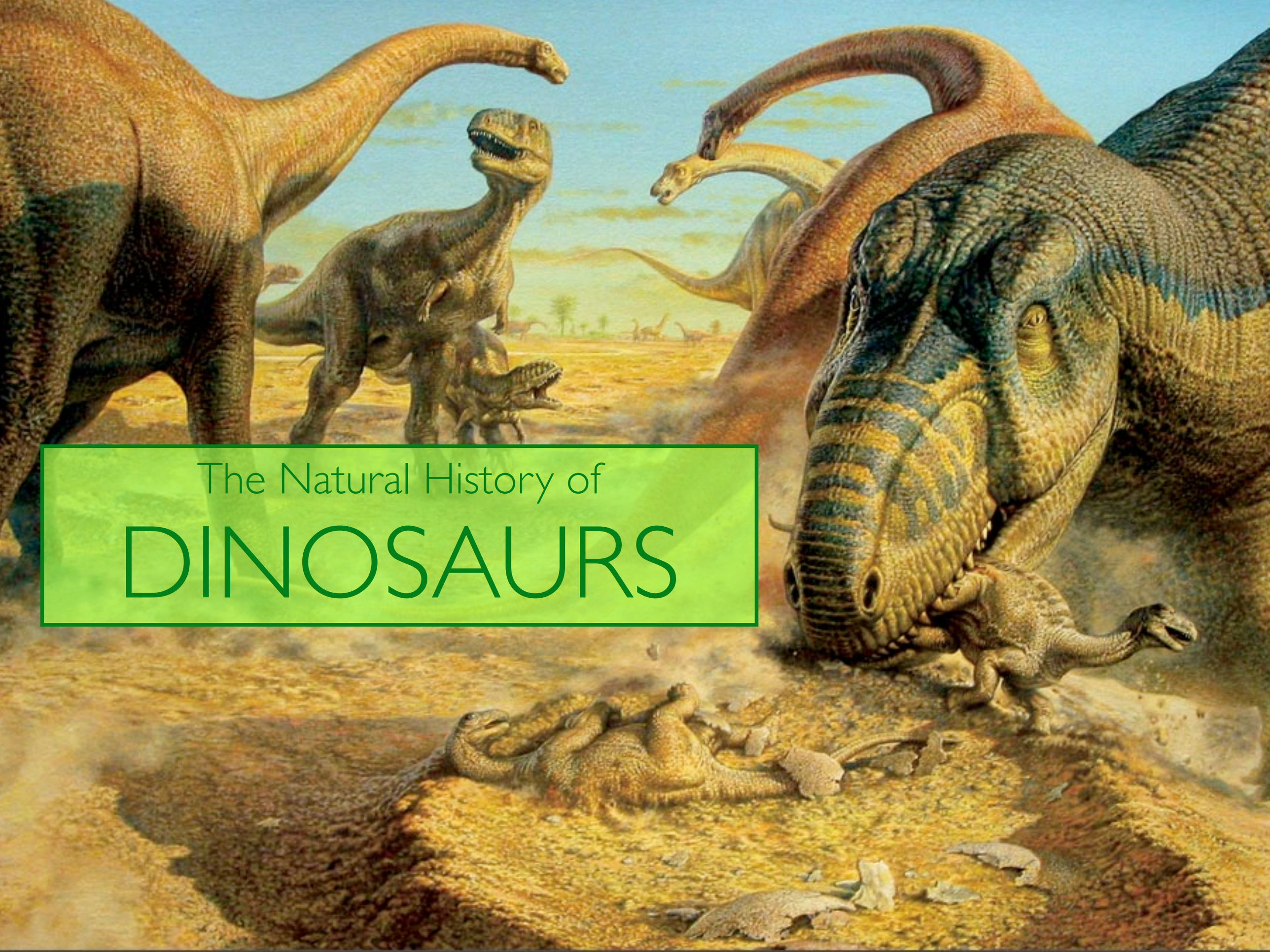
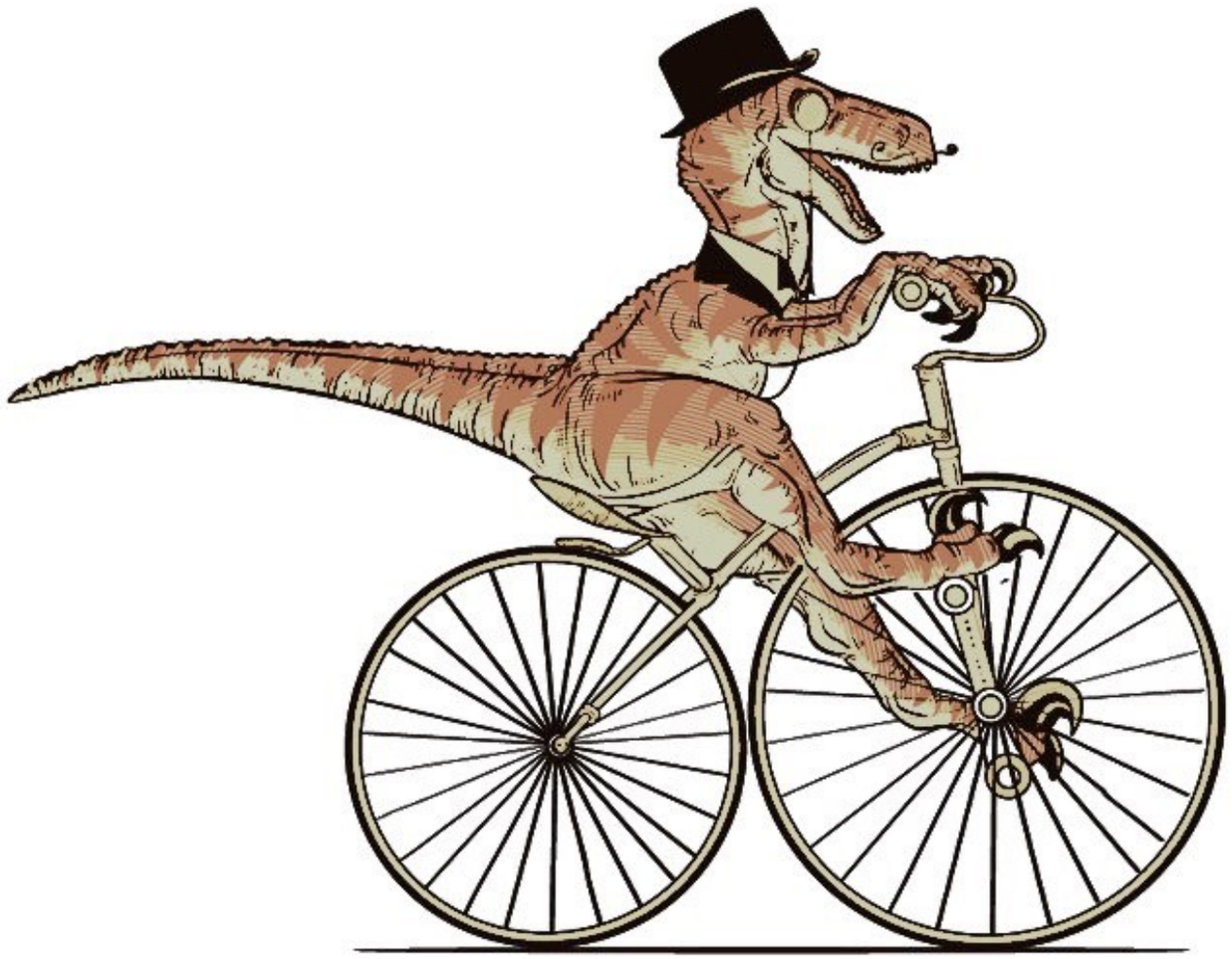
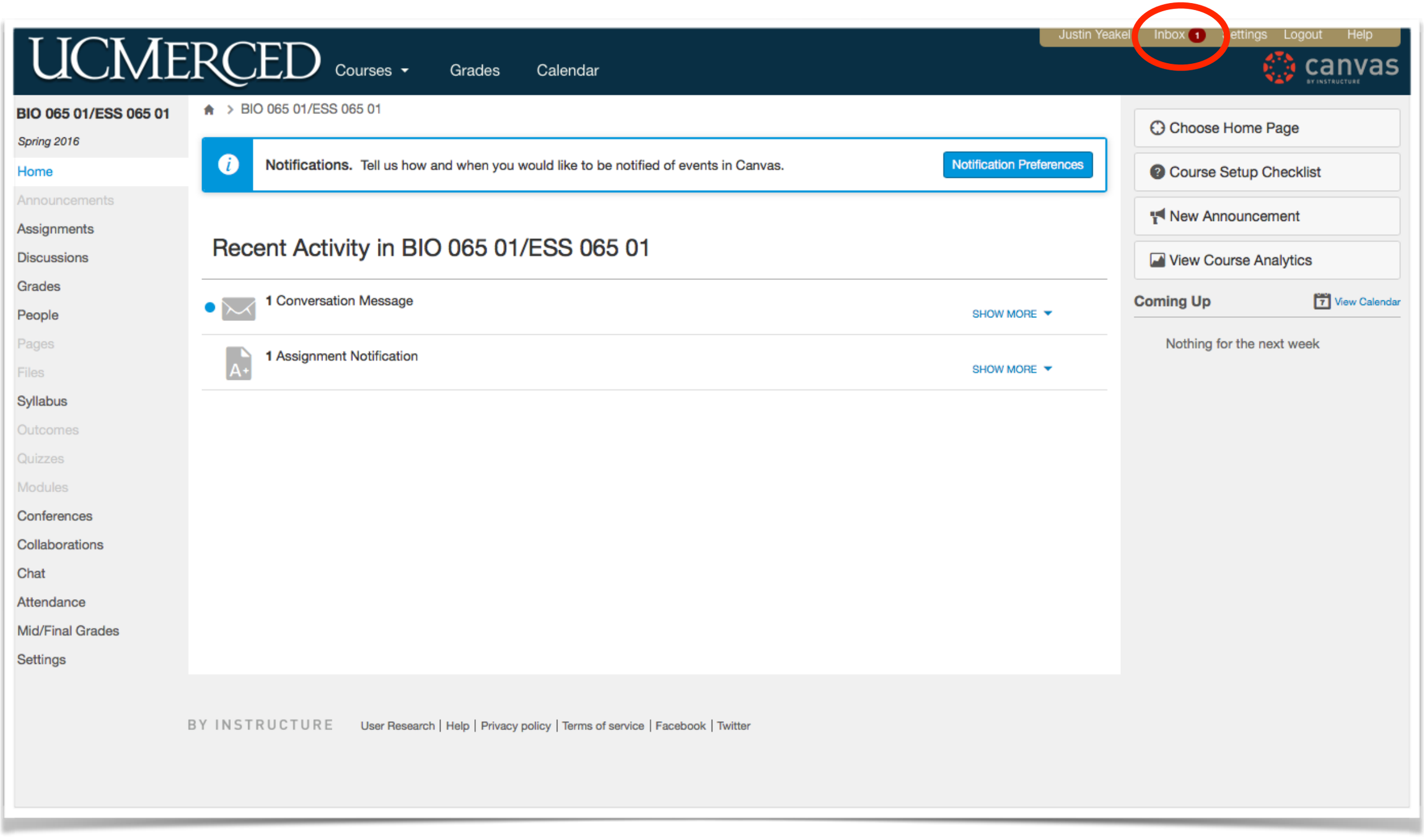


The Natural History of DINOSAURS

http://jdyeakel.github.io/teaching/dinos/



How to contact me



Important information:

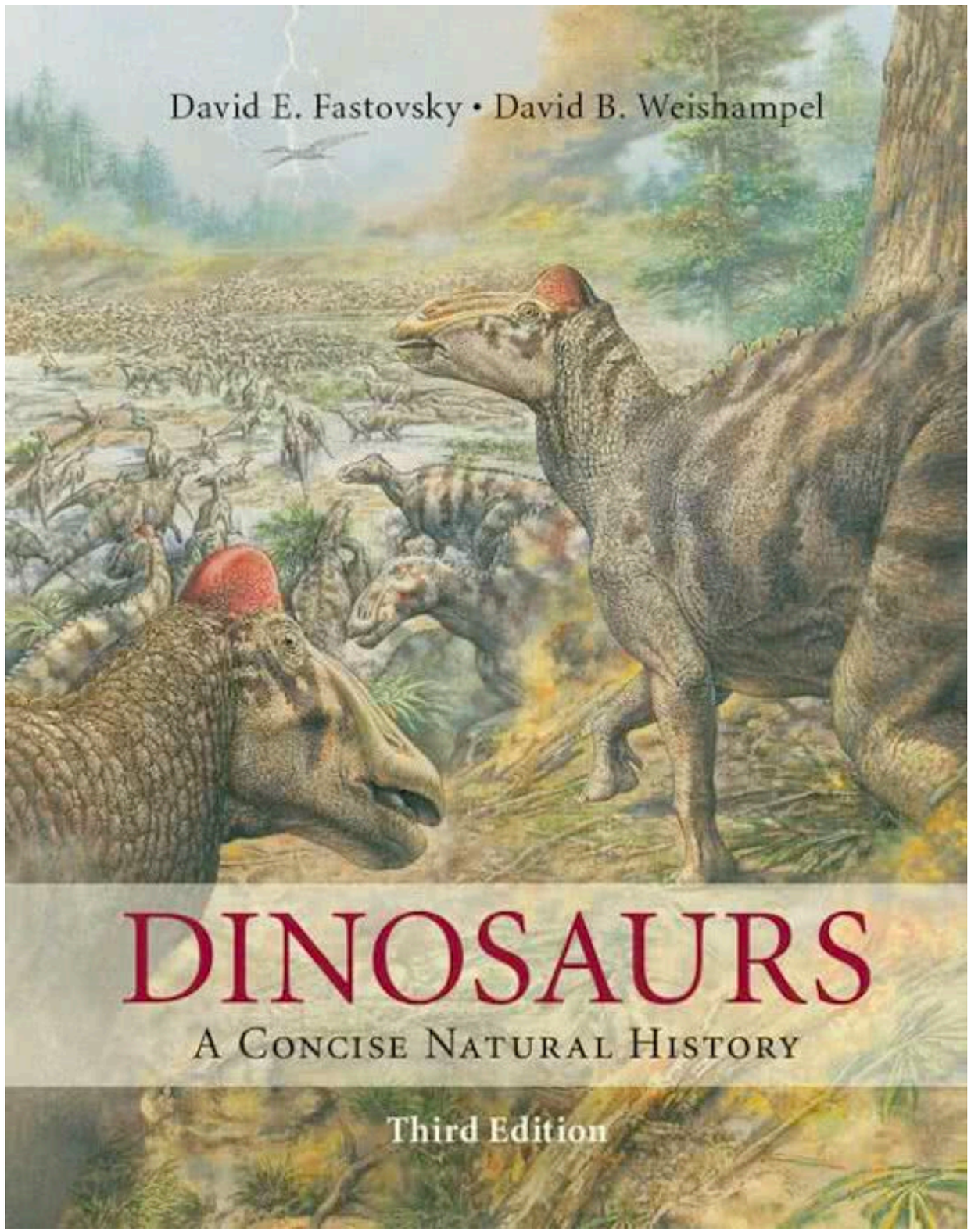
Discussion sections: Taran Rallings
Monday @ 12:30-1:20, CLSSRM 279
Wednesday @ 1:30-2:20, CLSSRM 288
Monday @ 6:30-7:20, CLSSRM 203

Discussion section starts NEXT week
Make sure you are signed up…

Justin office hours: MW 9-10 (or by appt) SE1 288
Taran office hours: R 11-1 SE1 278

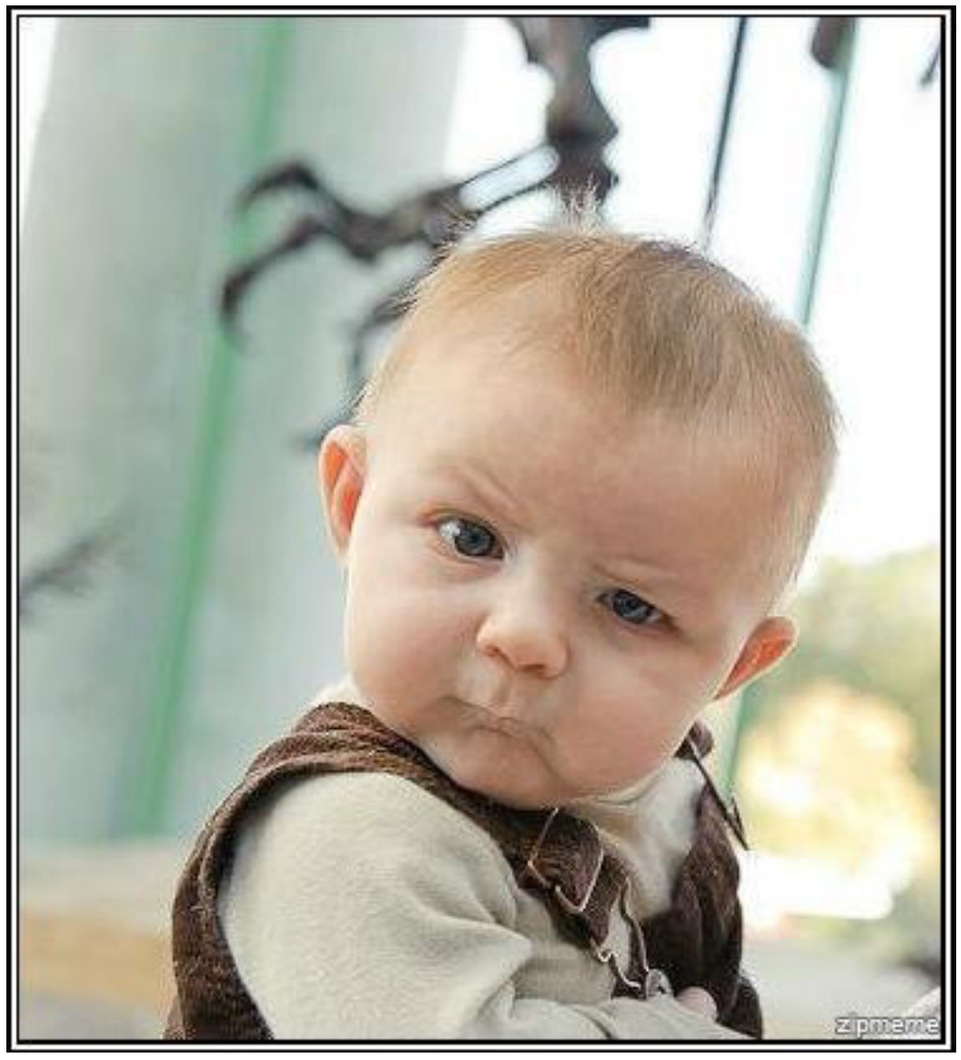
Important Dates
Class add/drop deadline: 2/5

The Textbook



$38 on Amazon
?? UC Merced bookstore

Who are you and why are you here?



Name
Major
Year
What you want from Dinosaurs

Tentative Weekly Schedule: Please note that the Instructor reserves the right to change the schedule. You will be advised in advance of any changes via email or the UC web system. ¶

¶

Week	Date	Topic	Description	Readings	Assessments
1	1/17	Introduction to paleontology I	Intro, timescales & fossils	Fastovsky Chpt 1	
S1		**No Section - Organizational**			
2	1/22	Evolution and classification I	Introduction to evolution and natural selection	Fastovsky Chpt 2,3	
	1/24	Early life history	More on natural selection and an introduction to classification		
S2		**Sedimentology**	**HW1: Sedimentology worksheet**		
3	1/29	Tetrapods & Dinosauria	Life in the Permian & basal dinosaurs	Fastovsky Chpt 4	
	1/31	Thyreophorans	Stegosauria & Ankylosauria	Fastovsky Part 2 & Chpt 5	
S3		**Cladistics**	**HW2: Cladogram worksheet**		**Homework 1 due**
4	2/5	Prepare for Exam I			
	2/7	**Exam I**	Good Luck!		
S4		**Film: Dinosaur Wars**			**Homework 2 due**
5	2/12	Pachycephalosaurs	Intraspecies competition then and now	Fastovsky Chpt 6	
	2/14	Ceratopsians	After the frill is gone: diversity and movement over space		
S5		**Anatomy**	**HW3: Anatomy worksheet**		
6	2/21	Ornithopoda I	Functional morphology and complex dentition	Fastovsky Chpt 7	
S6		**No Section**			**Homework 3 due**
7	2/26	Ornithopoda II	Dinosaur behavioral ecology		
	2/28	Sauropods	Carnivorous ancestors to gentle giants	Fastovsky Part 3 & Chpt 8	
S7		**Sauropods**			
8	3/5	Prepare for Exam II			
	3/7	**Exam II**	Good Luck!		
S8		**Film: Giants of Patagonia**			
9	3/12	Dino metabolism I	Reproduction and growth	Brusatte Chpt 8	
	3/14	Dino metabolism II	Diet and food webs		

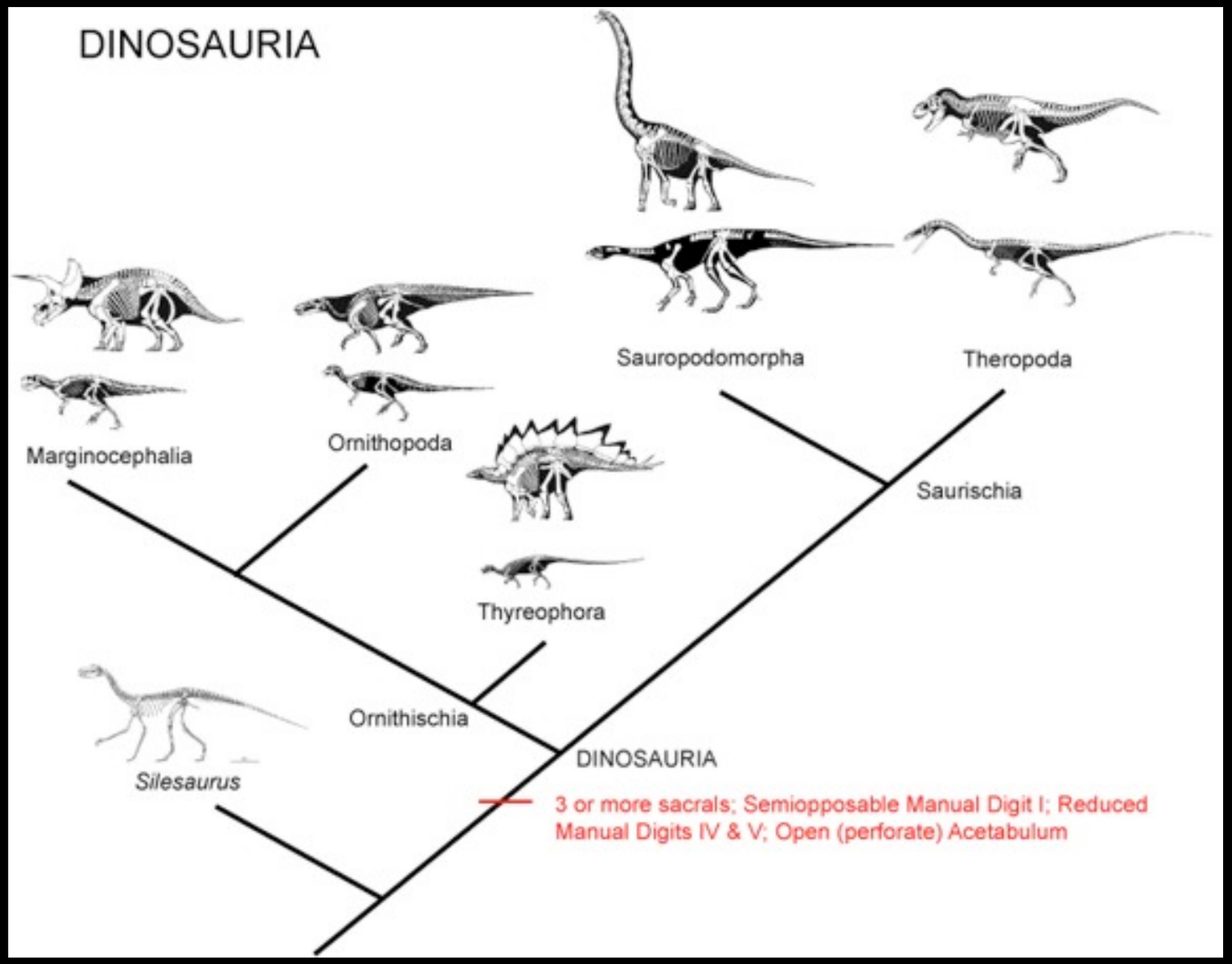
What is a dinosaur???

