

What type of eruptive product is this?

A) A'a flow

B) Pahoehoe flow

C) Pyroclastic flow

D) Mudflow



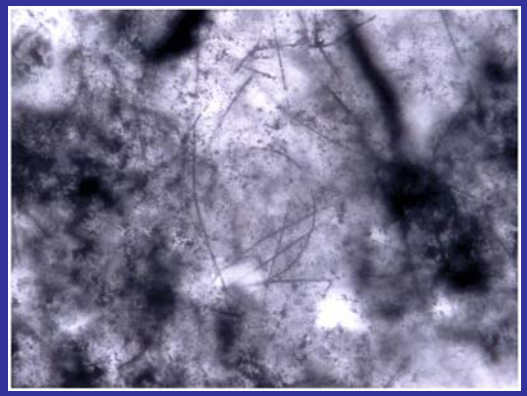
SCHEDULE

Week	Topic
1	Origin of solar system, Early Earth
2	Plate tectonics
3	Minerals
4	Igneous rocks
Feb. 7	Exam I
5	Volcanoes
6	Weathering, Sedimentary rocks
7	Metamorphic rocks
8	Geologic time
Mar. 6	Exam II
Mar. 7-9	*BIG ISLAND FIELD TRIP!*
9	Relative & radiometric dating
10	Folds and faults, mountain building
11	Earthquakes
12	Surface water
Apr. 10	Exam III
13	Groundwater
Apr. 16	*Waihe'e Tunnel Field Trip!*
14	Glaciers
15	Global warming
16	Review
May 15	Final Exam

1/2 way already!

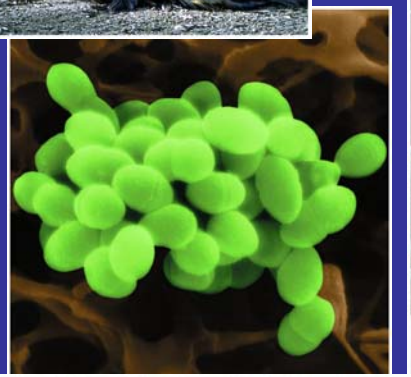
Grading:	#	% final grade
Exams (I, II, III, Final)	4	60%
In-class activities/homework	11 (10)	25%
Field Trip (one required)	1	10%
iClicker participation	daily	5%
Optional extra credit activities	*1-3*	*up to 5%*













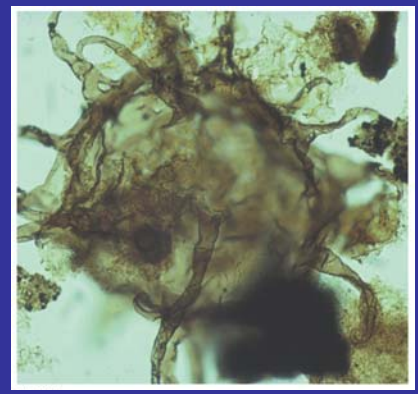


Similarities?

A) Breathing
B) Digestion
C) Cellular structure
D) Warm blooded
E) Living

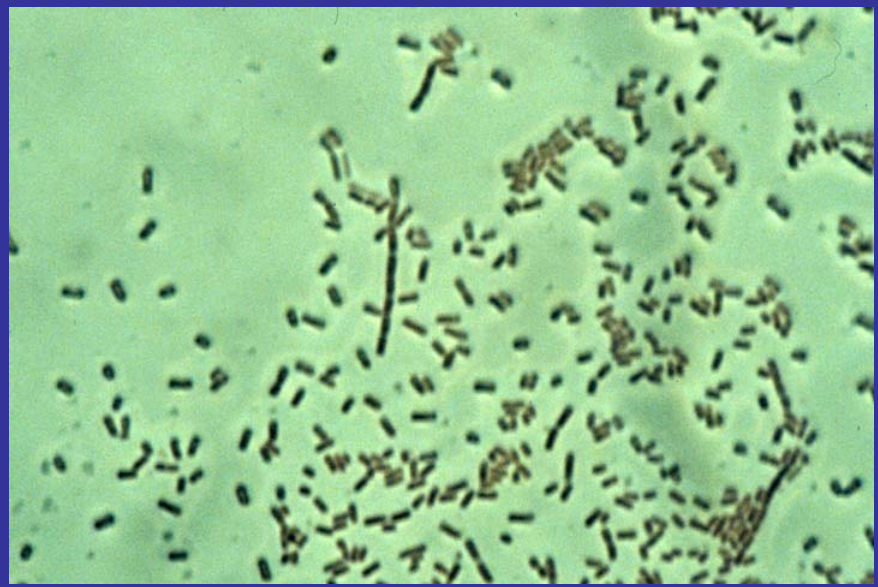


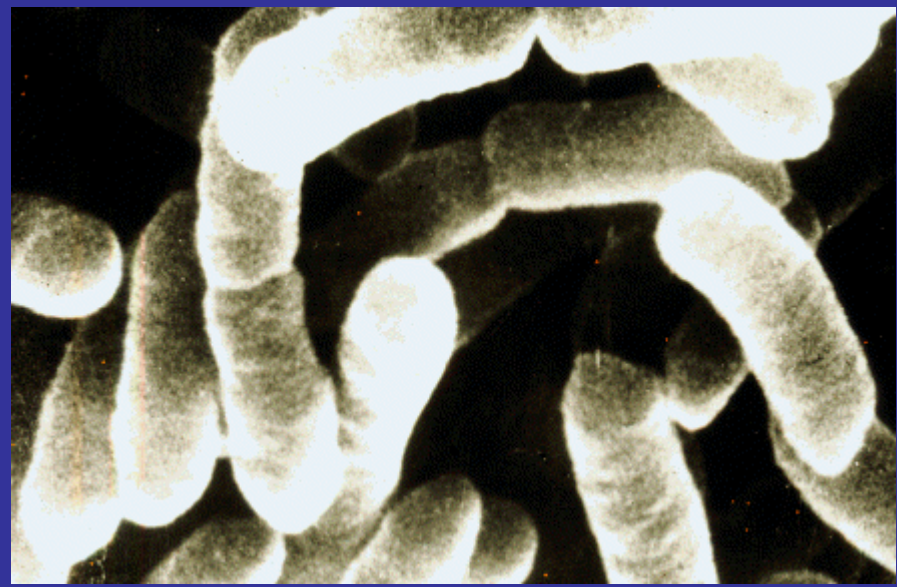




What defines

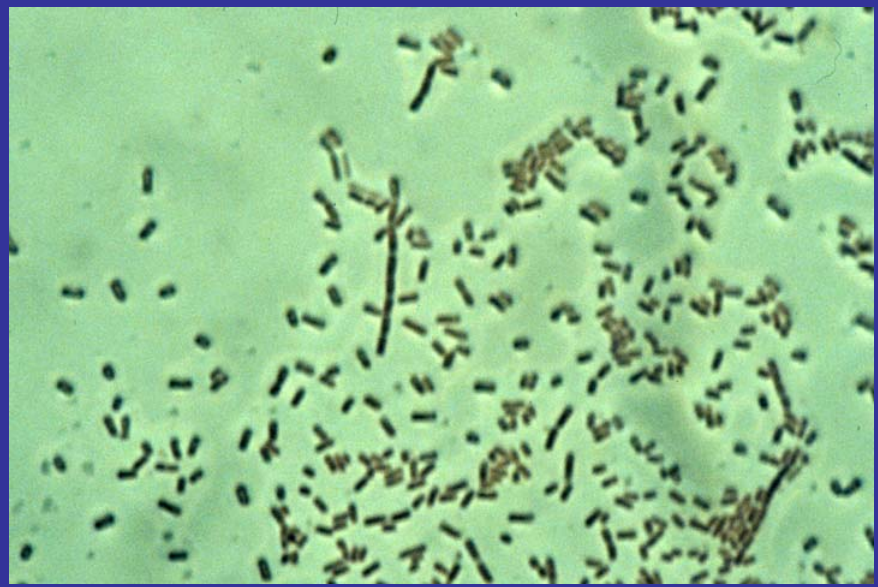
LIFE?





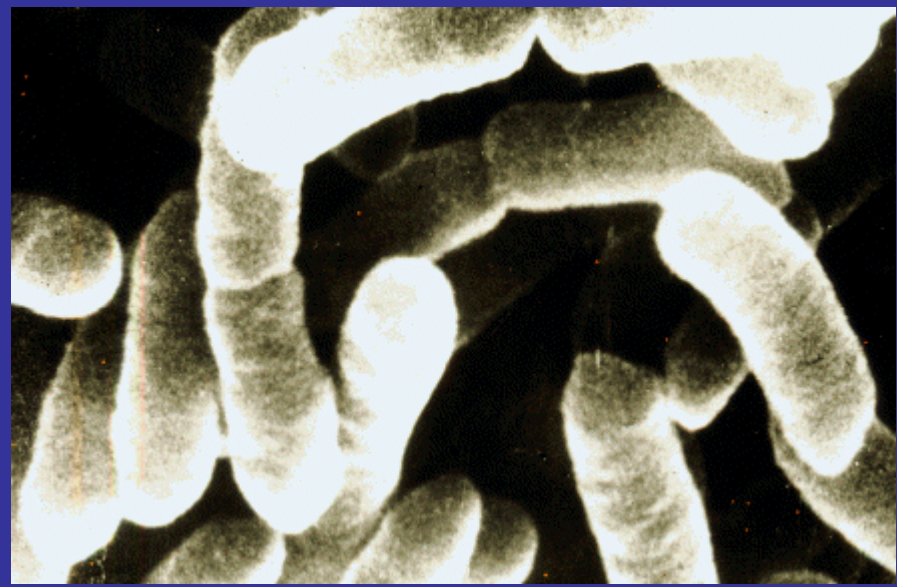
What defines

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?

A) The right size

B) Right temperature

C) Water is liquid

D) Seasonality

E) Polar ice caps



Why is Earth UNIQUE?

A) The right size

B) Right temperature

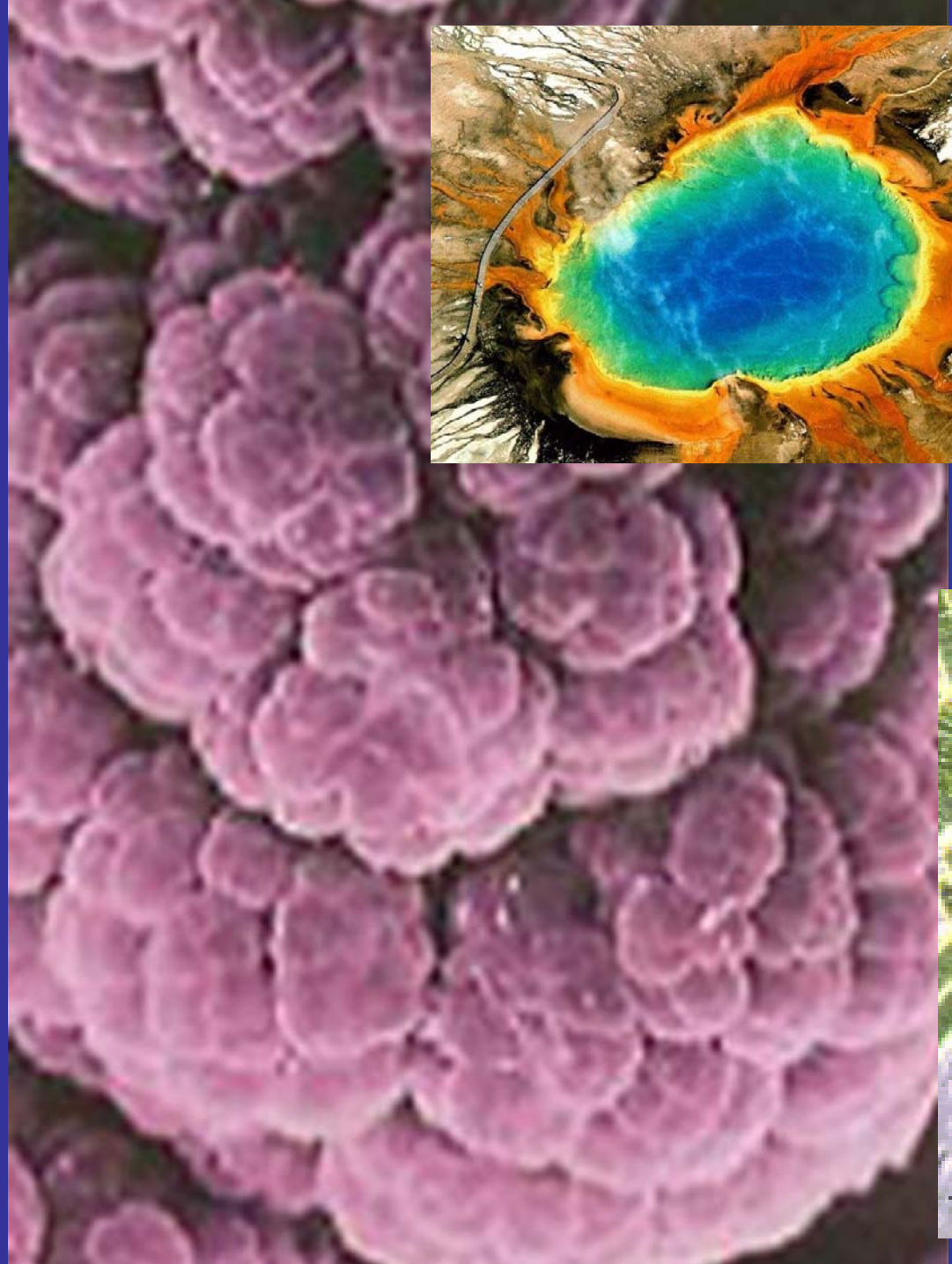
C) Water is liquid

These traits allow Earth to host LIFE

Where did life originate?

How do we know?


Where did life originate?
How do we know?



Archaebacteria tolerate extreme environments:

<u>HIGH</u>

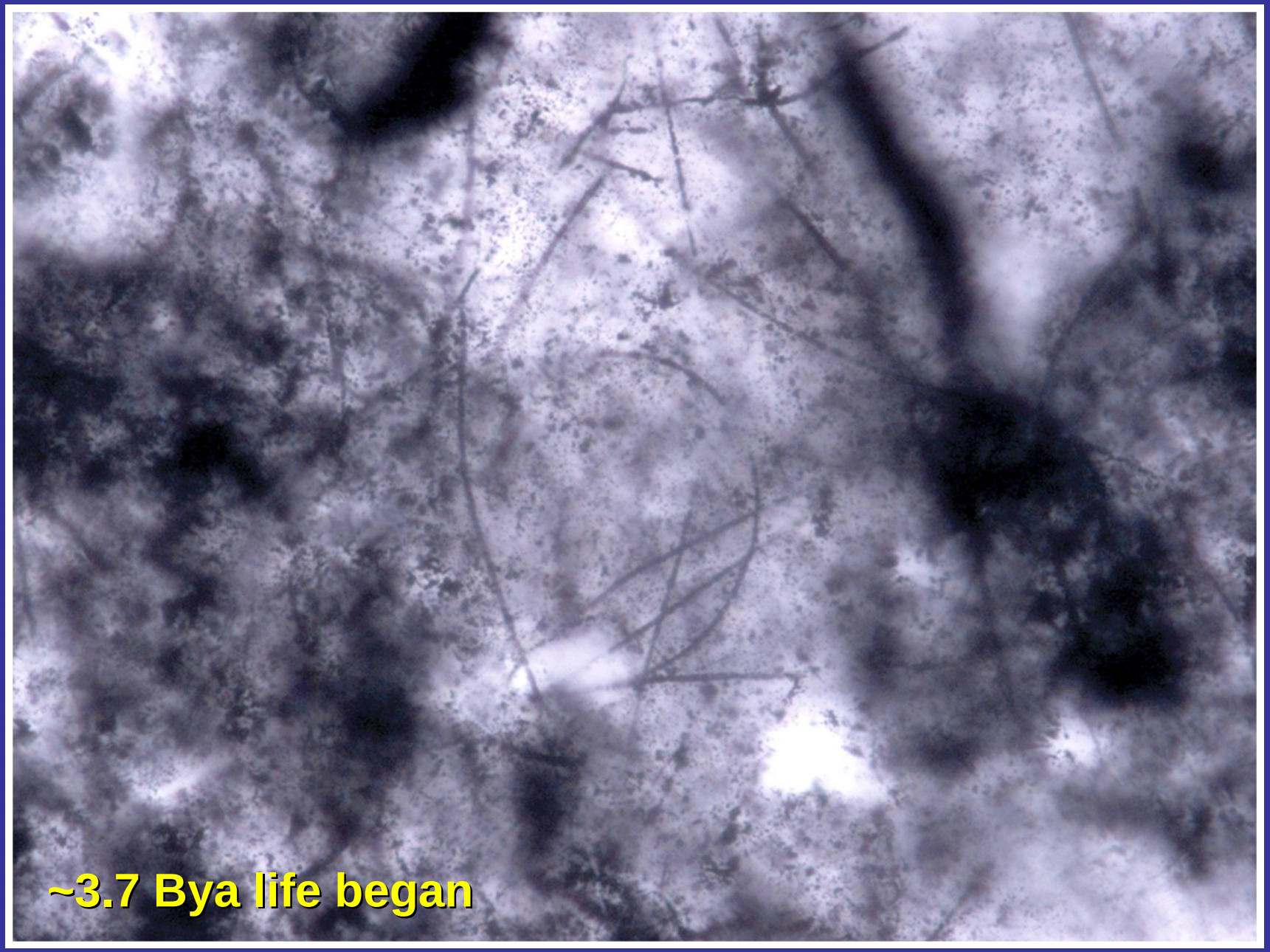
1) temperature

2) salinity

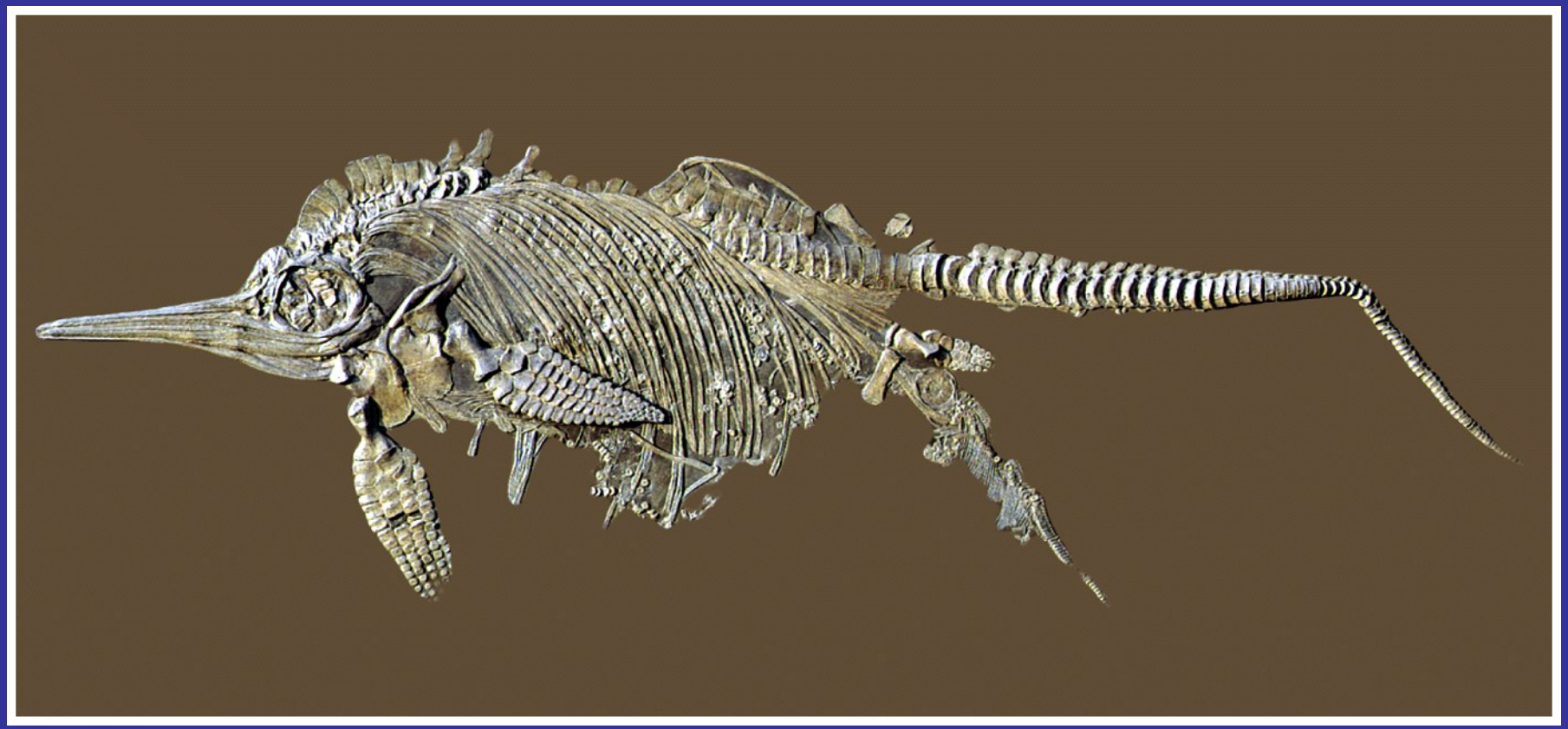
3) acidity



Oldest known fossil? Host rock 3.2 billion yrs old.



What two factors influence fossil preservation?

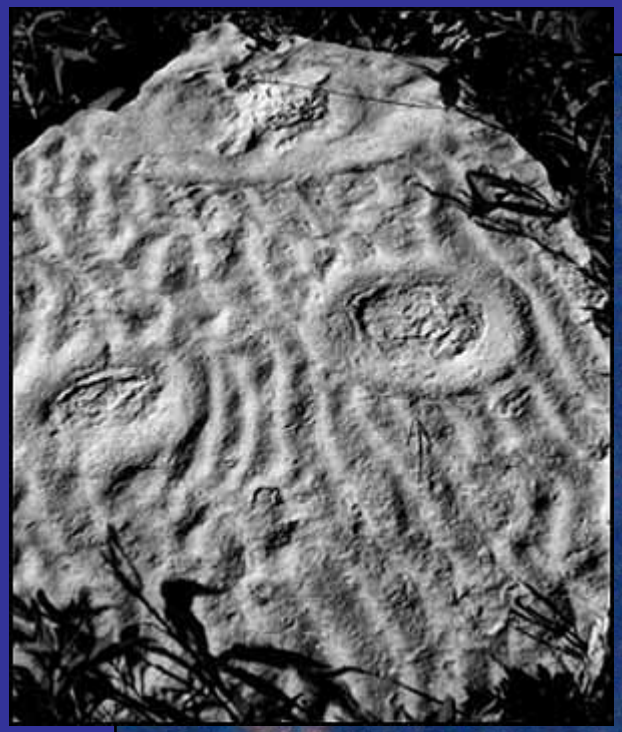


Icthyosaur (Jurassic 206-144 Mya)

What two factors influence fossil preservation?

