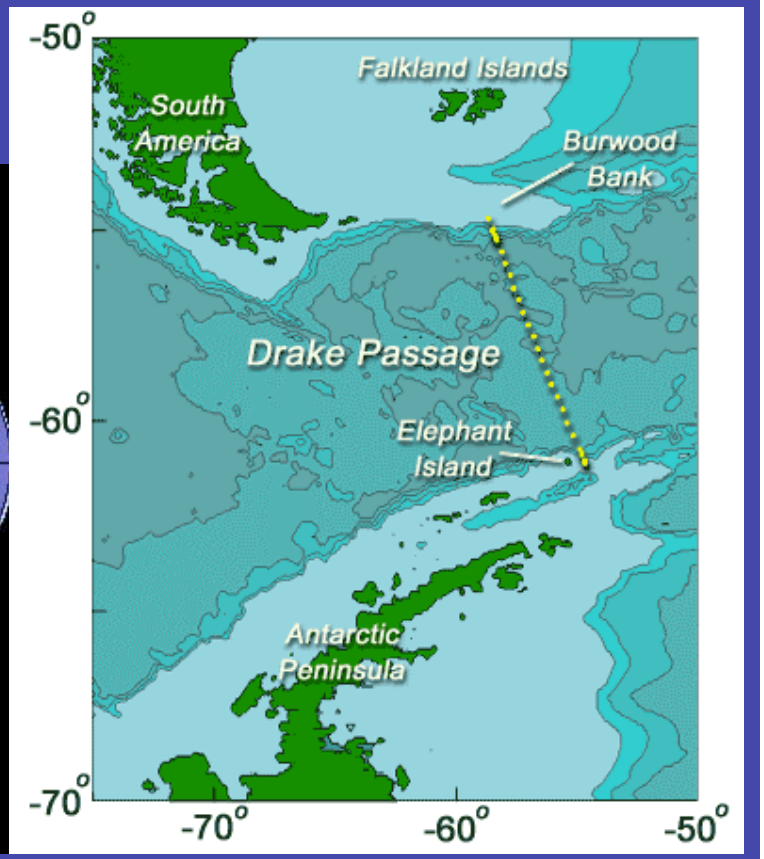
Opening of Drake Passage

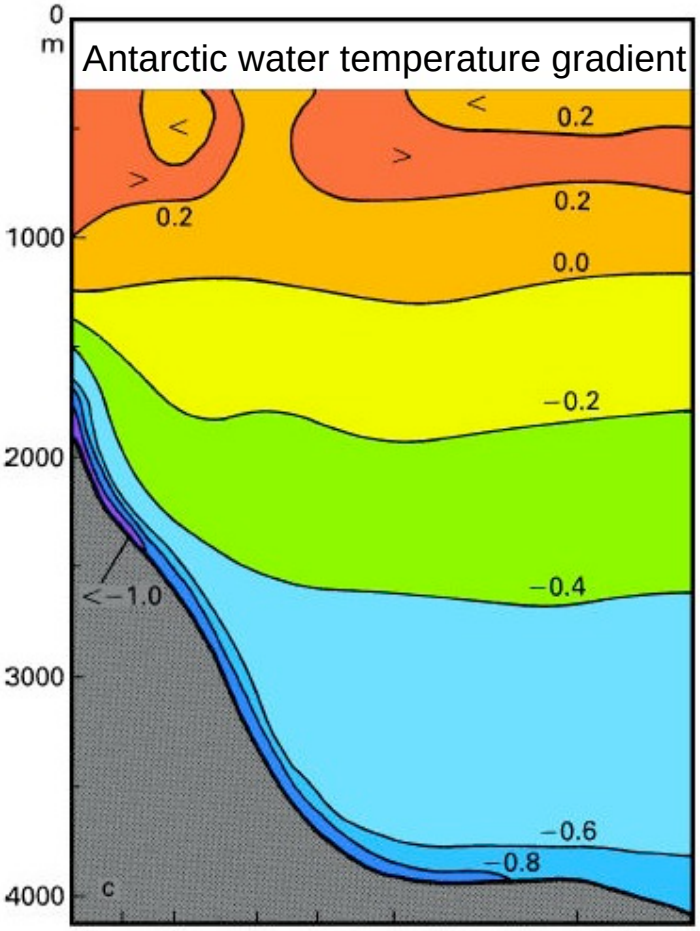
Antarctic Circumpolar Gyre

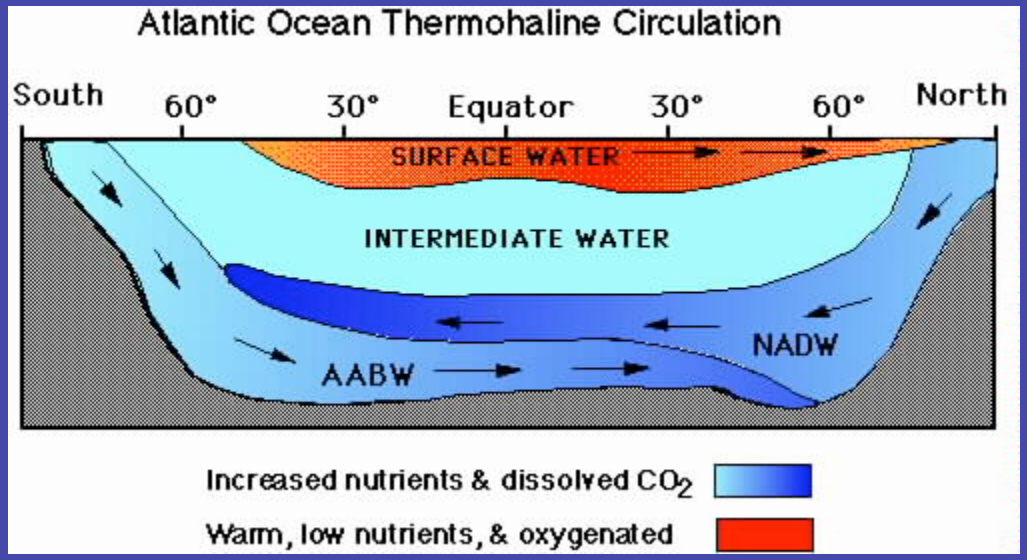


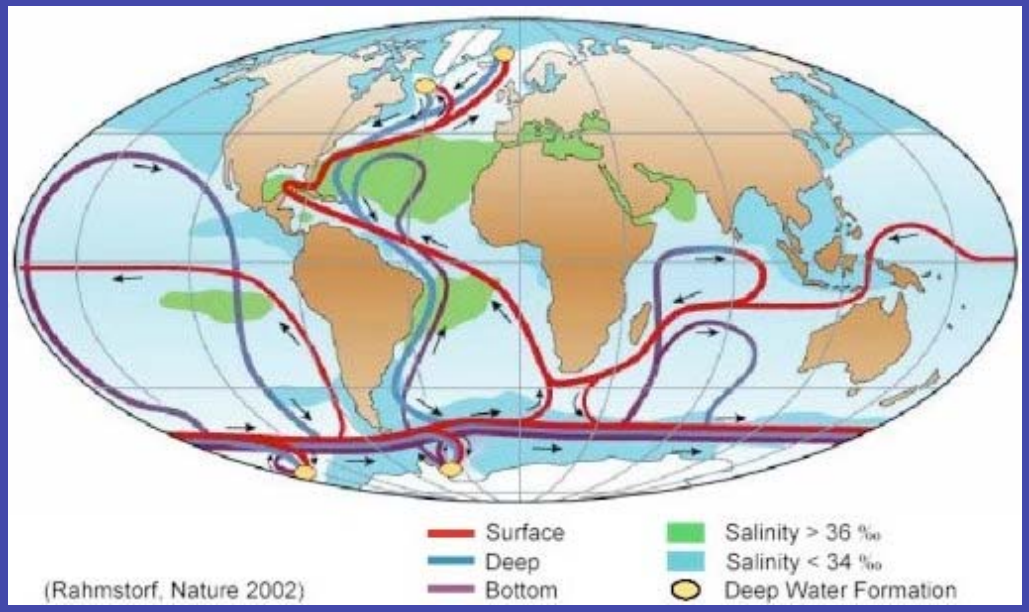