Scales: Space

Scales: Time

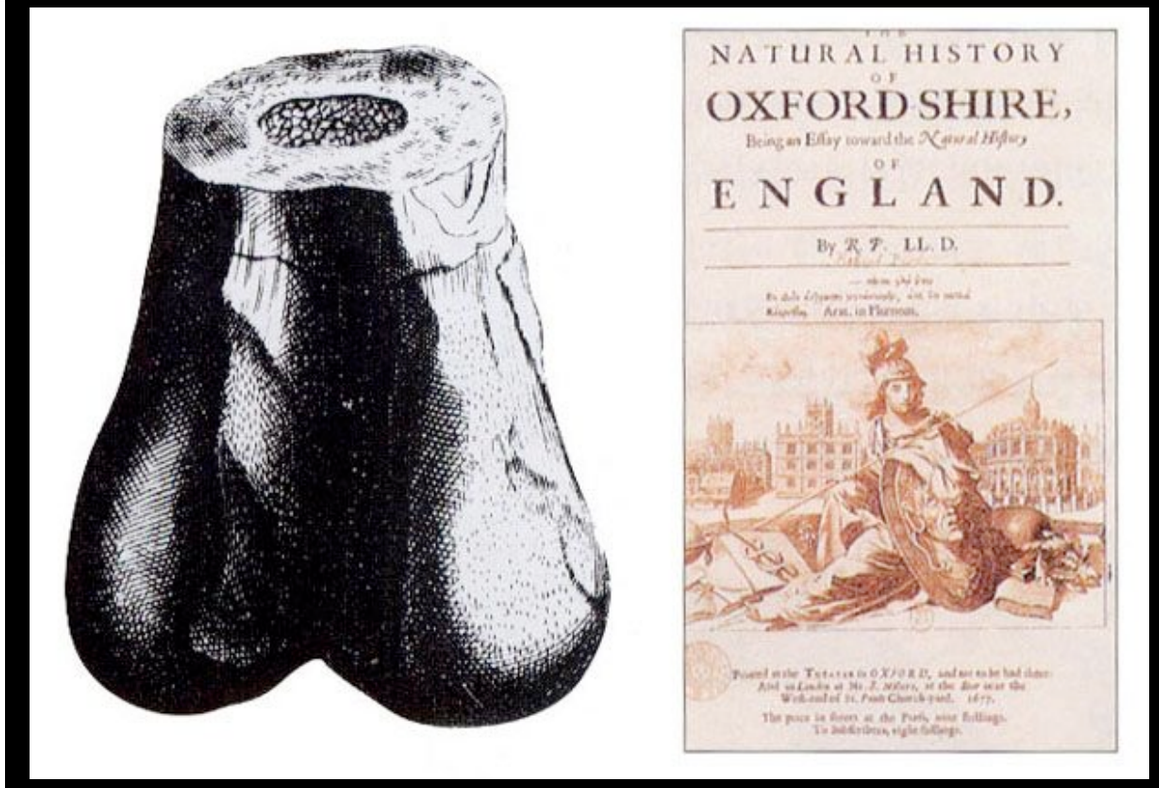
Where do Dinos fit in?

Fossilization and Taphonomy

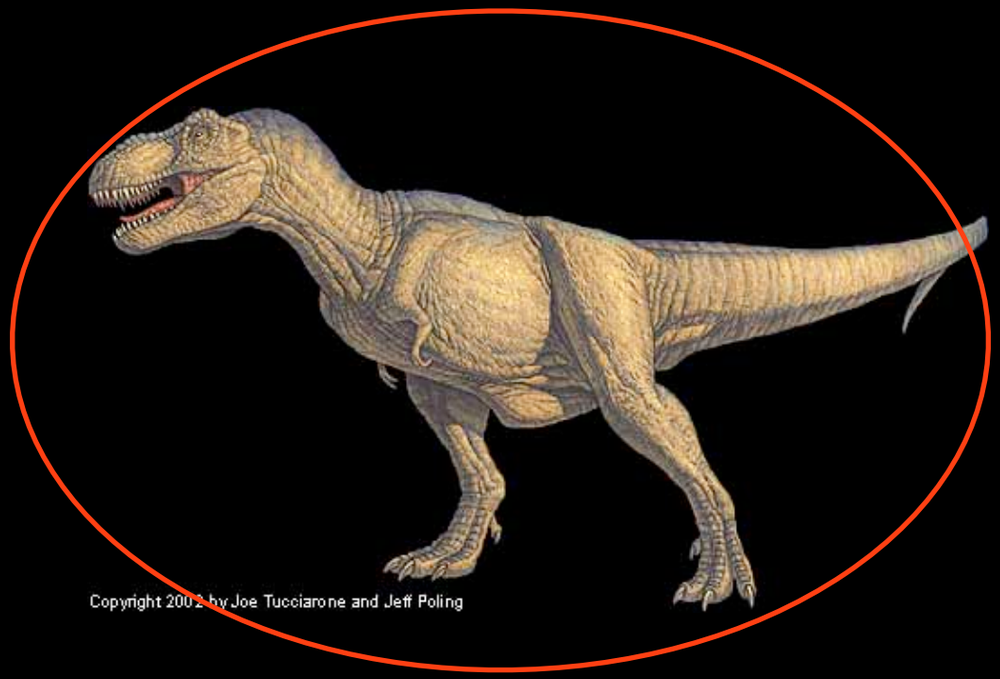


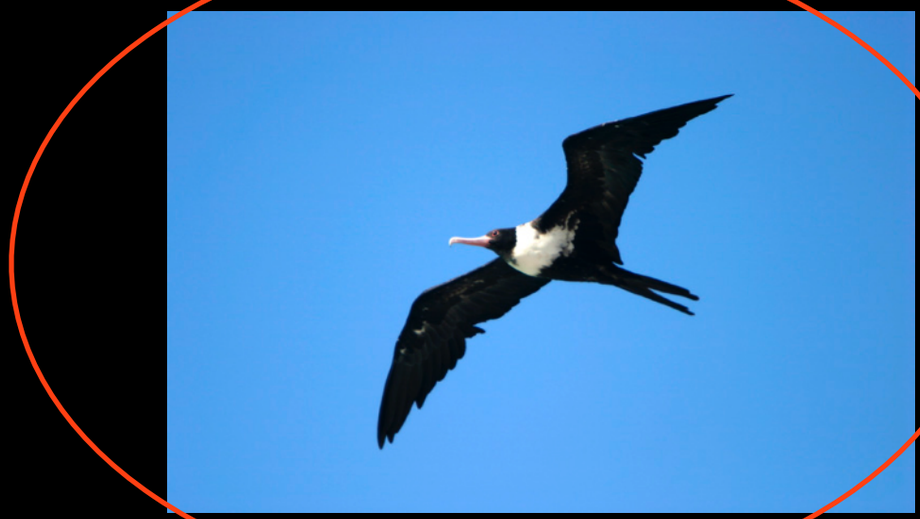
Dinosauria:
A monophyletic clade

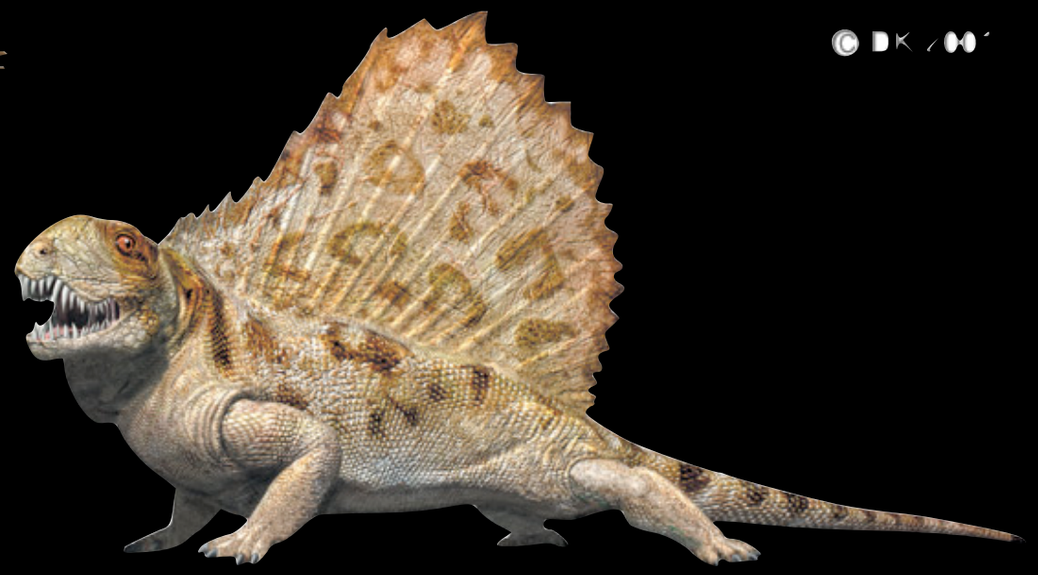
Dr. Robert Plot



Scrotum humanum
The distal femur of Megalosaurus







Dinosaur?

What is the age of the Earth?

a) 6000 years old

b) 1.8 million years old

c) 20.2 billion years old

d) 4.6 billion years old

When did dinosaurs first appear on Earth?

a) 1 million BC

c) 231 million years ago

b) 500 million years ago

d) 251 million years ago

Mesozoic dinosaurs are rare in California because:

a) they are in rocks that are still buried beneath the surface
b) California was too cold in the Mesozoic
c) California was mostly underwater
d) Dinosaurs don't like hippies

Orders of Magnitude

$10^{10} = 10000000000$

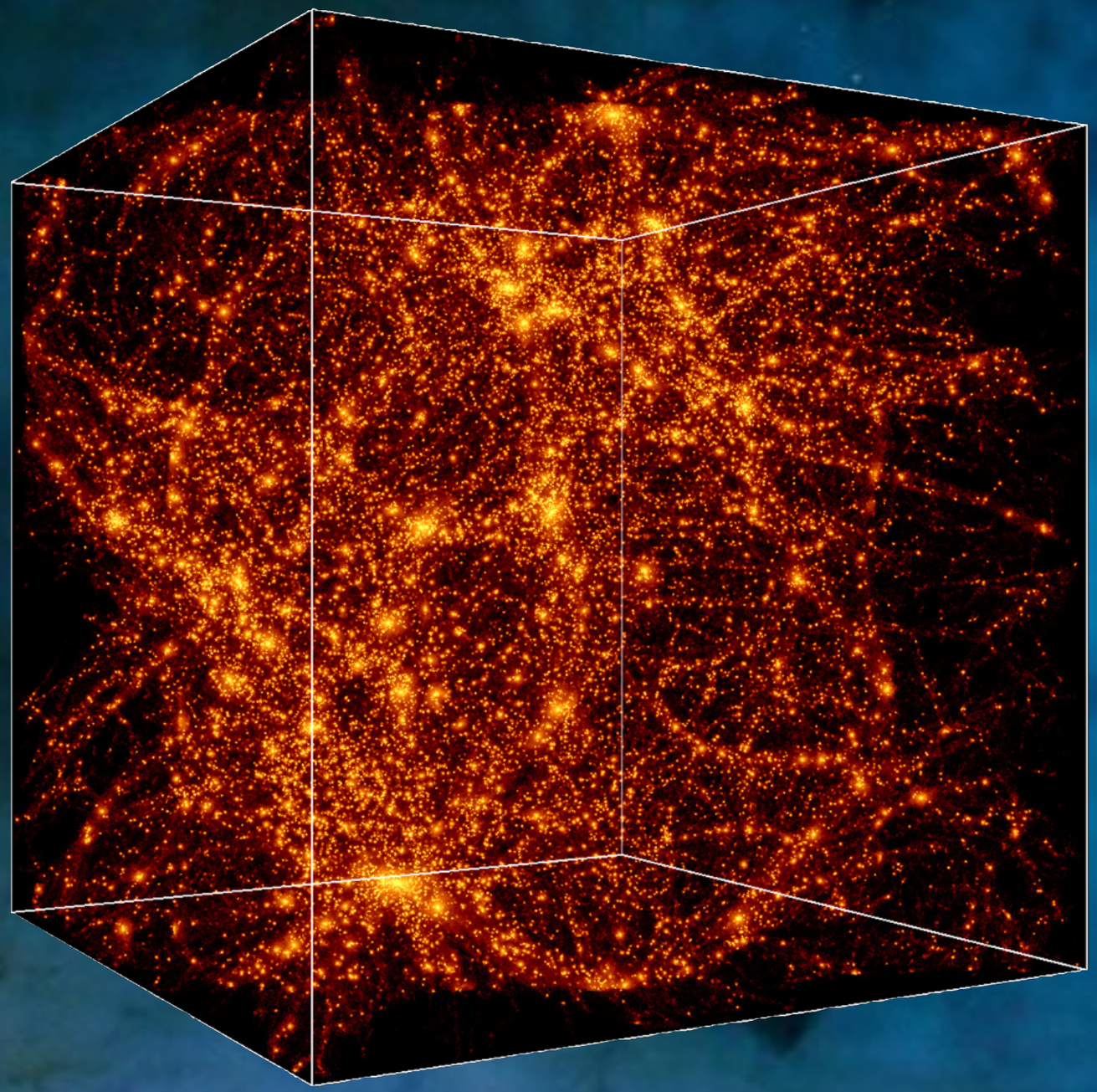
$= 10*10*10*10*10*10*10*10*10*10$

$10^{-10} = 0.0000000001$

$= .10*.10*.10*.10*.10*.10*.10*.10*.10*.10$

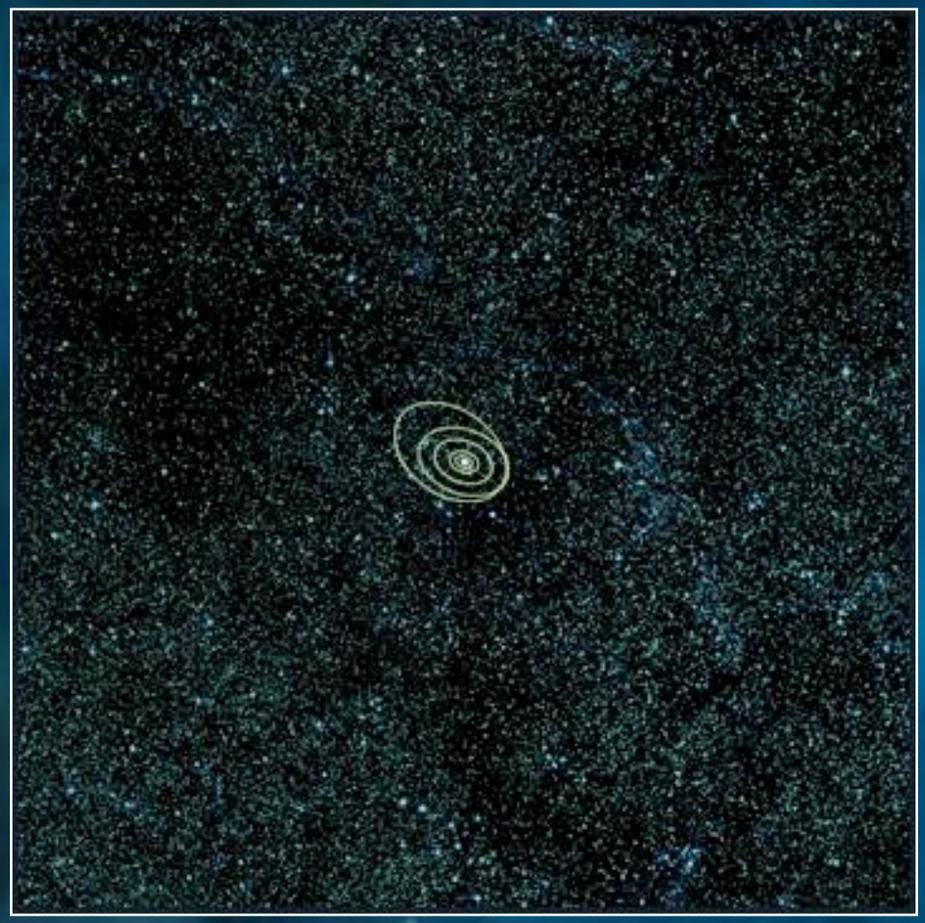
Spatial Scales

Orders of Magnitude



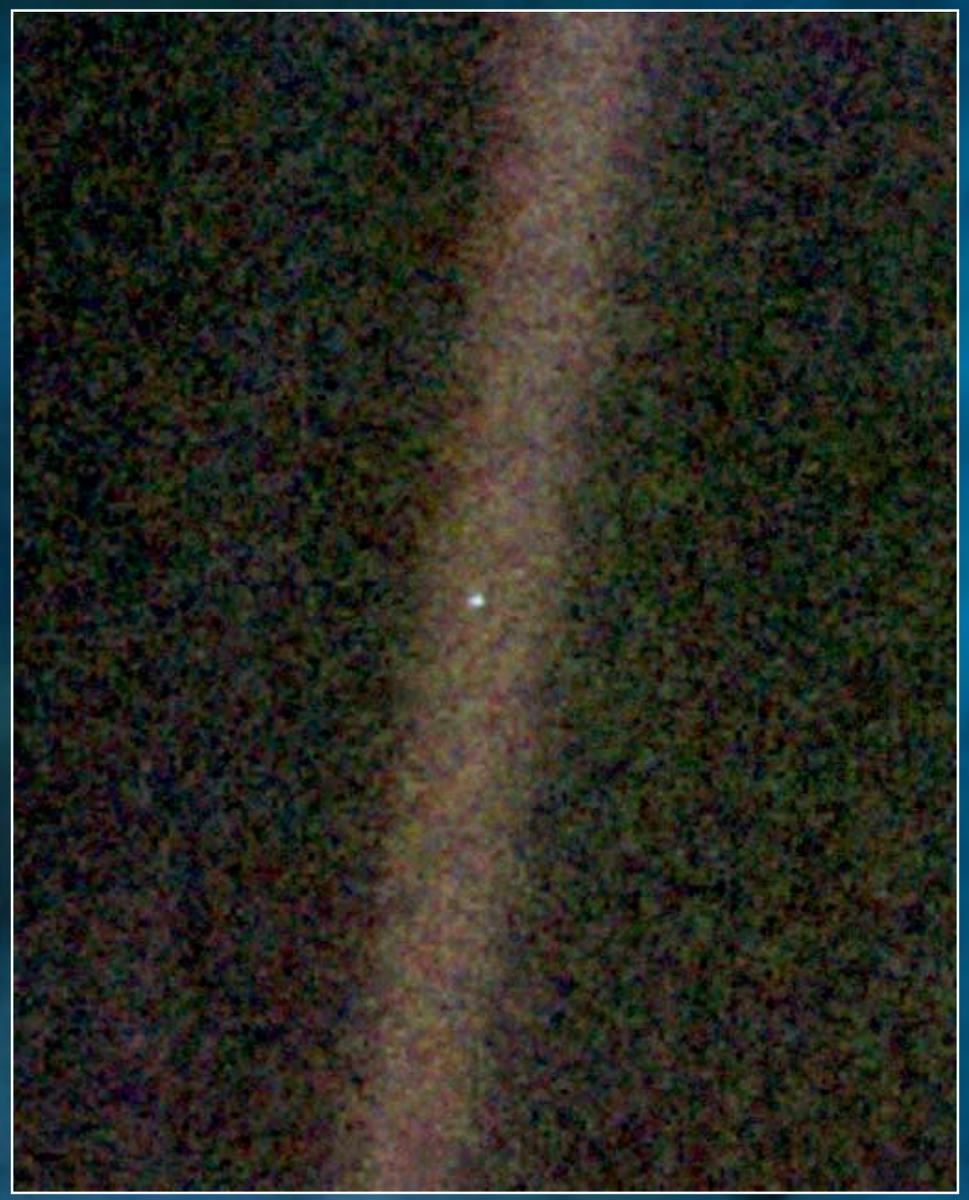
10^{26}

Orders of Magnitude



10^{15}

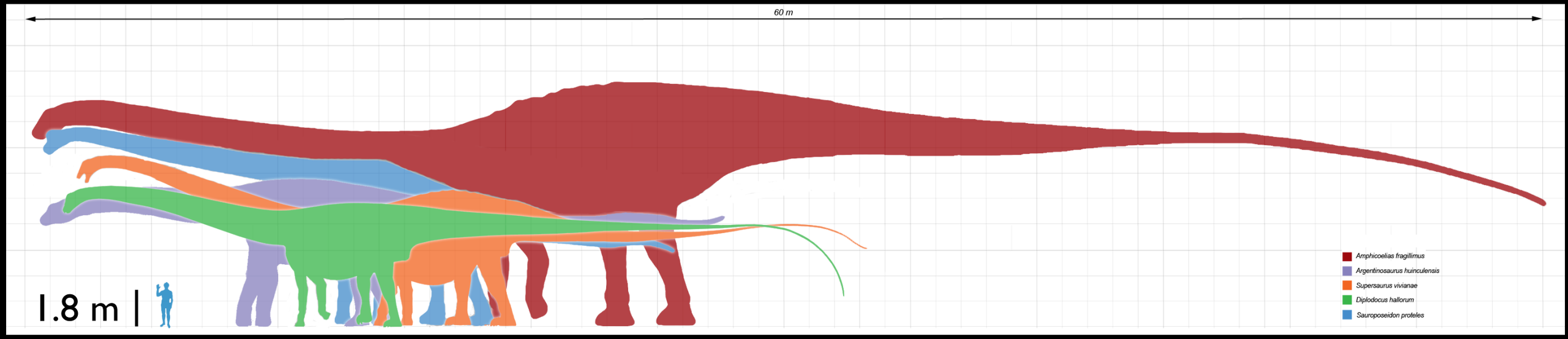
Orders of Magnitude



10^{10}

Orders of Magnitude

10^6


60 m
1.8 m
Amphicoelias fragillimus
Argentinosaurus huinculensis
Supersaurus vivianae
Diplodocus hallorum
Sauroposeidon proteles