1) Hard parts

2) Rapid burial



Cambrian (525 Mya)

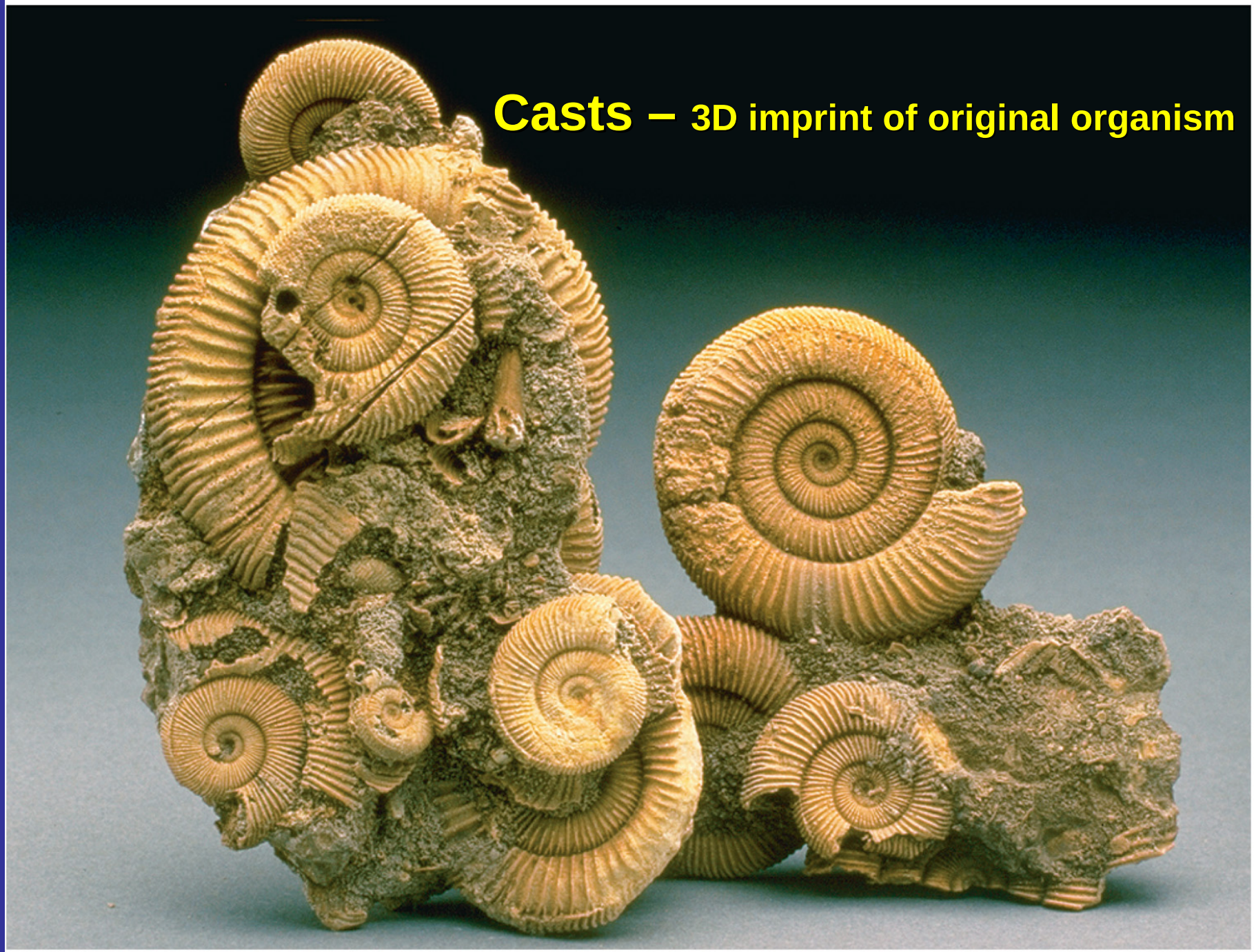


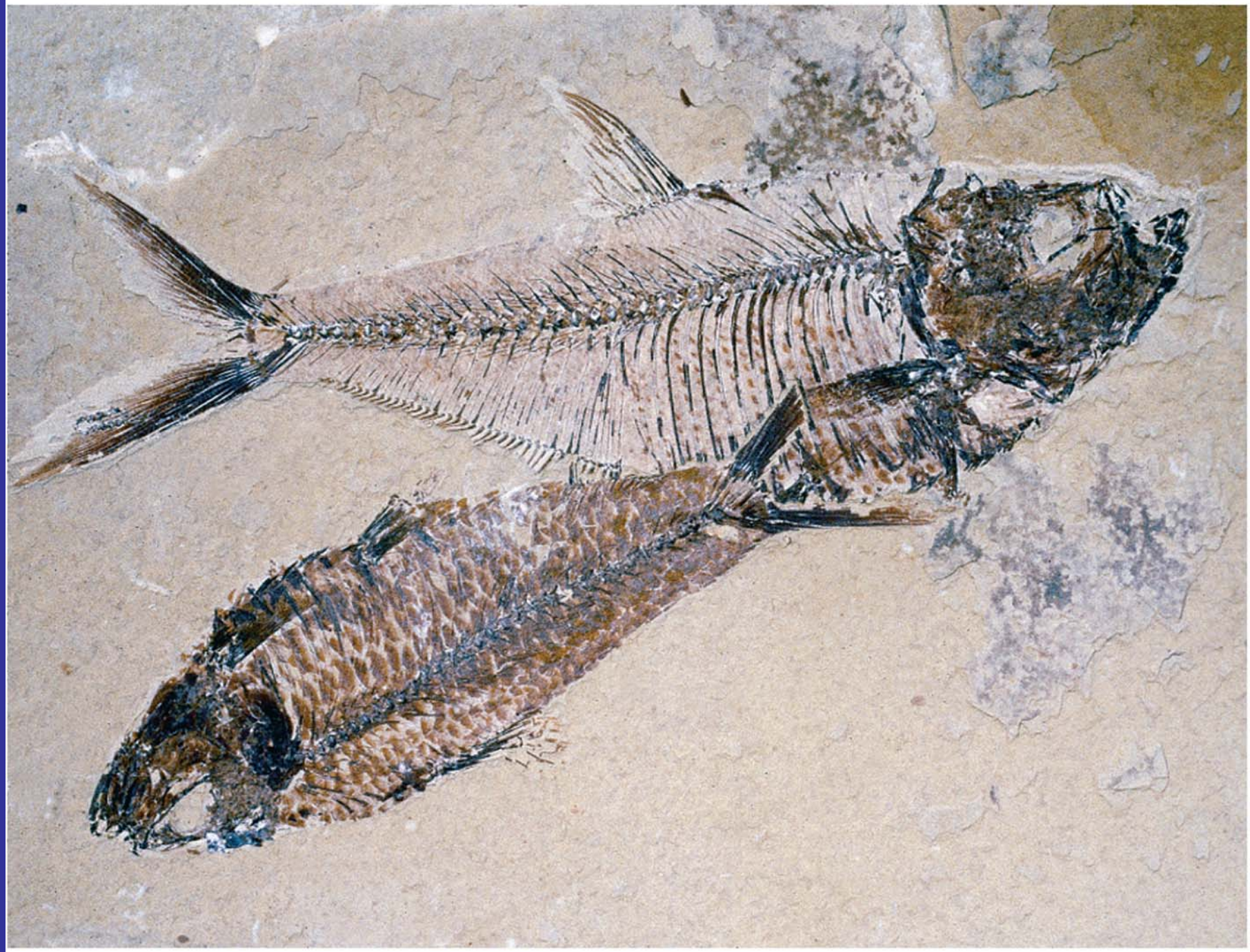
Eocene Mammal (54.8-33.7 Mya)

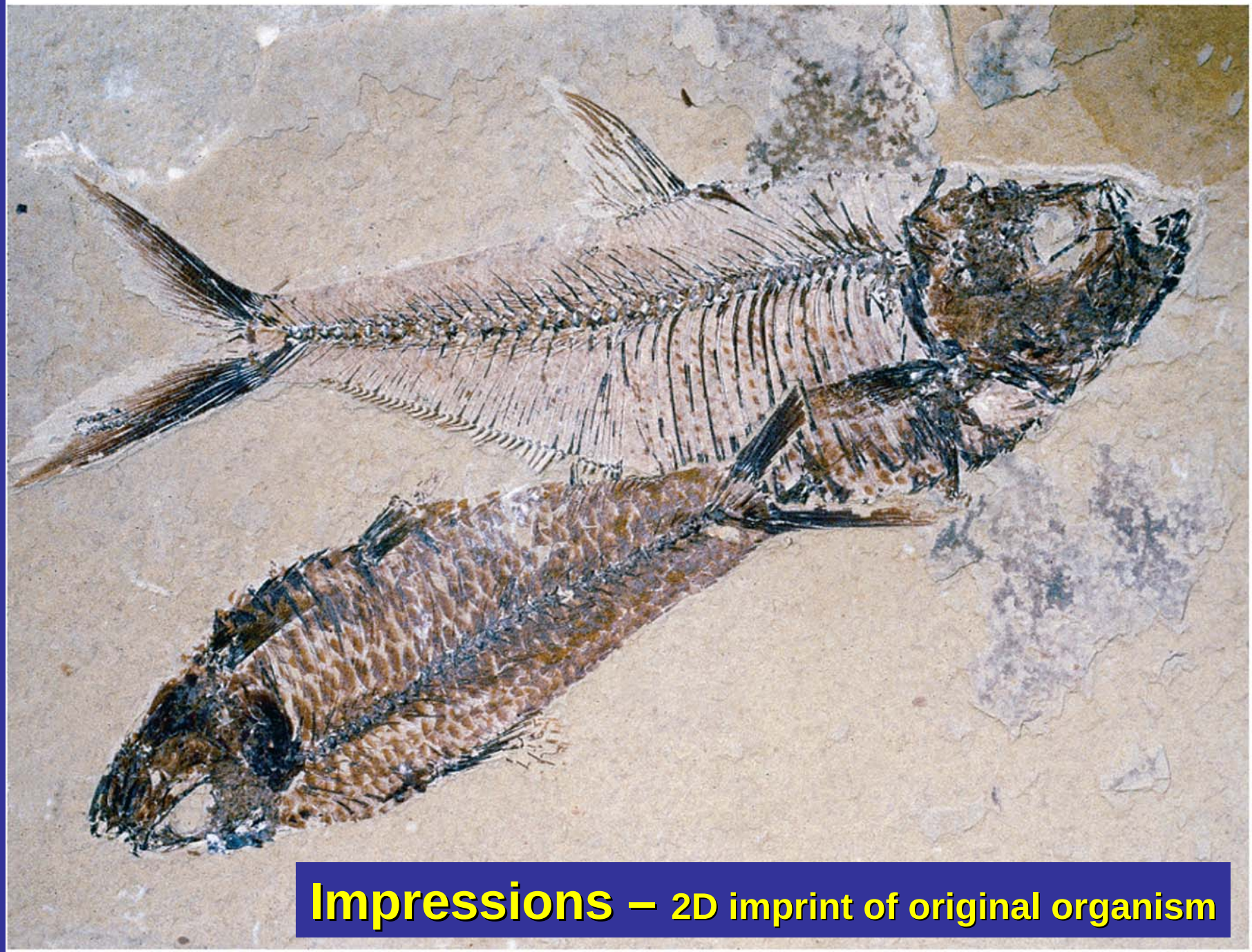



Petrified Wood – organic materials replaced with minerals




Casts – 3D imprint of original organism





Impressions – 2D imprint of original organism

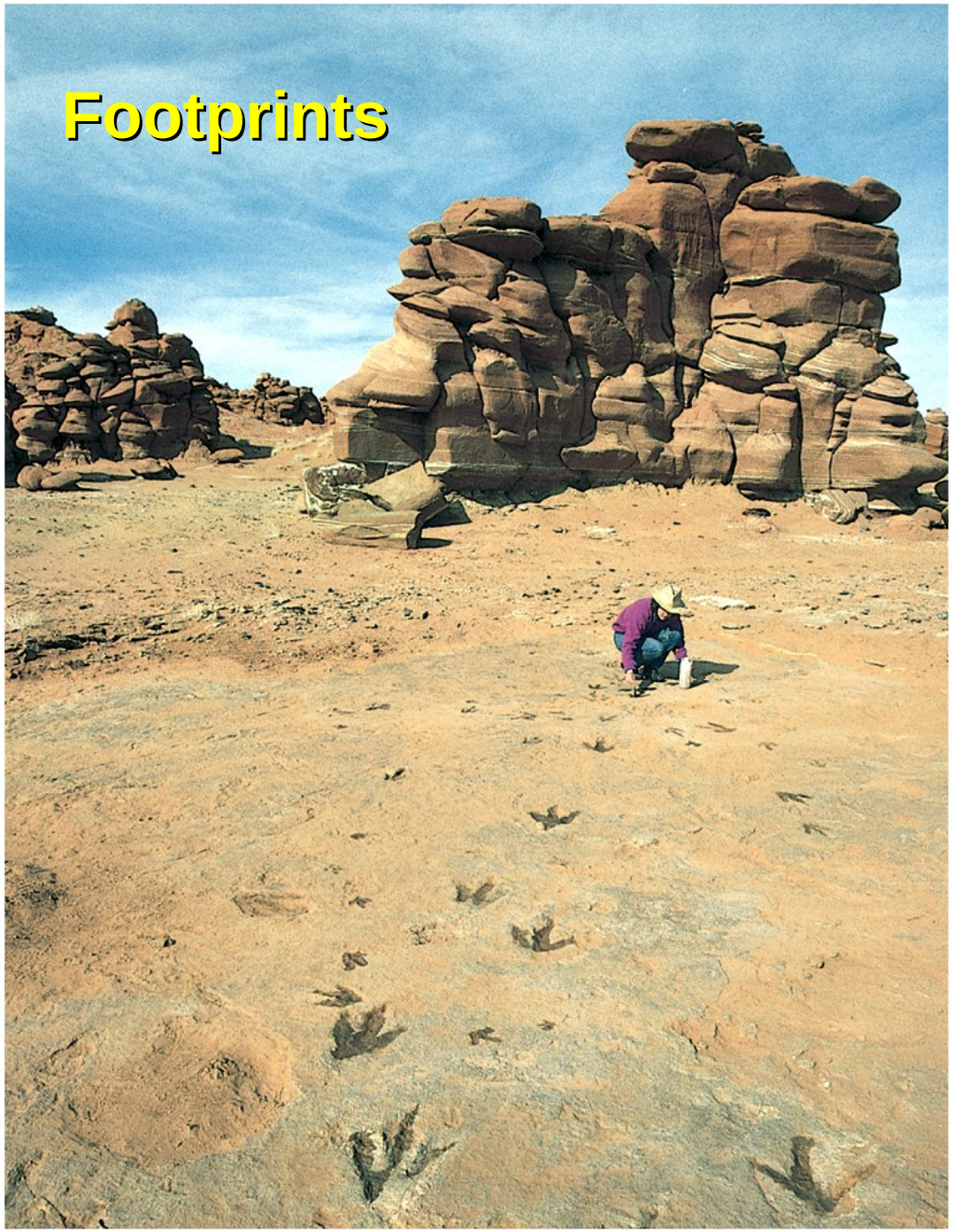



Carbon films –
anoxic burial preserves carbon residue




Amber – fossil tree resin




Footprints





Coprolites (feces)







Burrows



Stratigraphic correlation

A

B

C

D

E









Stratigraphic correlation

A

B

C

D

E



100Ka

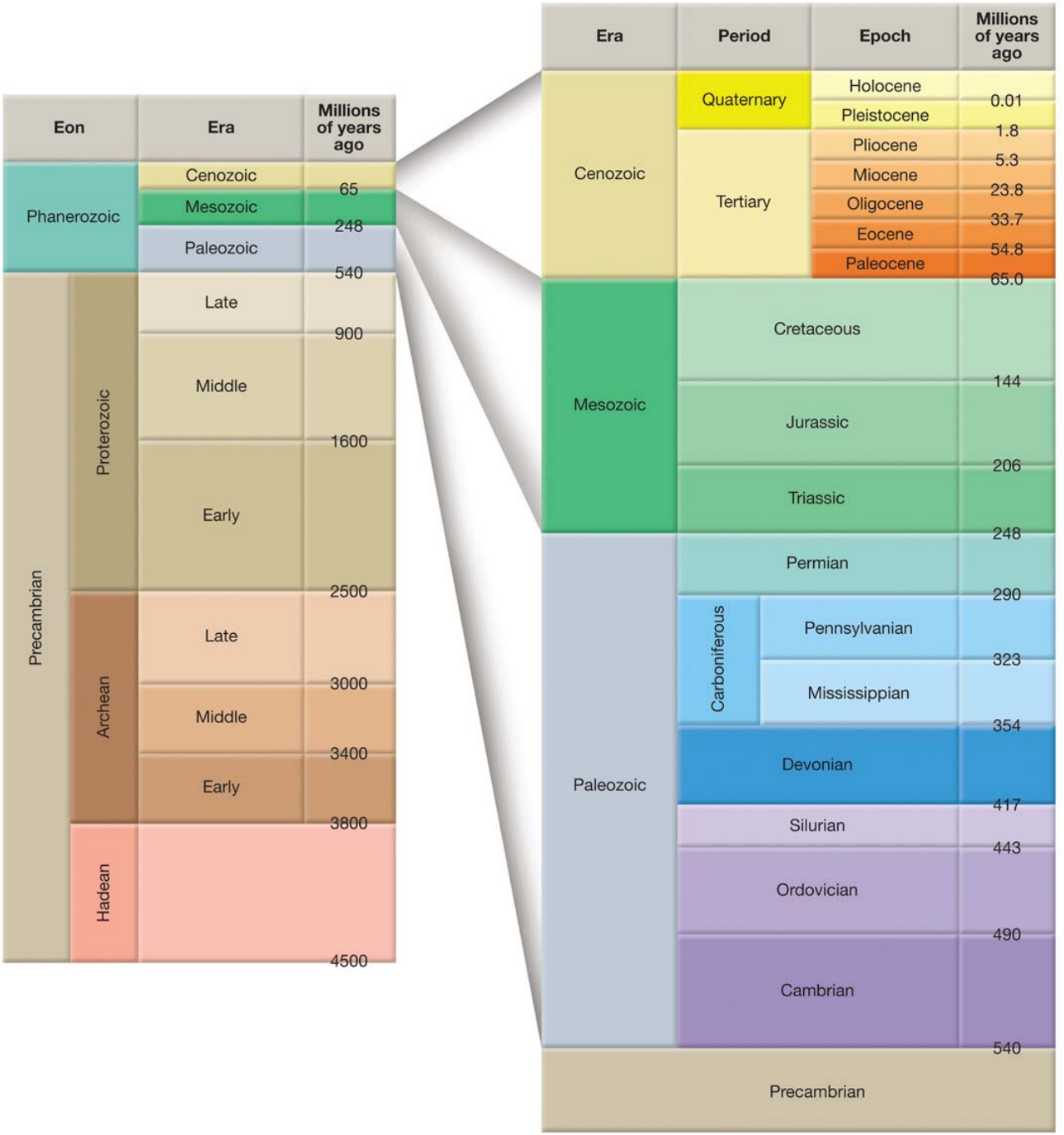


200Ka





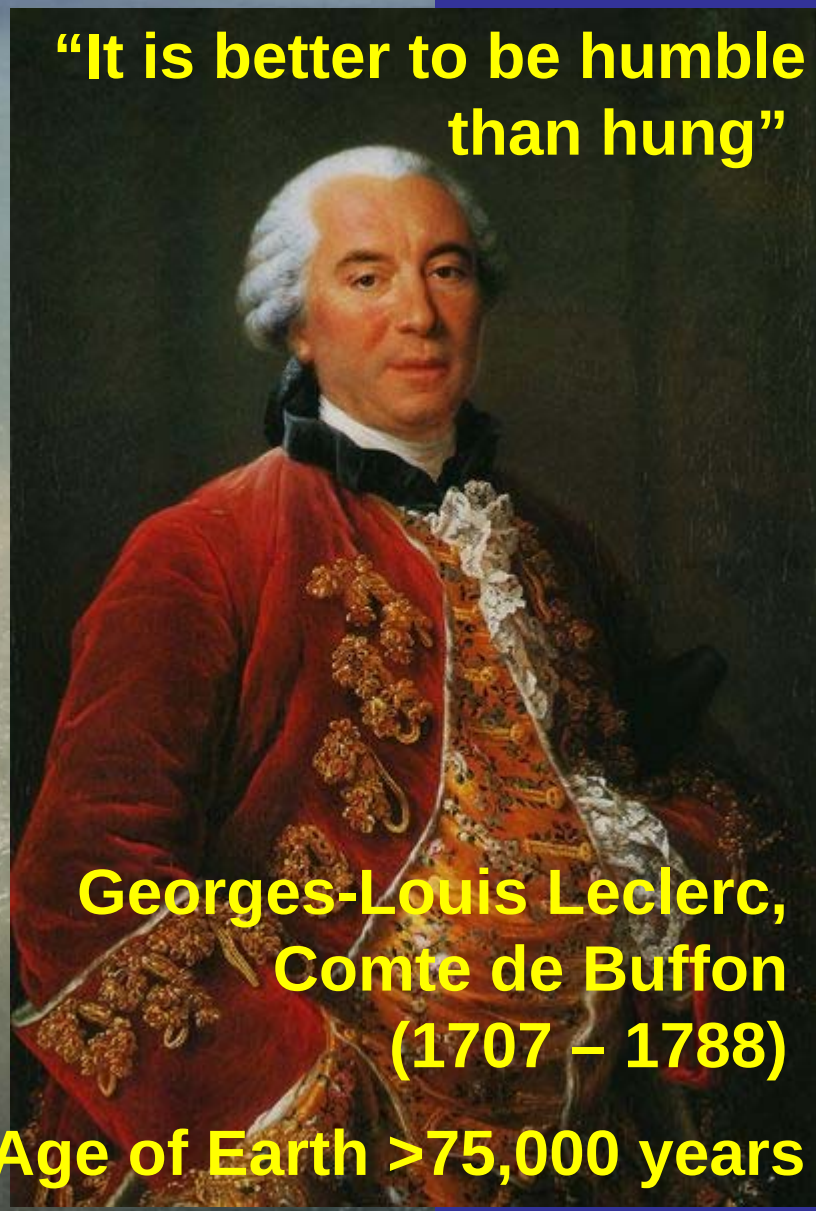
300Ka



Fossils define the:

"Geologic Timescale"

350 feet high, 136 Mya



"It is better to be humble than hung"

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

Age of Earth >75,000 years

James Ussher (1581–1656) Anglican Archbishop of Armagh and Primate of All Ireland



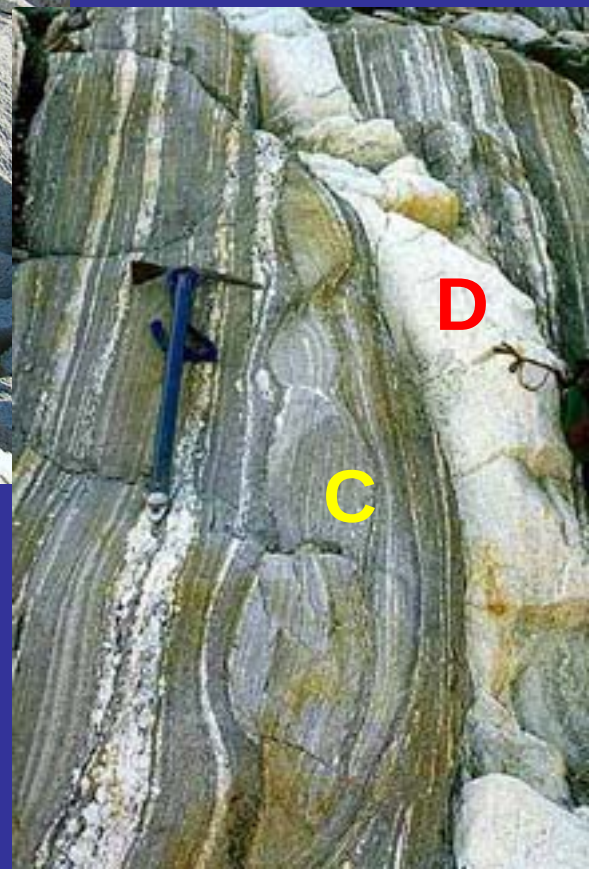
4004 BC - Creation
(at nightfall preceding 23 October)

2348 BC - The Great Flood
1921 BC - Yahweh's call to Abraham
1491 BC - The Exodus from Egypt
1012 BC - The founding of the Temple in Jerusalem
586 BC - The destruction of Jerusalem by Babylon and the beginning of the Babylonian Captivity
4 BC - The birth of Christ

Published 1650, therefore age of Earth assumed to be 5,654 yrs old.

‘Principle of Cross-Cutting Relationships’

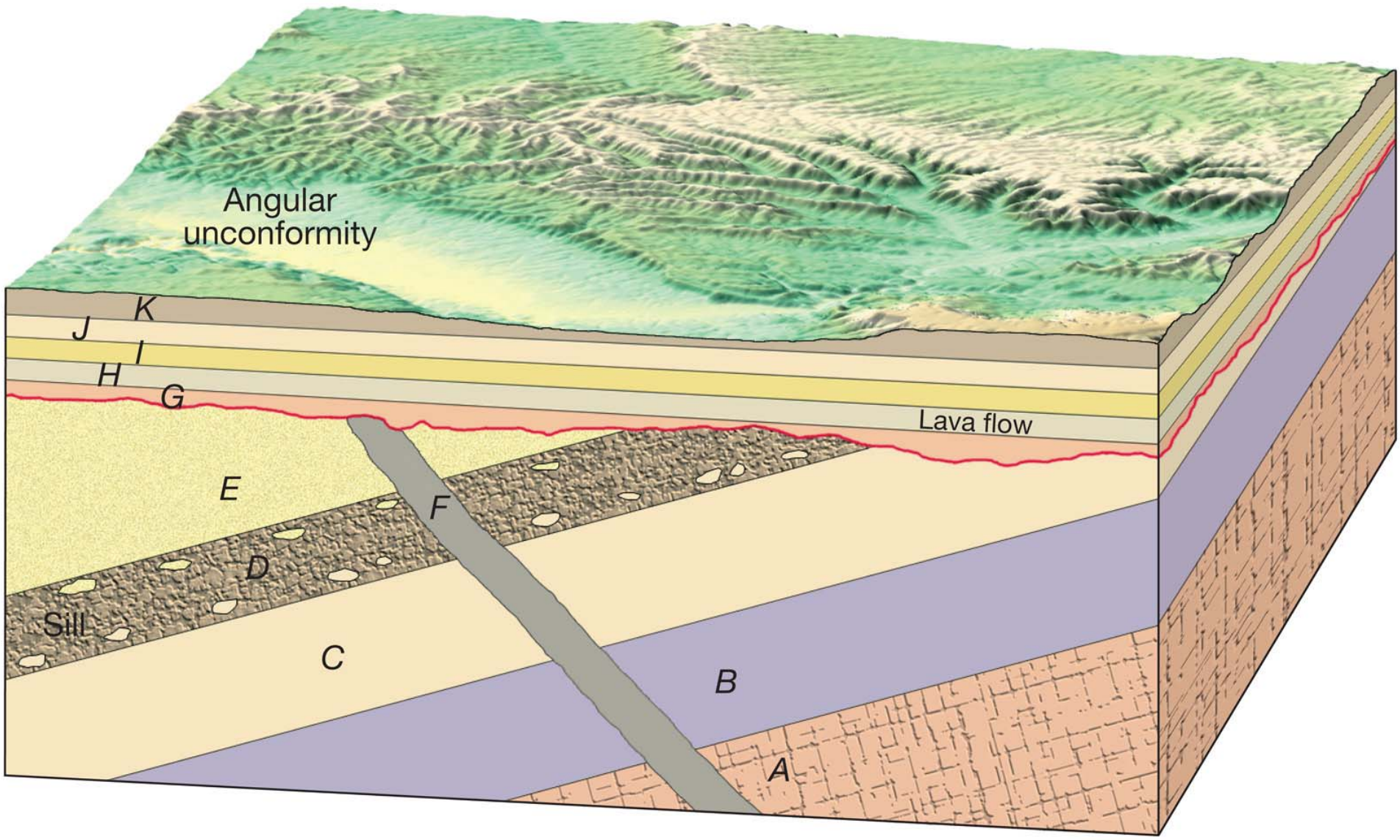




Which are youngest?