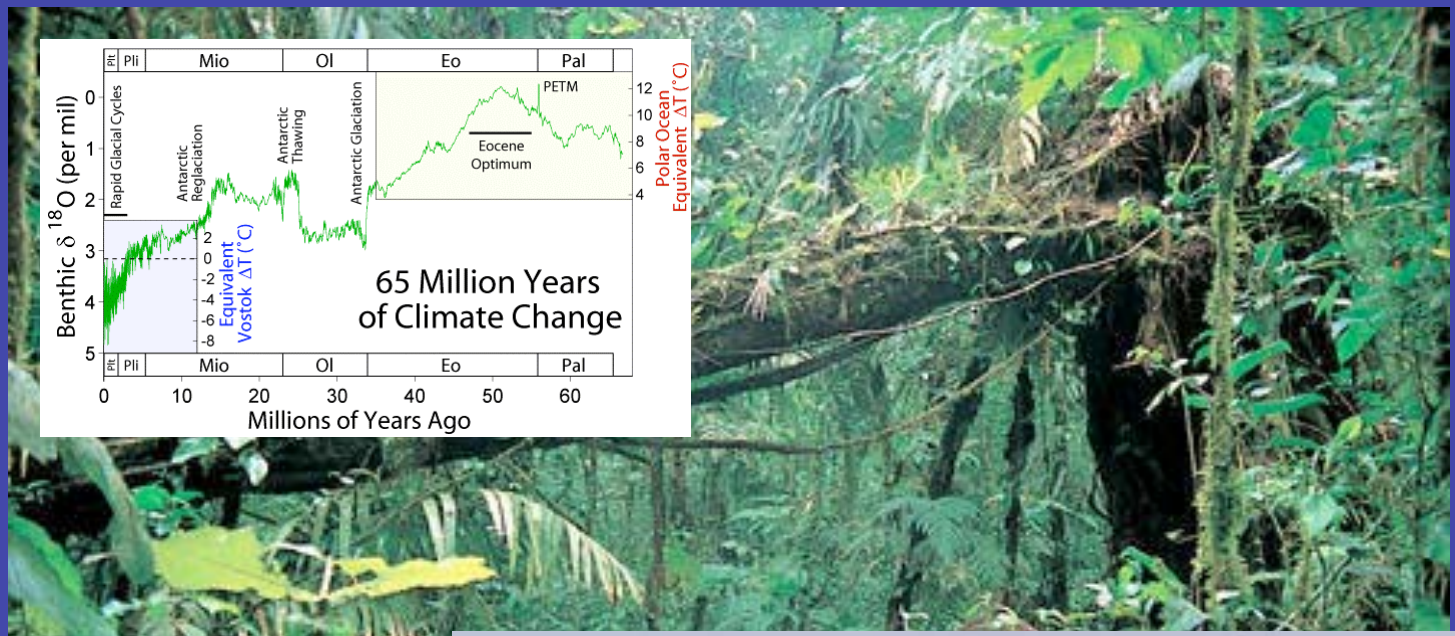






Cold Antarctic water is circulated around the globe by oceanic currents

How are cold oceans going to affect precipitation and temperature on land?