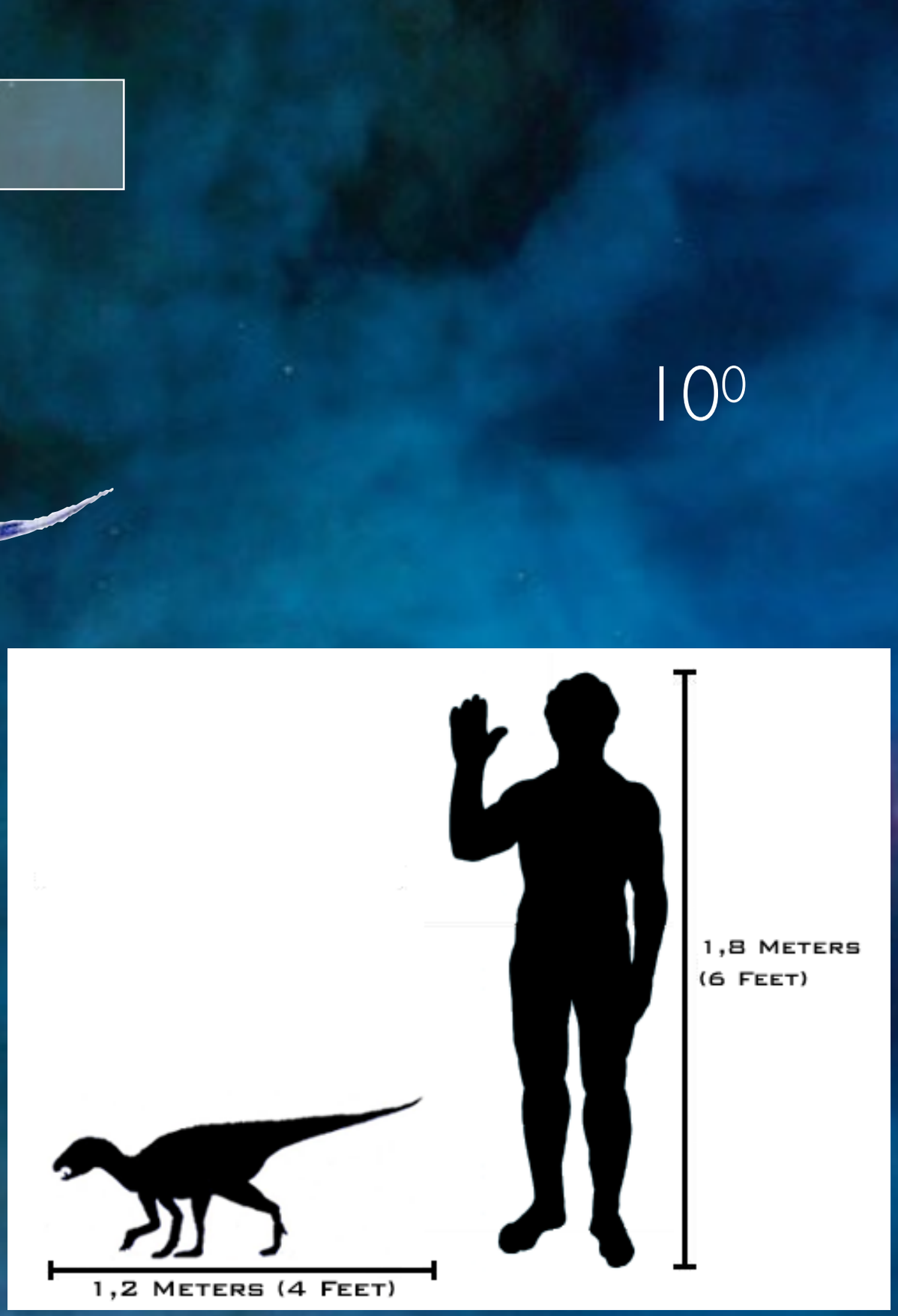
60 m


Amphicoelias fragillimus
Argentinosaurus huinculensis
Supersaurus vivianae
Diplodocus hallorum
Sauroposeidon proteles

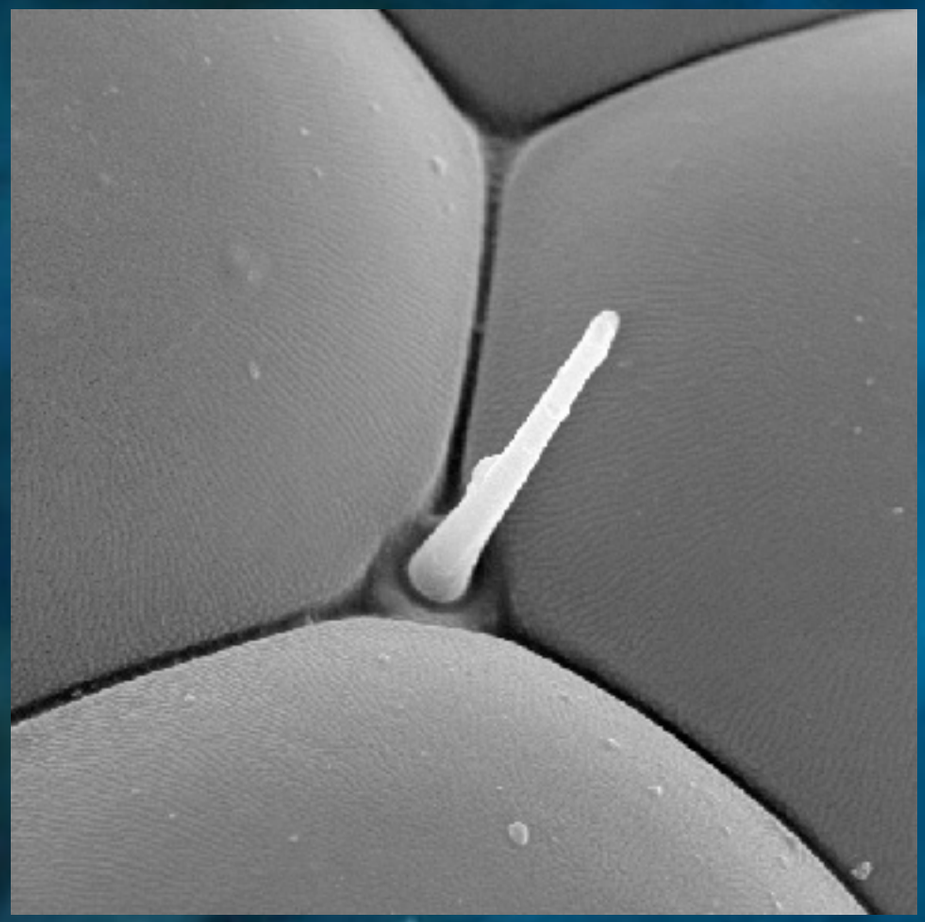

THE TITANOS

Orders of Magnitude

10^0

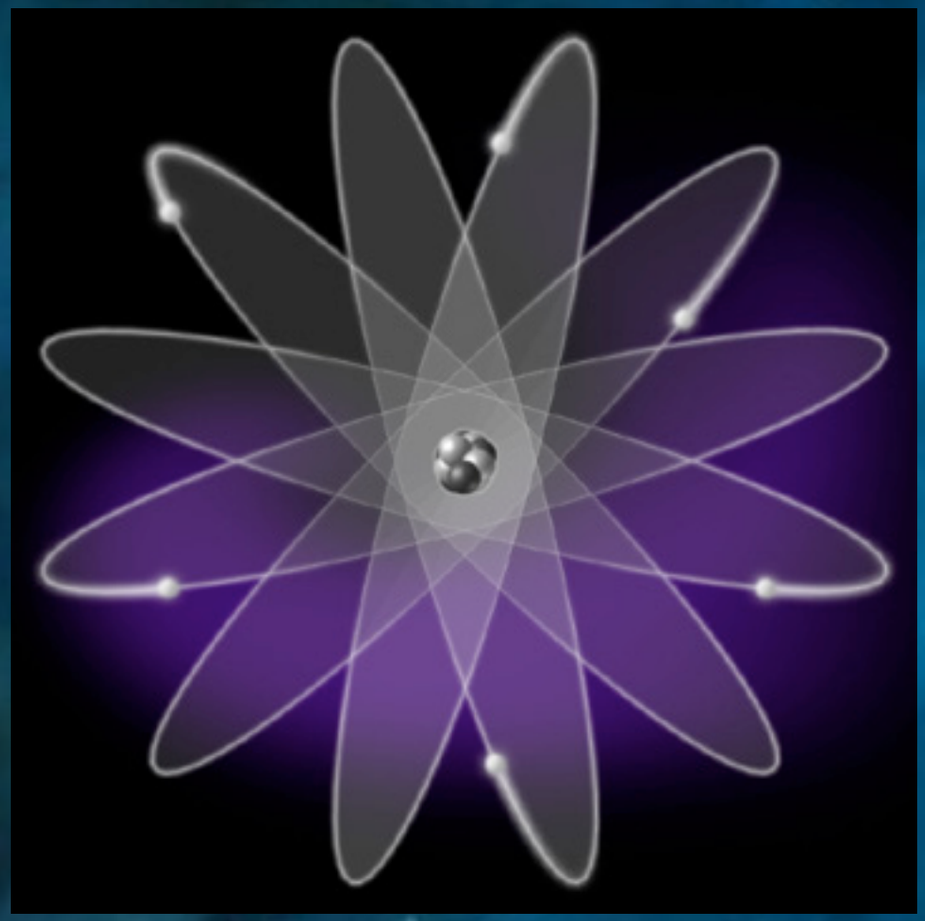


Orders of Magnitude



10^{-5}

Orders of Magnitude



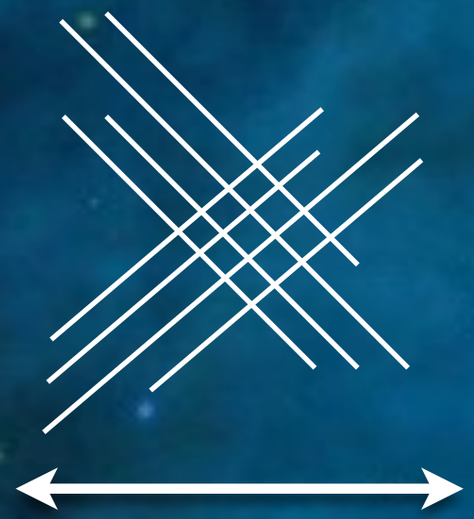
10^{-10}

Orders of Magnitude

10^{-15}

Orders of Magnitude

10^{-34}



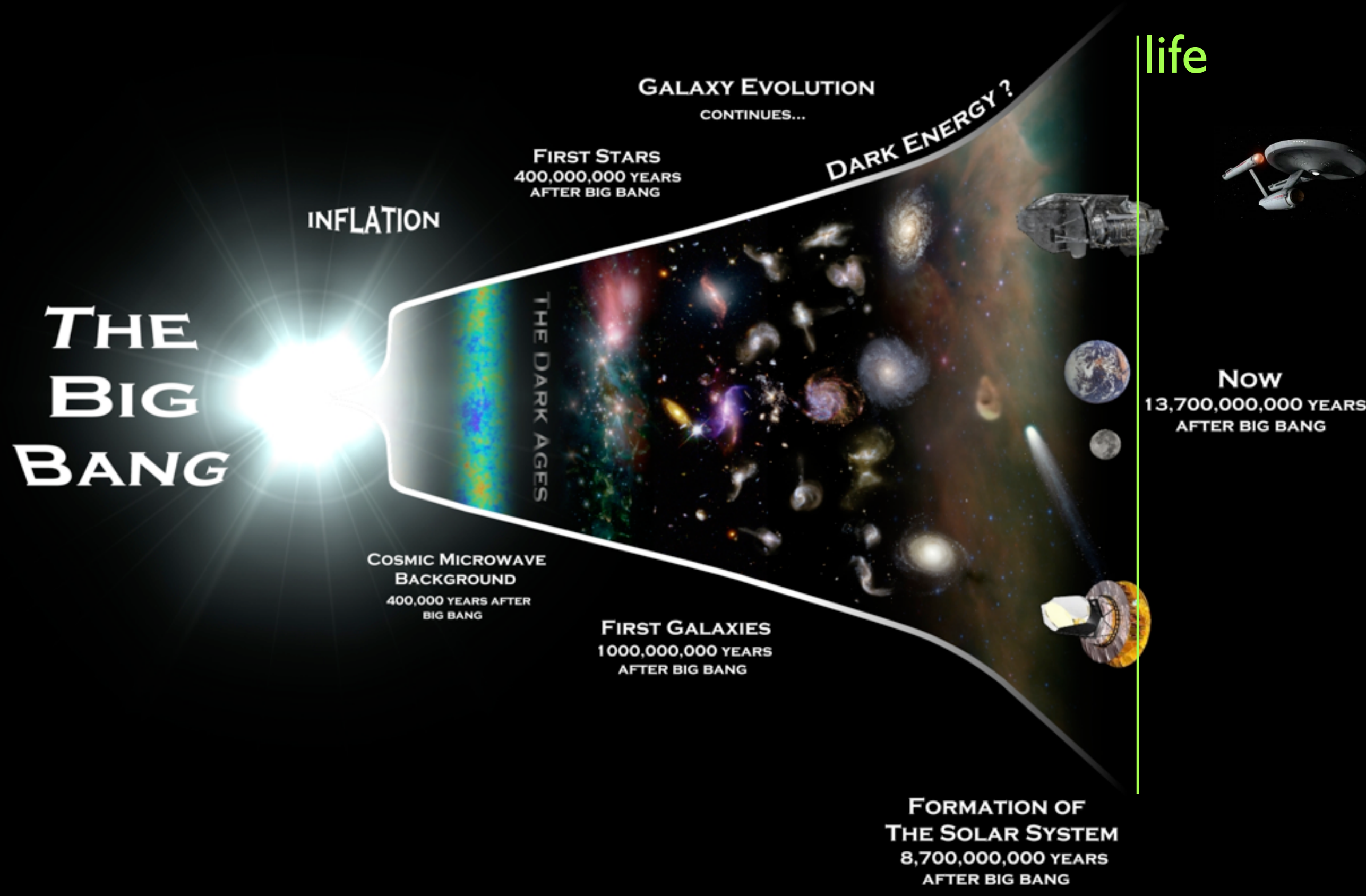
Plank's Constant

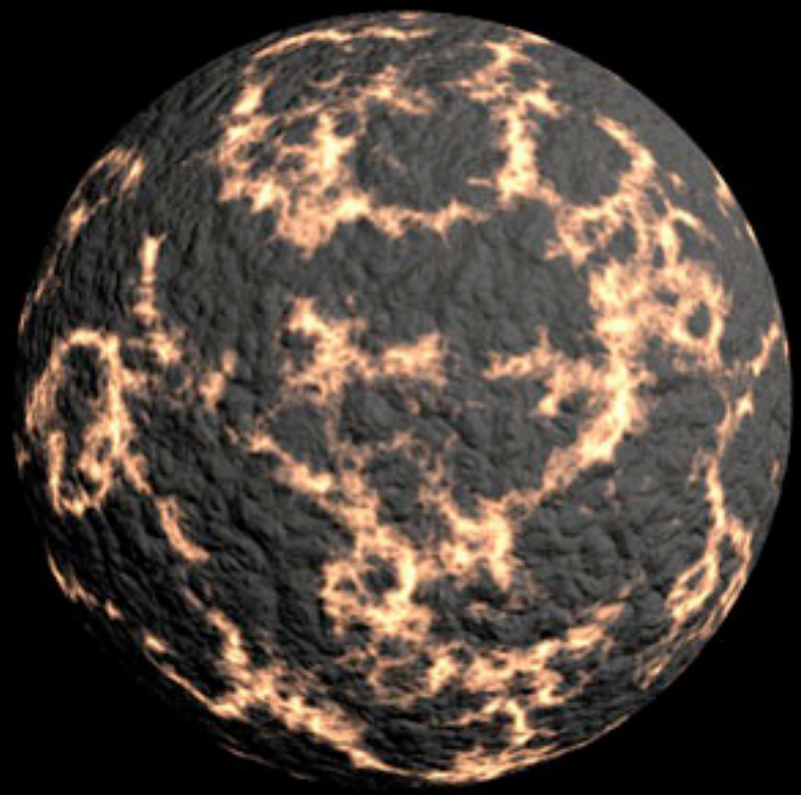
$h = 6.63 \times 10^{-34}$

Temporal Scales

13.3-13.9 Ga

0


life
THE BIG BANG
INFLATION
FIRST STARS
400,000,000 YEARS
AFTER BIG BANG
GALAXY EVOLUTION
CONTINUES...
DARK ENERGY ?
THE DARK AGES
NOW
13,700,000,000 YEARS
AFTER BIG BANG
COSMIC MICROWAVE
BACKGROUND
400,000 YEARS AFTER
BIG BANG
FIRST GALAXIES
1000,000,000 YEARS
AFTER BIG BANG
FORMATION OF
THE SOLAR SYSTEM
8,700,000,000 YEARS
AFTER BIG BANG

