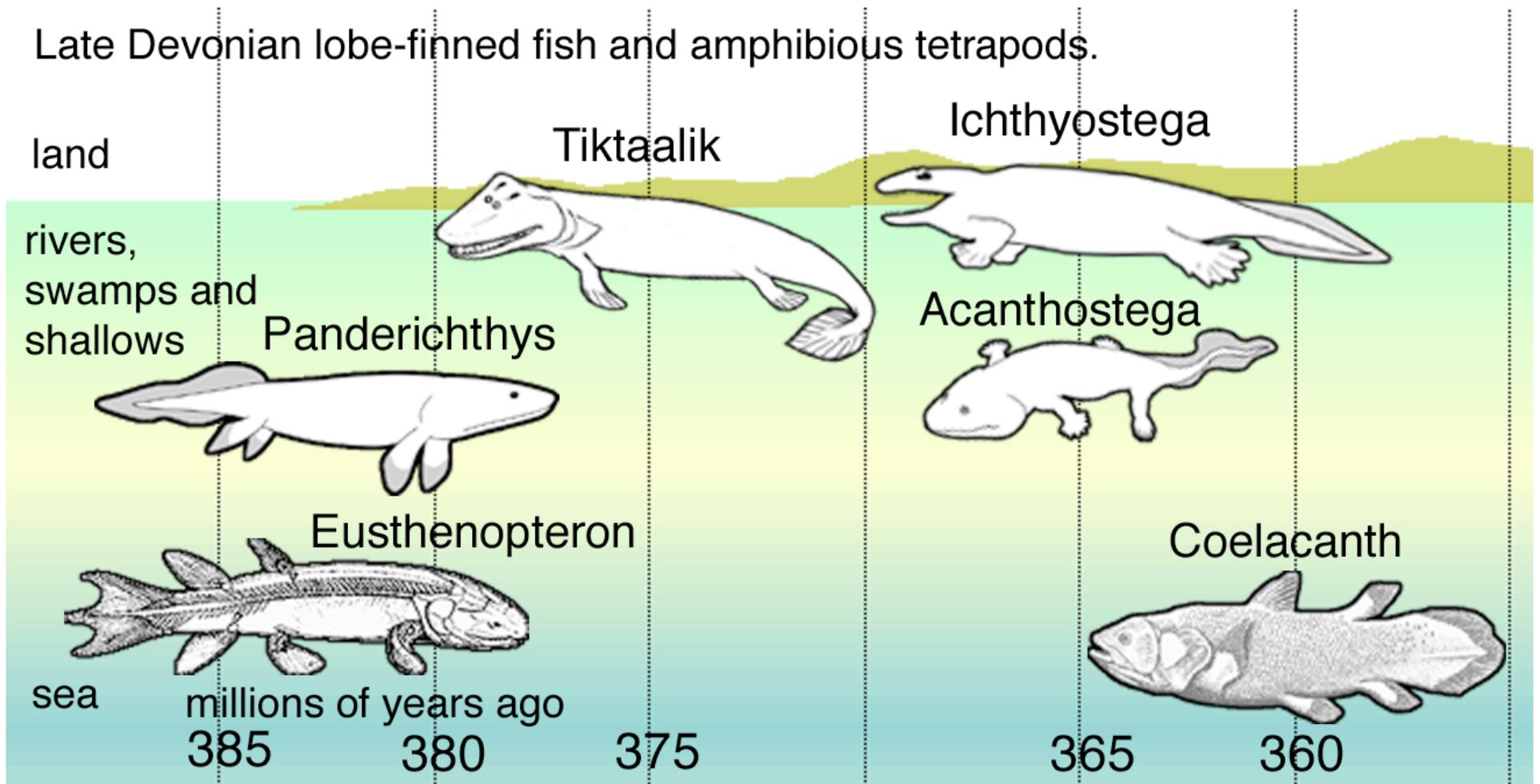
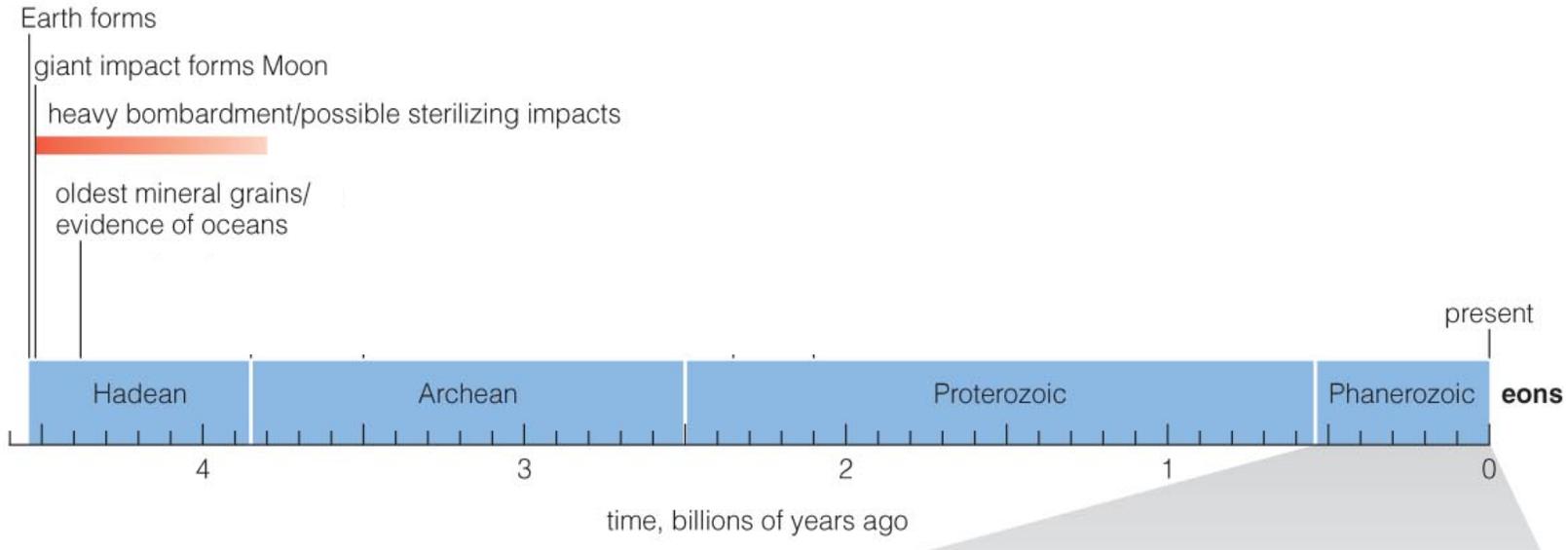