Transition from tropical to grassland environment



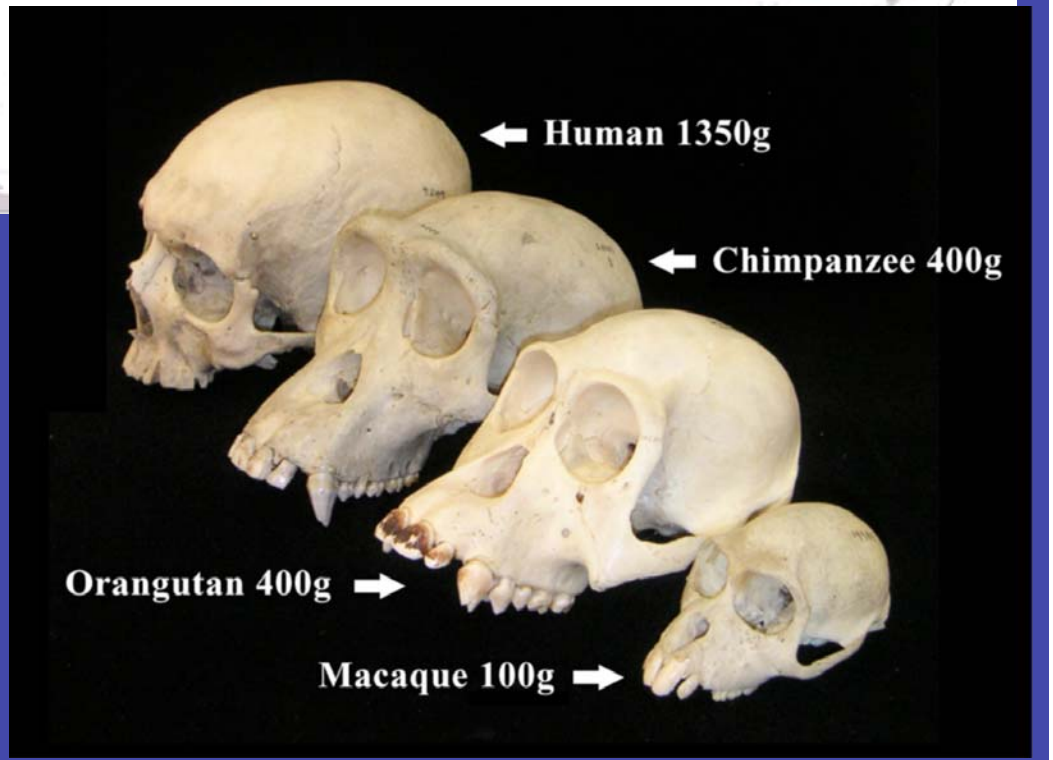


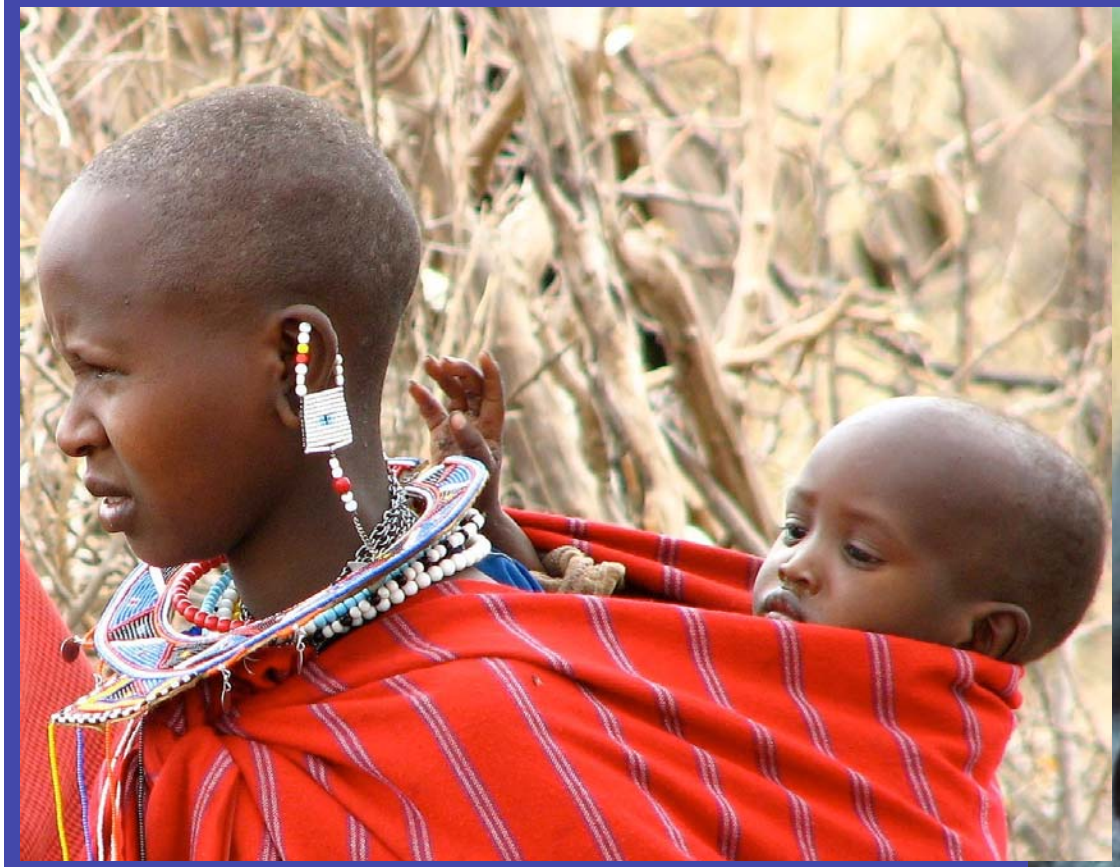
Cooling and drying worldwide

Origin of Humans











How do our young differ?