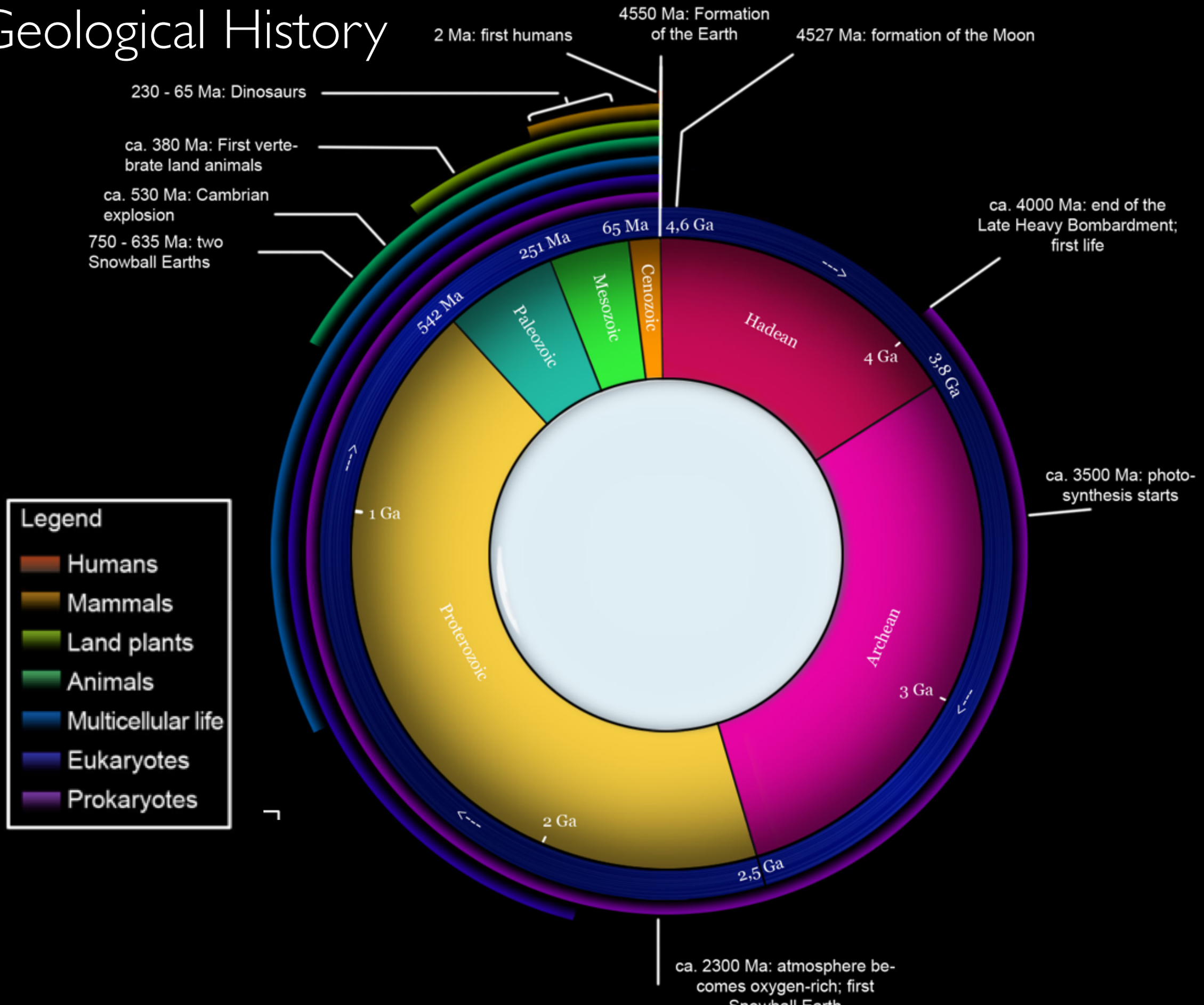


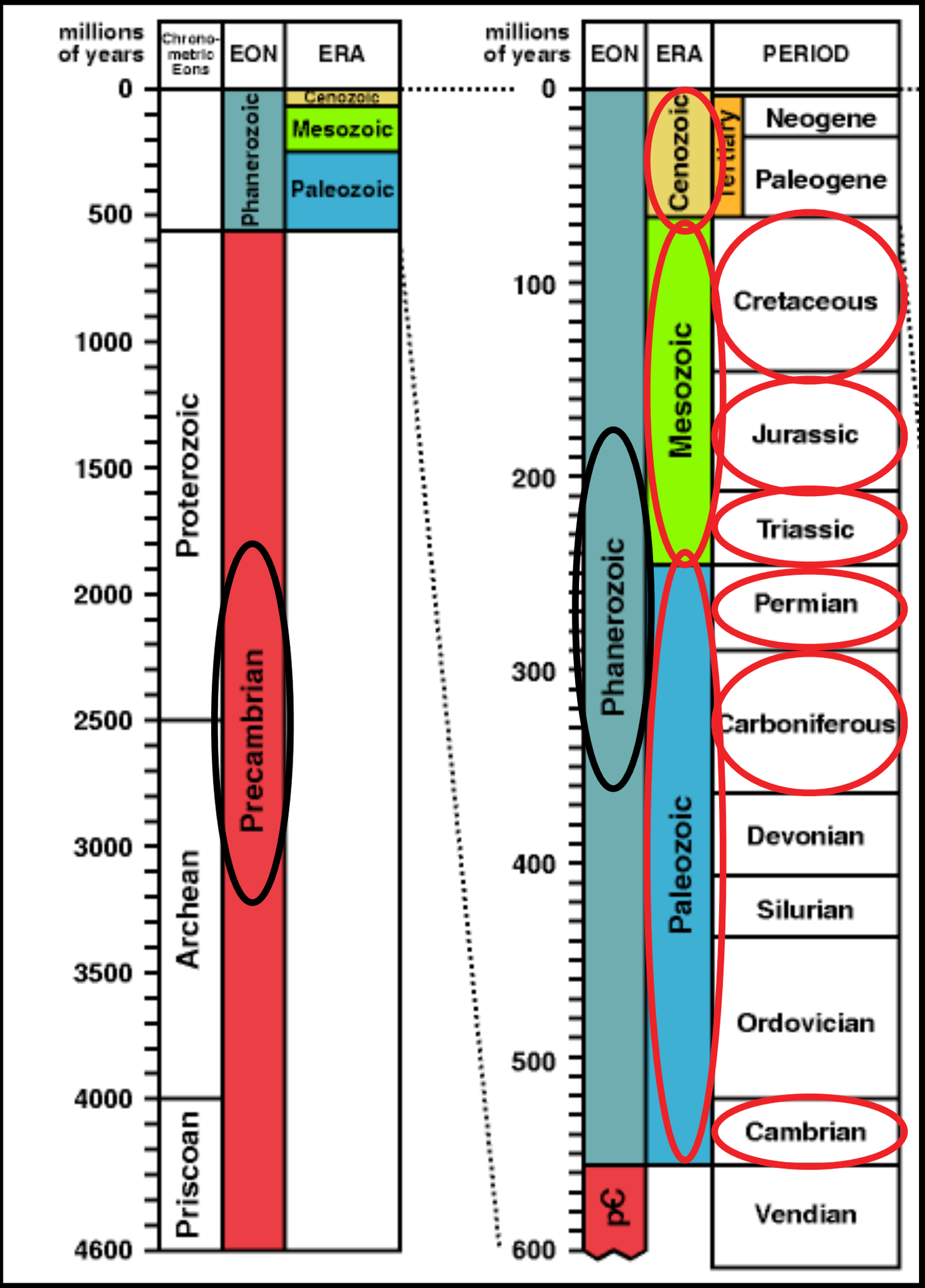
4.56 gyr

4.527 gyr

> 4.527 gyr

Geological History

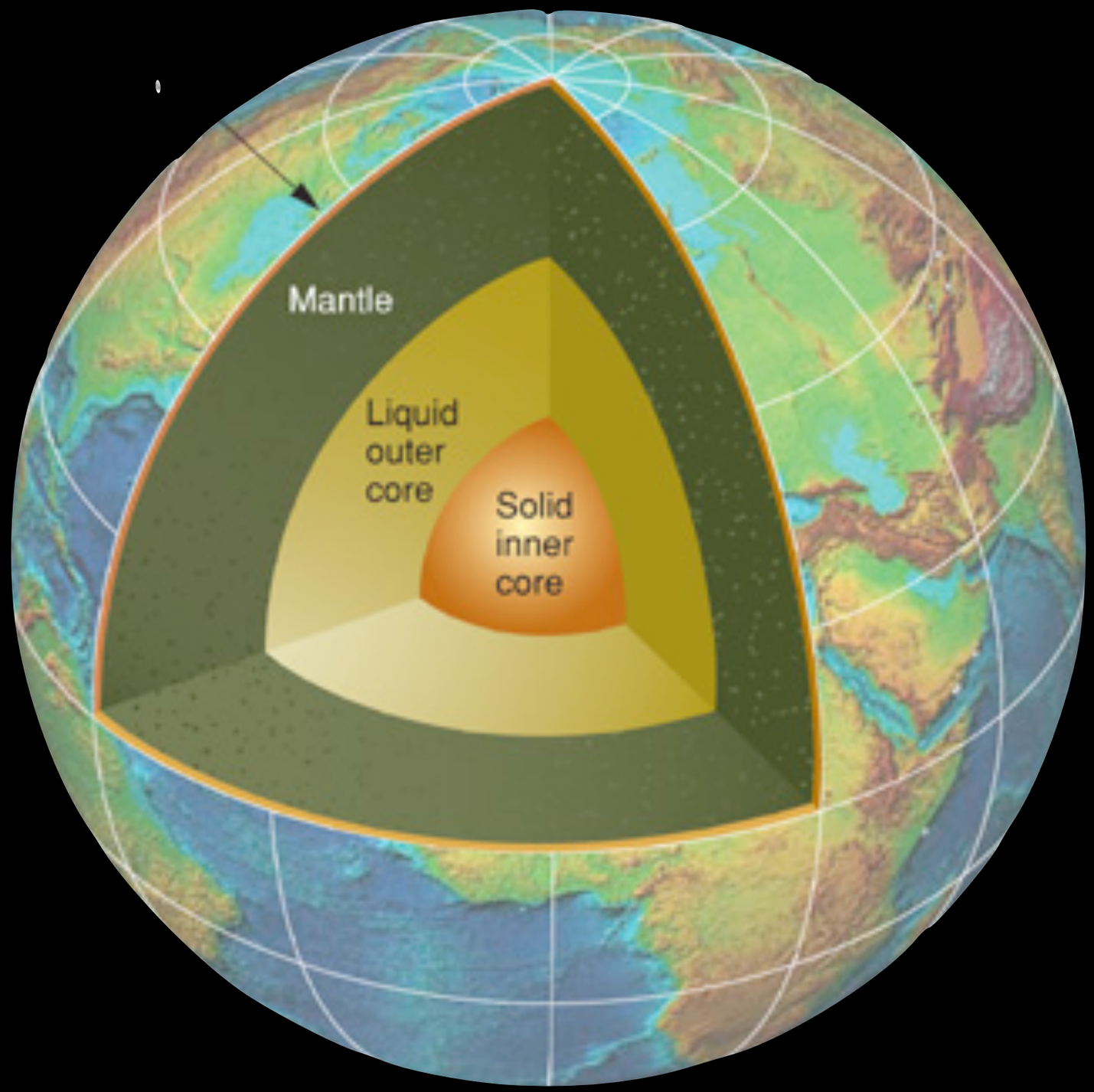




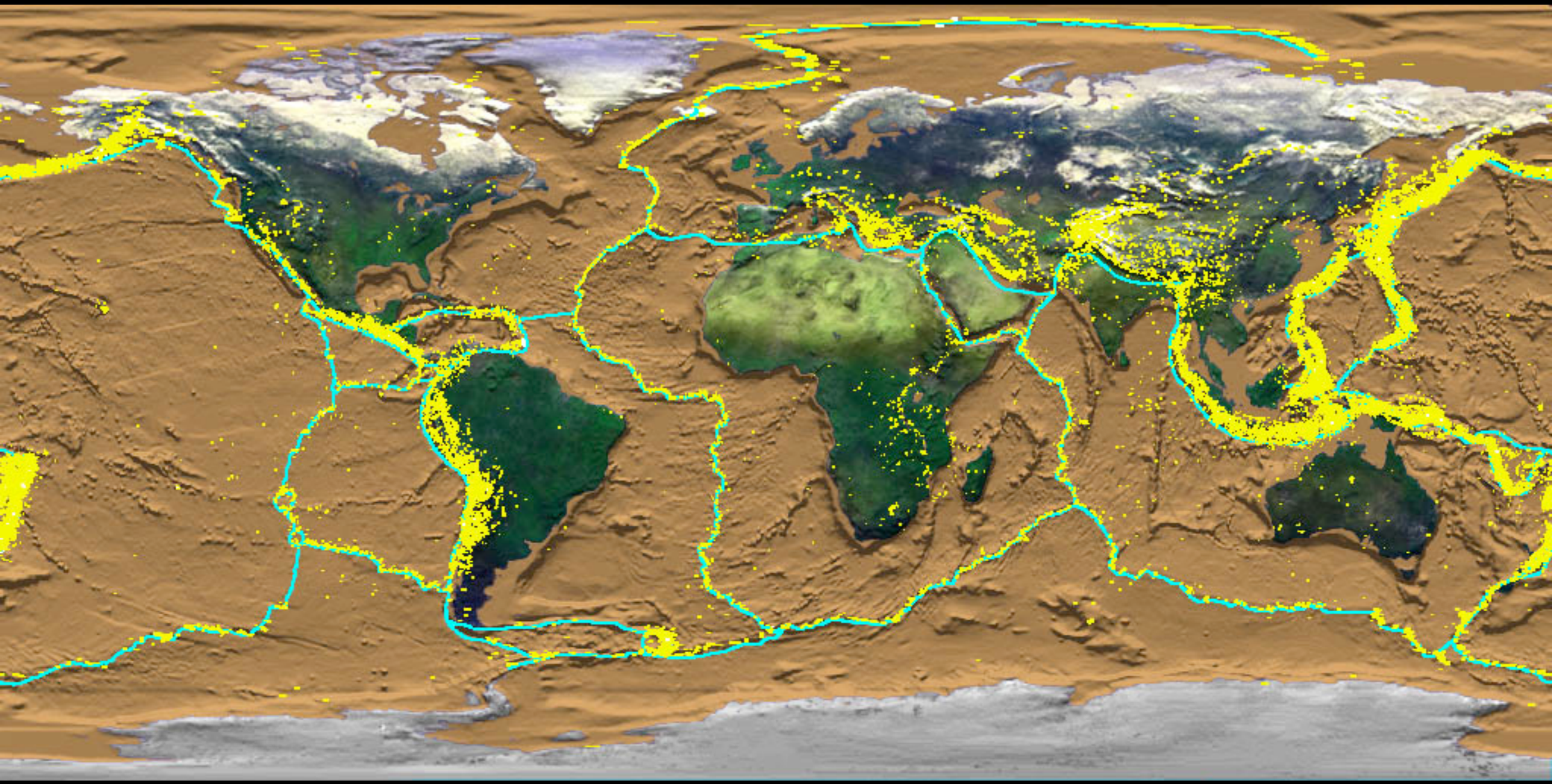
Be Familiar

Know

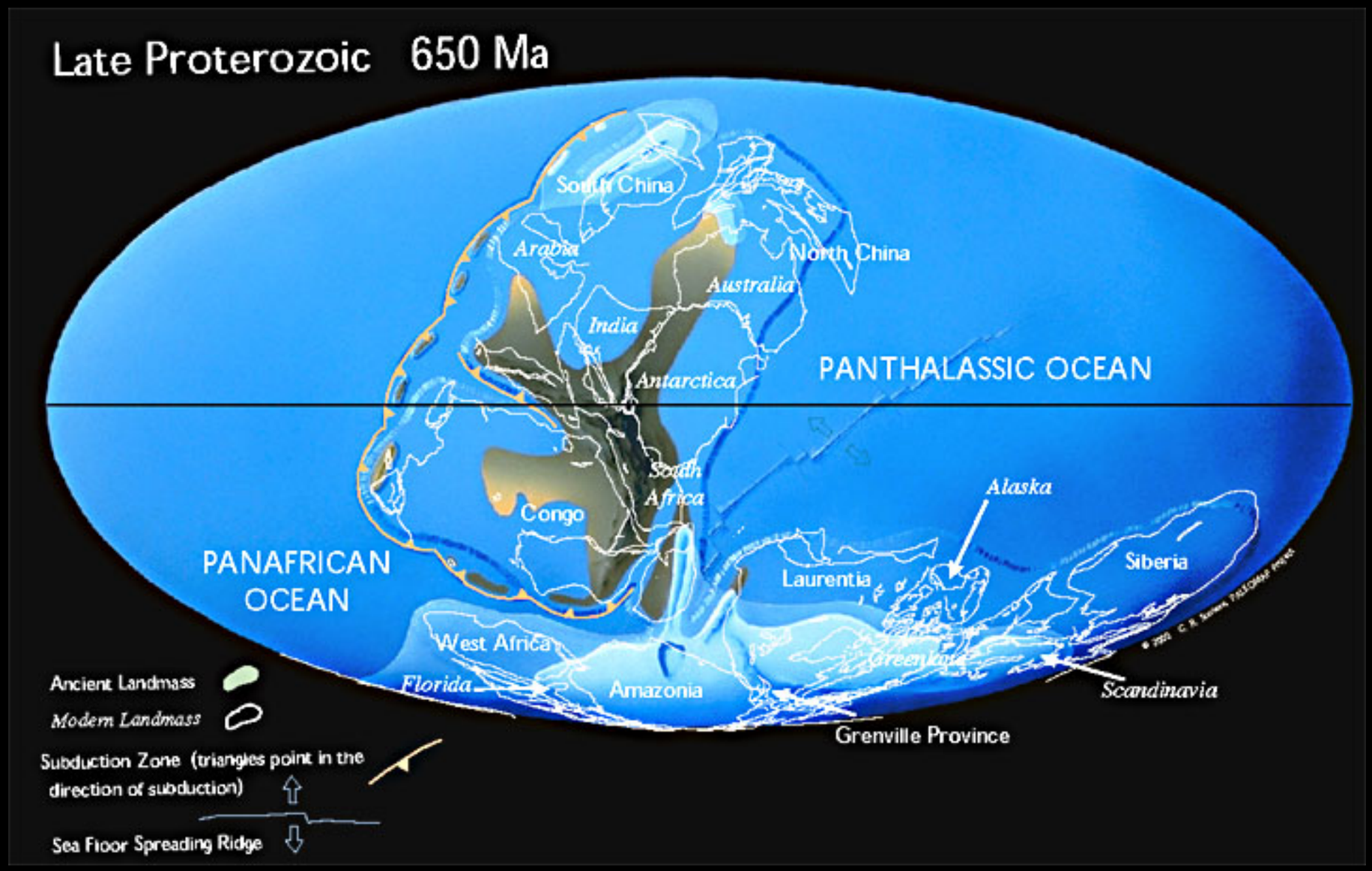
- Precambrian Eon
- Phanerozoic Eon
  - Paleozoic
    - Cambrian (542:488 Ma)
    - Carboniferous (360:299 Ma)
    - Permian (299:251 Ma)
  - Mesozoic
    - Triassic (251:200 Ma)
    - Jurassic (200:146 Ma)
    - Cretaceous (146:65.5)
  - Cenozoic (65.5:now)