A) A&C, B) A&D, C) B&C, D) B&D

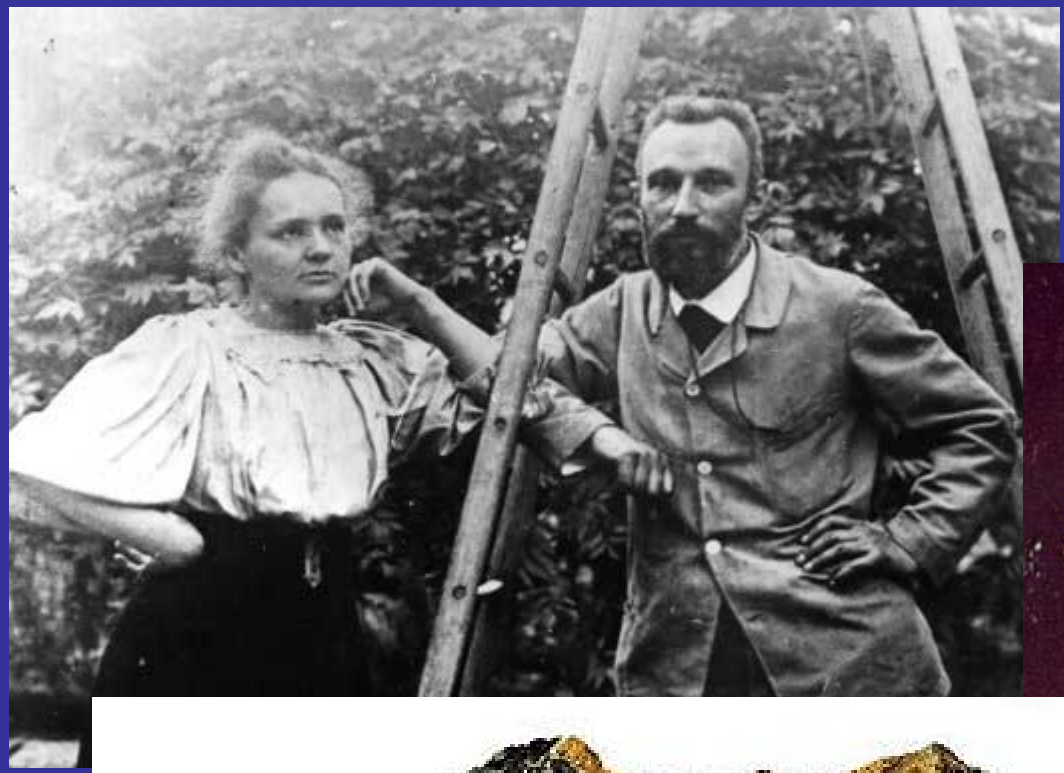
Youngest material not cut (or overlain) by any other strata





James Hutton
(1726-1797)

"the mind seemed to grow giddy by looking so far into the abyss of time" (1786)



Radioactivity:

Henri Becquerel (1896)
Marie & Pierre Curie (1898)



chalcolite



pitchblende

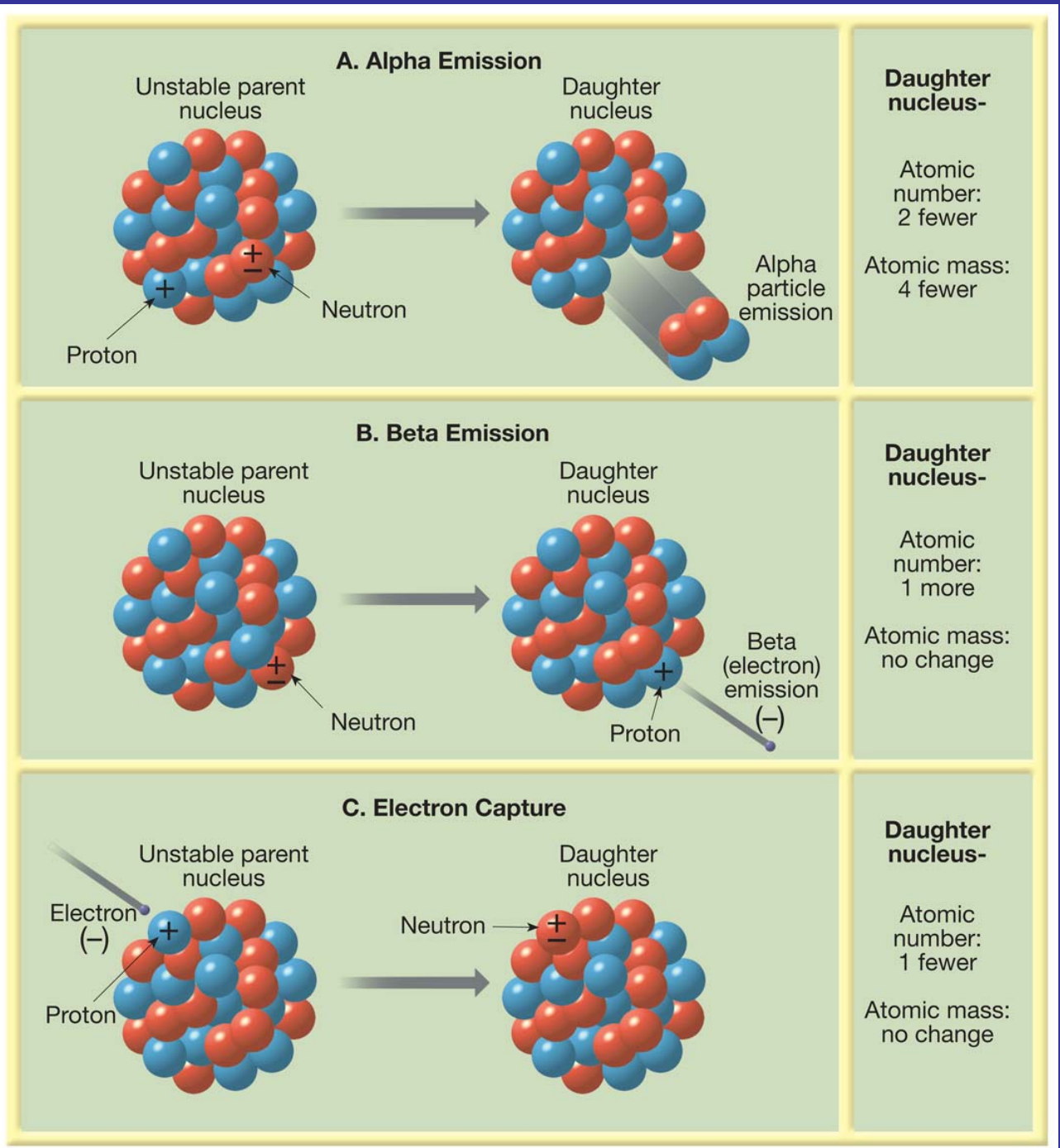


Isotope: same element, variable neutron number

Uranium isotopes:

	protons	neutrons
U-234	92	142
U-235	92	143
U-238	92	146





2 protons & 2 neutrons emitted

1 electron emitted

1 electron captured

Why do we care about radioactivity?

Why do we care about radioactivity?

1) Radioactivity produces HEAT energy
(i.e. not all of Earth's heat has to have come from the Sun)

2) Radioactive decay happens on a measurable timescale – this gives us a calendar for Earth materials

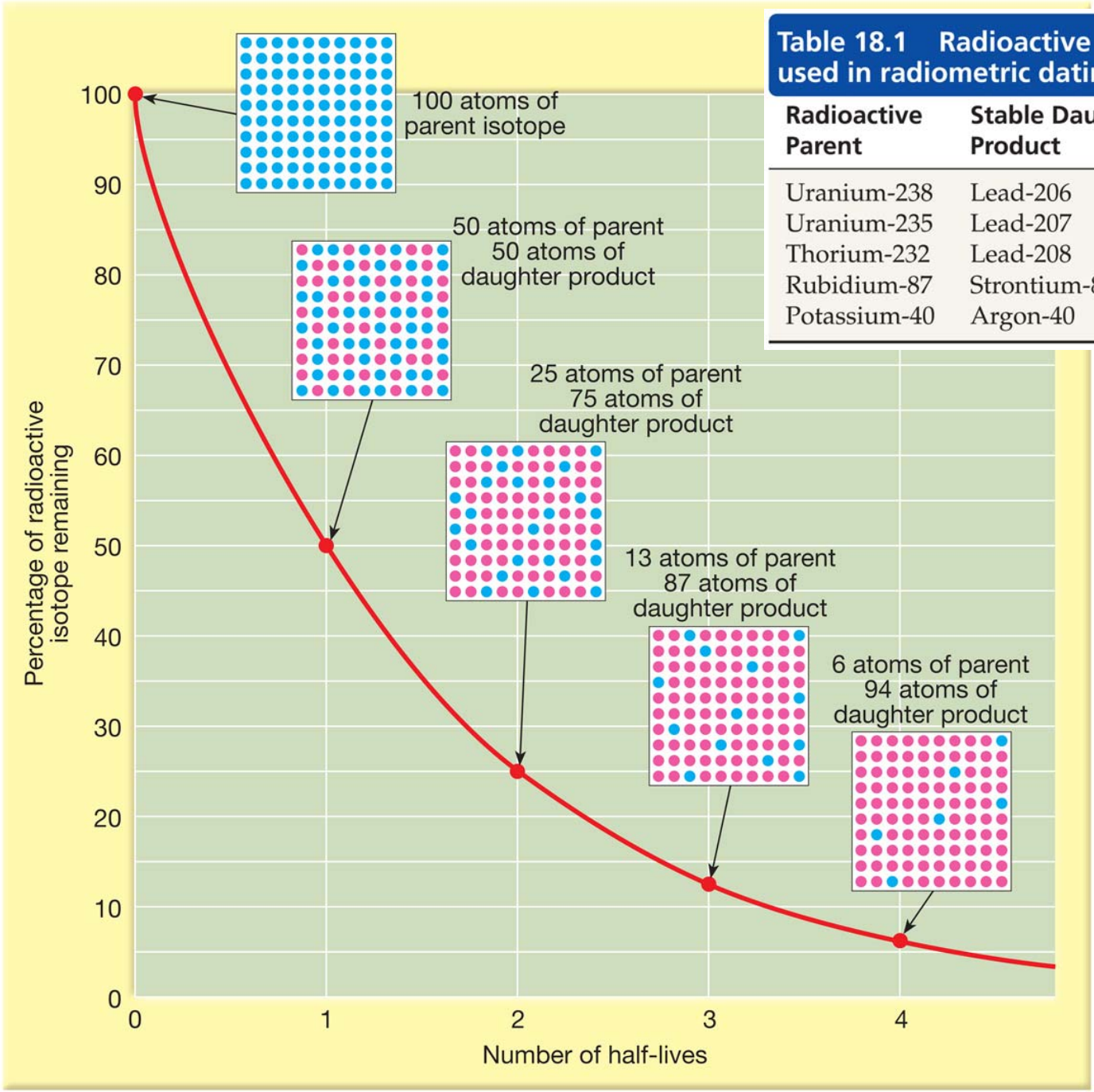


Table 18.1 Radioactive isotopes frequently used in radiometric dating.

Radioactive Parent	Stable Daughter Product	Currently Accepted Half-life Values
Uranium-238	Lead-206	4.5 billion years
Uranium-235	Lead-207	713 million years
Thorium-232	Lead-208	14.1 billion years
Rubidium-87	Strontium-87	47.0 billion years
Potassium-40	Argon-40	1.3 billion years

parent/ daughter ratio yields:

AGE

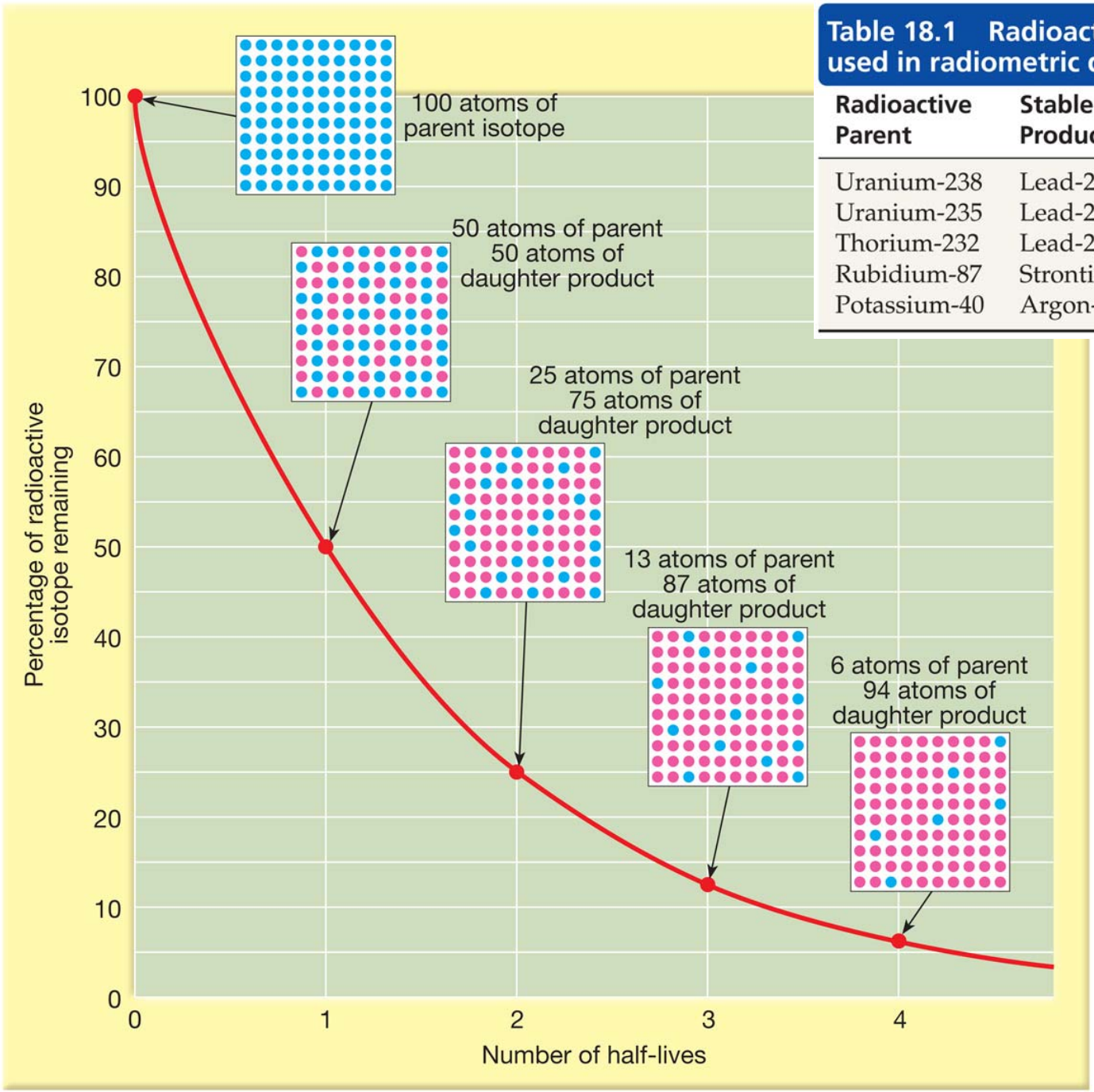


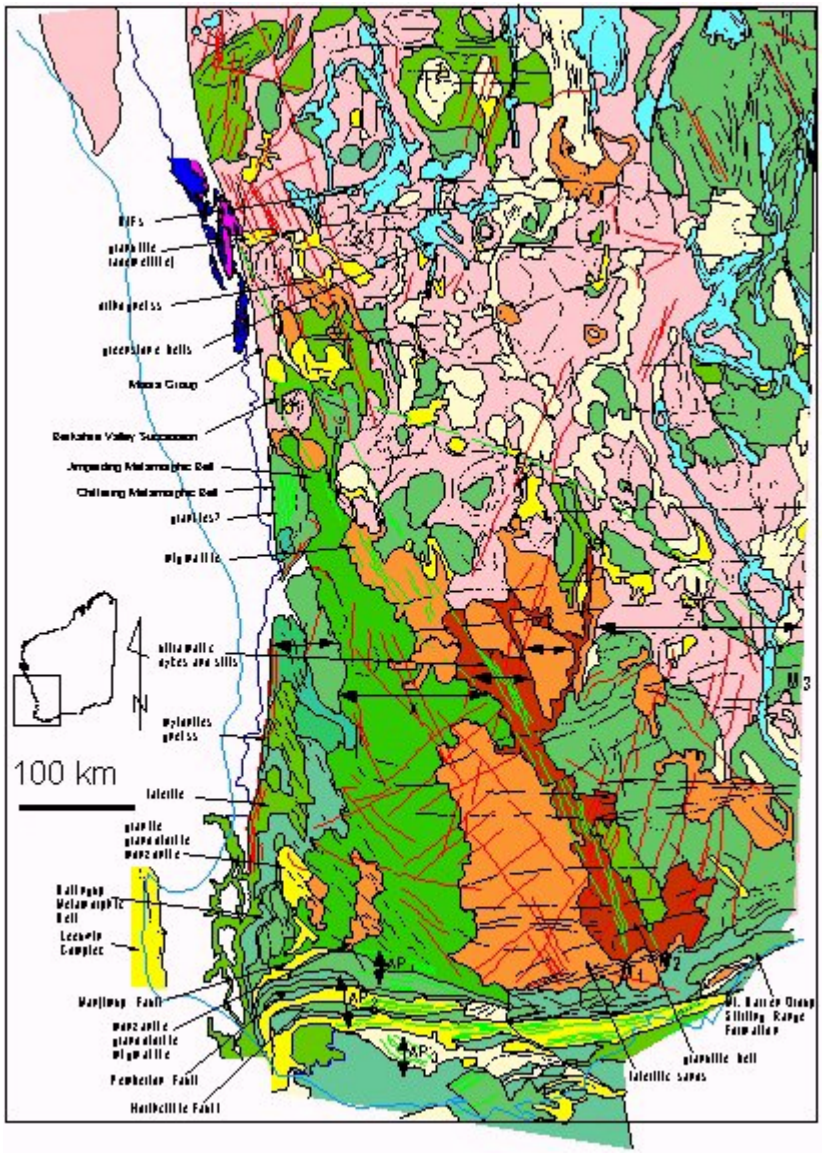
Table 18.1 Radioactive isotopes frequently used in radiometric dating.

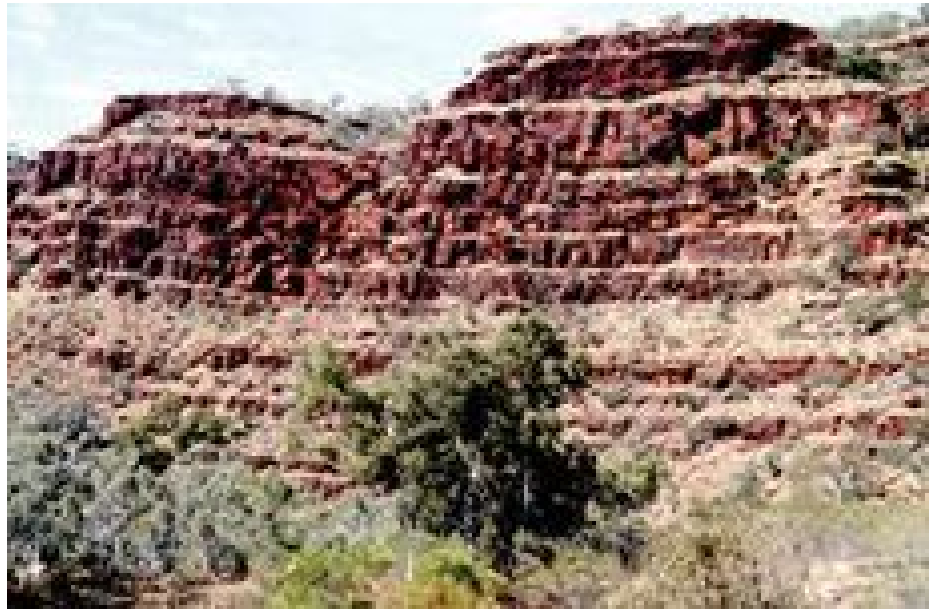
Radioactive Parent	Stable Daughter Product	Currently Accepted Half-life Values
Uranium-238	Lead-206	4.5 billion years
Uranium-235	Lead-207	713 million years
Thorium-232	Lead-208	14.1 billion years
Rubidium-87	Strontium-87	47.0 billion years
Potassium-40	Argon-40	1.3 billion years

Rock contains:
Potassium-40
P/D = 13/87

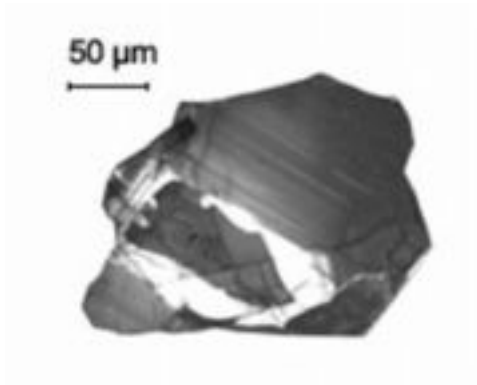
Age = ?