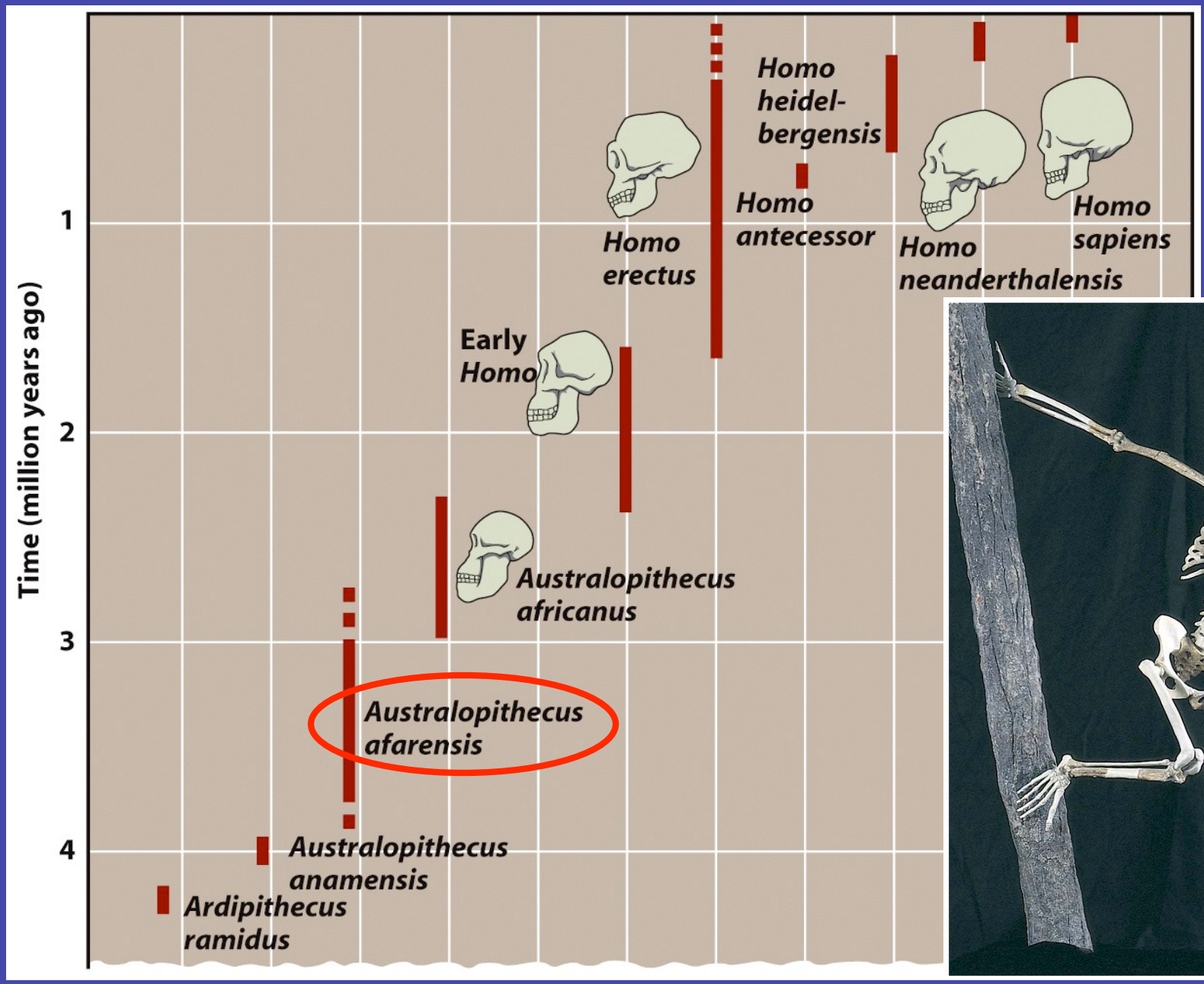


Where will humans thrive?



Where will chimps thrive?