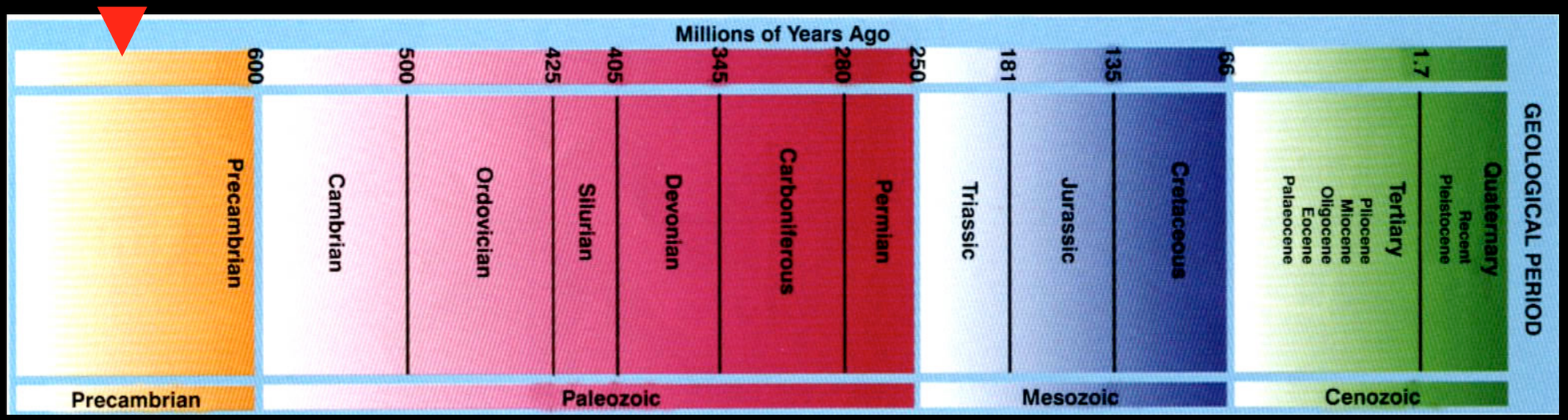

Mantle
Liquid
outer
core
Solid
inner
core

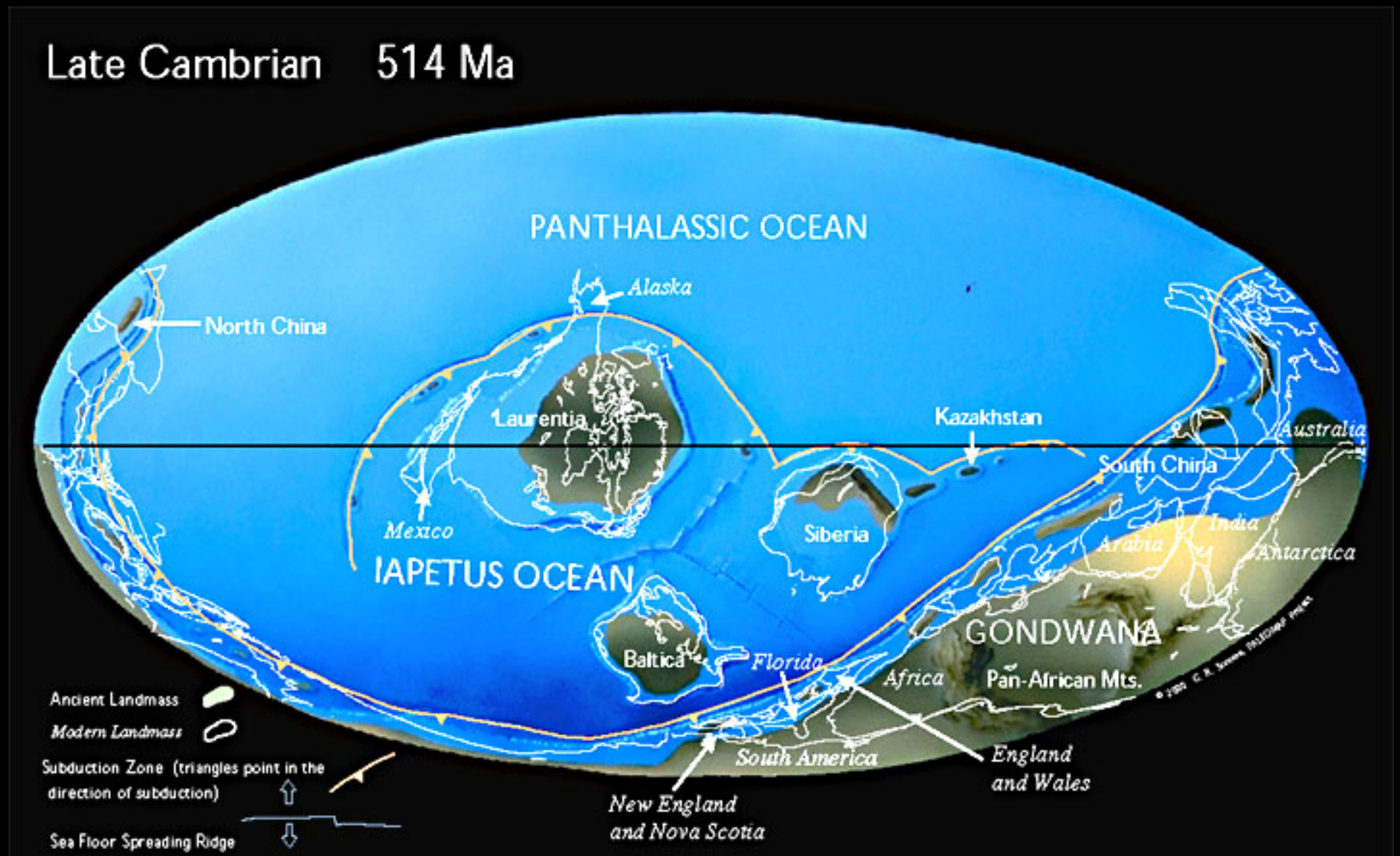
Continental Plates

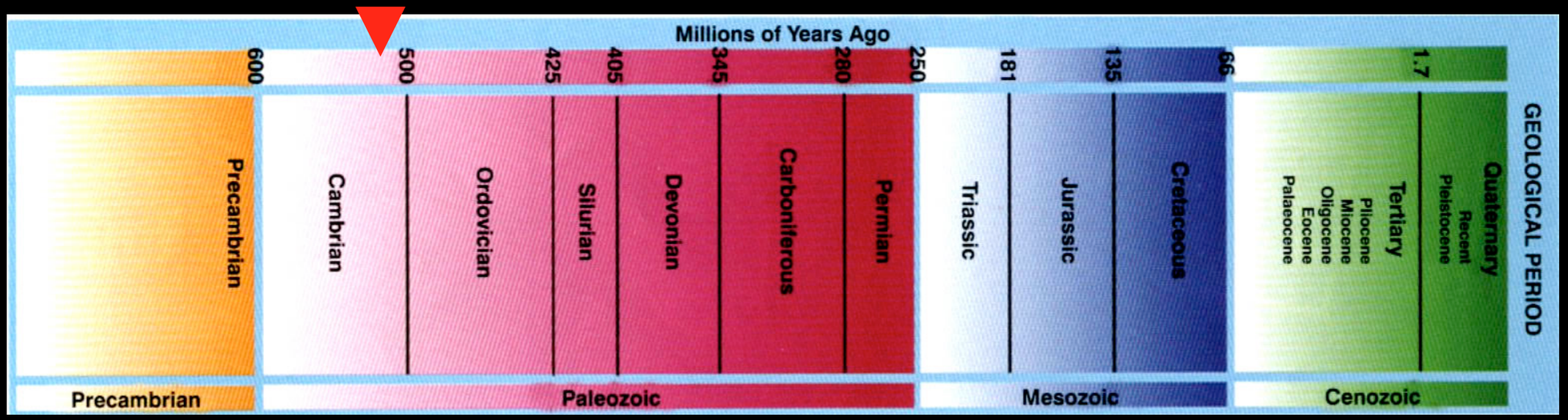


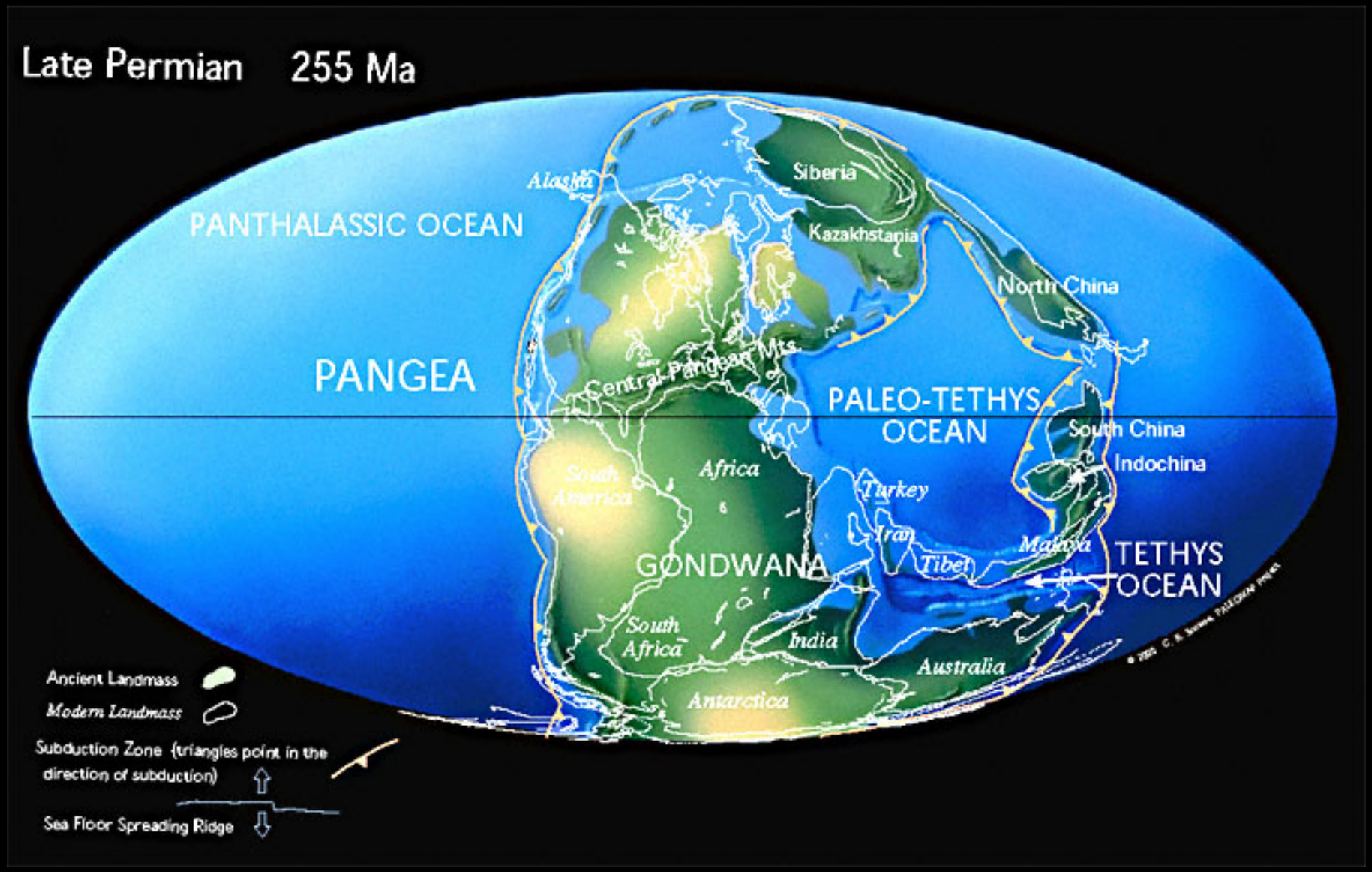
- = earthquakes

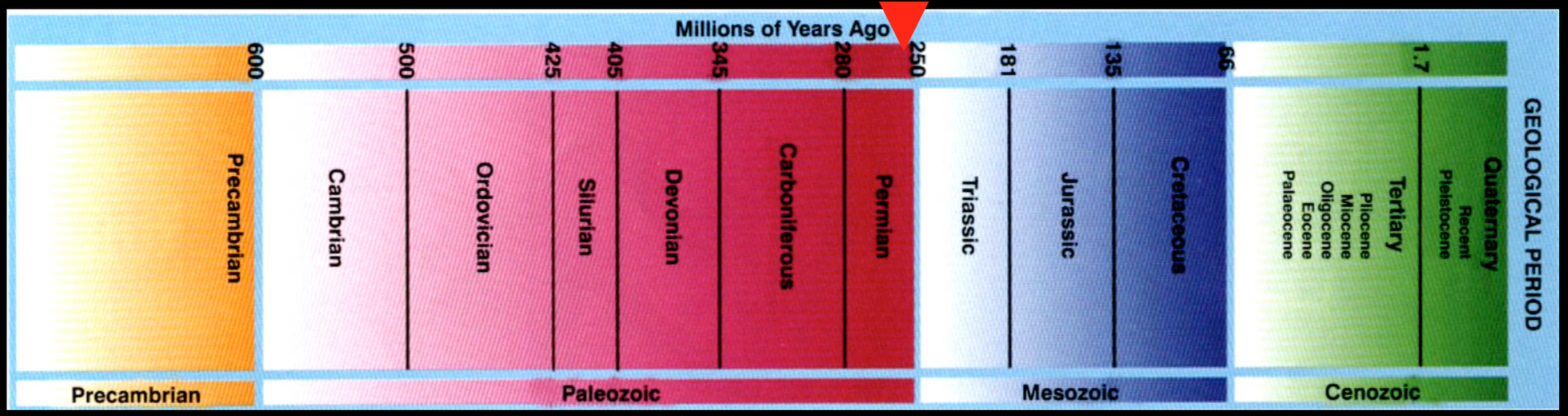

Late Proterozoic 650 Ma
South China
Arabia
North China
Australia
India
Antarctica
PANTHALASSIC OCEAN
South Africa
Congo
Alaska
PANAFRICAN OCEAN
Laurentia
Siberia
West Africa
Florida
Amazonia
Greenland
Scandinavia
Grenville Province
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge

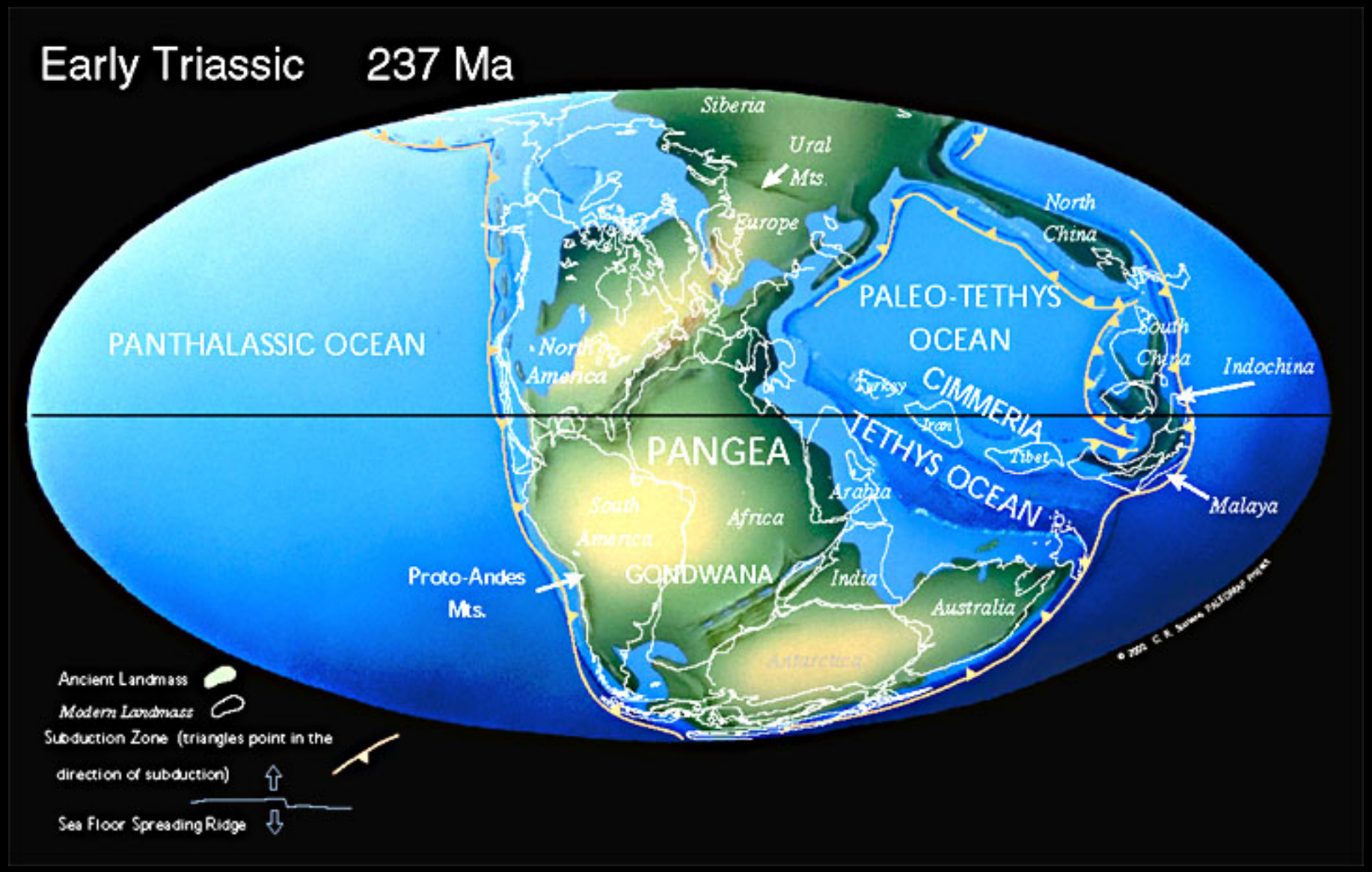

Millions of Years Ago
600
500
425
405
345
280
250
181
135
66
1.7
Precambrian
Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
Quaternary
Recent
Pleistocene
Tertiary
Pliocene
Miocene
Oligocene
Eocene
Palaeocene
GEOLOGICAL PERIOD
Precambrian
Paleozoic
Mesozoic
Cenozoic

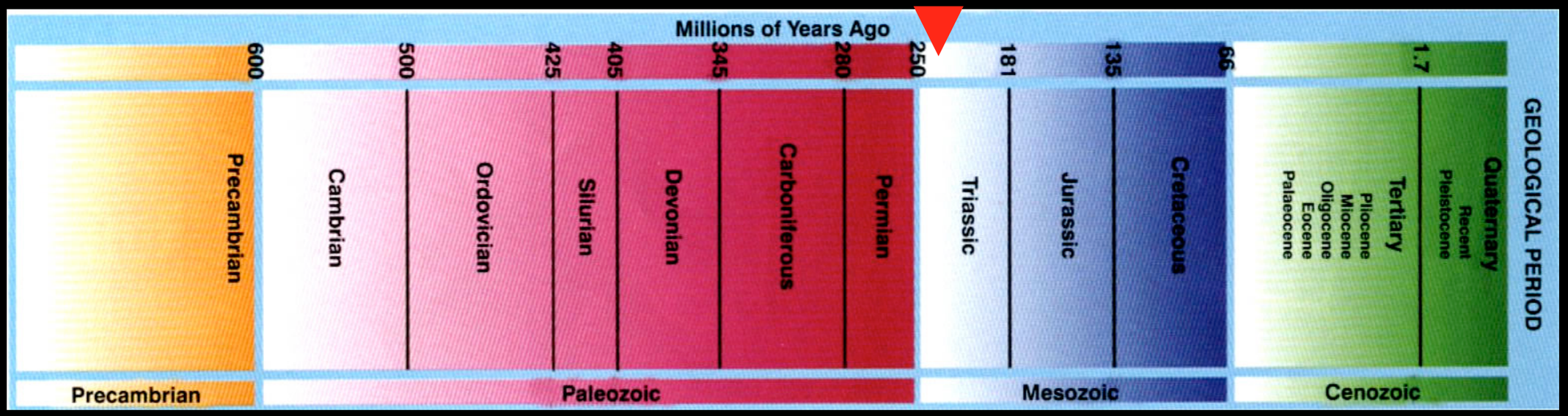

Late Cambrian 514 Ma
PANTHALASSIC OCEAN
Alaska
North China
Laurentia
Kazakhstan
Australia
South China
Mexico
Siberia
India
Arabia
Antarctica
IAPETUS OCEAN
GONDWANA
Baltica
Florida
Africa
Pan-African Mts.
South America
England and Wales
New England and Nova Scotia
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge

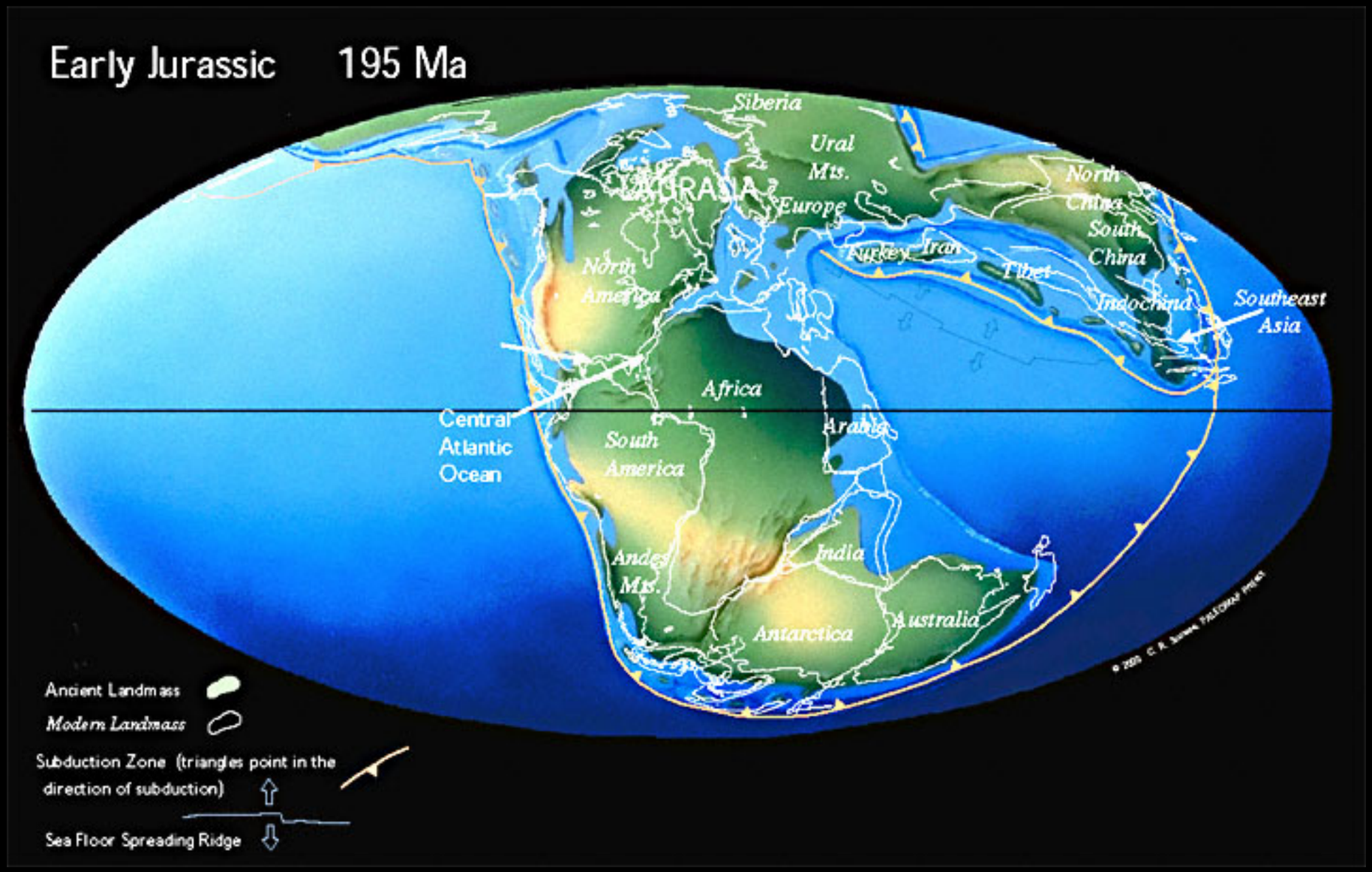

Millions of Years Ago
600
500
425
405
345
280
250
181
135
66
1.7
Precambrian
Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
Quaternary
Recent
Pleistocene
Tertiary
Pliocene
Miocene
Oligocene
Eocene
Palaeocene
GEOLOGICAL PERIOD
Precambrian
Paleozoic
Mesozoic
Cenozoic

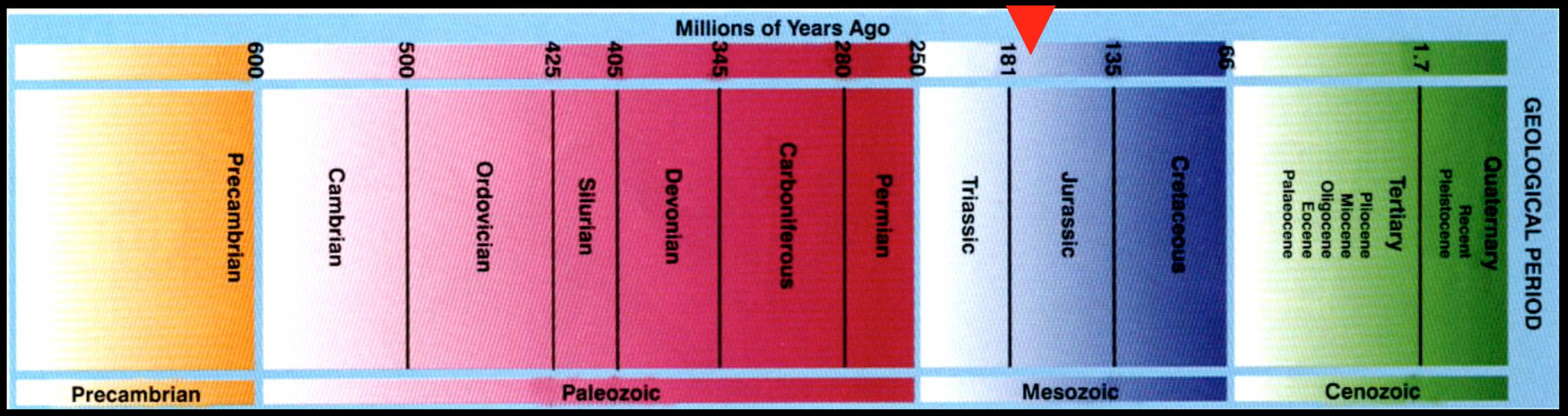

Late Permian 255 Ma
PANTHALASSIC OCEAN
PANGEA
Alaska
Siberia
Kazakhstania
North China
Central Pangean Mts.
PALEO-TETHYS OCEAN
South China
Indochina
South America
Africa
Turkey
Iran
Malaya
Tibet
GONDWANA
TETHYS OCEAN
South Africa
India
Australia
Antarctica
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge


Millions of Years Ago
600
500
425
405
345
280
250
181
135
66
1.7
Precambrian
Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
Quaternary
Recent
Pleistocene
Tertiary
Pliocene
Miocene
Oligocene
Eocene
Palaeocene
GEOLOGICAL PERIOD
Precambrian
Paleozoic
Mesozoic
Cenozoic


Early Triassic 237 Ma
Siberia
Ural Mts.
Europe
North China
PALEO-TETHYS OCEAN
PANTHALASSIC OCEAN
North America
South China
Indochina
CIMMERIA
Turkey
Iran
Tibet
PANGEA
TETHYS OCEAN
Arabia
Malaya
South America
Africa
Proto-Andes Mts.
GONDWANA
India
Australia
Antarctica
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge


Millions of Years Ago
600
500
425
405
345
280
250
181
135
66
1.7
Precambrian
Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
Quaternary
Recent
Pleistocene
Tertiary
Pliocene
Miocene
Oligocene
Eocene
Palaeocene
GEOLOGICAL PERIOD
Precambrian
Paleozoic
Mesozoic
Cenozoic


Early Jurassic 195 Ma
Siberia
Ural Mts.
LAURASIA
Europe
North America
Turkey
Iran
Tibet
North China
South China
Indochina
Southeast Asia
Central Atlantic Ocean
Africa
Arabia
South America
India
Andes Mts.
Australia
Antarctica
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge


Millions of Years Ago
600
500
425
405
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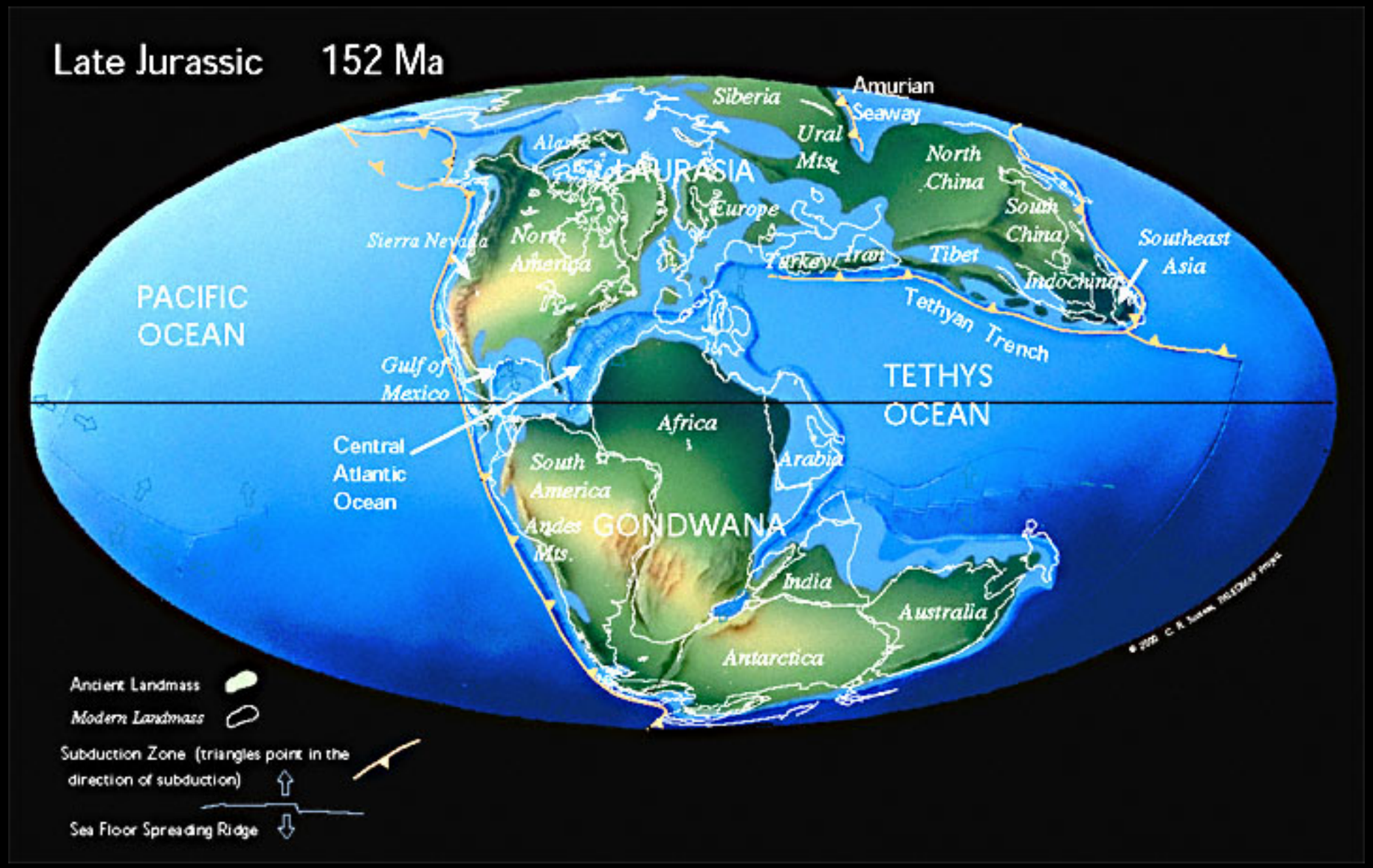
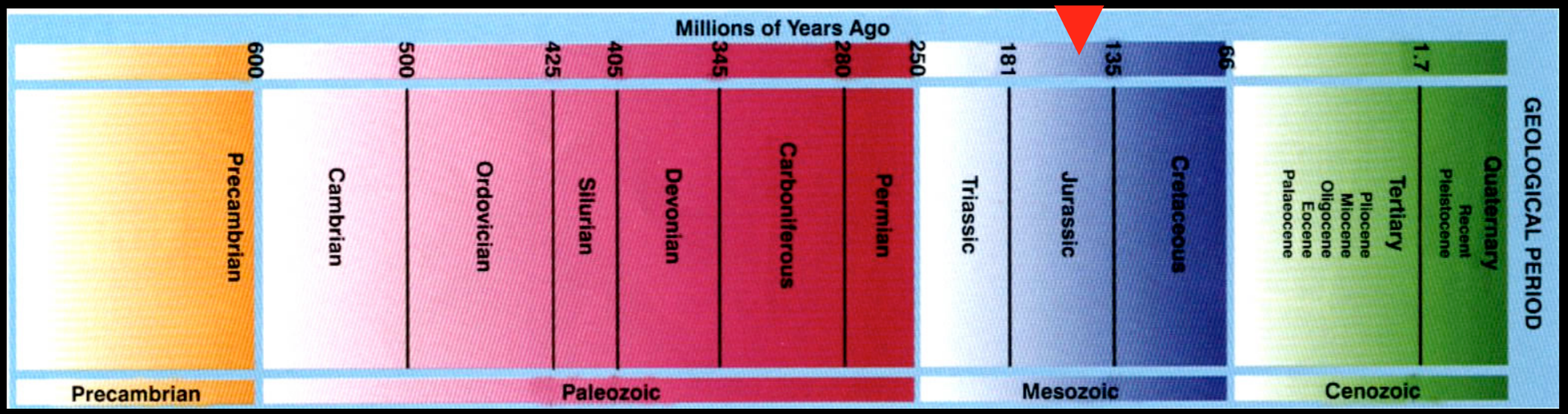
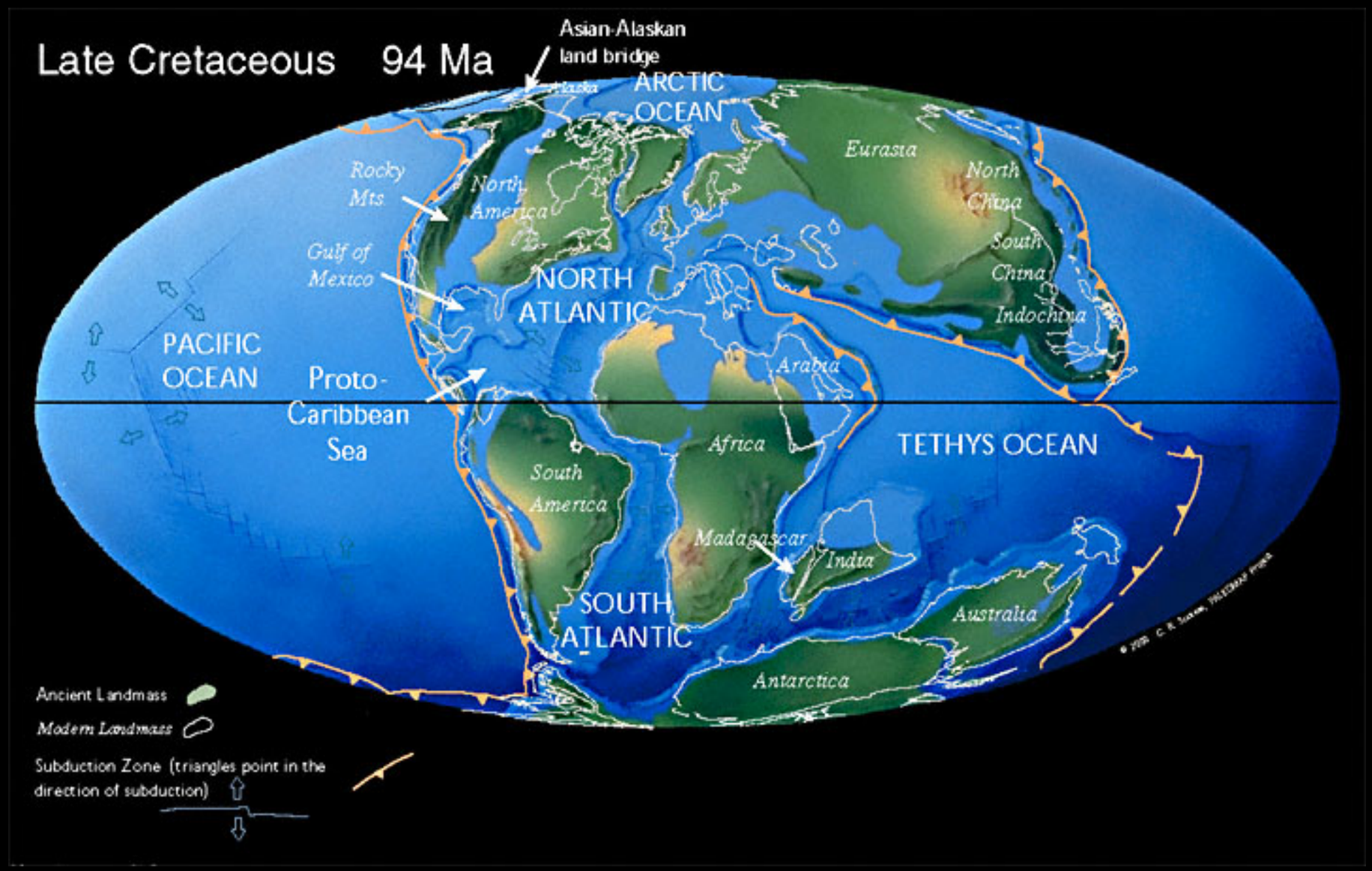
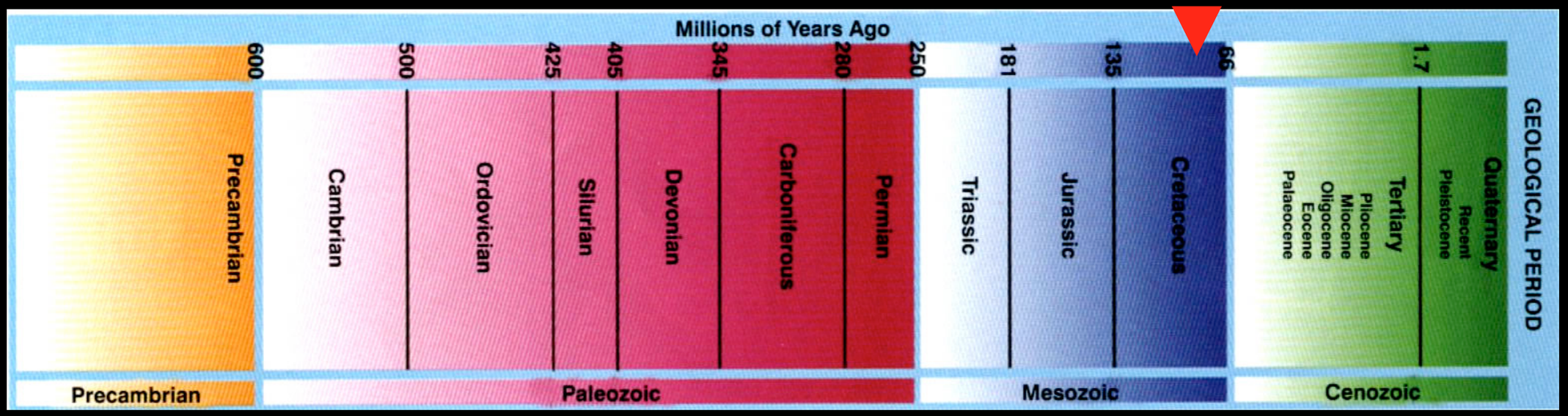
250
181
135
66
1.7
Precambrian
Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
Tertiary
Pliocene
Miocene
Oligocene
Eocene
Palaeocene
Quaternary
Recent
Pleistocene
GEOLOGICAL PERIOD
Precambrian
Paleozoic
Mesozoic
Cenozoic


Late Jurassic 152 Ma
Siberia
Amurian Seaway
Ural Mts.
LAURASIA
North China
South China
Southeast Asia
Indochina
Tibet
Iran
Turkey
Europe
North America
Sierra Nevada
PACIFIC OCEAN
Tethyan Trench
TETHYS OCEAN
Gulf of Mexico
Central Atlantic Ocean
Africa
Arabia
South America
Andes Mts.
GONDWANA
India
Australia
Antarctica
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge


Millions of Years Ago
600
500
425
405
345
280
250
181
135
66
1.7
Precambrian
Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
Quaternary
Recent
Pleistocene
Tertiary
Pliocene
Miocene
Oligocene
Eocene
Palaeocene
GEOLOGICAL PERIOD
Precambrian
Paleozoic
Mesozoic
Cenozoic


Late Cretaceous 94 Ma
Asian-Alaskan land bridge
Alaska
ARCTIC OCEAN
Eurasia
Rocky Mts.
North America
North China
Gulf of Mexico
NORTH ATLANTIC
South China
Indochina
PACIFIC OCEAN
Proto-Caribbean Sea
Arabia
Africa
TETHYS OCEAN
South America
Madagascar
India
SOUTH ATLANTIC
Australia
Antarctica
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)


Millions of Years Ago
600
500
425
405
345
280
250
181
135
66
1.7
Precambrian
Cambrian
Ordovician
Silurian
Devonian
Carboniferous
Permian
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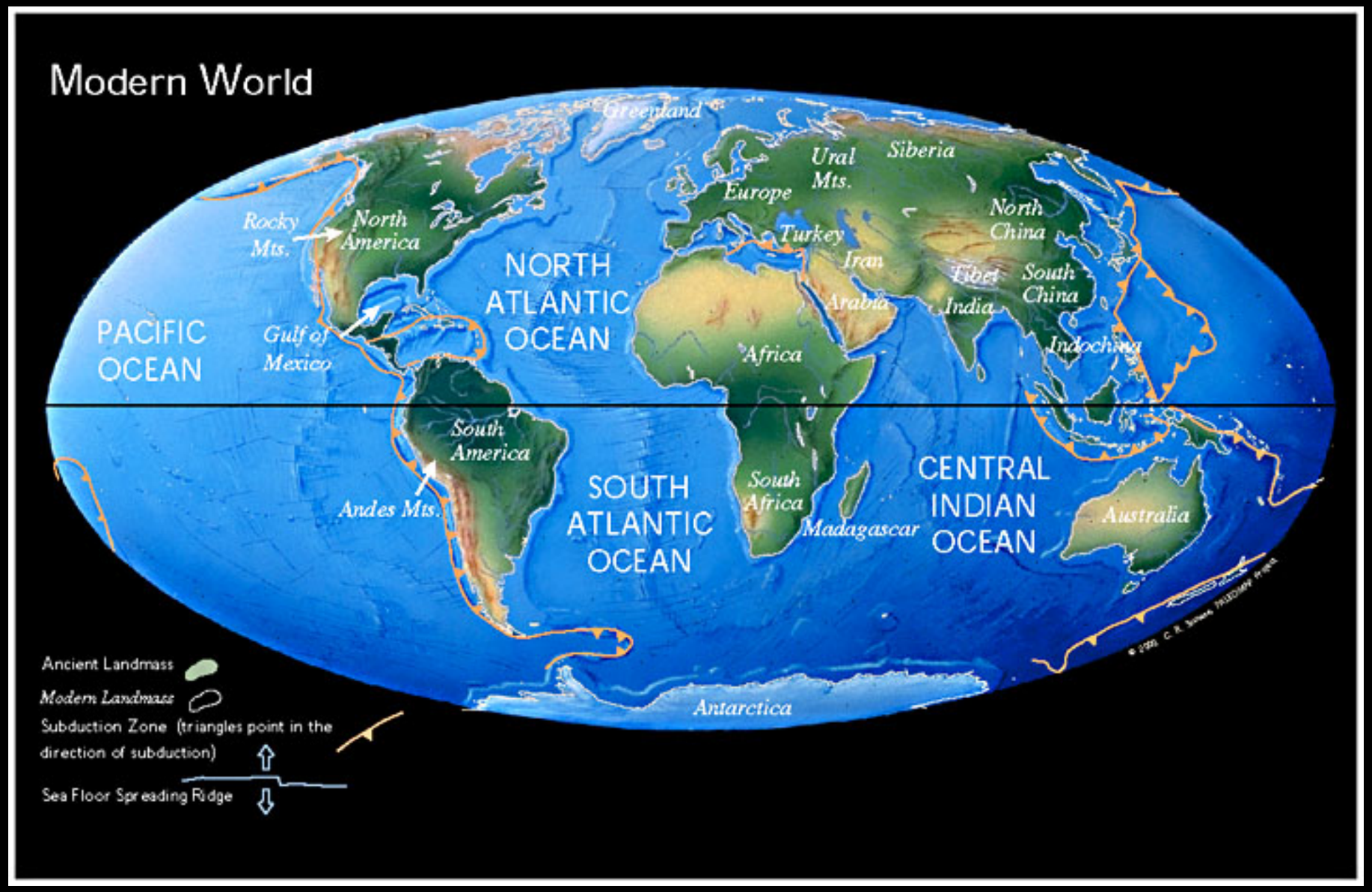
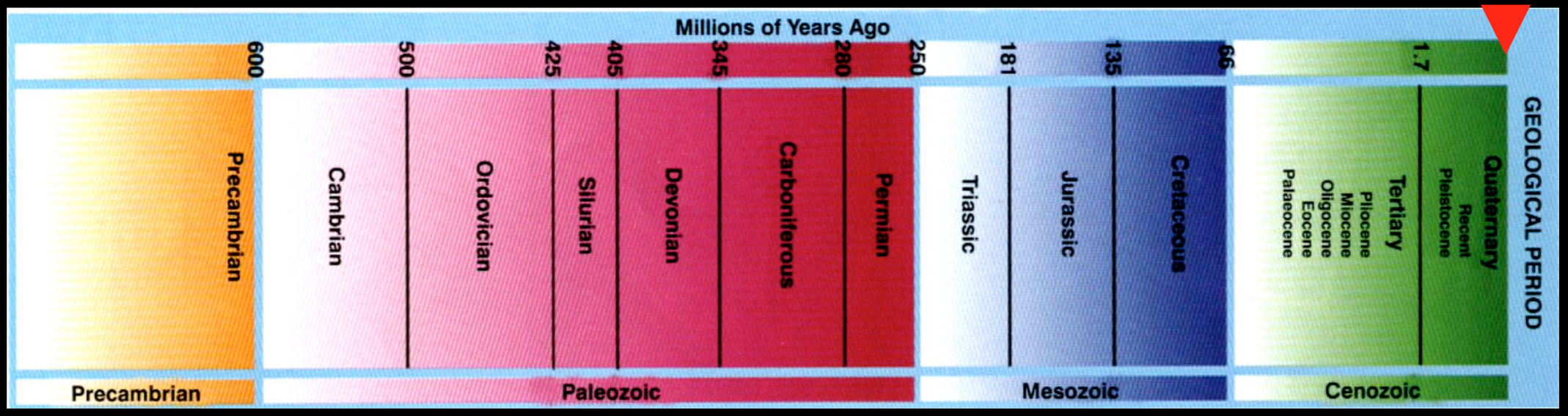

Modern World
Greenland
Ural Mts.
Siberia
Europe
North China
Rocky Mts.
North America
Turkey
Iran
Tibet
South China
Arabia
India
Indochina
PACIFIC OCEAN
NORTH ATLANTIC OCEAN
Gulf of Mexico
Africa
South America
Andes Mts.
SOUTH ATLANTIC OCEAN
South Africa
Madagascar
CENTRAL INDIAN OCEAN
Australia
Antarctica
Ancient Landmass
Modern Landmass
Subduction Zone (triangles point in the direction of subduction)
Sea Floor Spreading Ridge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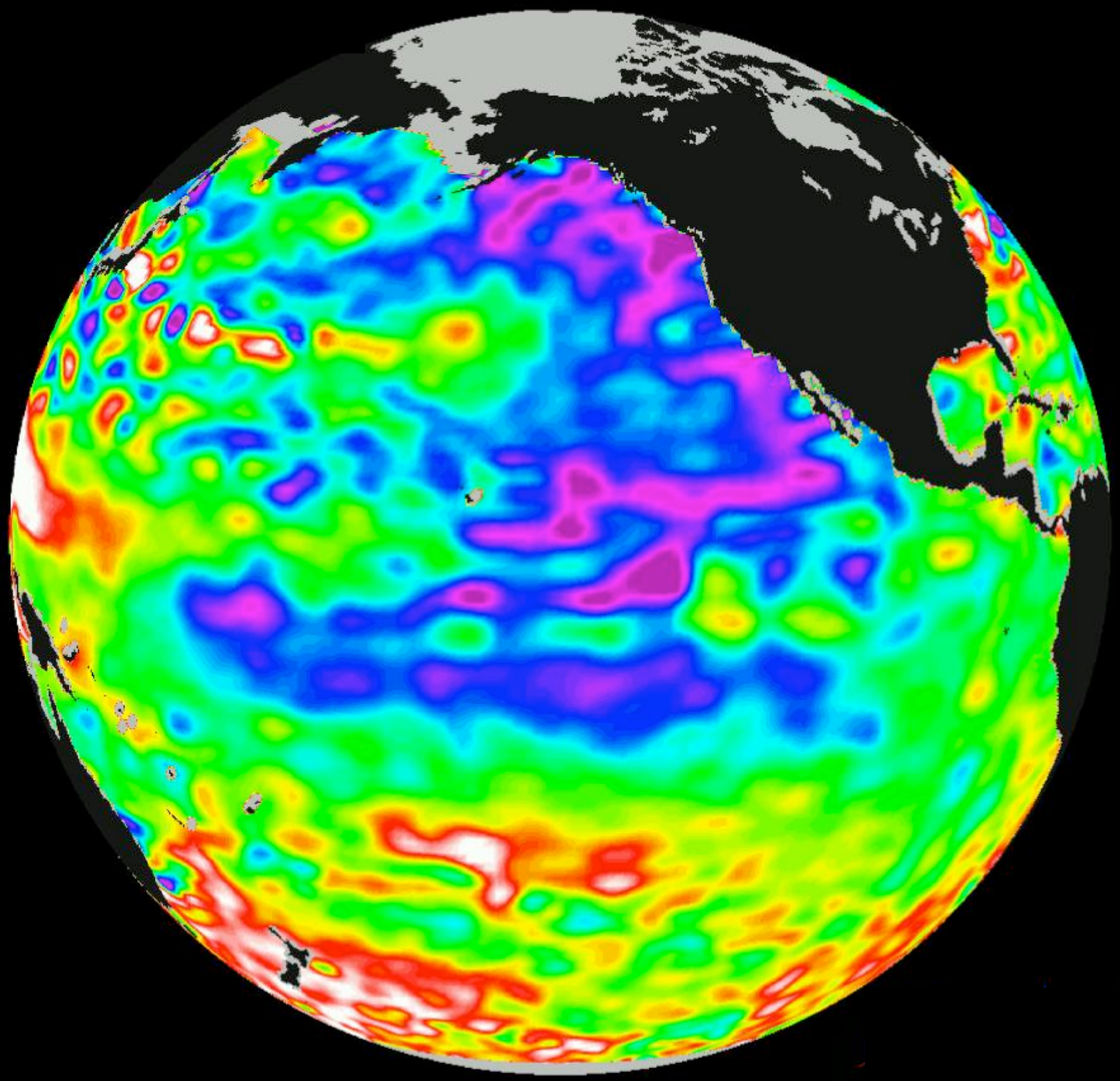
Cenozoic

Why do we care?



"Being a paleontologist is like being a coroner except that all the witnesses are dead and all the evidence has been left out in the rain for 65 million years."