a) 1.3 Billion
b) 2.6 Billion
c) 3.9 Billion
d) 5.2 Billion
e) 6.5 Billion

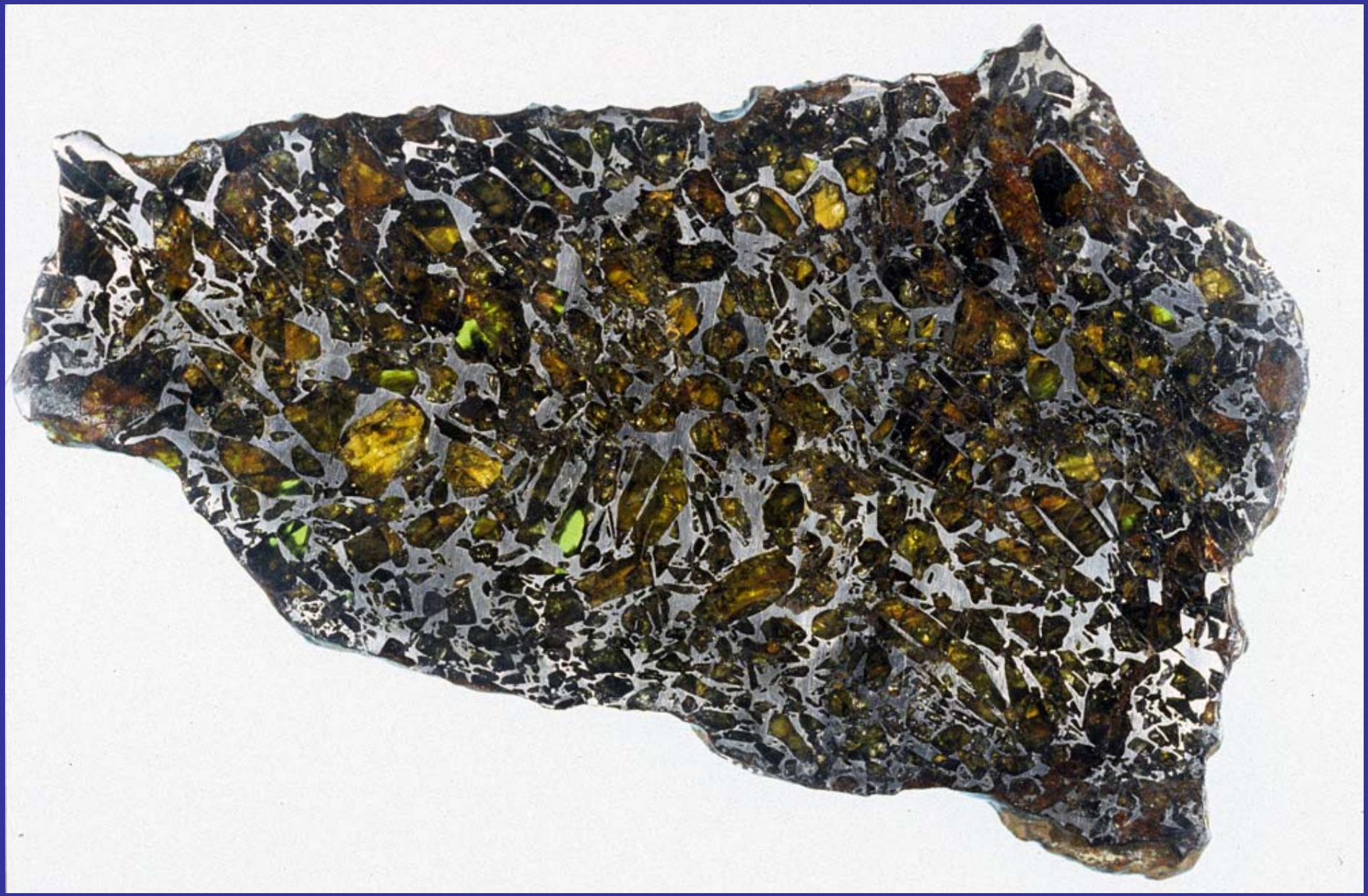




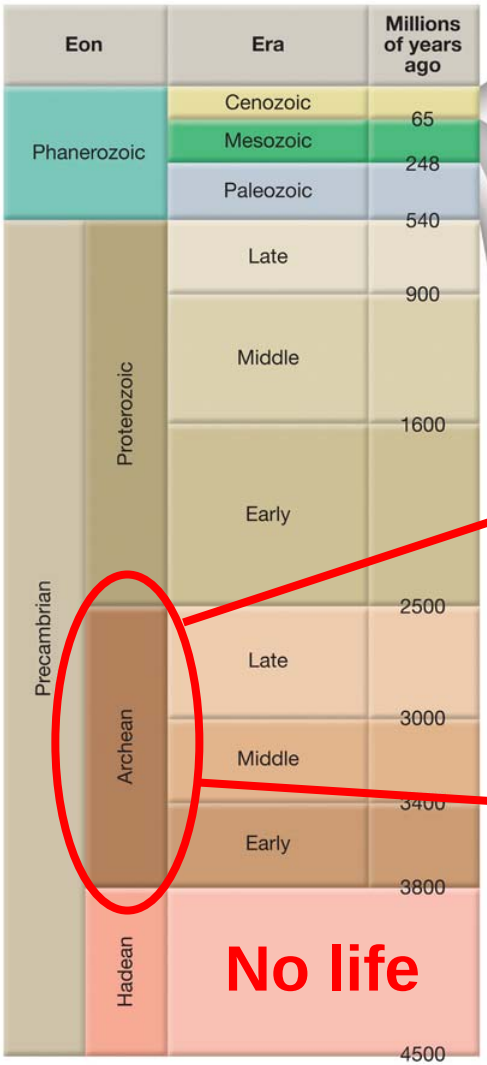
Oldest rock on Earth
4.404 Bya

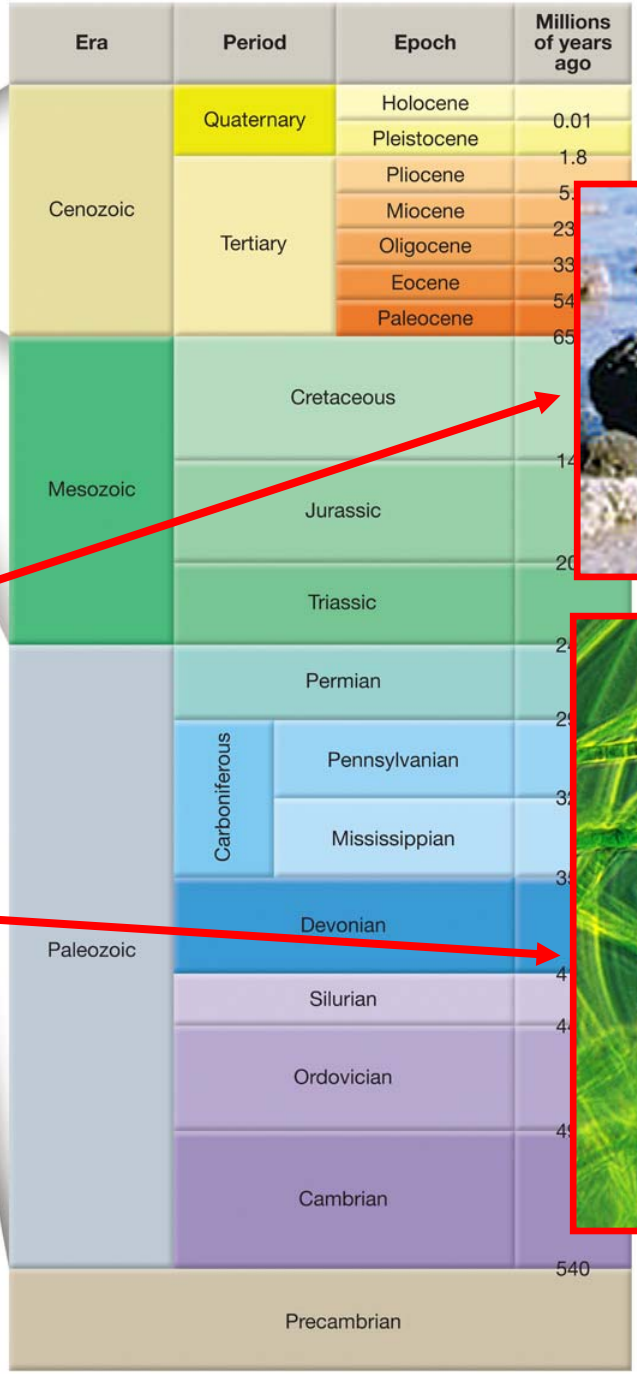


Jack Hills, Western Australia



Age of Earth from meteorites = 4.56 billion years





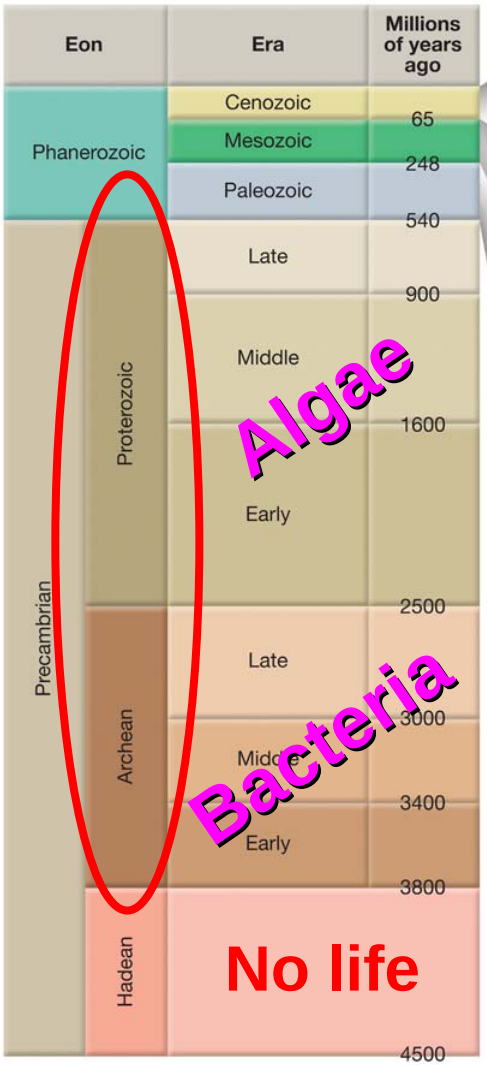
Hadean Eon
4.5-3.8 Bya

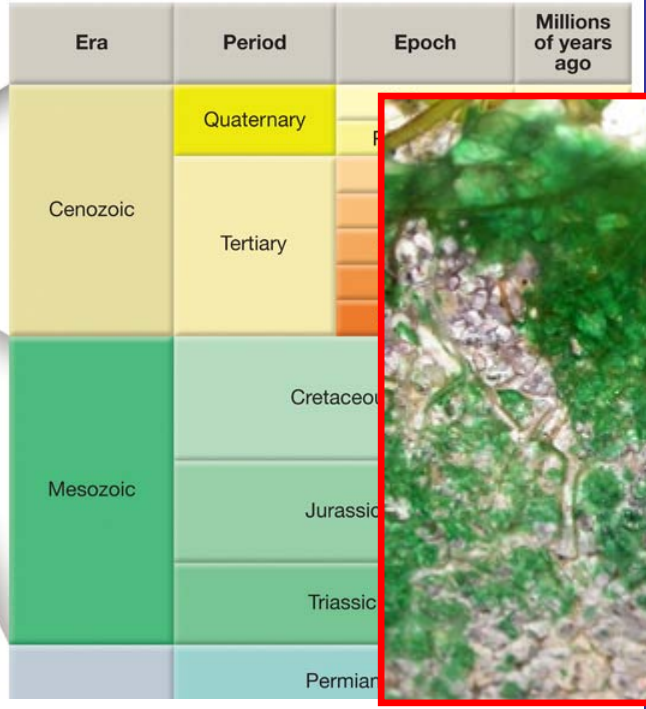
"Stromatolites"





Bacteria

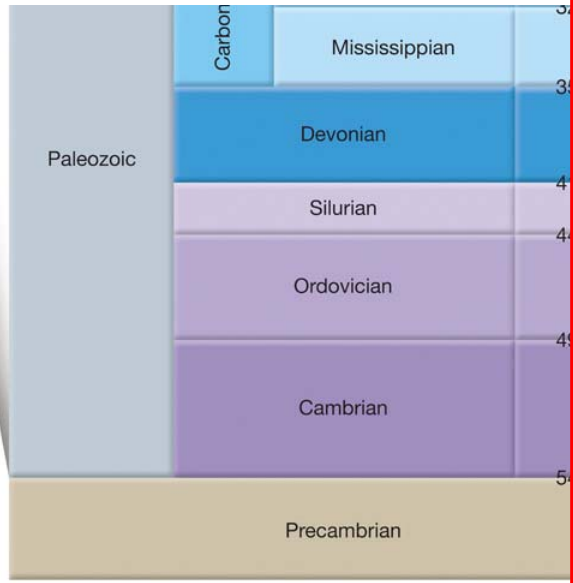


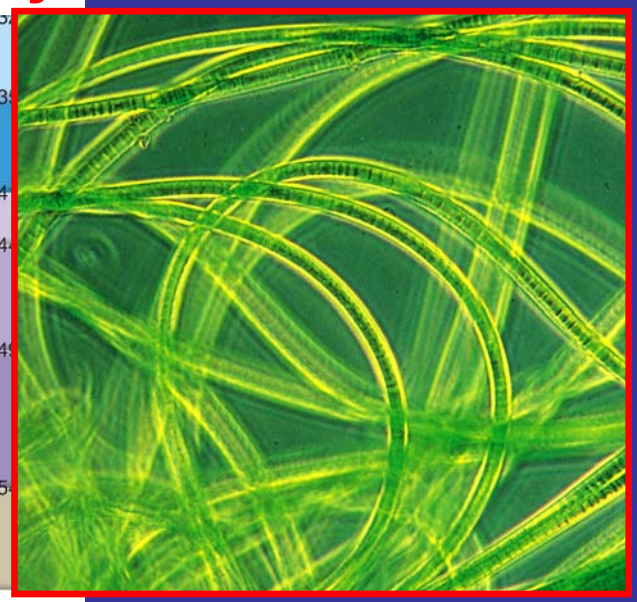


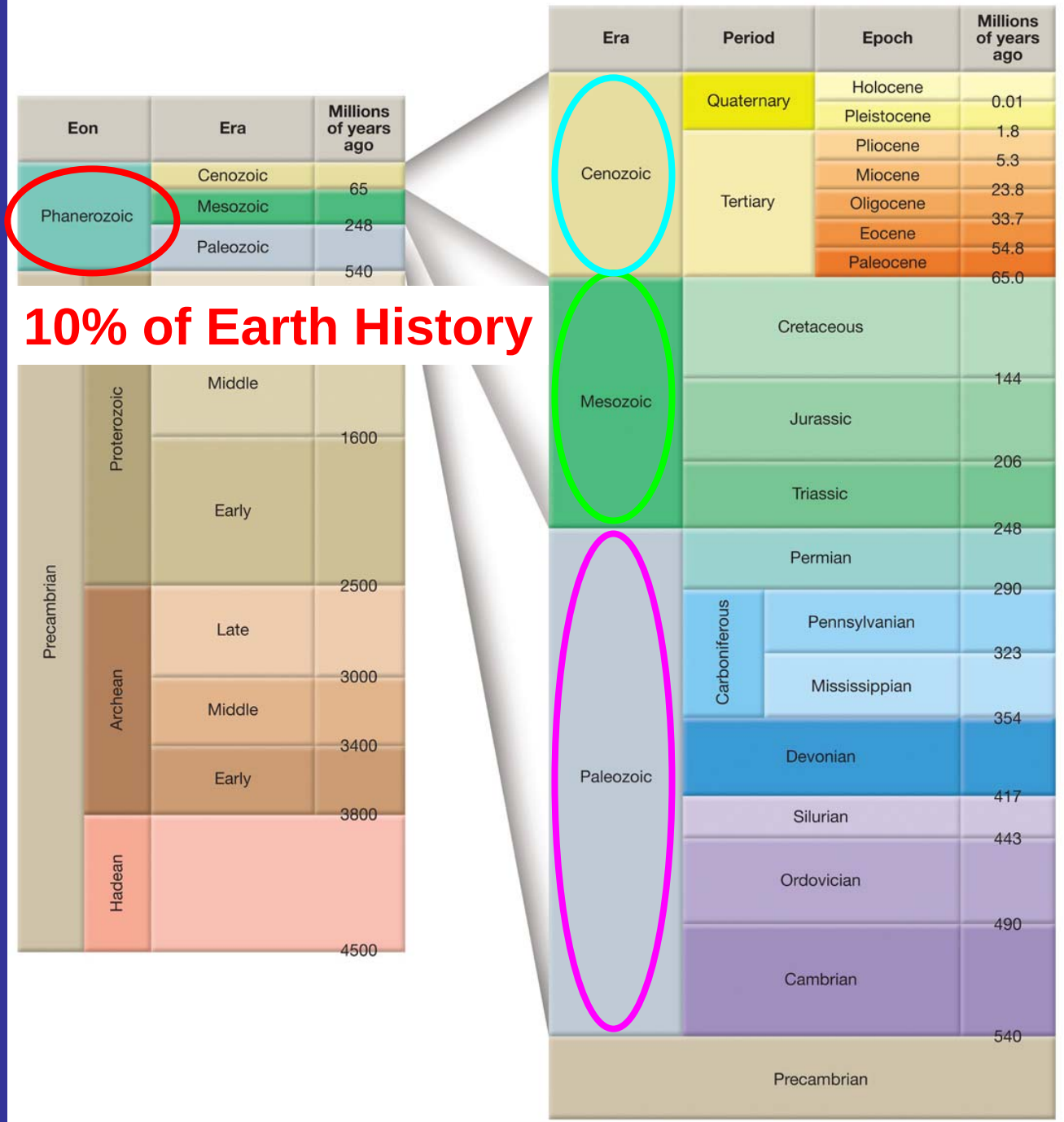


90% of Earth History

January 1 - November 18







Phanerozoic

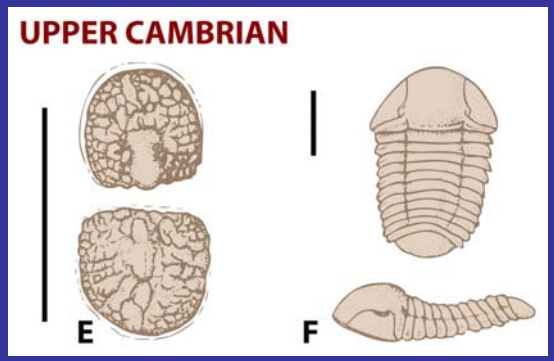
"Visible life"

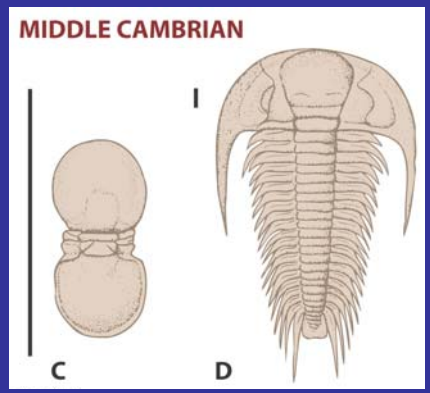
Recent life

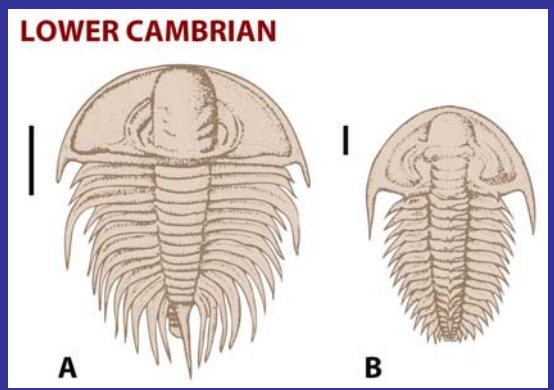
Middle life

Ancient life

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



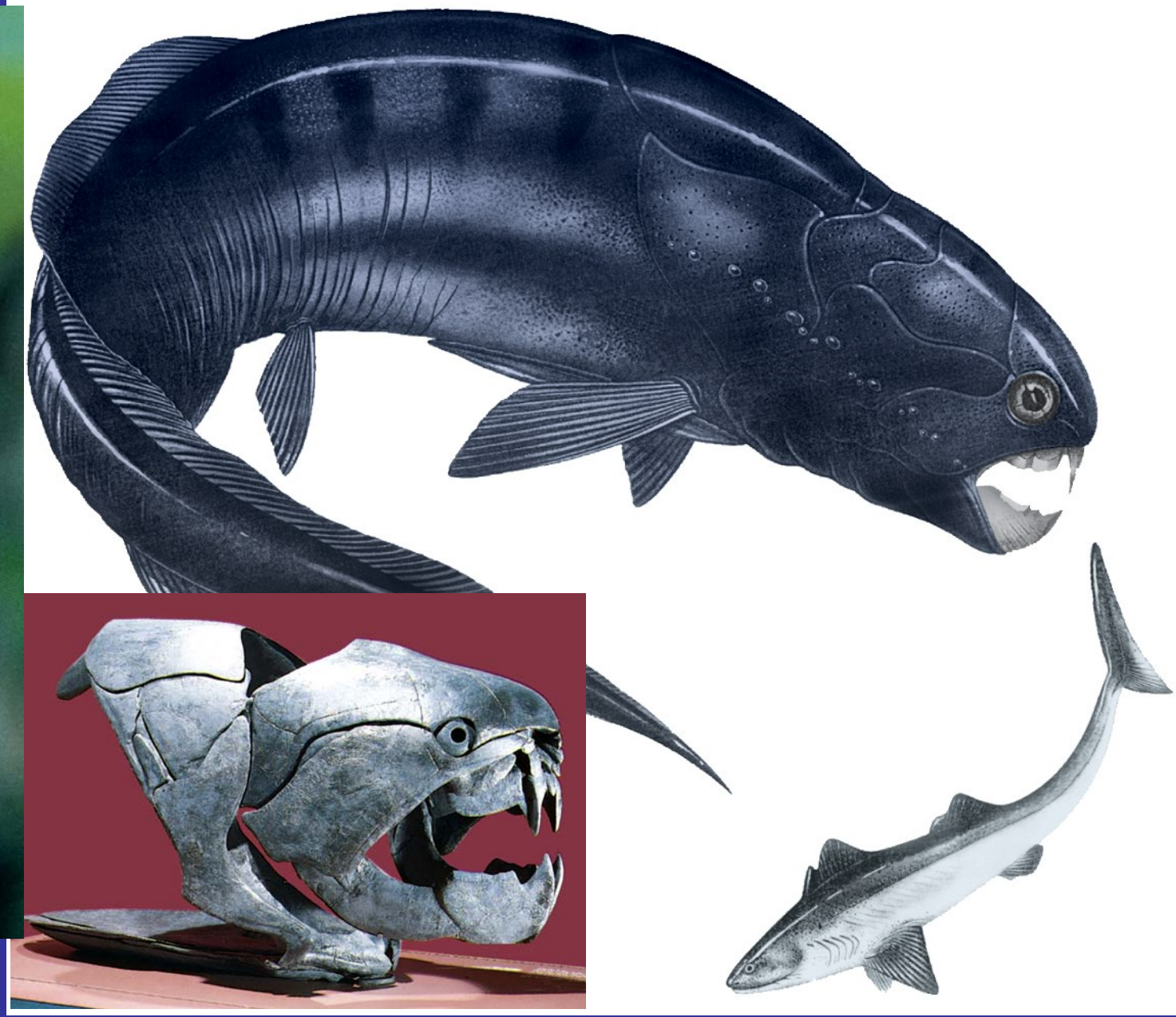




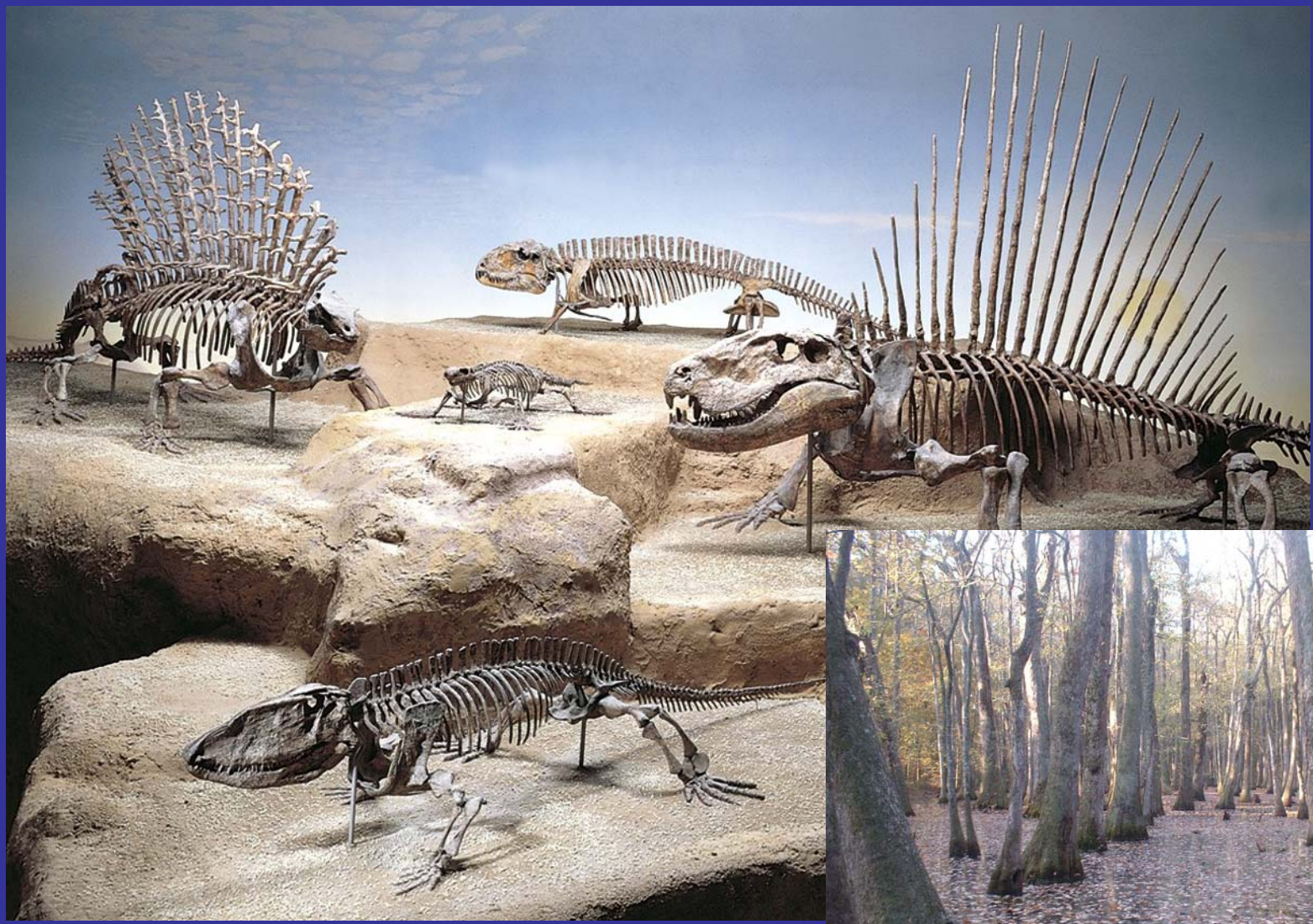


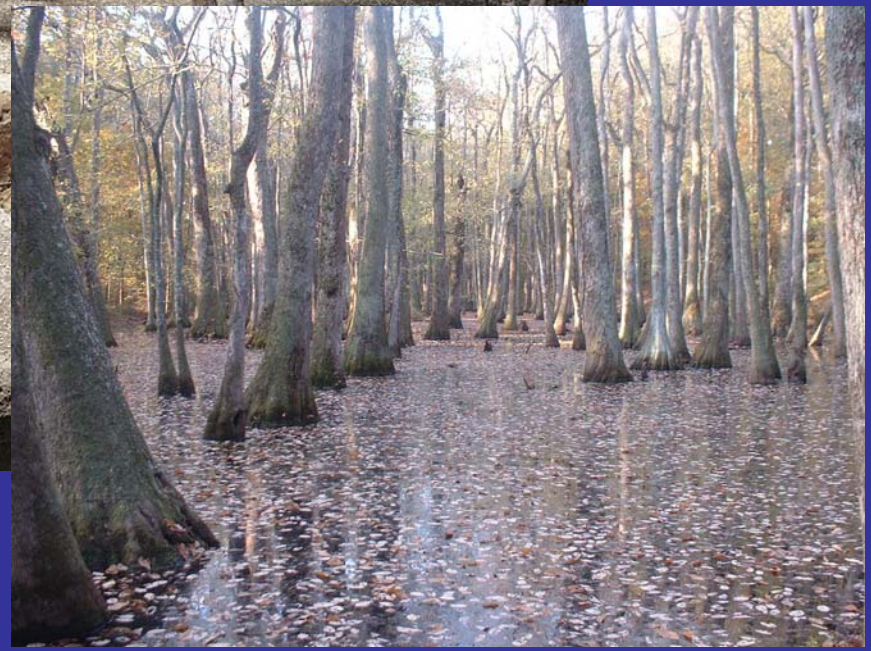
Middle Paleozoic (A.L.) – Jawed Fish: vertebrate predator; Seed Plants