Late (late) Cenozoic (Recent Life) – Human Evolution

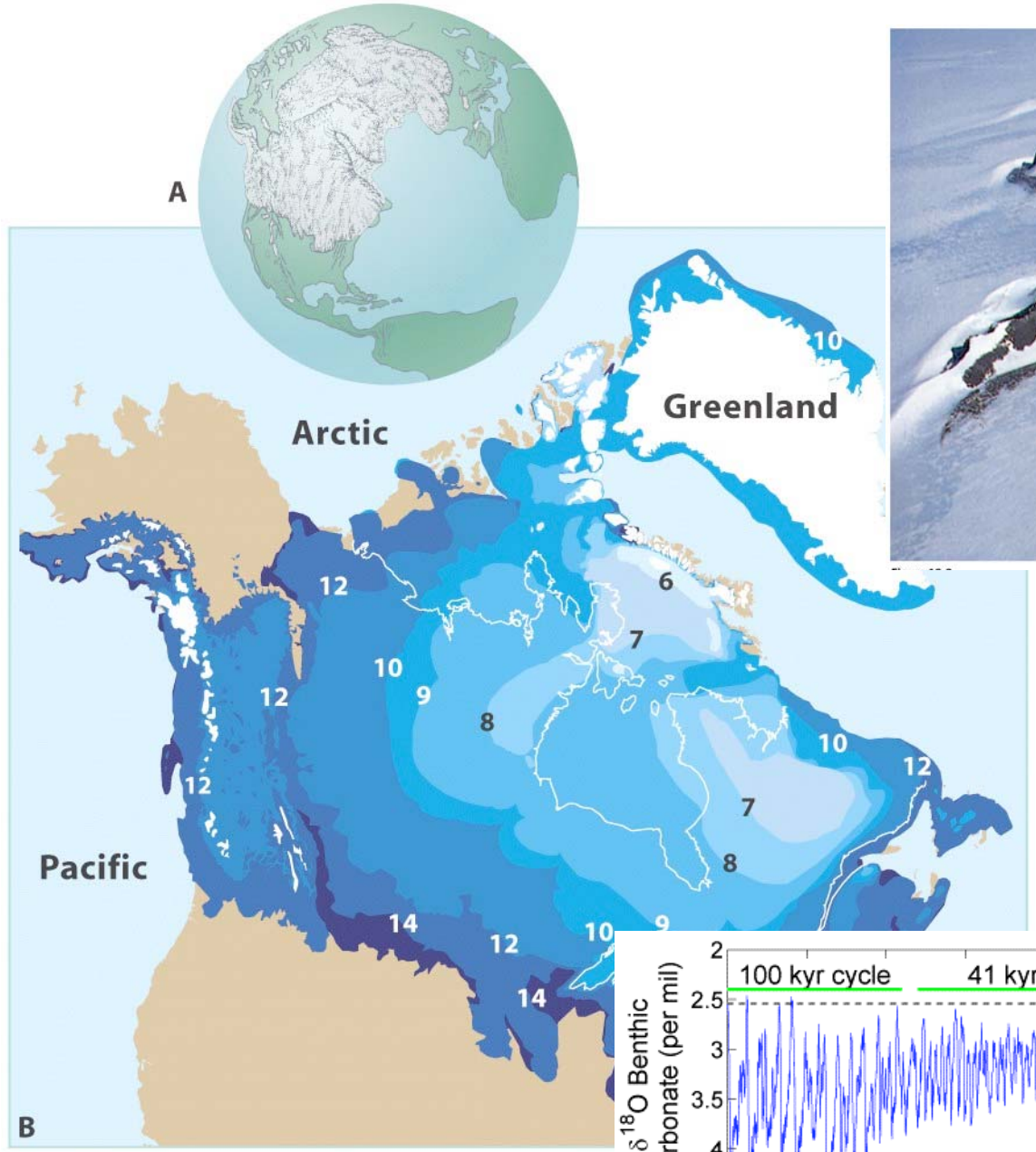


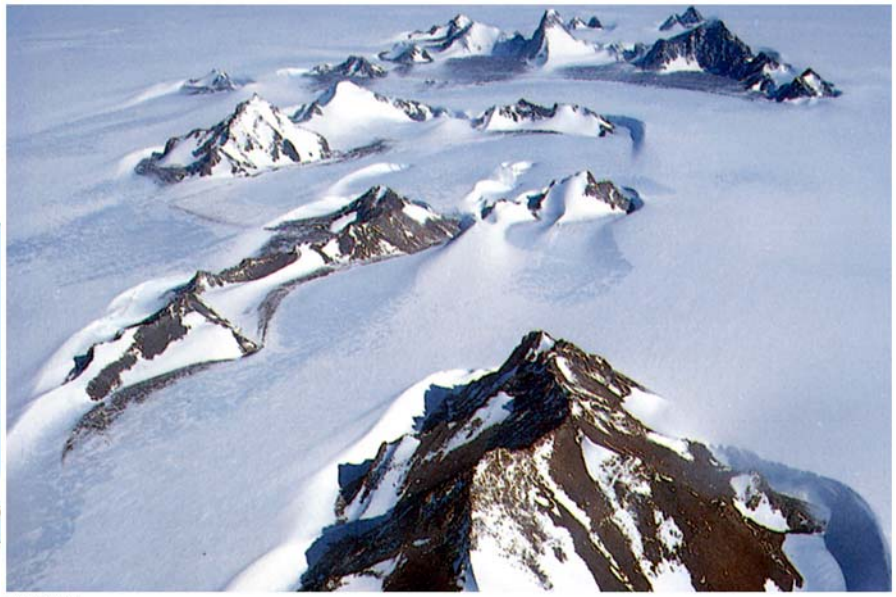
Lucy



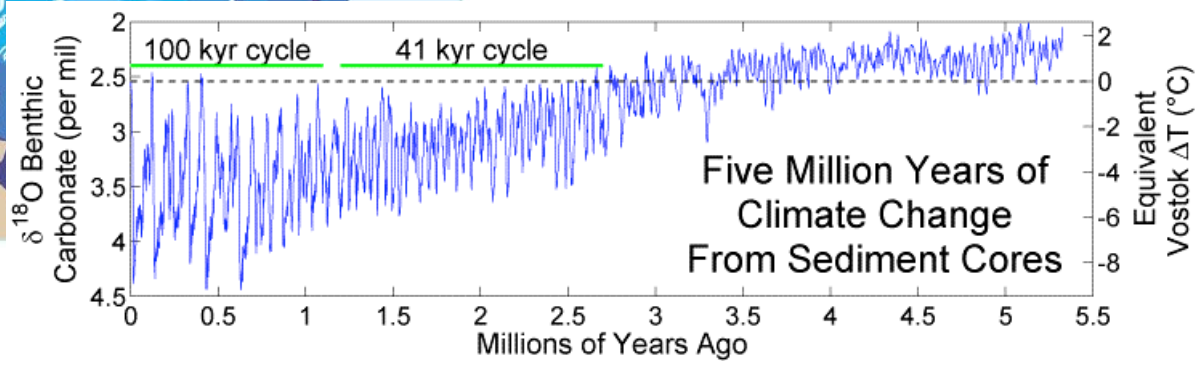
Forces driving human evolution:

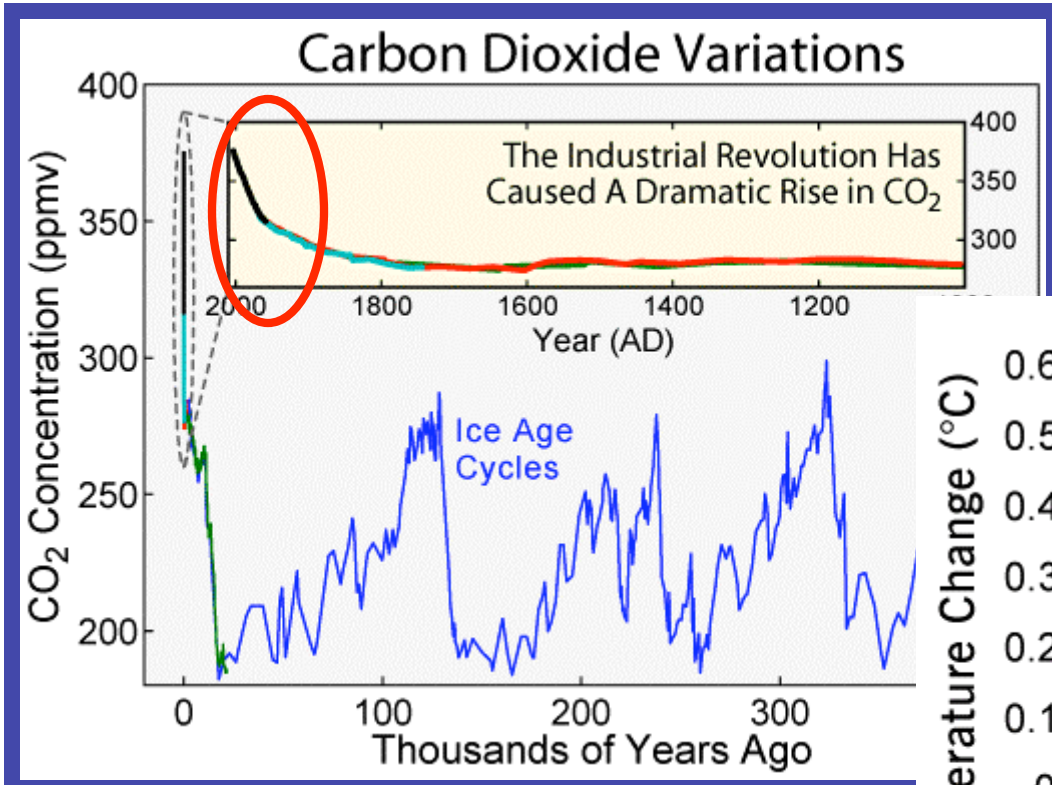
1. **Migration**
2. **Mutation** (caused by something external)
3. **Genetic drift** (random genetic change)
4. **Natural selection** (survival of fittest)