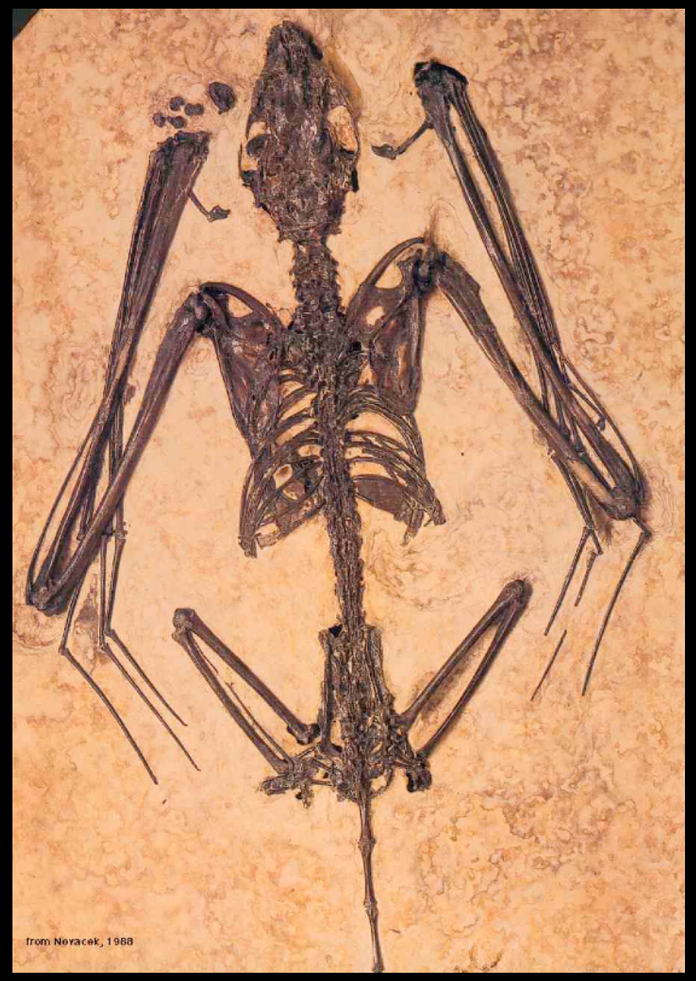
Mike Brett-Surman, 1994

Herrerasaurus

There is a lot that we don't know about dinosaurs…

Science is dynamic

Fossils and Preservation:



Many meanings... types of fossils

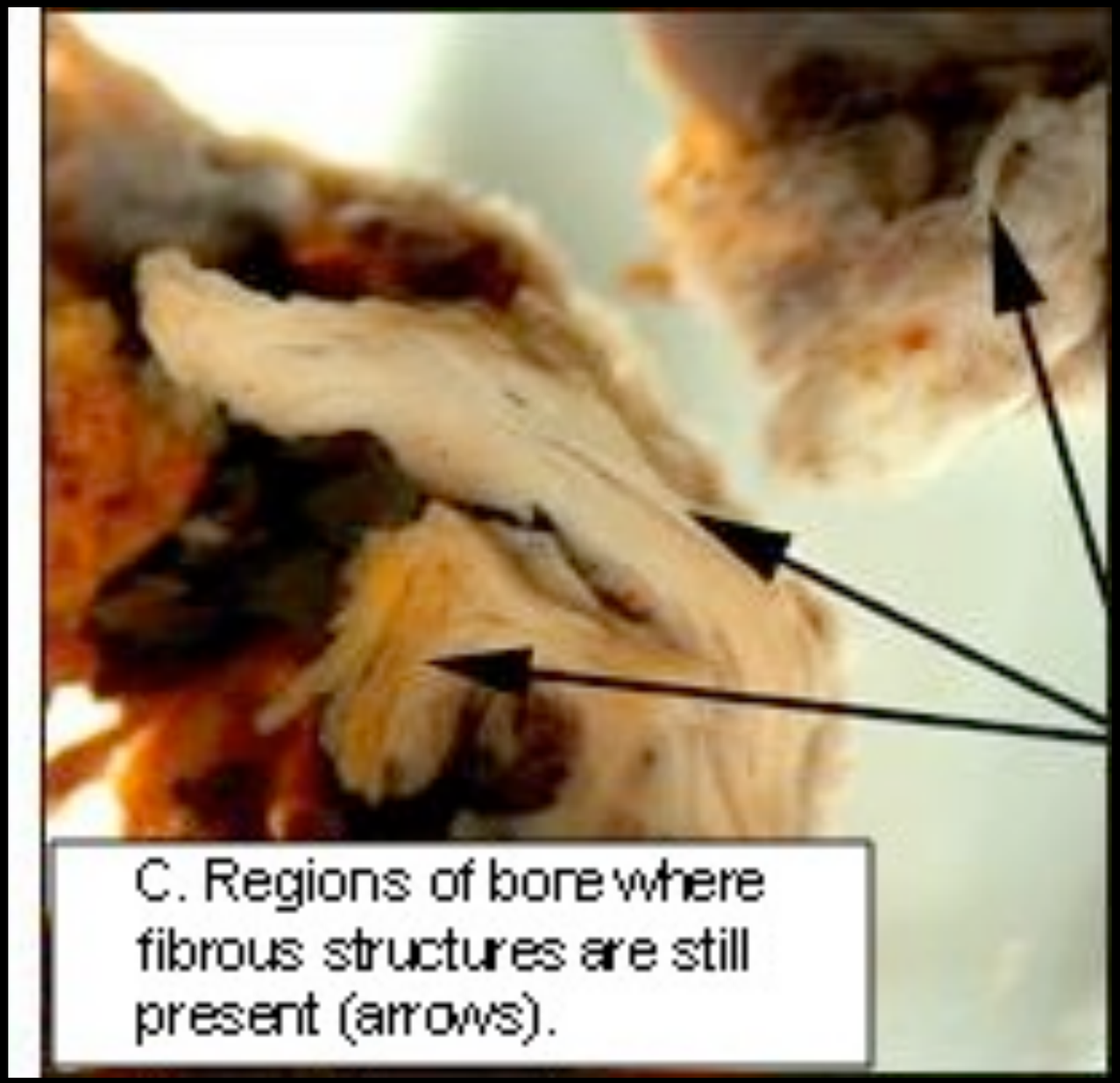
Trace Fossils

- Poo (Coprolites)
- Gastroliths
- Trackways

Soft Parts:
Impressions
Amber
Protein???

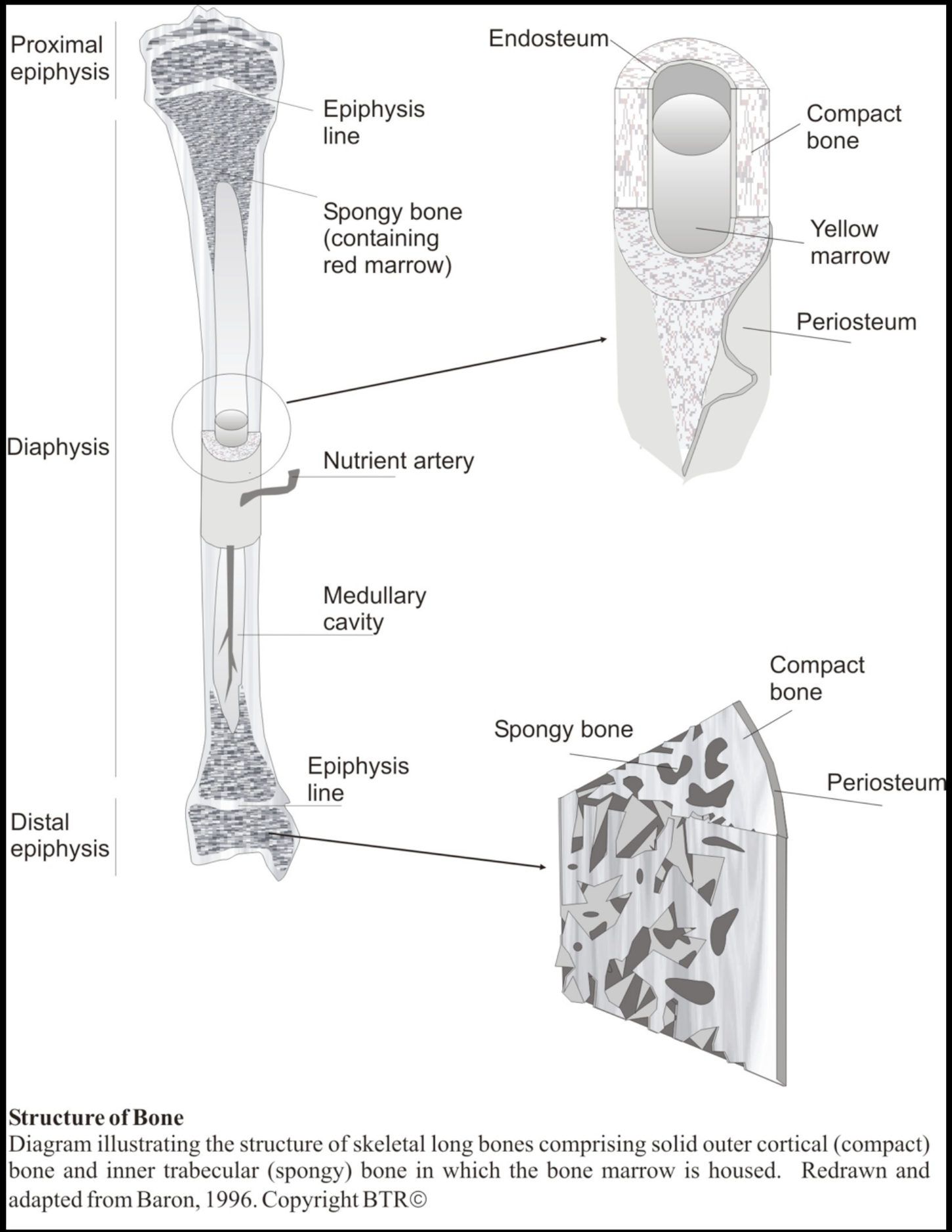
Hadrosaur skin

T. rex collagen?



68 Ma

Hard Parts: Living vs. Fossilized



Structure of Bone
Diagram illustrating the structure of skeletal long bones comprising solid outer cortical (compact) bone and inner trabecular (spongy) bone in which the bone marrow is housed. Redrawn and adapted from Baron, 1996. Copyright BTR©

Living Bone

Bone Matrix

- Organic
  - **Collagen**
- Nonorganic
  - Hydroxyapatite

Fossil Bone

$Ca_{10}(PO_4)_6(F, OH, Cl)_2$

Apatite Mineral Francolite

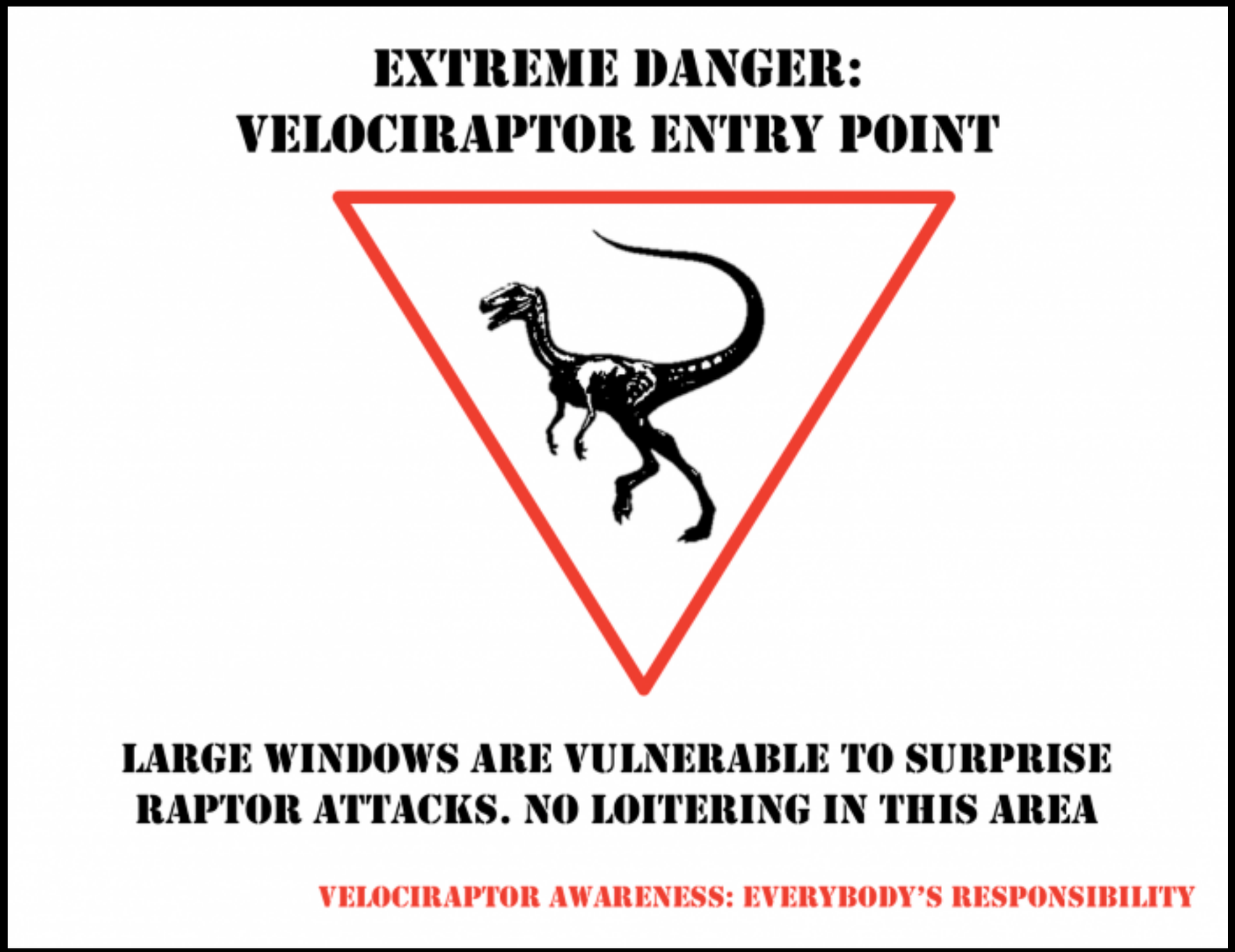
No longer biological- it's a rock.

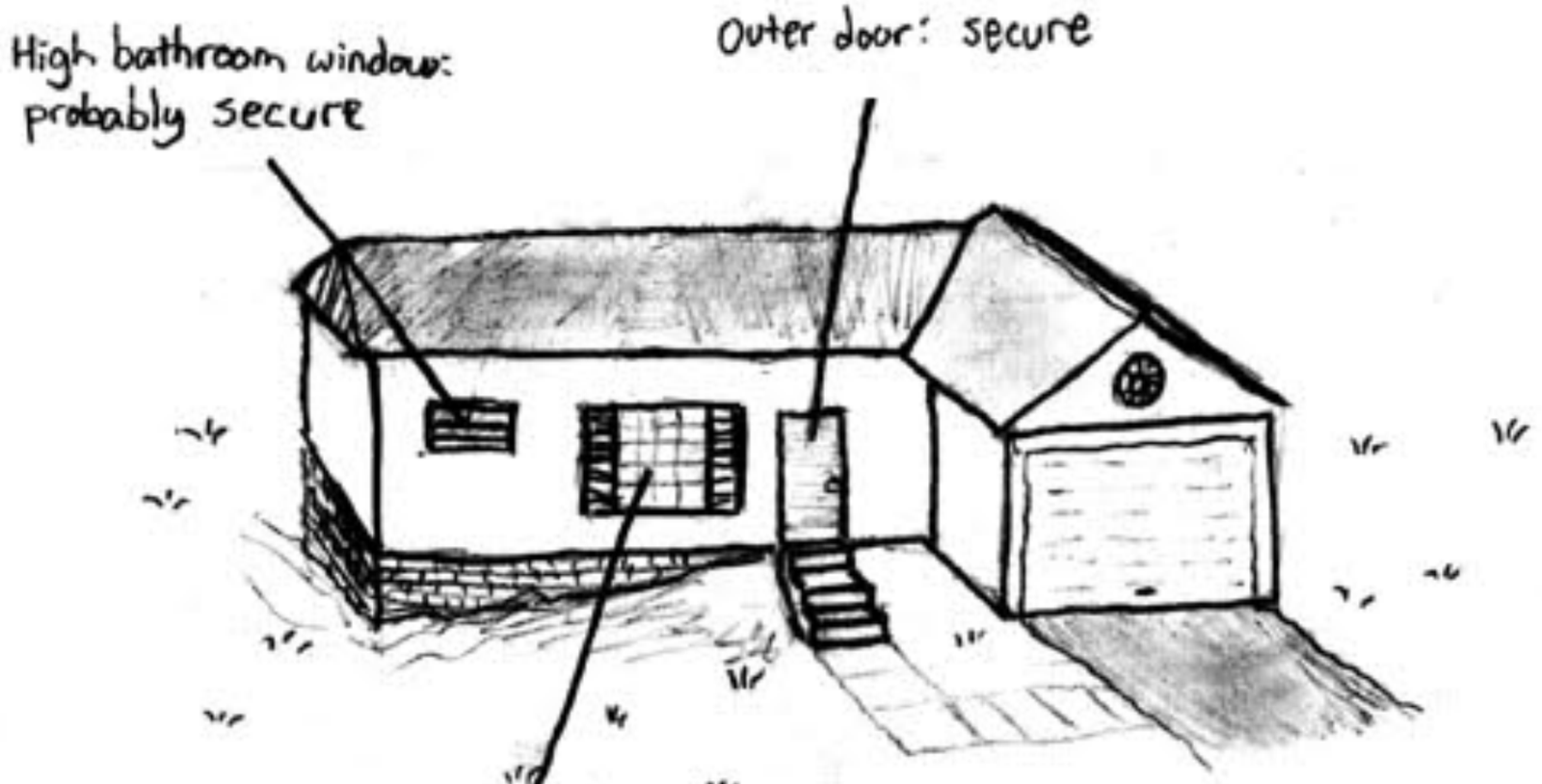
Unaltered remains

Bogs

- Acidic peat bogs, tar pits
- Pickling

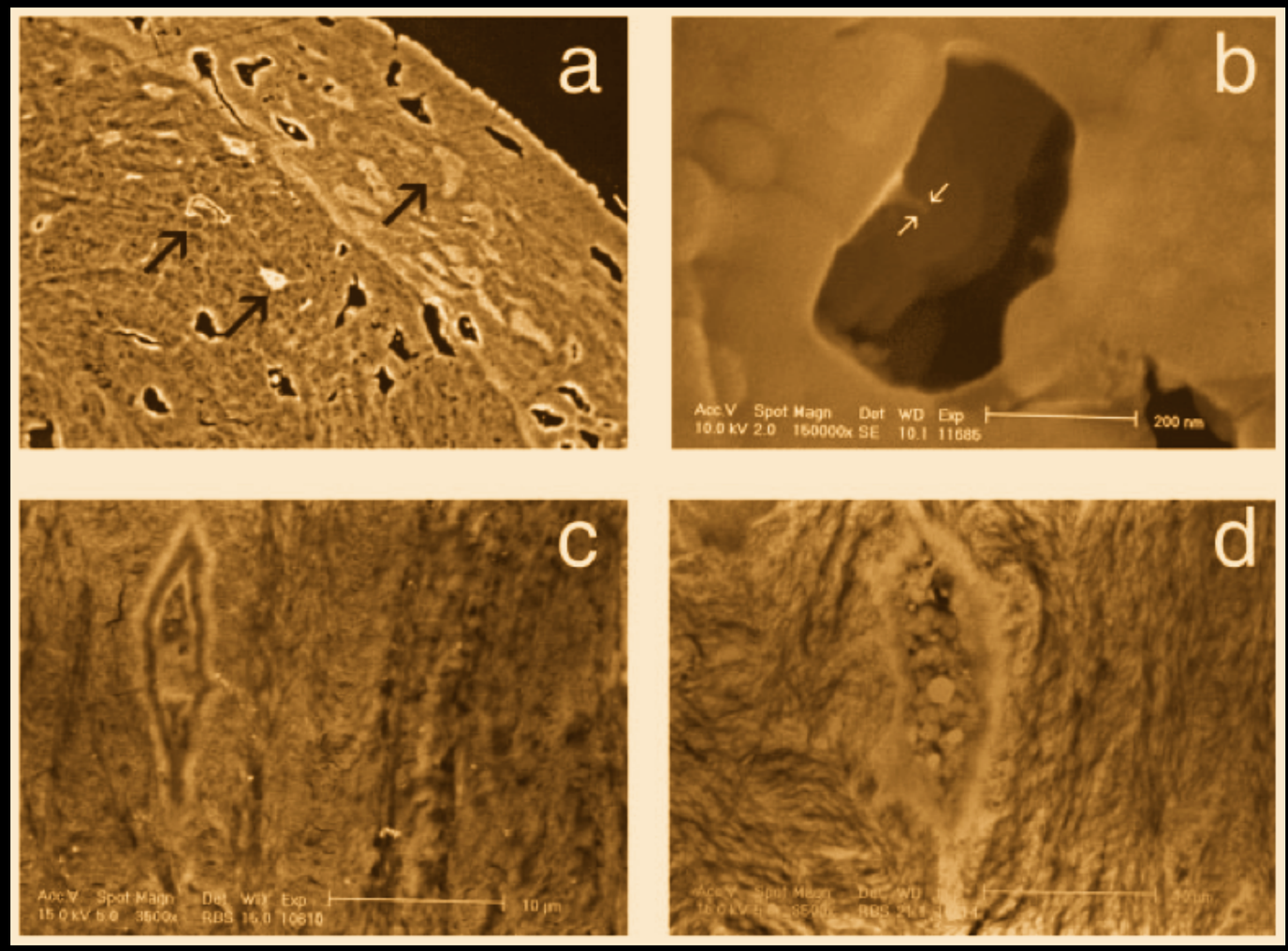
January is Velociraptor Awareness Month!!!





It's been over a decade since Jurassic Park opened, and I still size up buildings for their potential as shelter against velociraptor attacks.

Fossilization: A fine scale



Even osteocytes (bone cells) are preserved

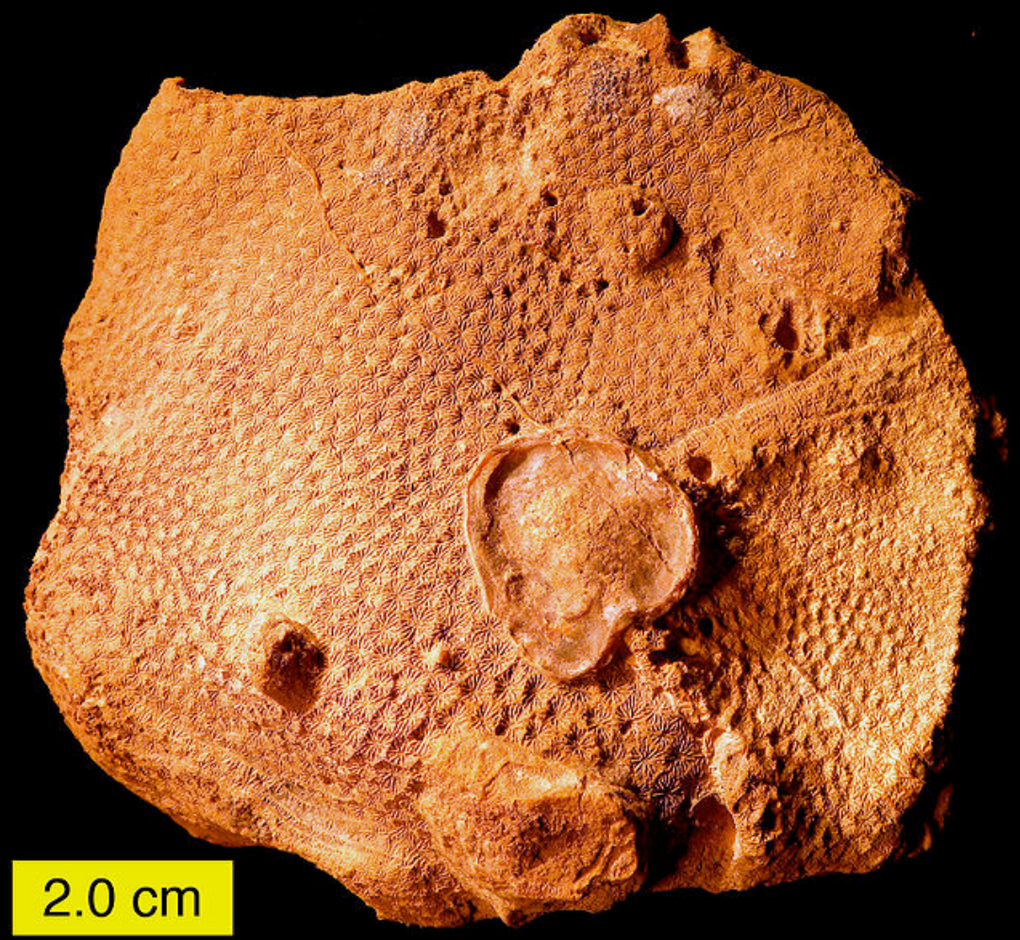
Routes to Fossilization

Trilobite

Permineralization

- **Open spaces in organic material is filled up with minerals**
- Crystals form within cell walls
- This type of preservation conserves cell structure