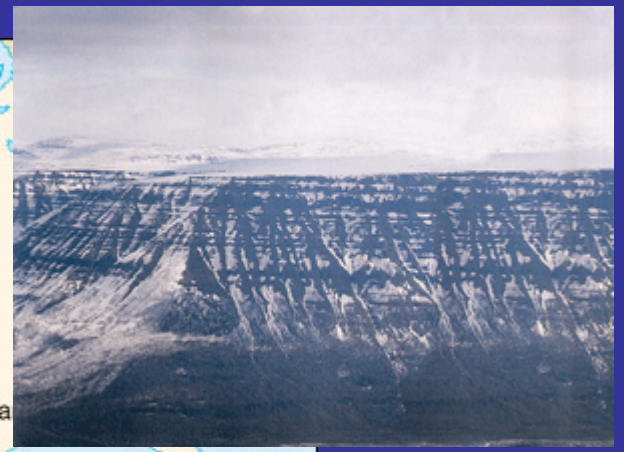
Late Paleozoic (A.L.) – Reptiles such as Dimetrodon, Coal Swamps





December 11



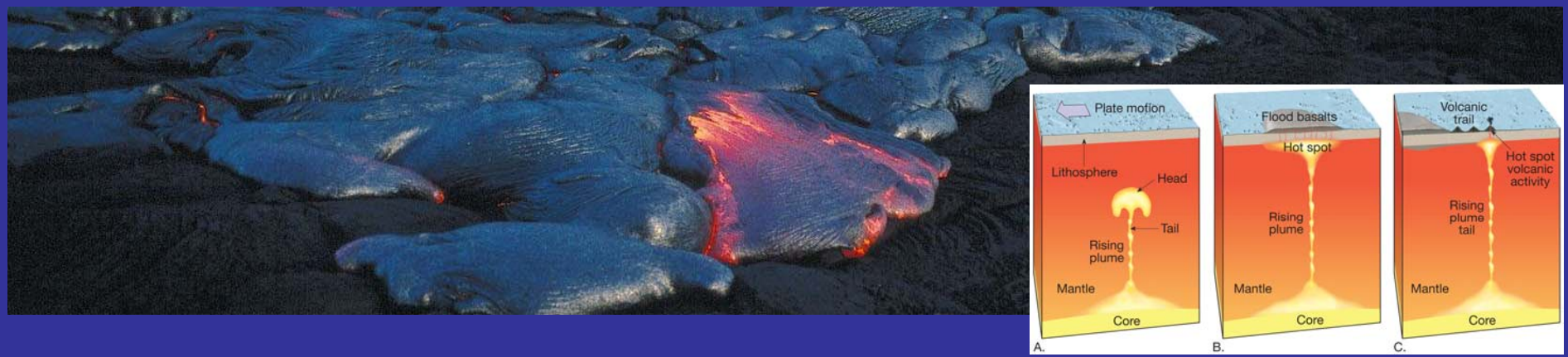


Permian Extinction

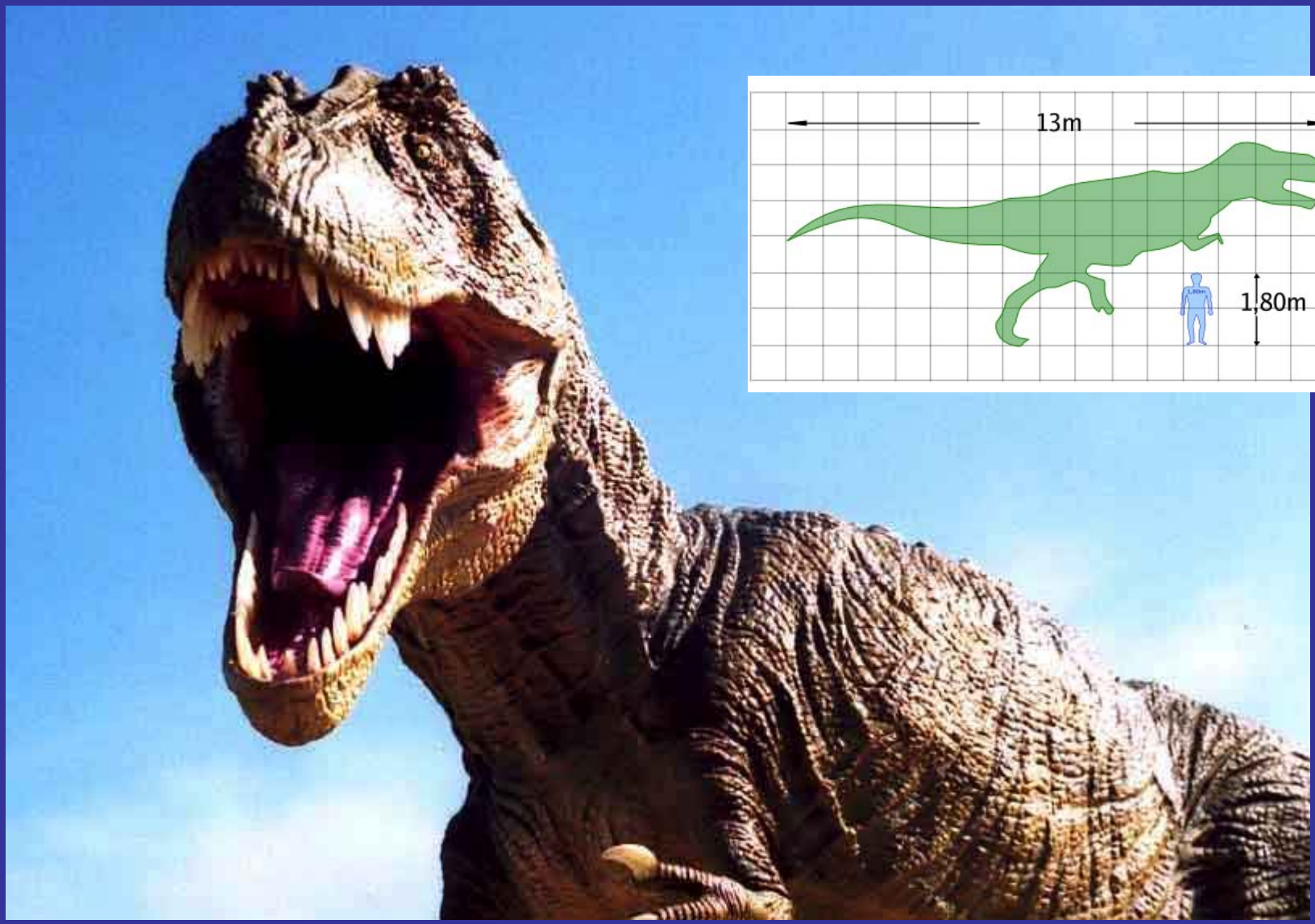
96% marine

70% terrestrial

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

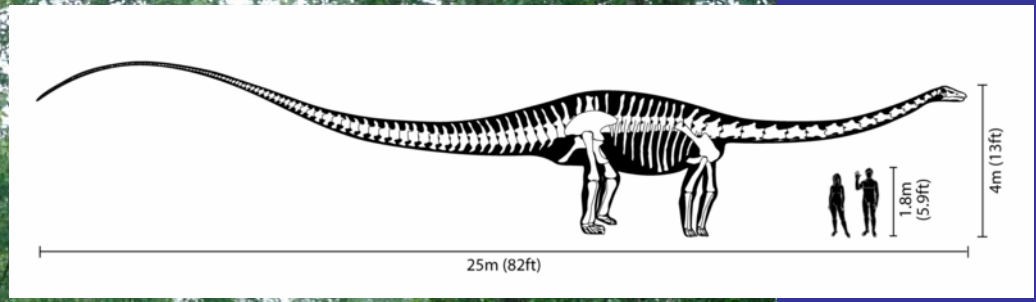


Early Mesozoic (Middle Life) – DINOSAURS!



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!

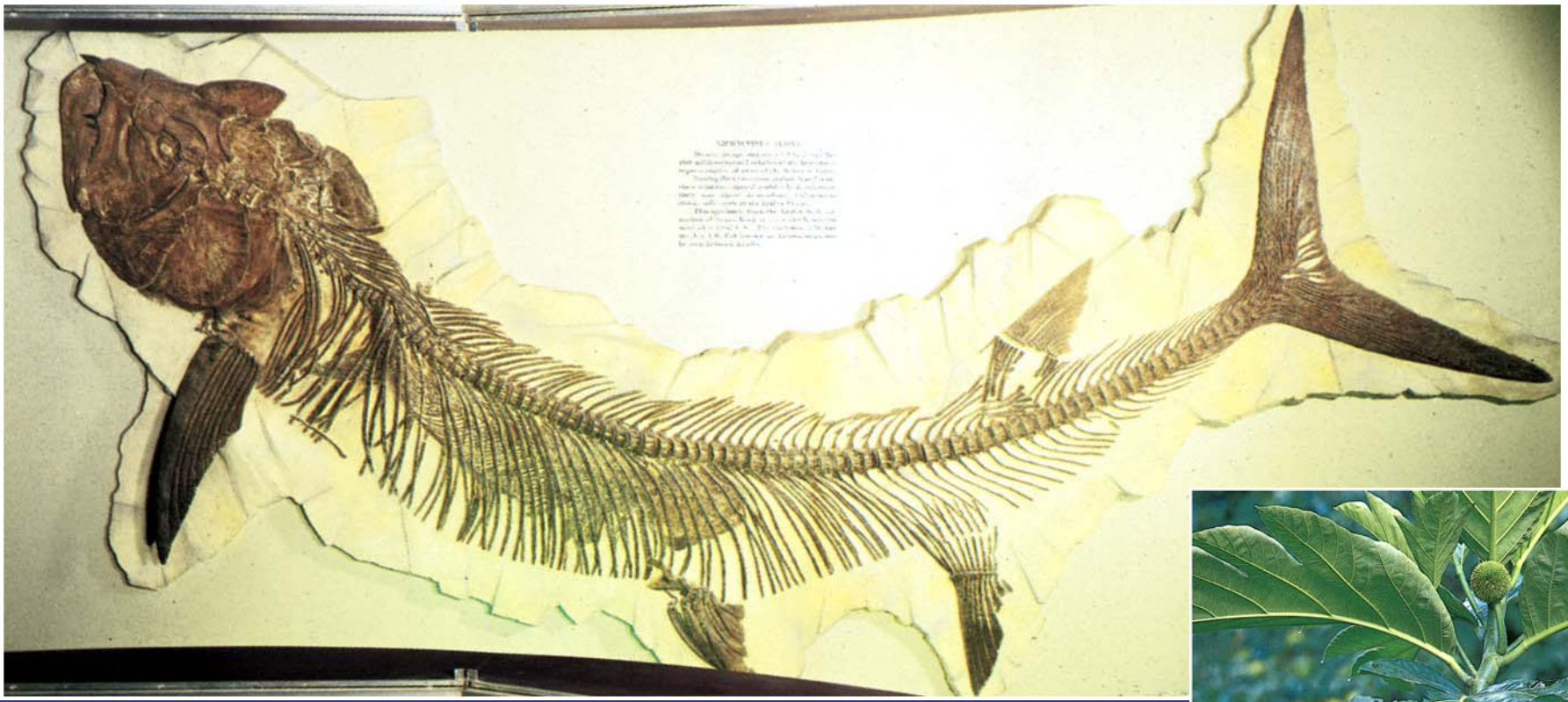




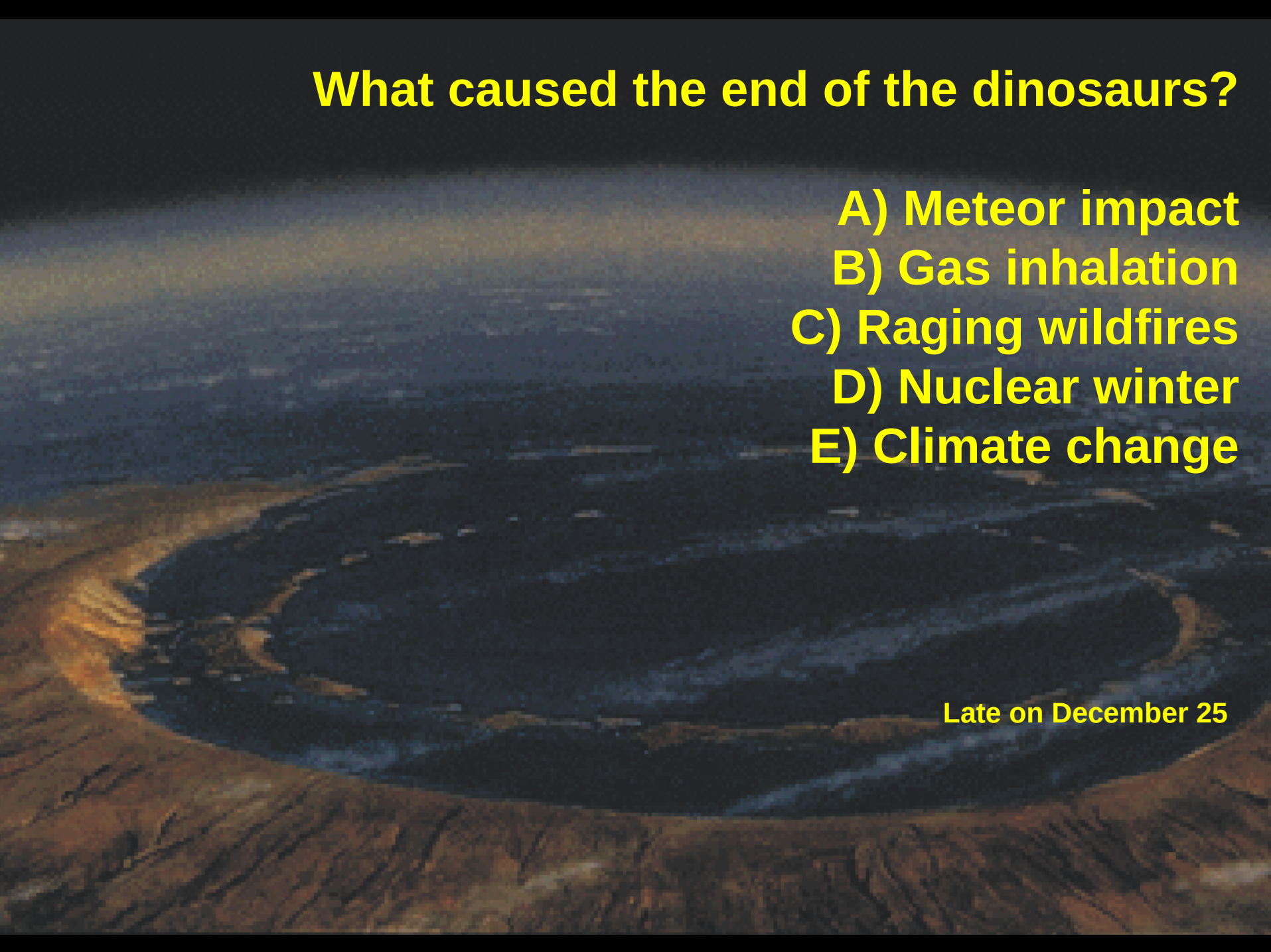
Median dinosaur weight 2 tons



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







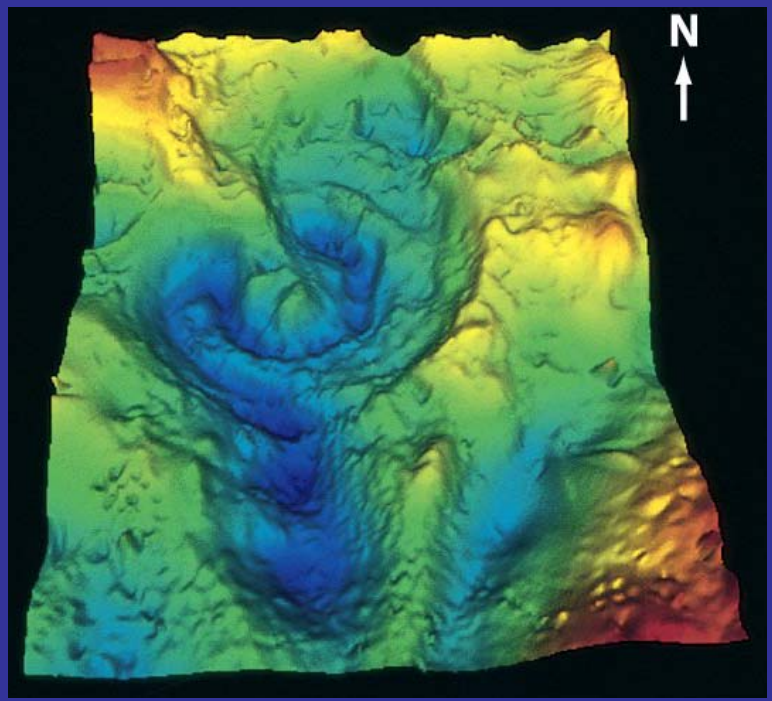
What caused the end of the dinosaurs?

A) Meteor impact
B) Gas inhalation
C) Raging wildfires
D) Nuclear winter
E) Climate change

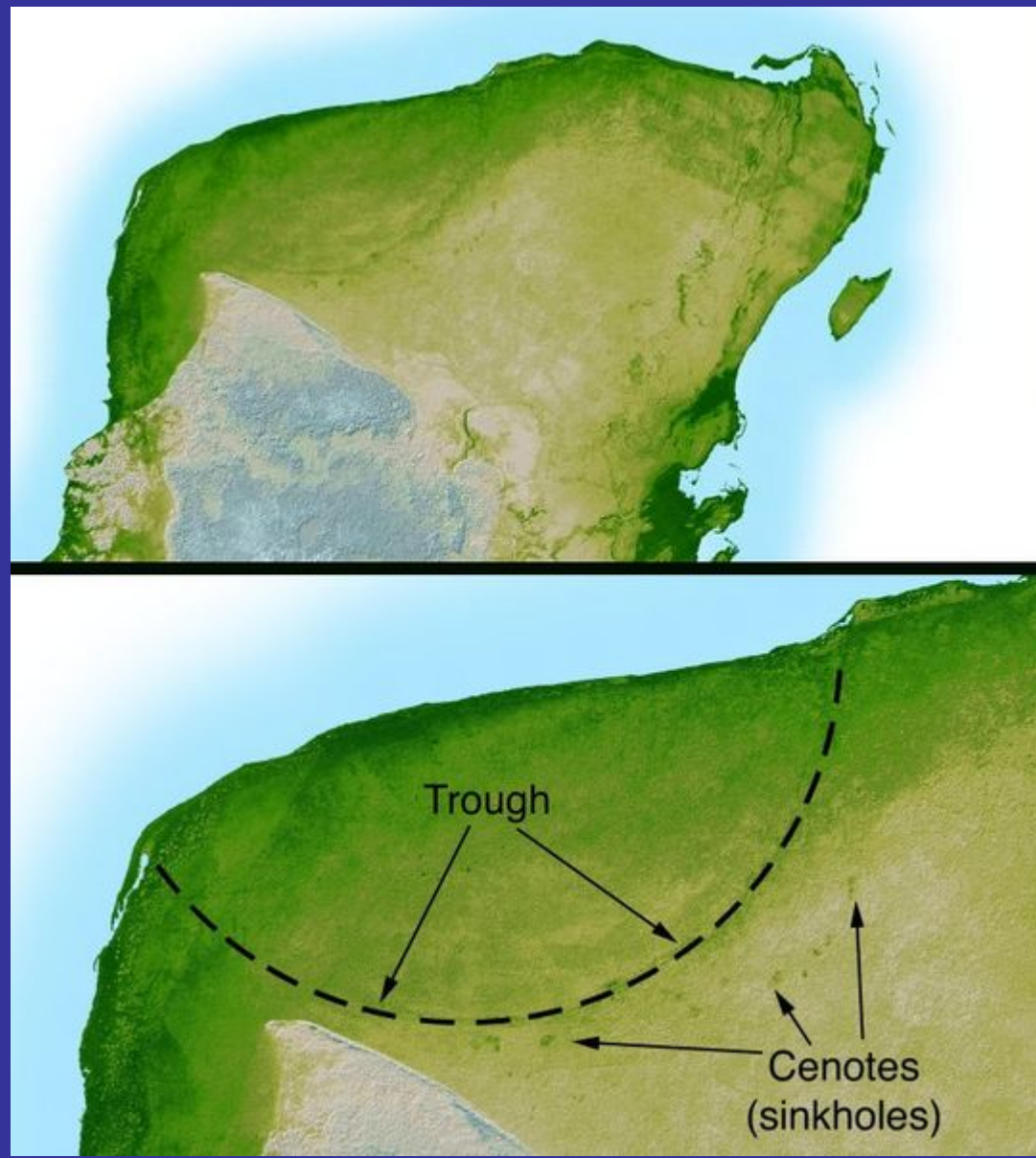
Late on December 25

Chicxulub Crater – >180km across





Andesite layer 1.3km down



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



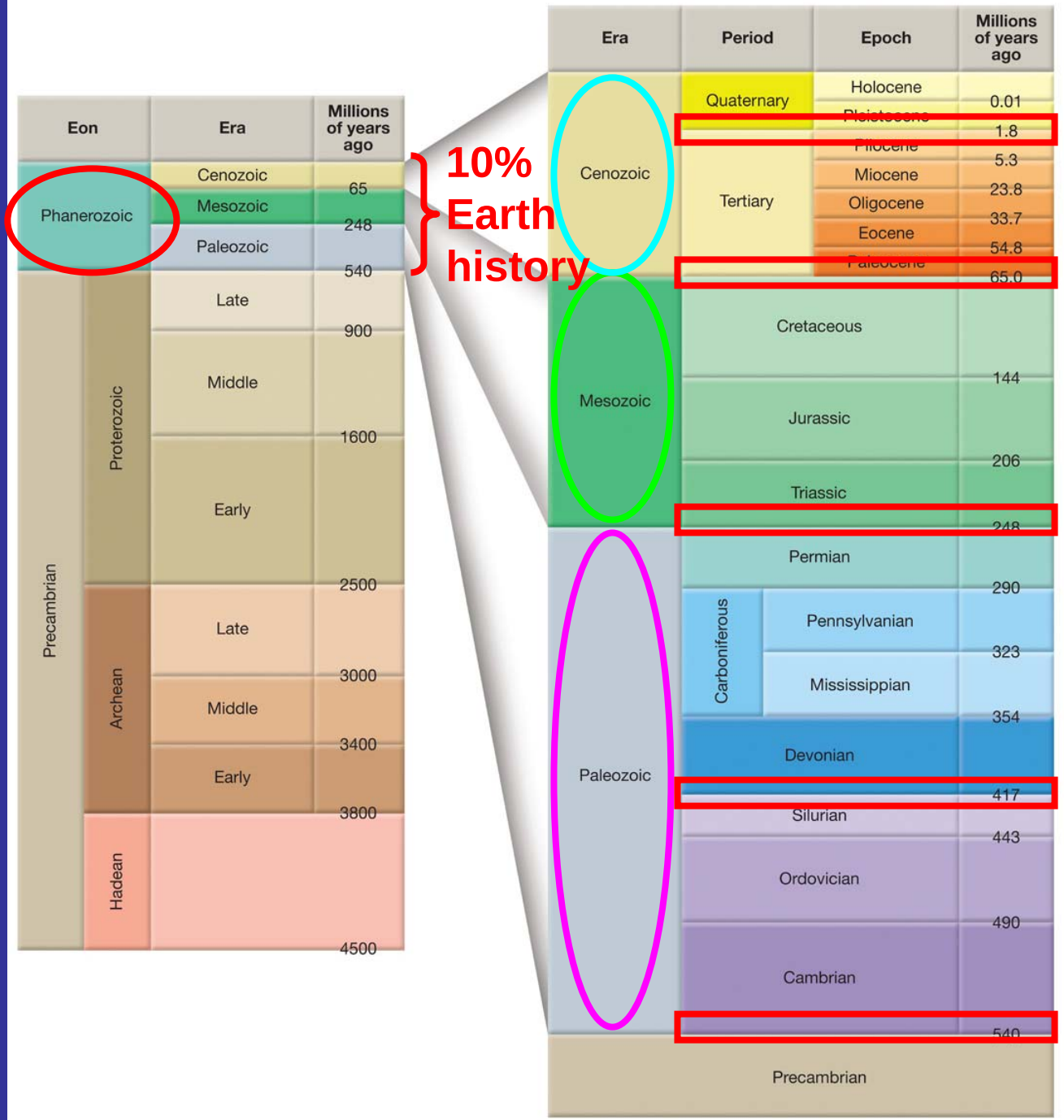
2 million times more powerful than largest nuclear explosion

K/T Boundary

65 Mya



spherules



What Organizes the Geologic Timescale?