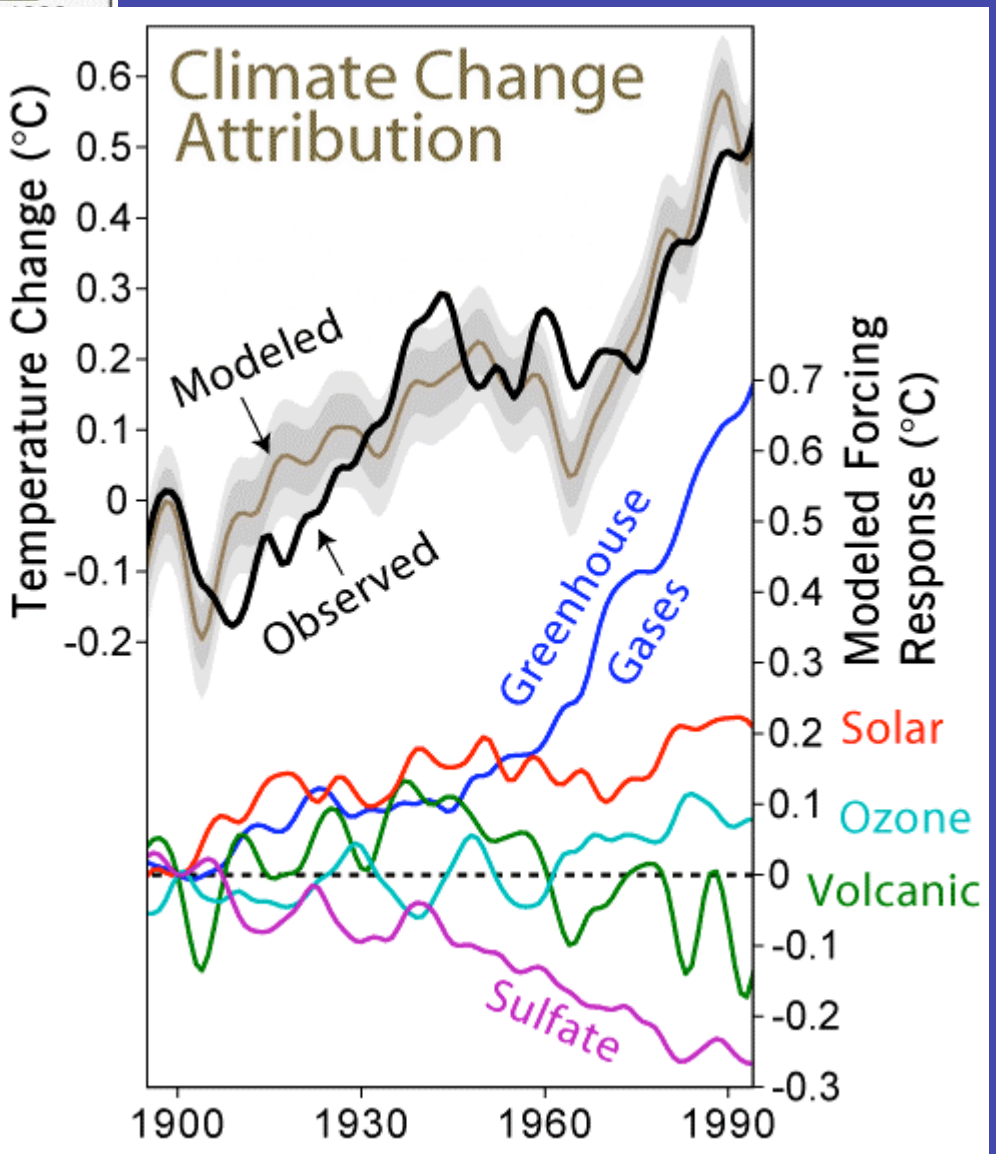
Ice ages controlled human migration patterns