Evolution of Life on Earth



EVOLUTION OF LIFE ON EARTH



Earth ~4.5 billion years ago



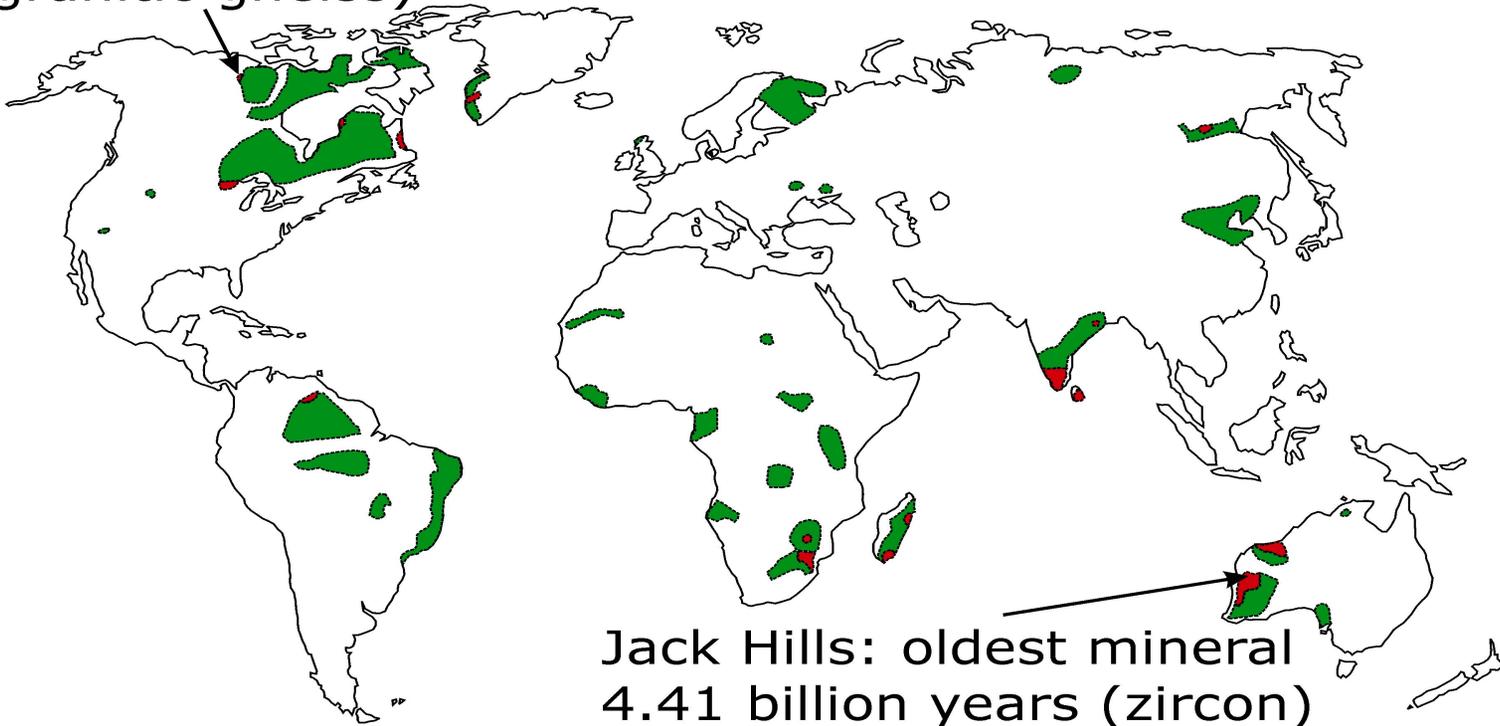
www.kindaroomy.com

© 2009 Christian Joore

A bad day