A) Time

B) Life

C) Fossils

D) Extinctions

E) Climate Change

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



1) Mega-tsunami kilometers high

2) Nuclear winter from atmospheric debris



spherules

Early Cenozoic (Recent Life) – Radiation of mammals

What dinosaur do paraceratherium resemble?

A) T-rex
B) Velociraptor
C) Sauropod
D) Pterodactyl





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

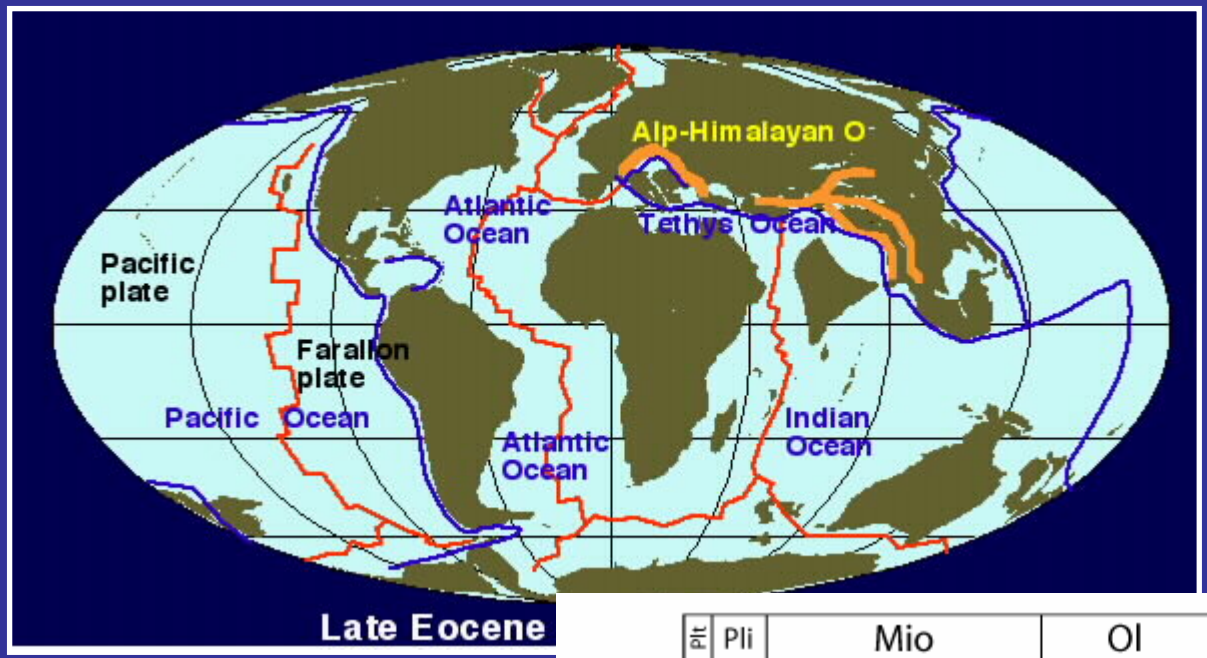






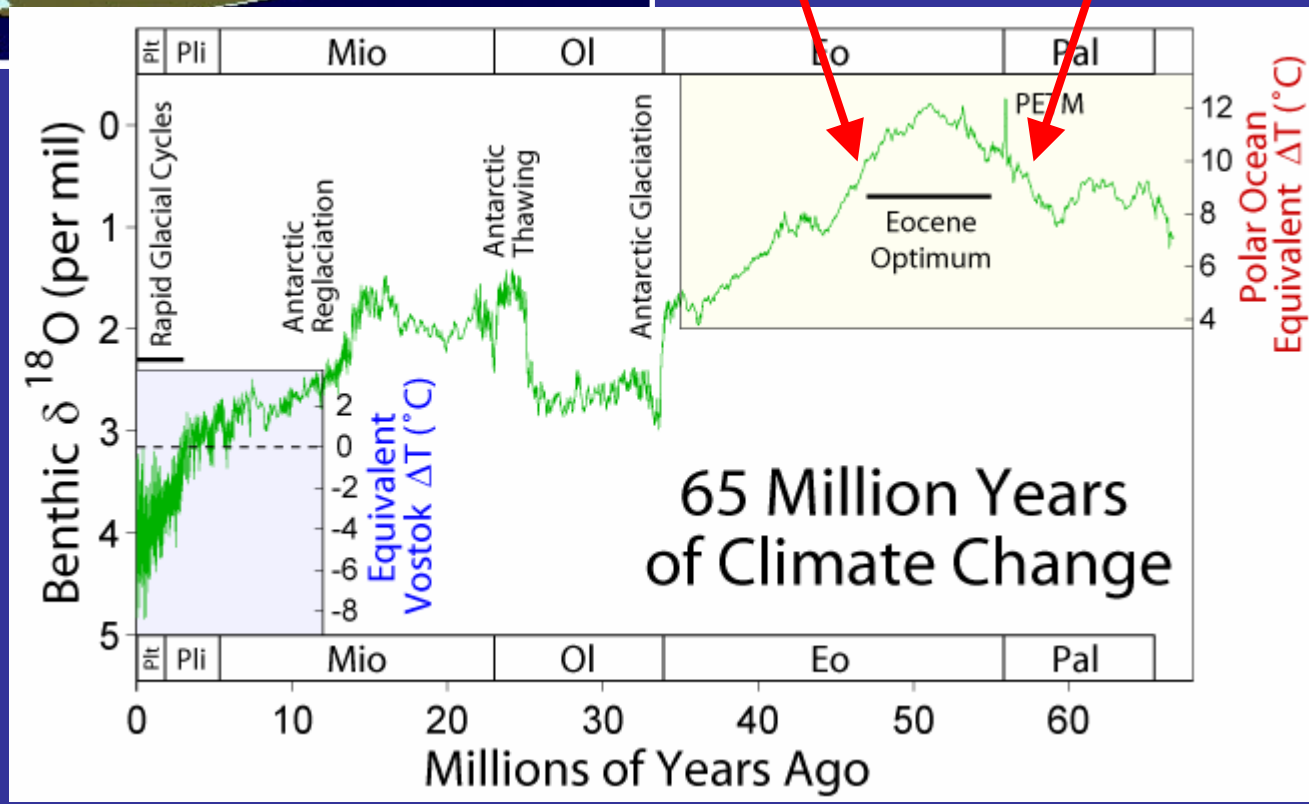
Why was Eocene climate so different from today?

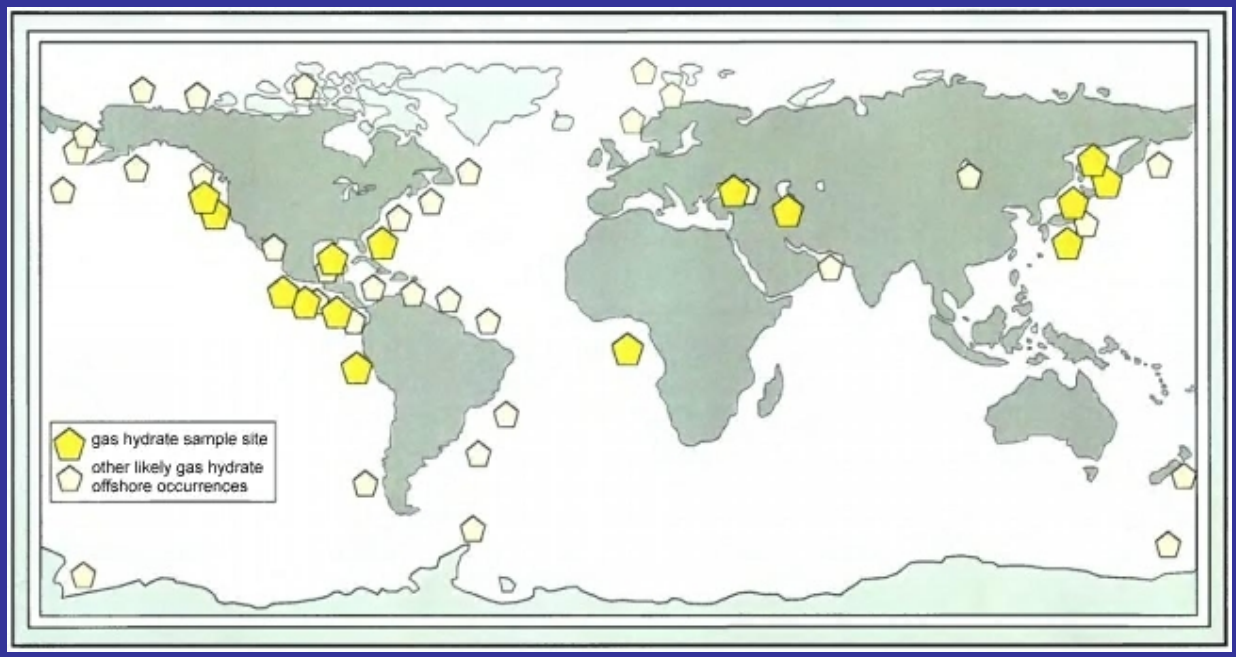




What was going on here to change global temperature?

Paleocene-Eocene Thermal Maximum



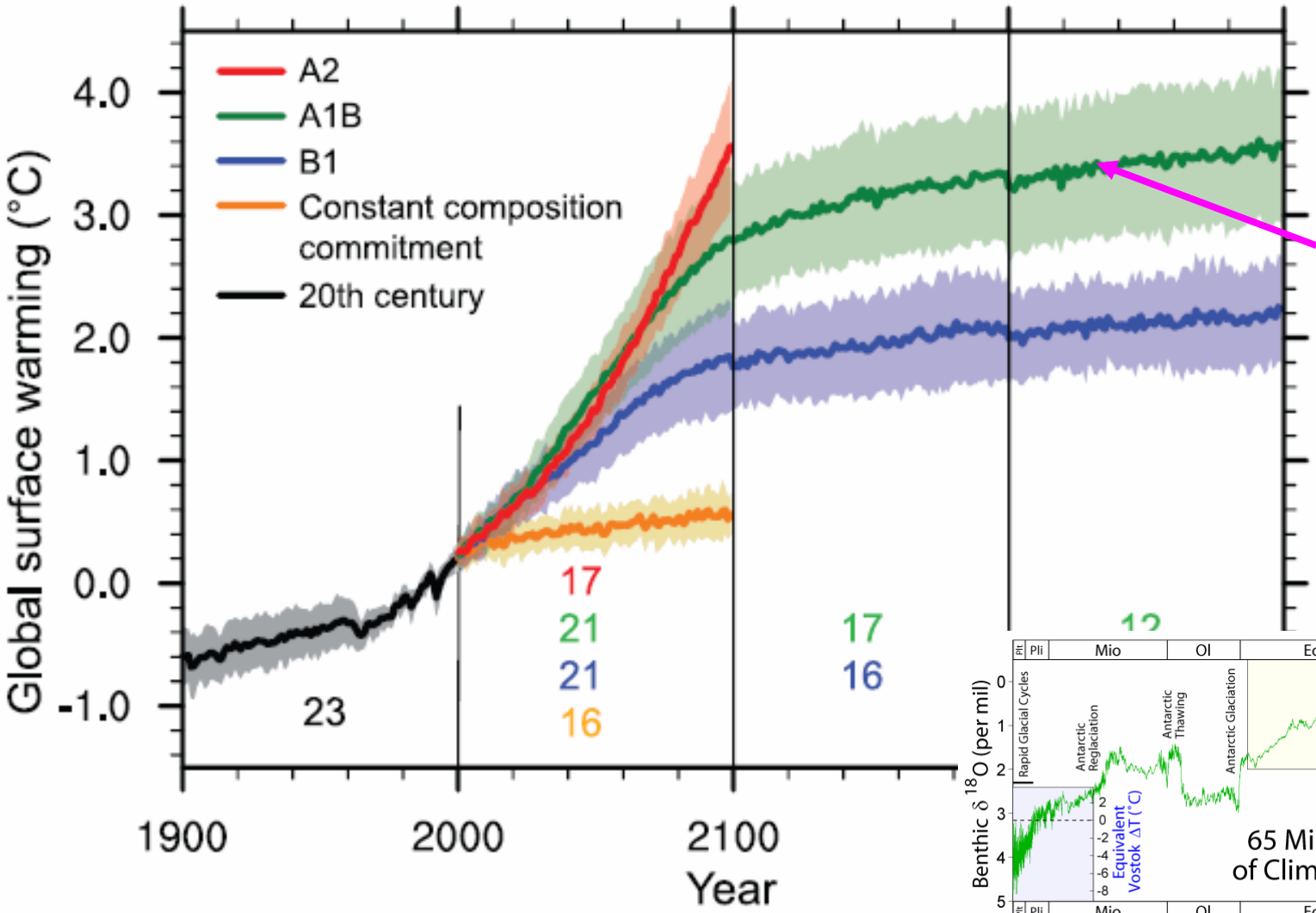




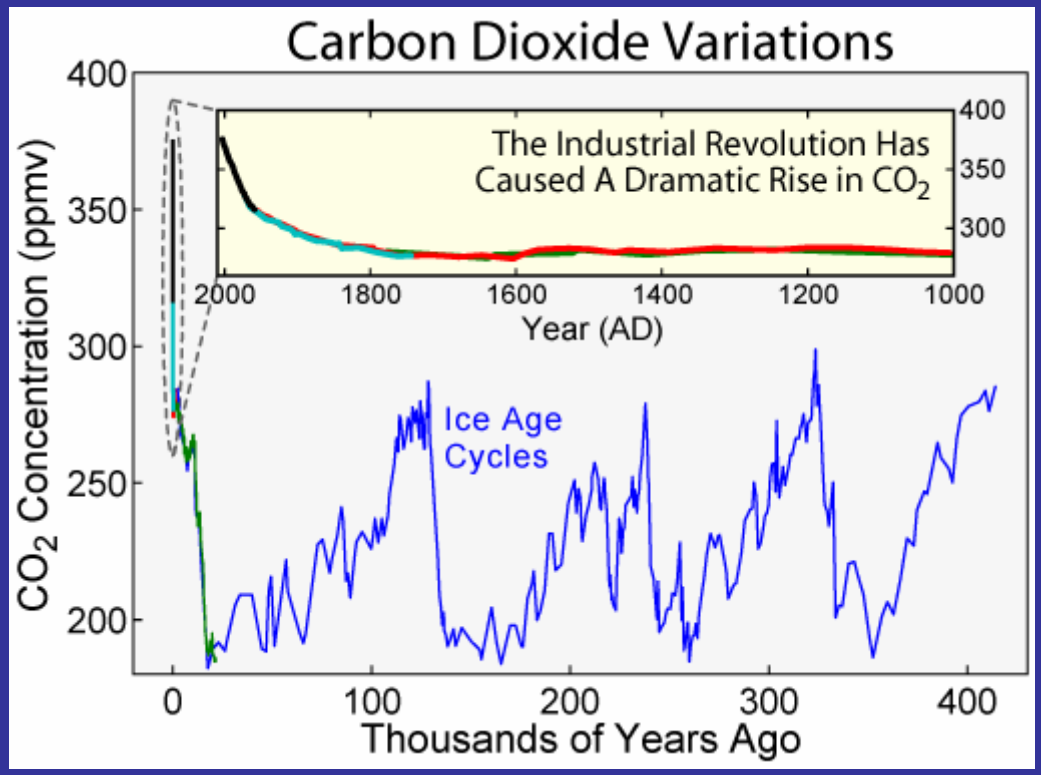
Sea surface temperatures rose 5-8ºC
Arctic Ocean sea surface temperatures were 23ºC
Drastic changes in ocean chemistry
Massive worldwide extinctions

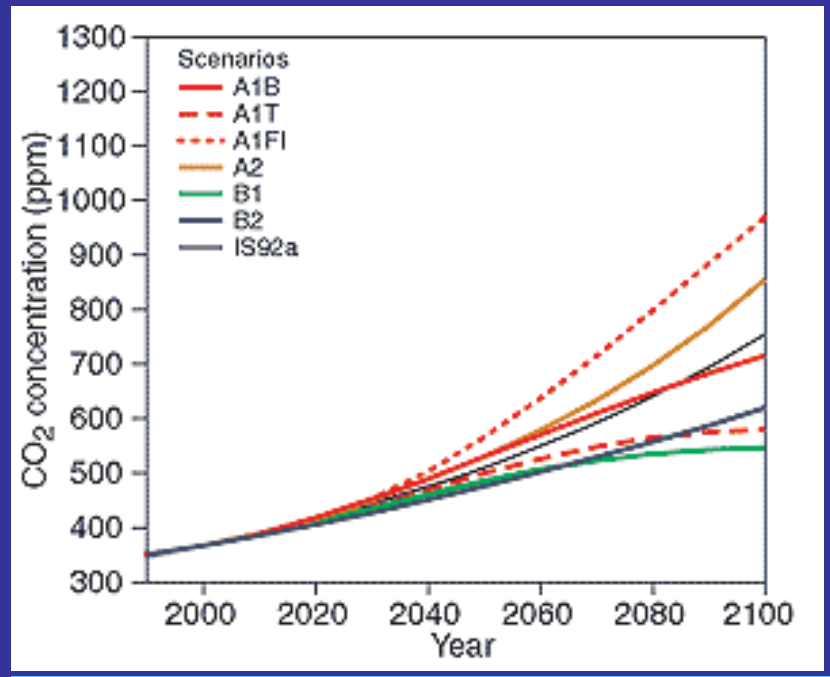
Sudden “global warming” caused by methane?

How is temperature projected to change in our lifetimes?



Intergovernmental Panel on Climate Change 2007







Could we have alligators in the Arctic again?





The New York Times

Grim Outlook for Polar Bears

By ANDREW C. REVKIN
Published: October 2, 2007

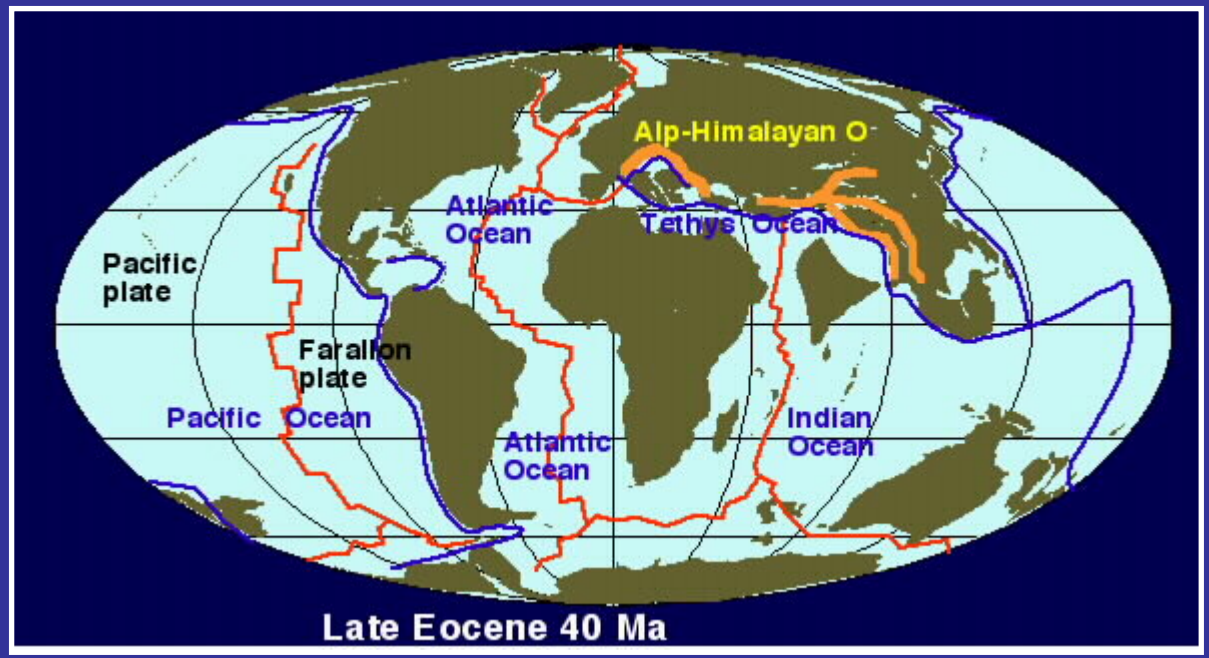
Two biologists who measure field time with polar bears in decades sat in a federal building here, envisioning two possible fates for this denizen of ice in a warming world -- and neither future looked bright.