Routes to Fossilization



- Shell, bone, tissue **replaced** with another mineral into a crystal

Fossil Coral: Jurassic

Mineralization and Recrystalization

Routes to Fossilization

Structure is typically compressed

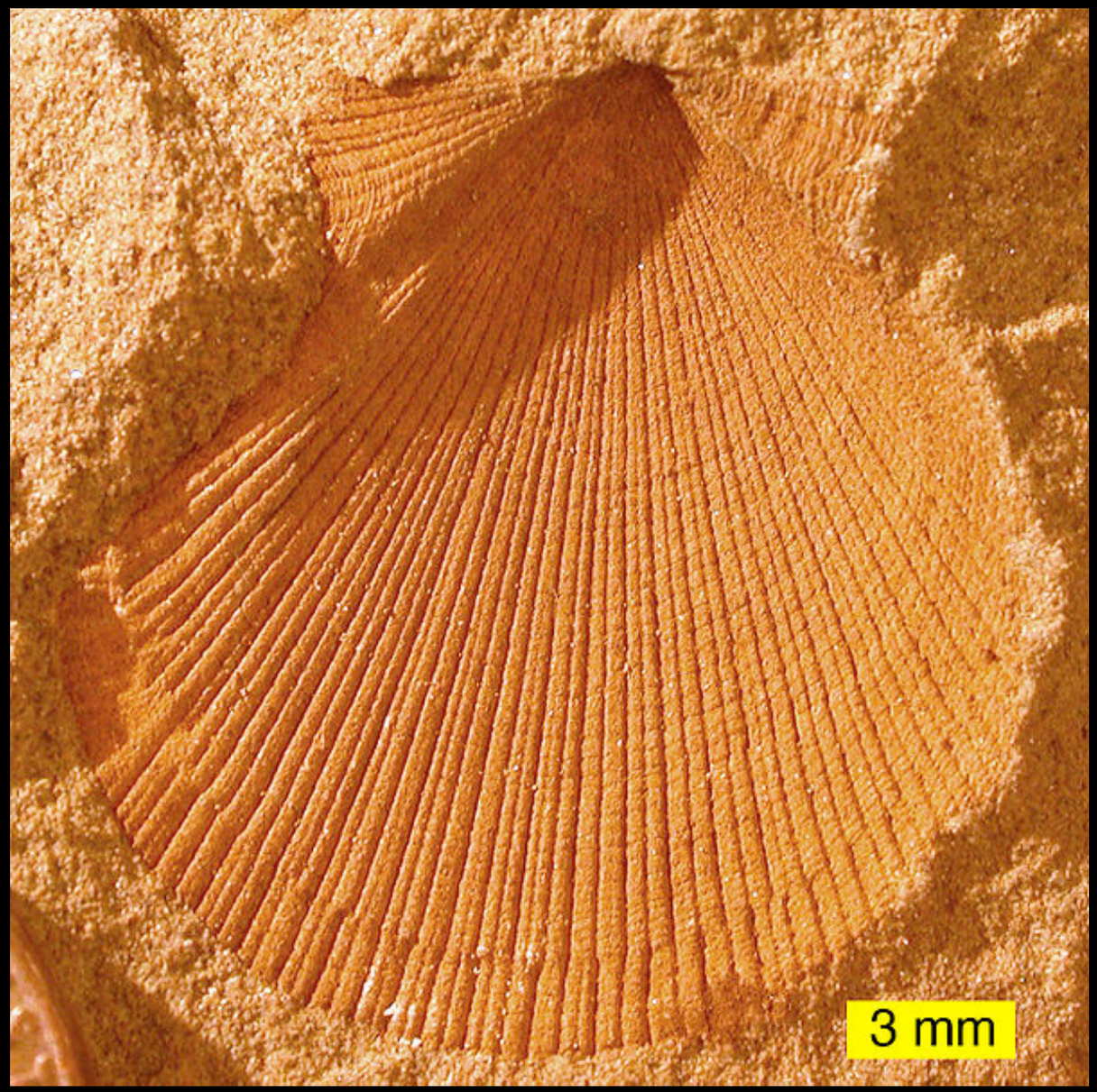
Pressure, heat force out gasses, liquids

Leaves behind a carbon film

!! Soft parts !!

Carbonization

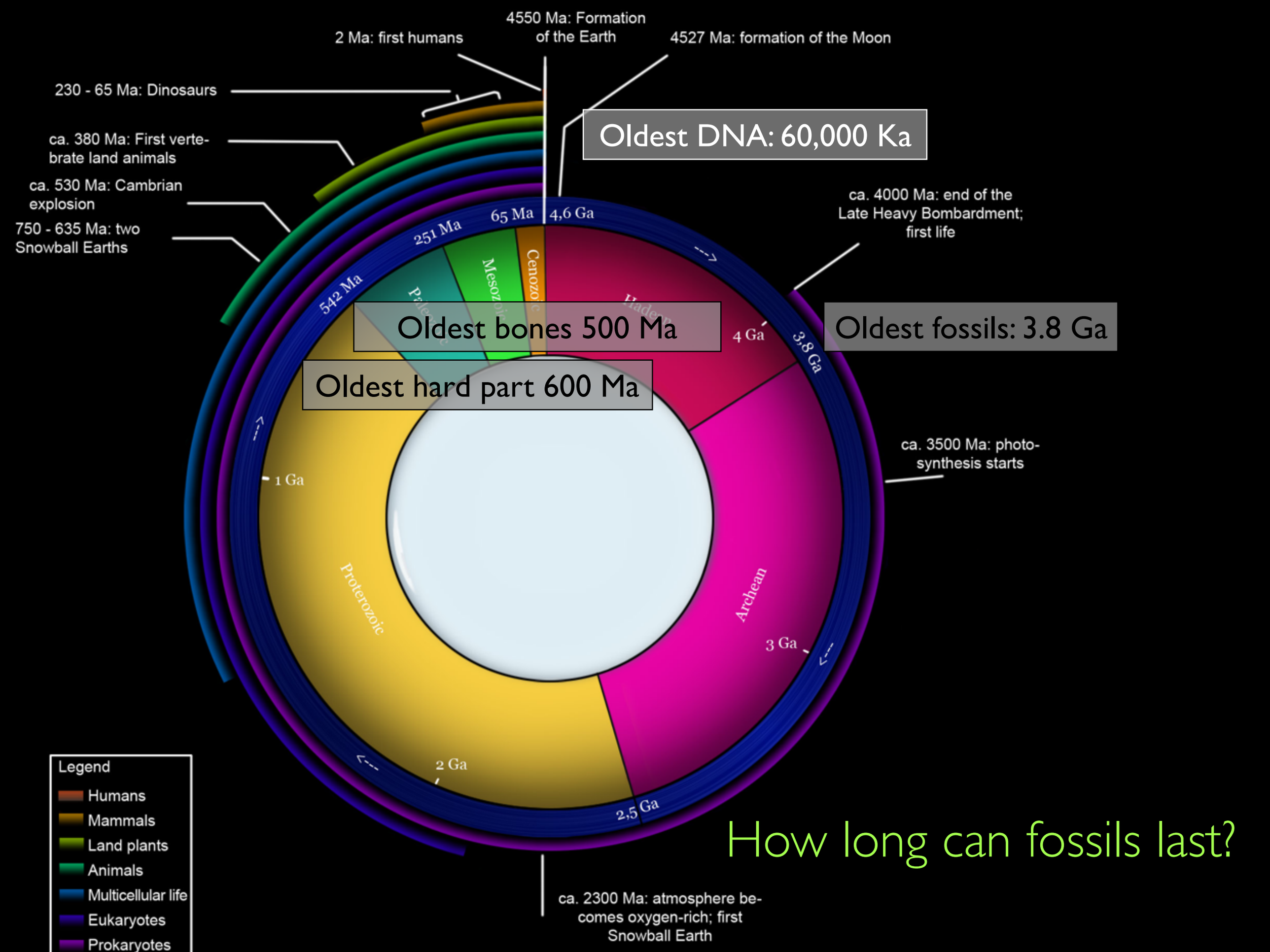
Routes to Fossilization



Molds, casts

- Molds
- Casts
- Little or no original material

T. rex brain cast



How long can fossils last?

Depositional Environments

& Taphonomy

Taphonomy: study of the transition from the biosphere to the lithosphere

Replacement and/or permineralization

Nearly complete specimen exposed

Quick burial

(a)

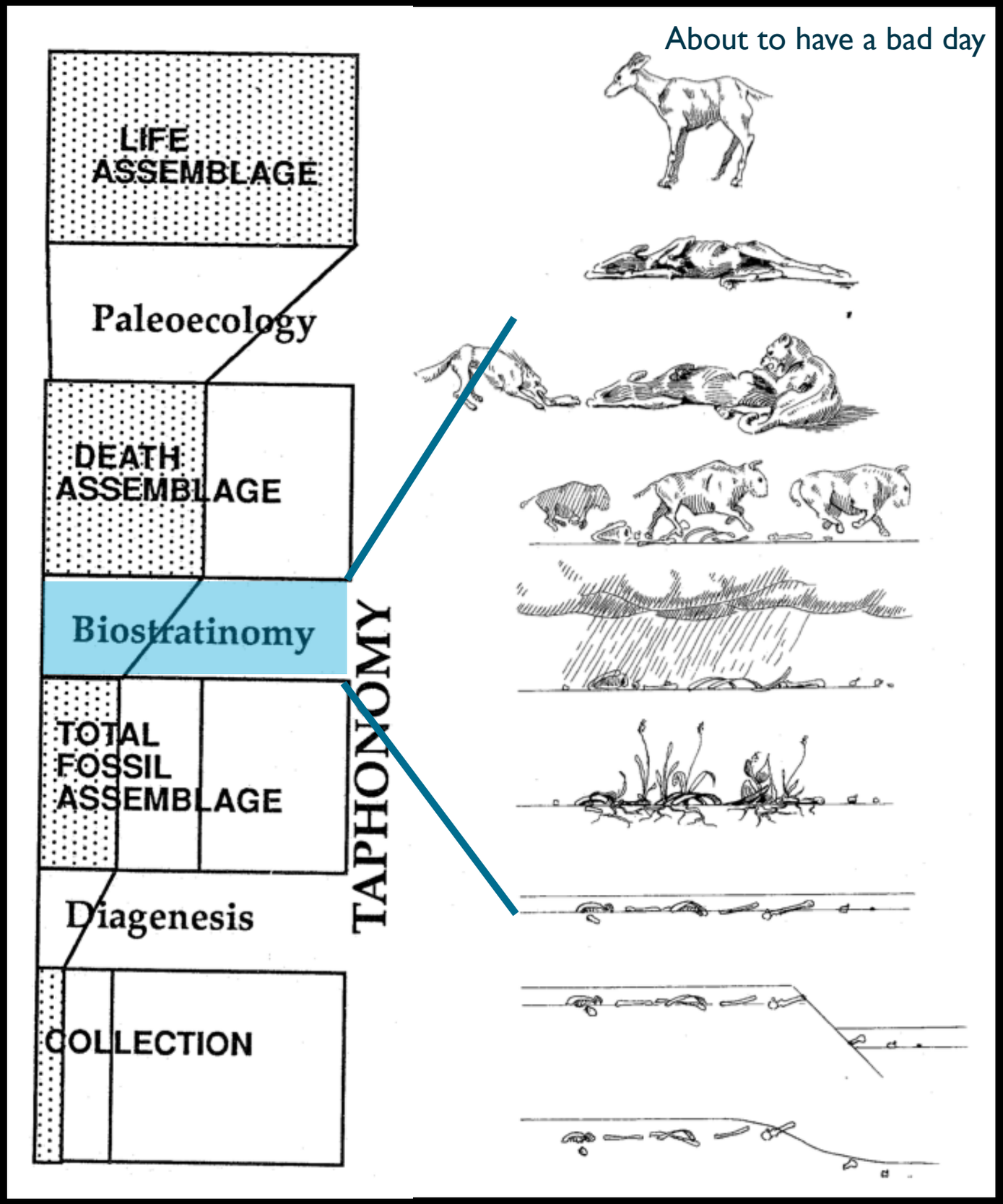
Dinosaur dies

(b)

Dismemberment before burial – scavenging and other natural processes

Isolated bones buried and mineralized

Isolated bones exposed



Key: Rapid Burial!

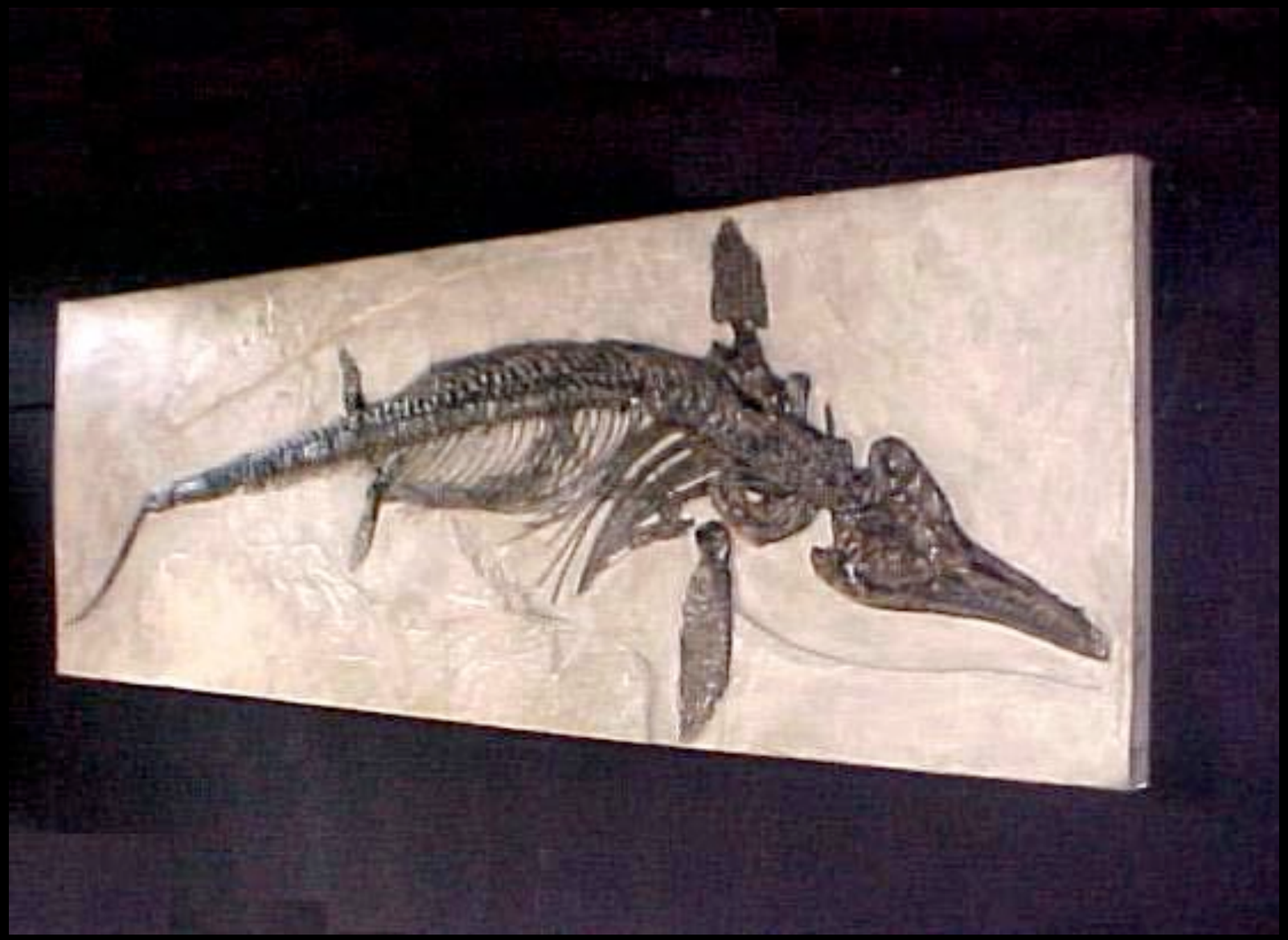
Remains preserved at the death site (autochthonous)

Remains transported (allochthonous)

Fluvial (Rivers)

Deserts
(rare)

Shallow Marine
(rare)

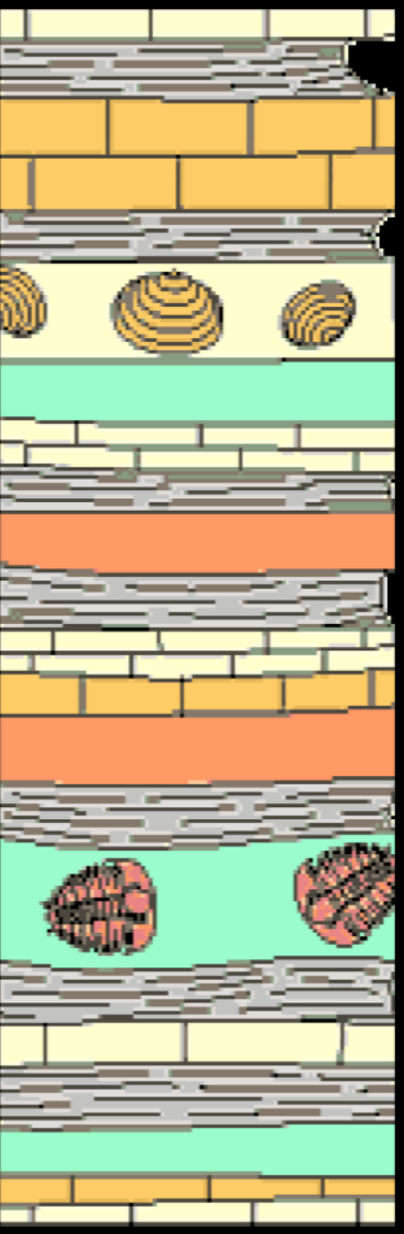


All dinosaurs lived on land. Why do we care about coastal fossil sites, etc.?

Placing fossils in TIME

Relative vs. Absolute Dating

YOUNGER



495 Ma

510 Ma

520 Ma

545 Ma

OLDER

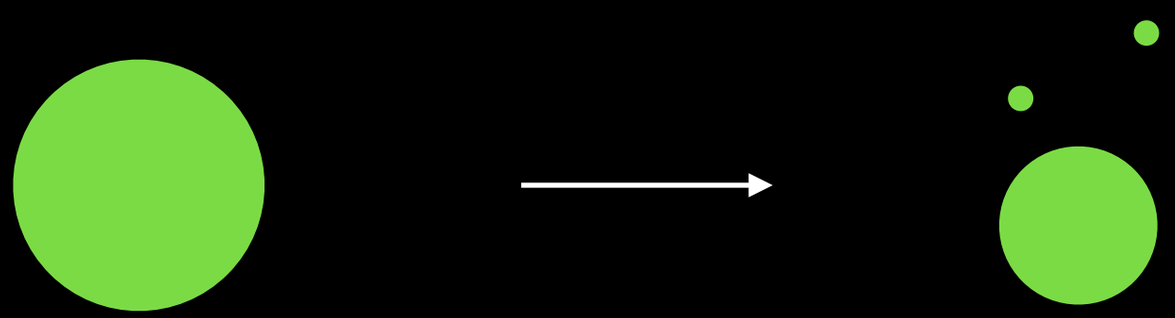
Absolute dates
Volcanic Ash

Relative ages

Issues:

- Last appearance
- Lazarus Taxa

Radiometric Dating
via radioactive (UNSTABLE) isotopes



If we know:
-Original amt of parent isotope
-How much of the parent isotope is left
-Rate of decay of that isotope

Then we can estimate:
Amount of elapsed time

Absolute dating!

Biostratigraphy

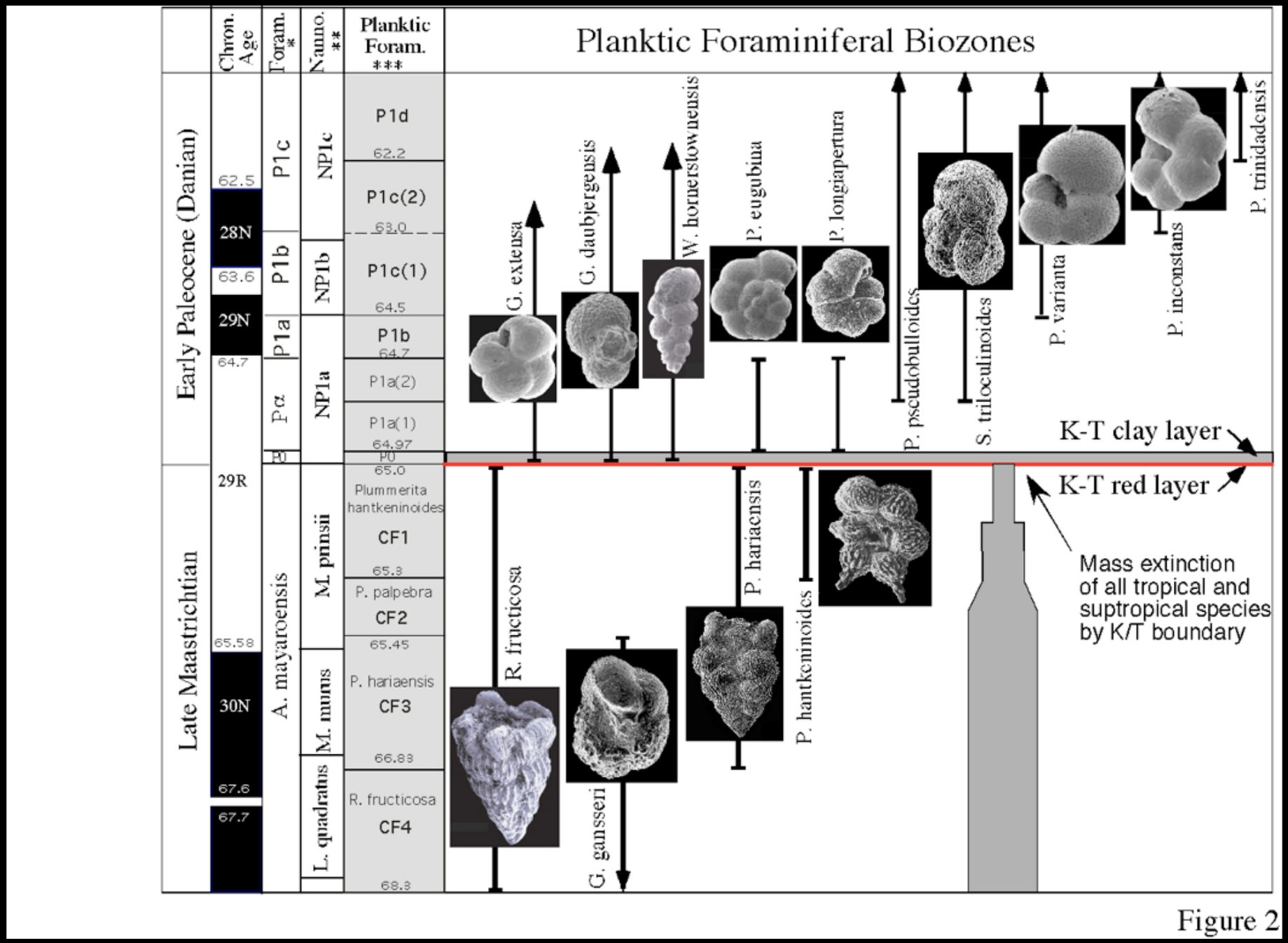


Figure 2

Relative Dating