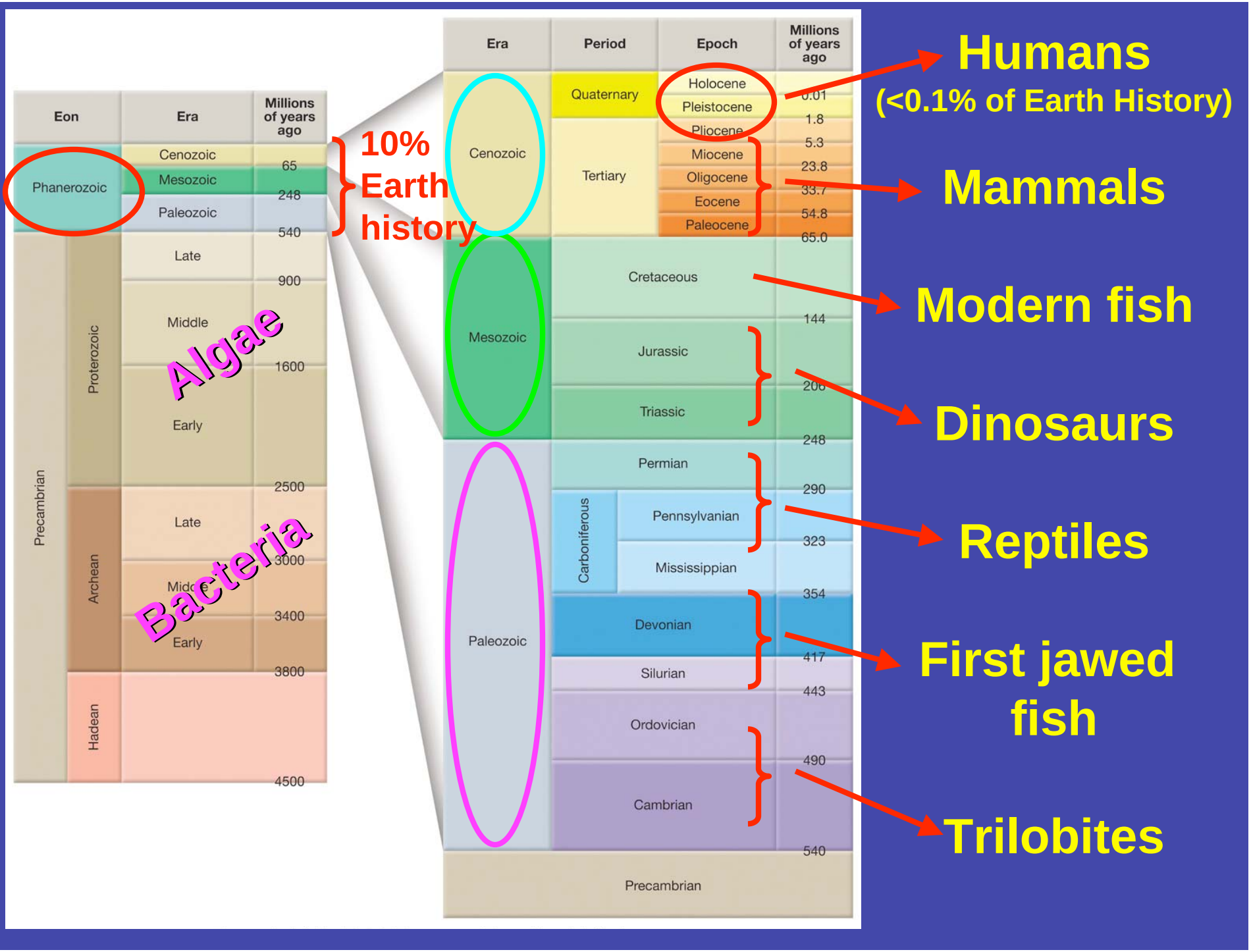


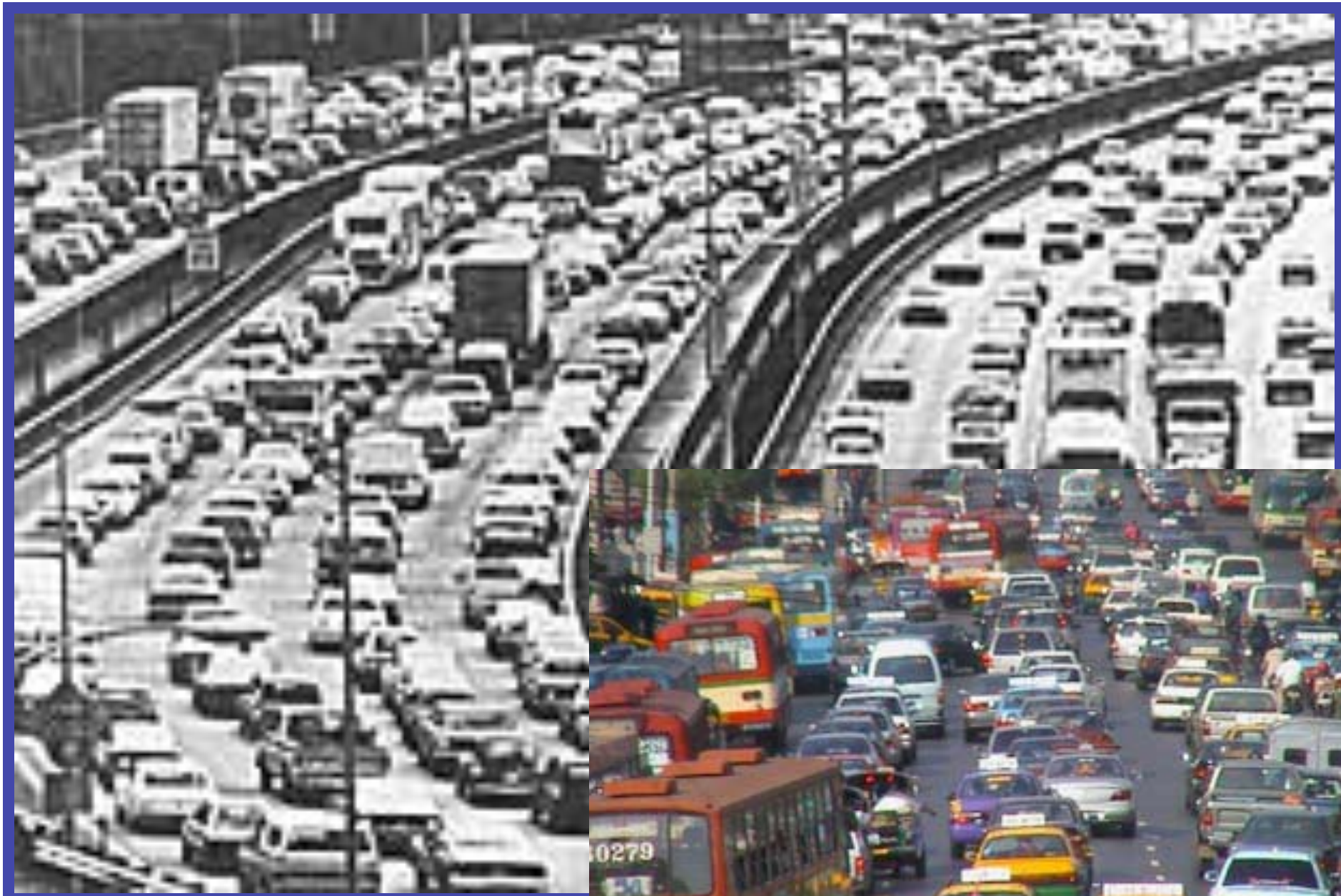


Burning of fossil fuels

CO_2 increases highly correlated with rising temperatures




Eon
Era
Millions of years ago
Phanerozoic
Cenozoic
Mesozoic
Paleozoic
65
248
540
Precambrian
Proterozoic
Late
Middle
Early
900
1600
2500
Archean
Late
Middle
Early
3000
3400
3800
Hadean
4500
Algae
Bacteria
10% Earth history
Era
Period
Epoch
Millions of years ago
Cenozoic
Quaternary
Holocene
Pleistocene
0.01
1.8
Tertiary
Pliocene
Miocene
Oligocene
Eocene
Paleocene
5.3
23.8
33.7
54.8
65.0
Mesozoic
Cretaceous
Jurassic
Triassic
144
206
248
Paleozoic
Permian
Carboniferous
Pennsylvanian
Mississippian
Devonian
Silurian
Ordovician
Cambrian
290
323
354
417
443
490
540
Precambrian
Humans
(<0.1% of Earth History)
Mammals
Modern fish
Dinosaurs
Reptiles
First jawed fish
Trilobites



Where will evolution take us next ?