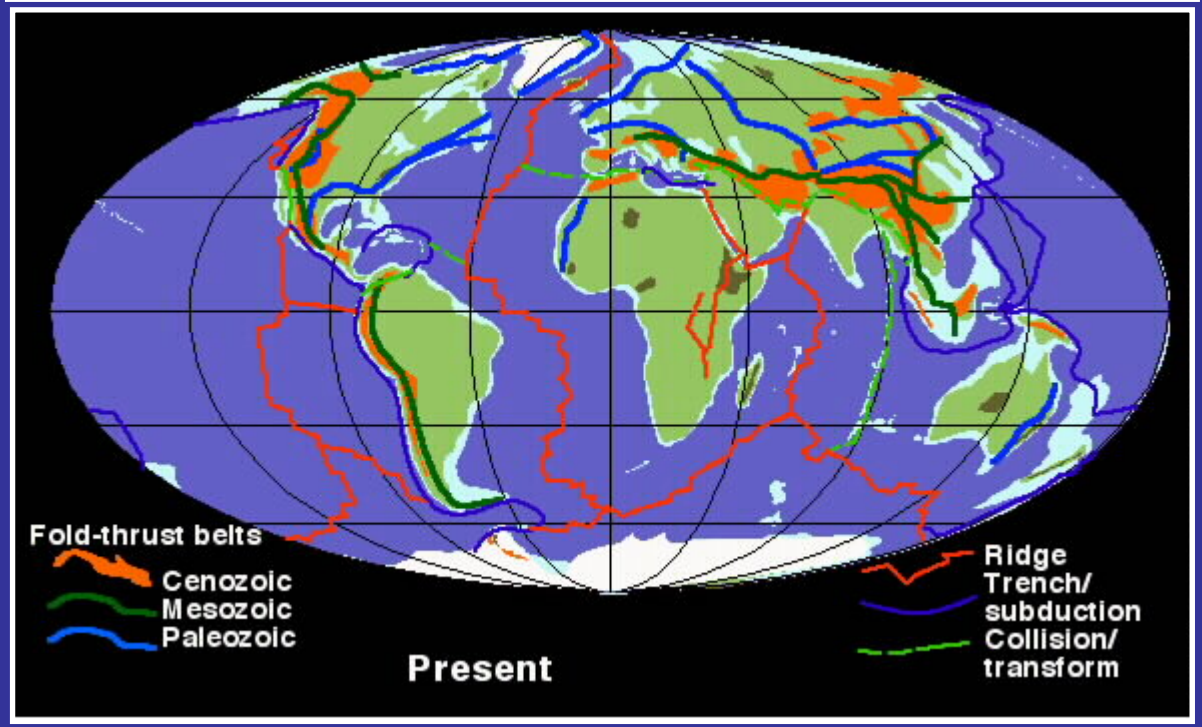


Late Cenozoic (Recent Life) – Diversification of mammals



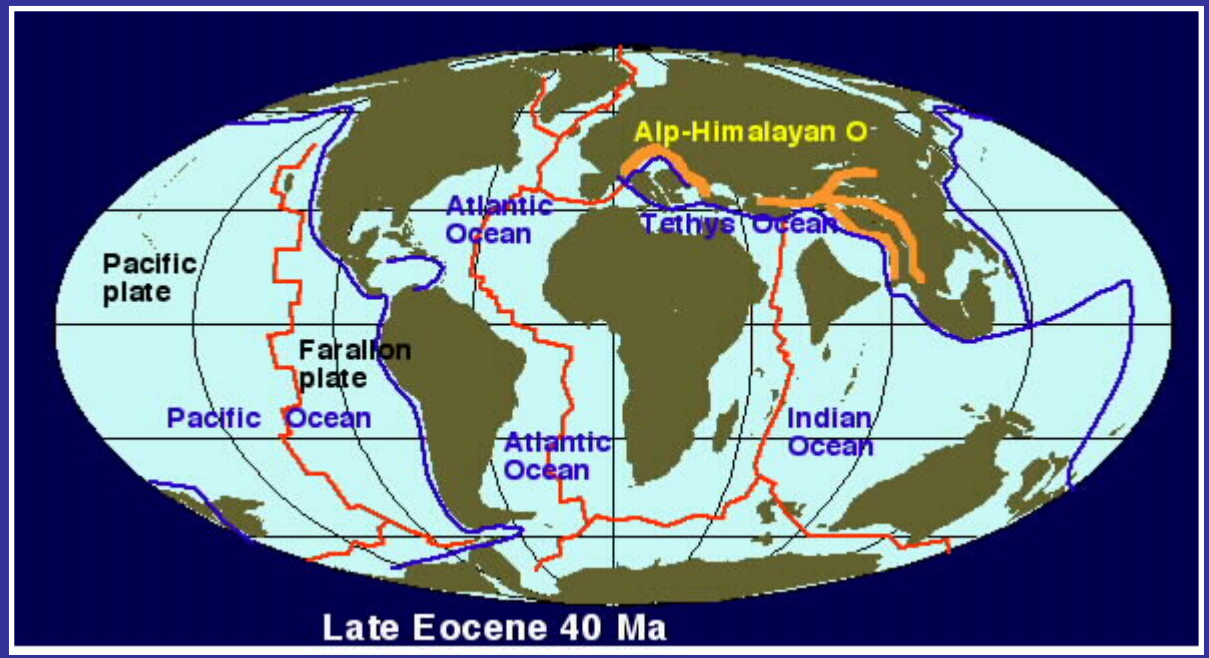
Grassland species thrive

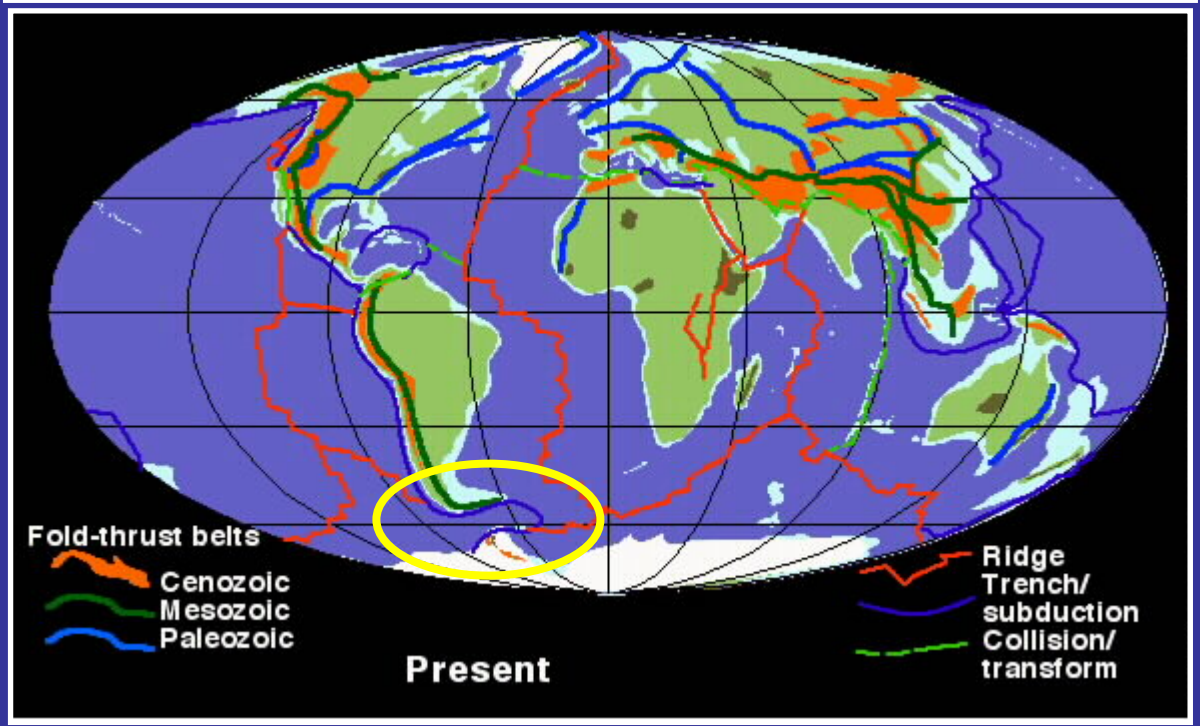




What happened between Eocene and Oligocene?

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



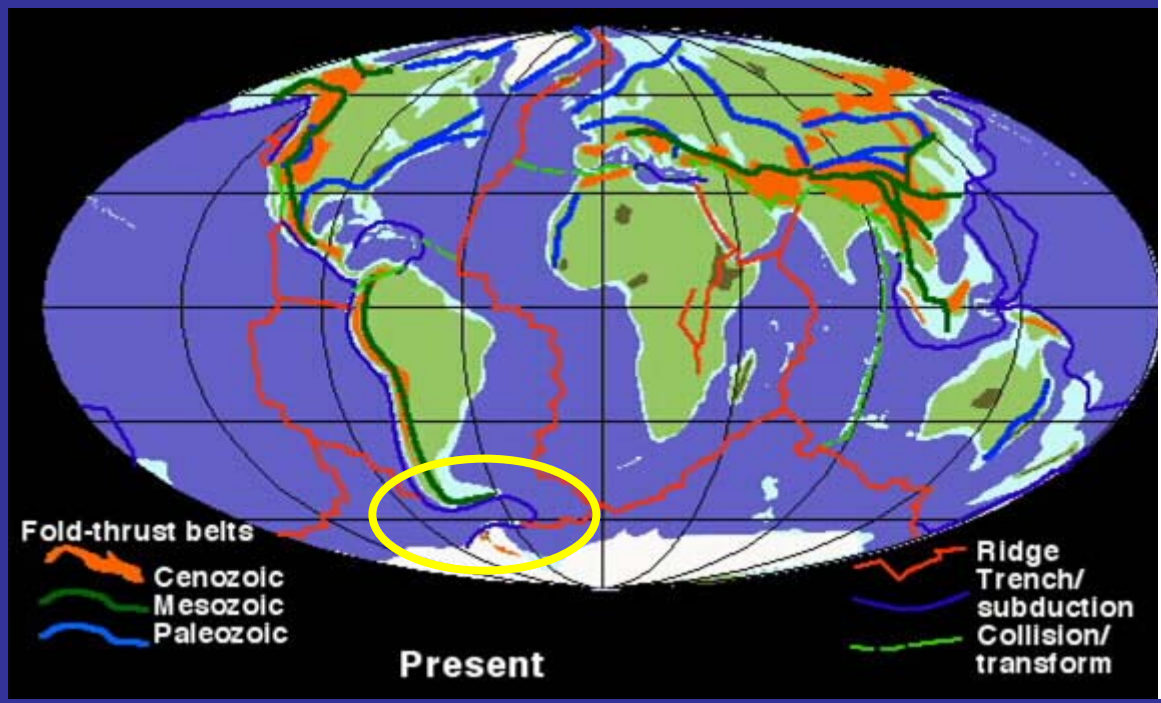


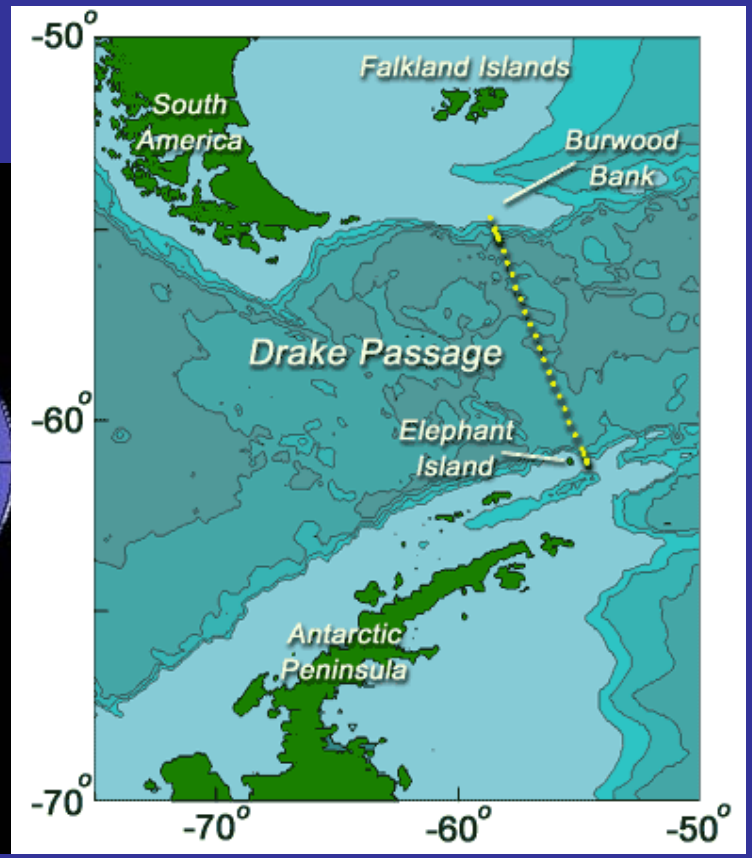
Opening of Drake Passage

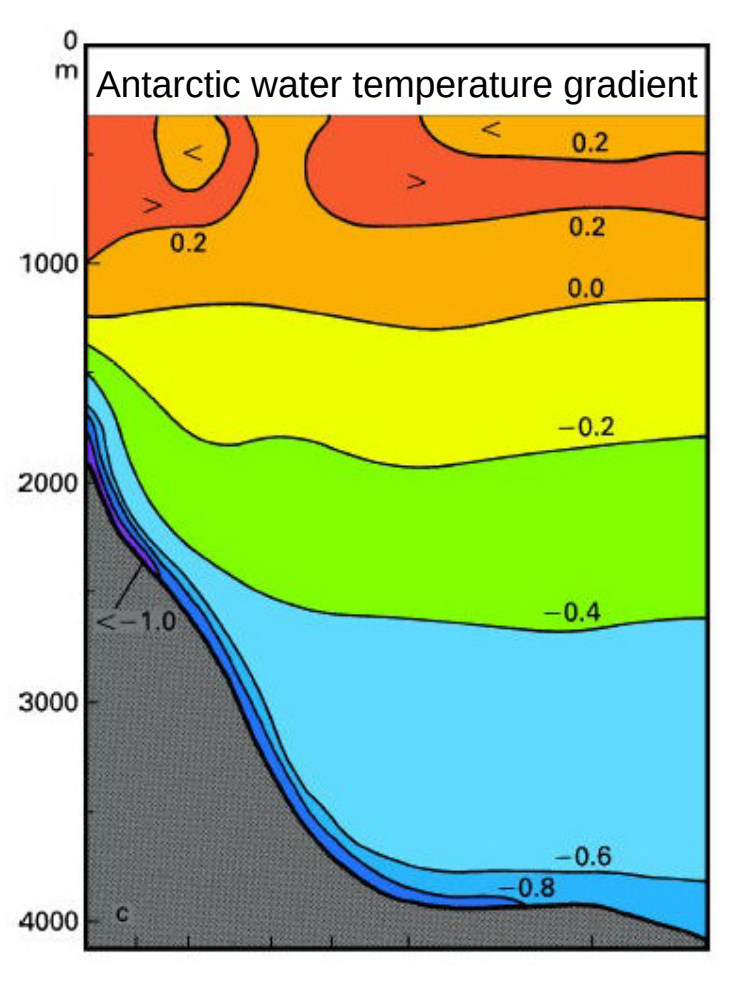
Antarctic Circumpolar Gyre

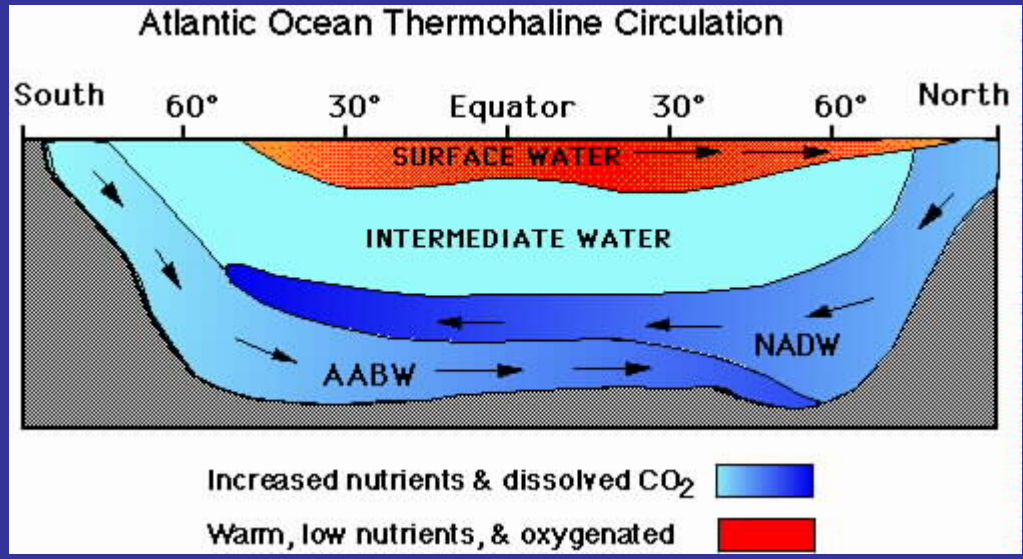


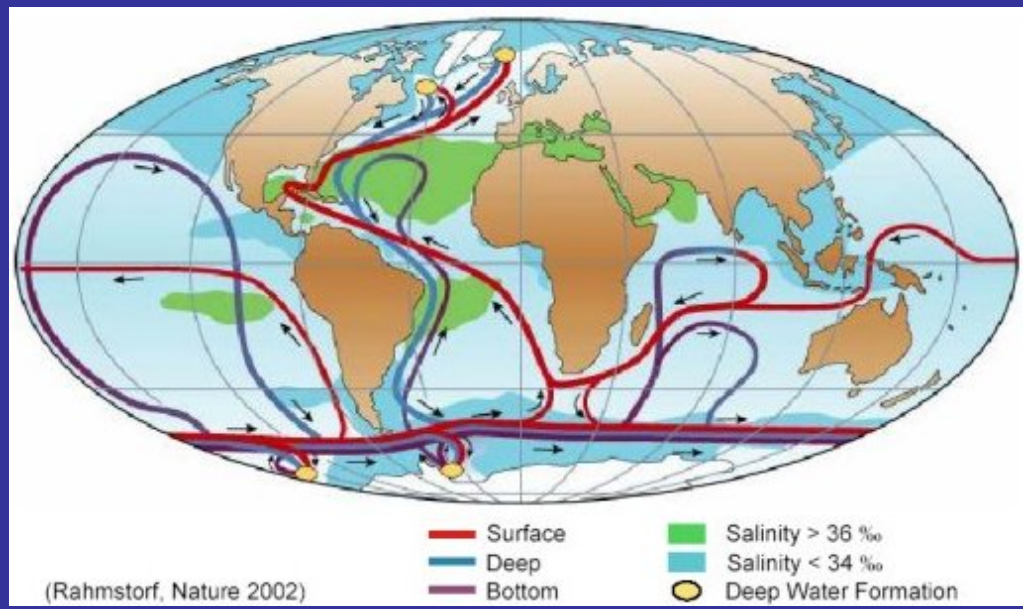










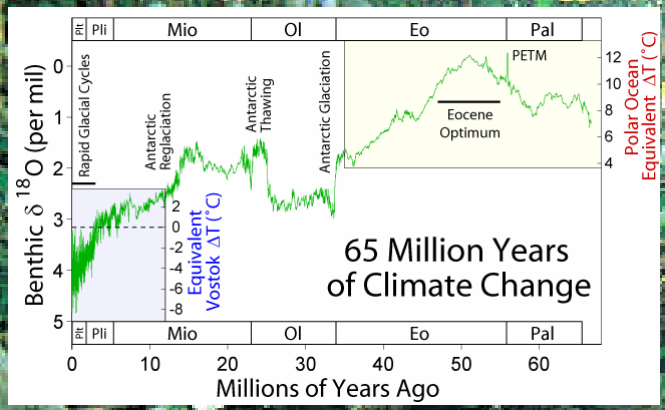


Cold Antarctic water is circulated around the globe by oceanic currents

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



A) Increase P & T
B) Decrease P & T
C) Increase P, Decrease T
D) Decrease P, Increase T
E) No impact



Transition from tropical to grassland environment



Cooling and drying worldwide



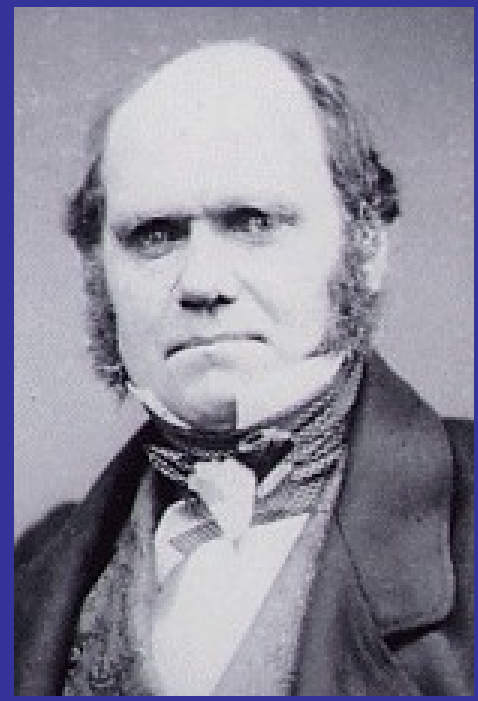
3°N
2°N
1°N
0°
1°S

°W 91°W 90°W 89°W 88°W 87°W 86°W 85°W 84°W

-3500 -3000 -2500 -2000 -1500 -1000 -500 0

Depth (m)





Charles Darwin
(1809-1882)





Voyage of the HMS Beagle
(1831-1836)

Galápagos tortoise

Average age 150 years
Weights up to 660 pounds















Santiago
Bartolomé
Rábida
Seymour Norte
Baltra
Fernandina
Plaza Sur
Santa Cruz
Isabela
Pinzón
San Cristobal
Santa Fé
Tortuga
Floreana
Española

13 original subspecies
11 survive today

If each tortoise lives on average 150 years, how long would it take to see evolutionary change?













A) <10,000 yrs
B) >1,000,000 yrs





Harriet (1830-2006)

Collected by Darwin?



Lonesome George

Last Pinta Tortoise

Evolution & Natural Selection

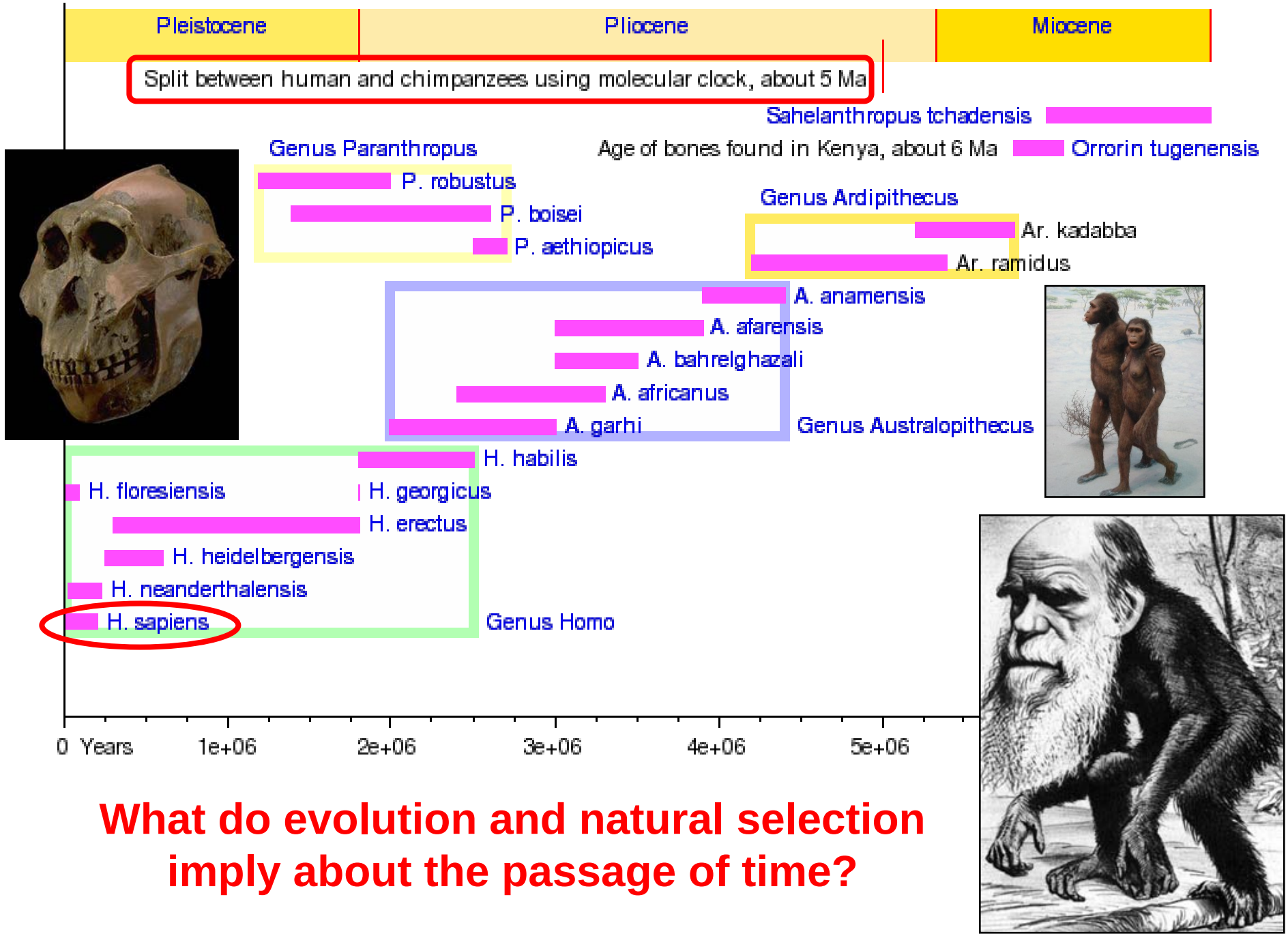








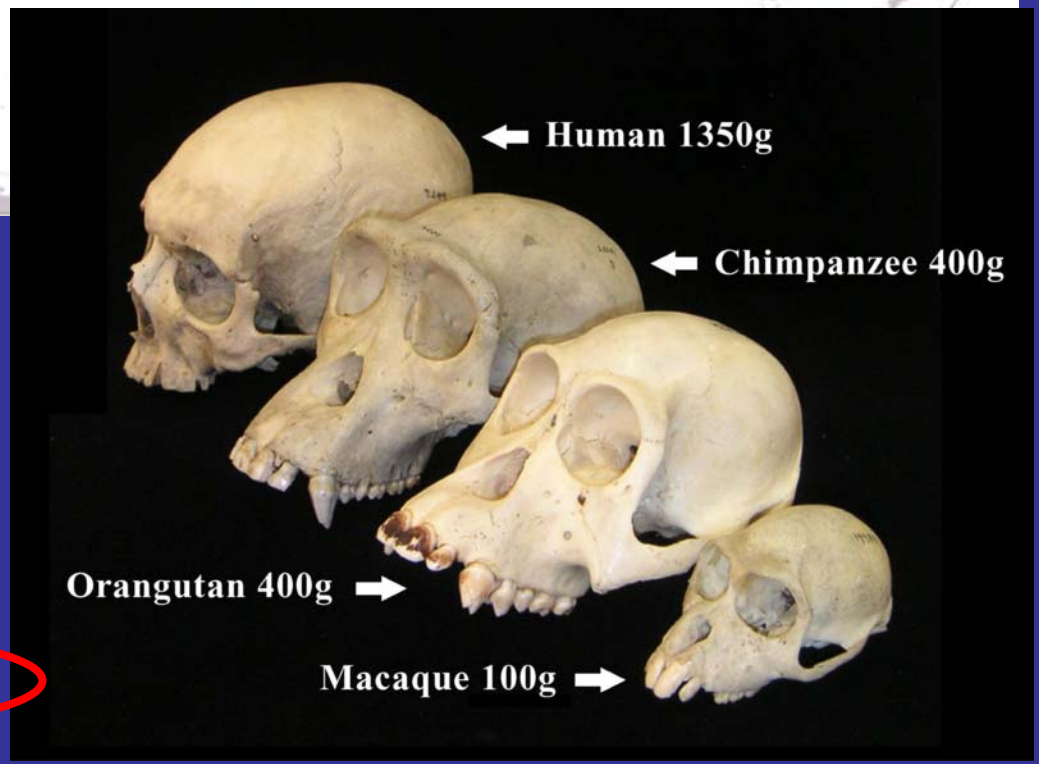
Do we share a common ancestry?



What do evolution and natural selection imply about the passage of time?

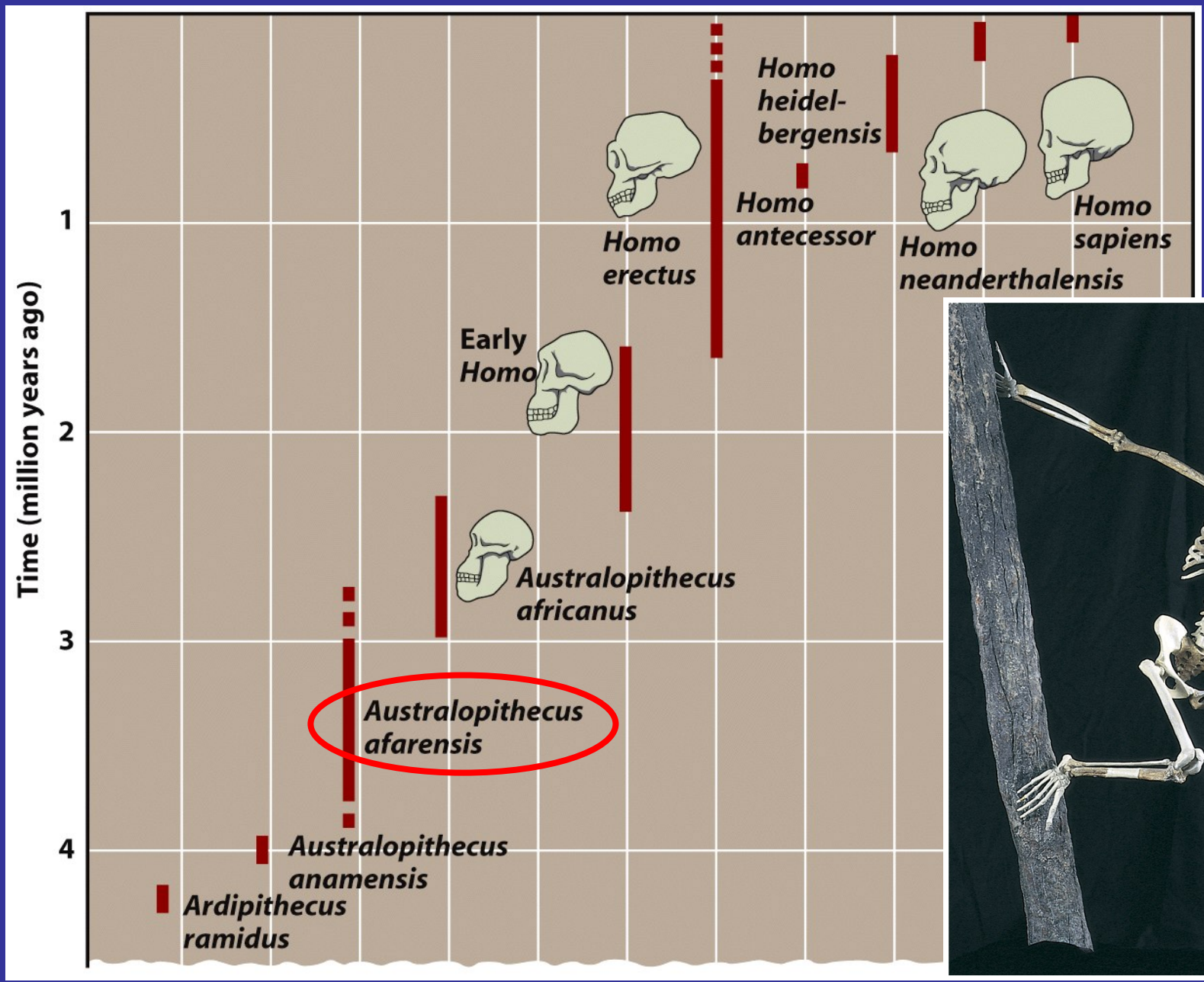
Origin of Humans





December 31, 11:42pm

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



Lucy





How do our young differ?



Where will humans thrive?



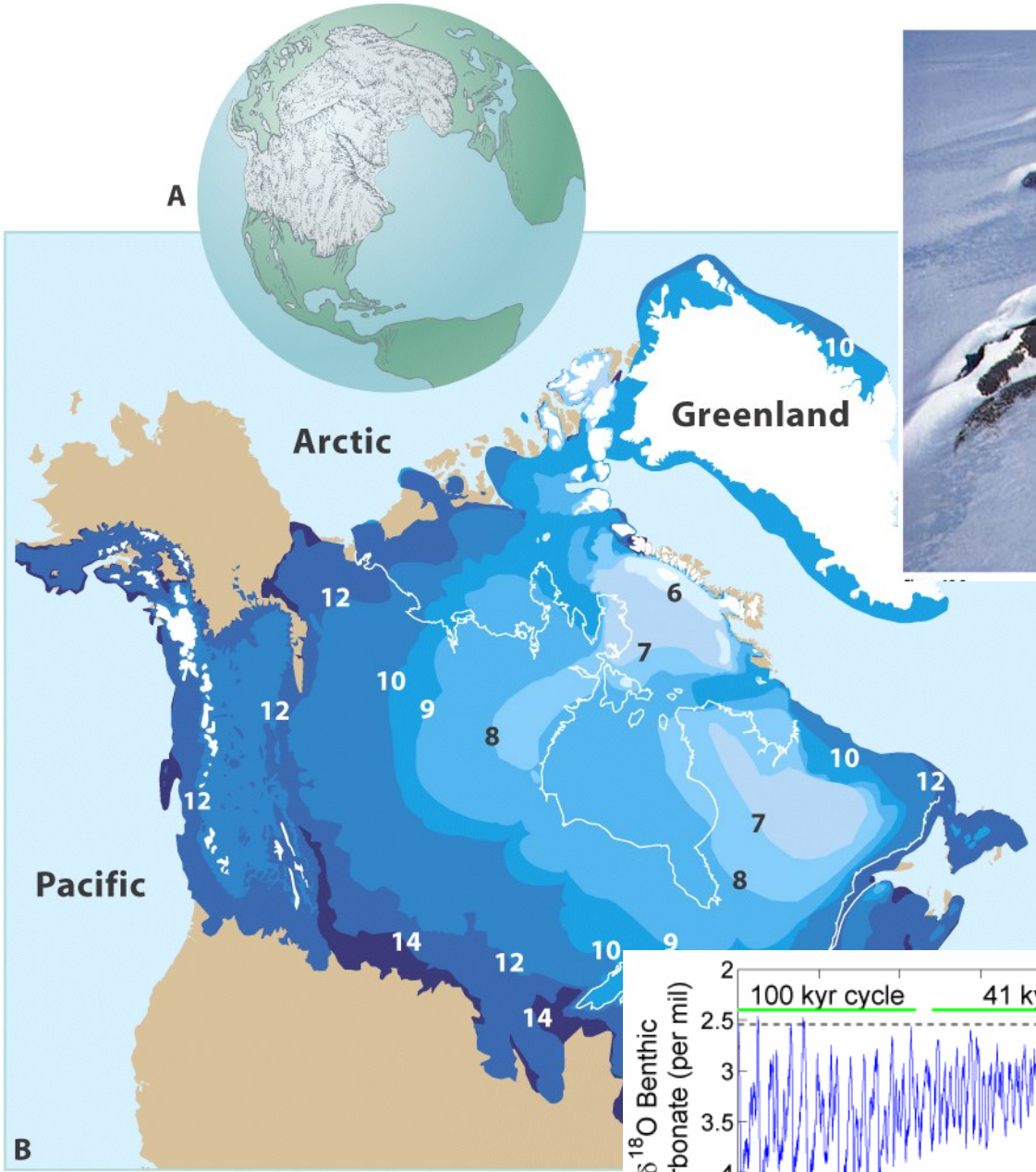


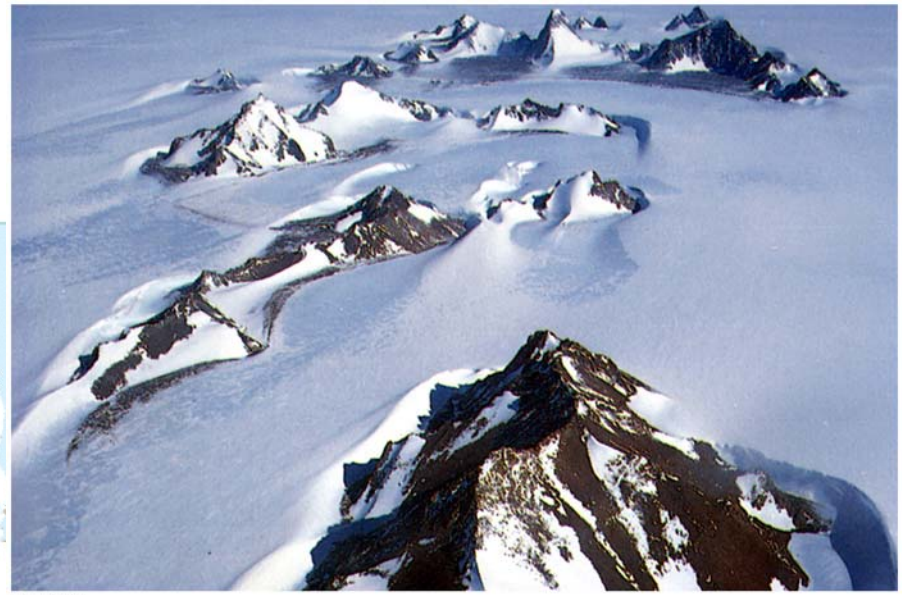
Where will chimps thrive?



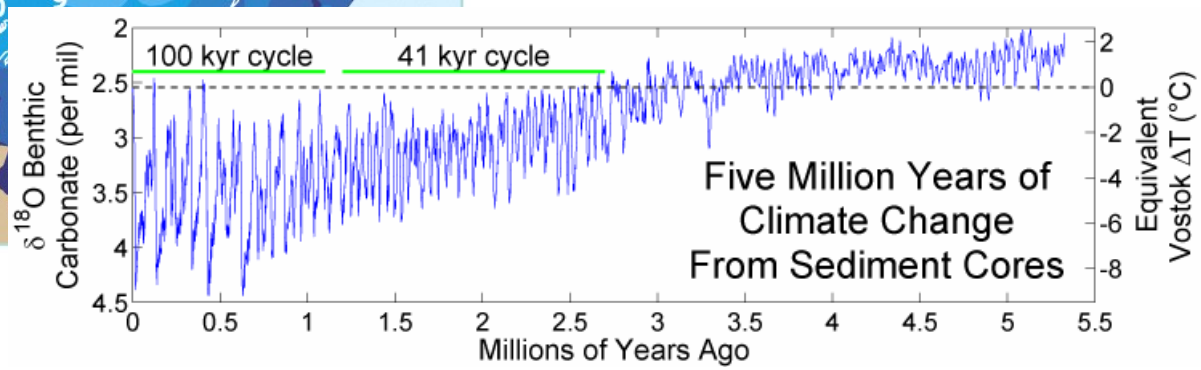
Forces driving human evolution:

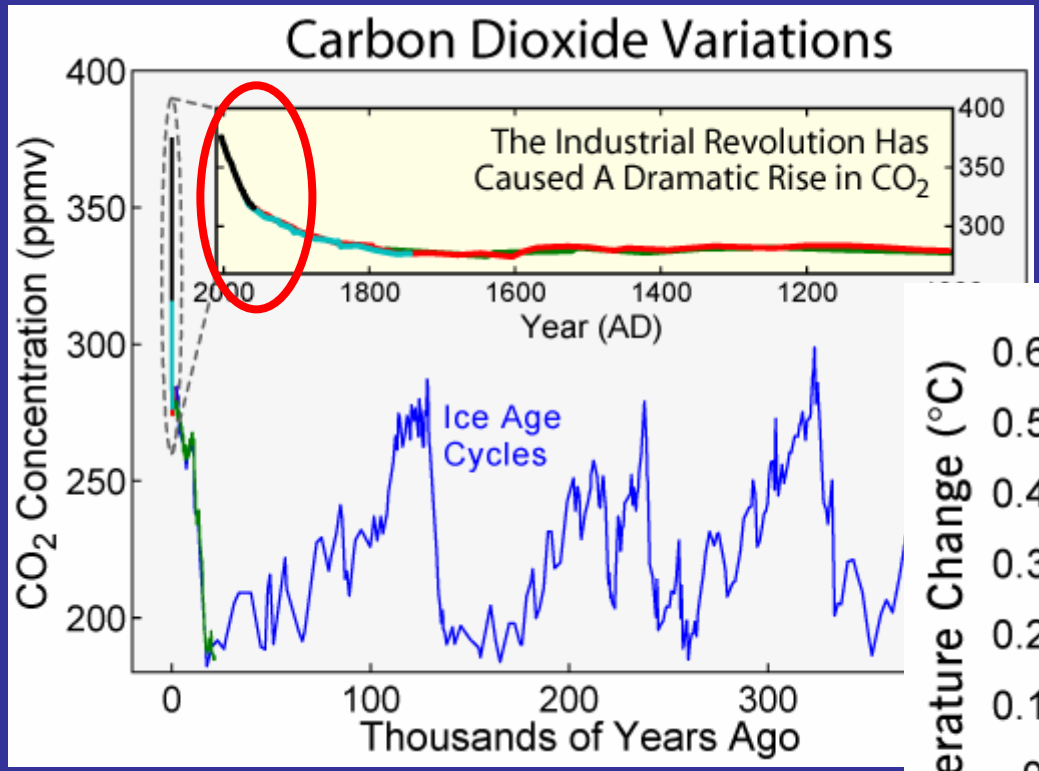
1. Migration
2. Mutation (caused by something external)
3. Genetic drift (random genetic change)
4. Natural selection (survival of fittest)



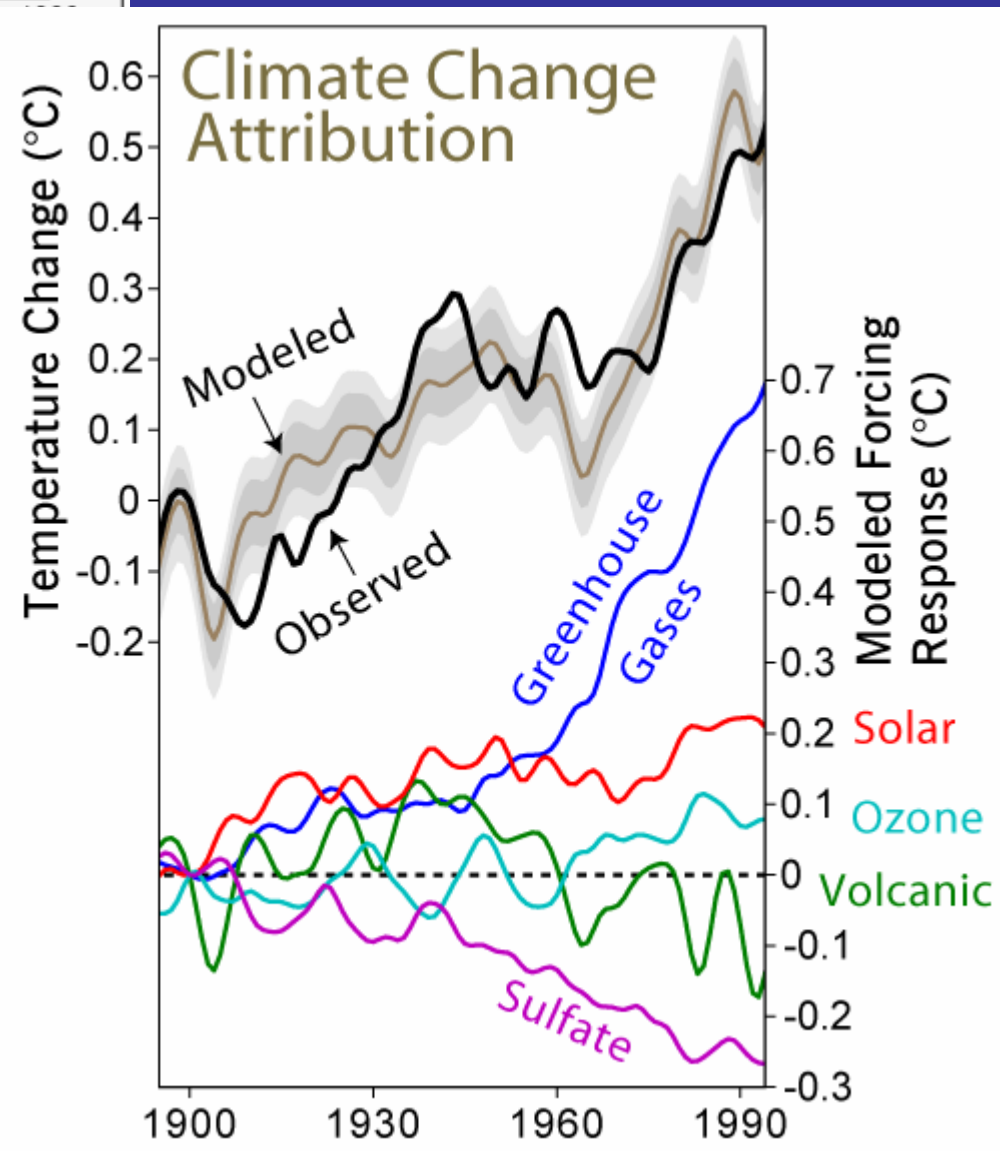


Ice ages controlled human migration patterns

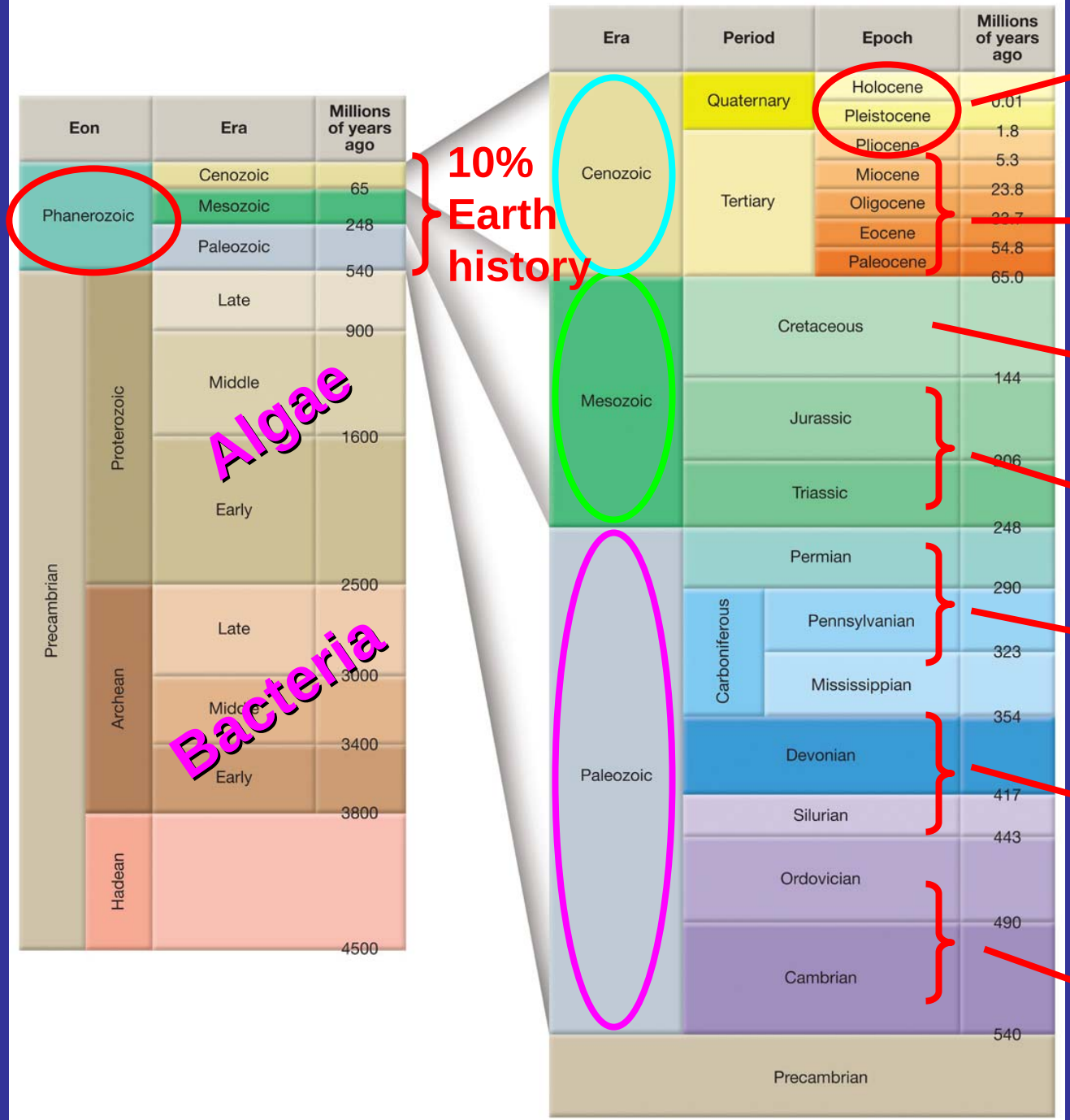


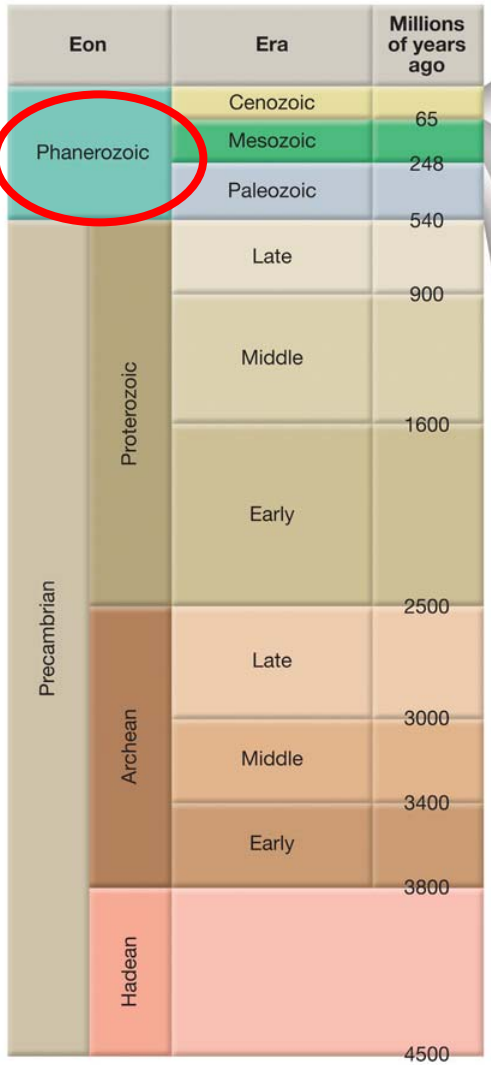


Burning of fossil fuels

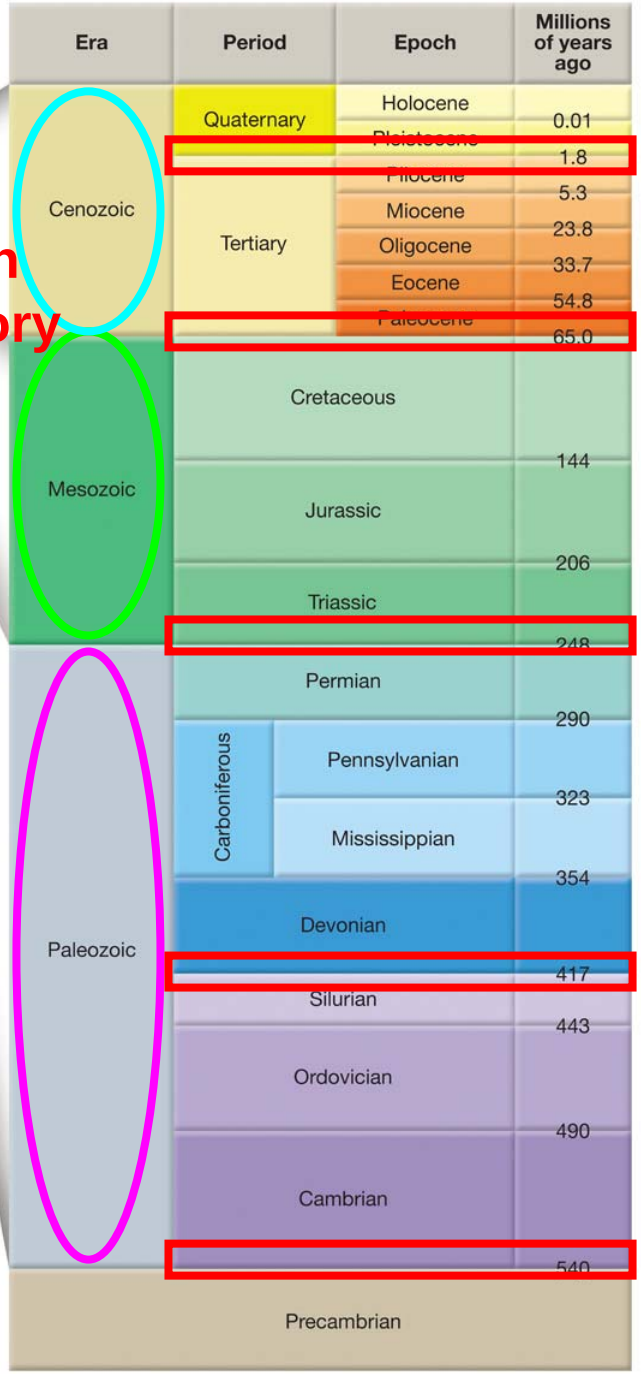


CO_2 increases highly correlated with rising temperatures


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
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
Humans
(<0.1% of Earth History)
Mammals
Modern fish
Dinosaurs
Reptiles
First jawed fish
Trilobites
"Life Assemblages"



10% Earth history



Extinctions define boundaries on geologic timescale:

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

Result:

Climate change







Where will evolution take us next ?