Old (Archean) Rocks

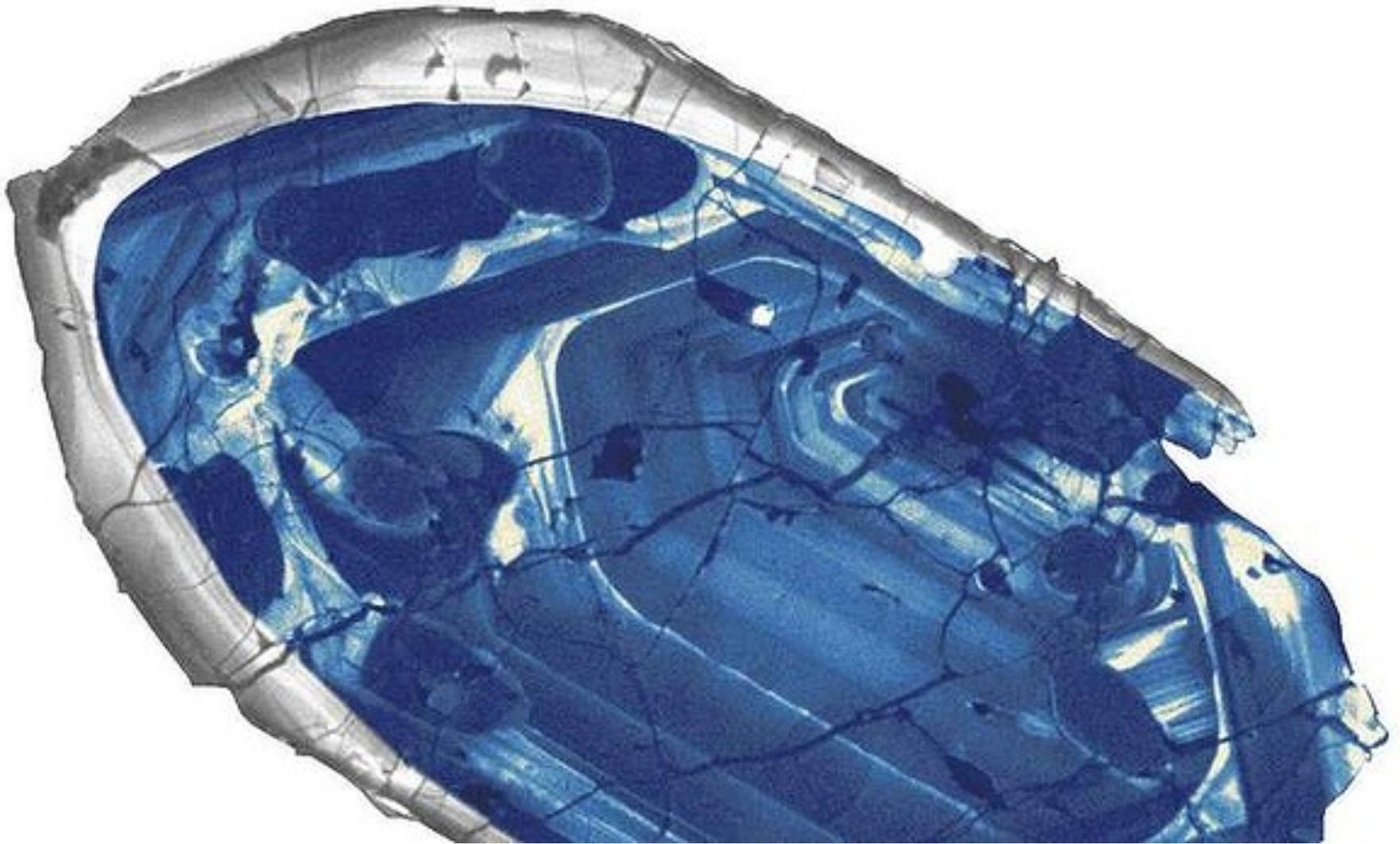
Acasta: oldest rock
4.02 billion years
(granitic gneiss)



 Early Archean rocks (>3.0 Ga)

 Late Archean rocks (2.5-3.0 Ga)

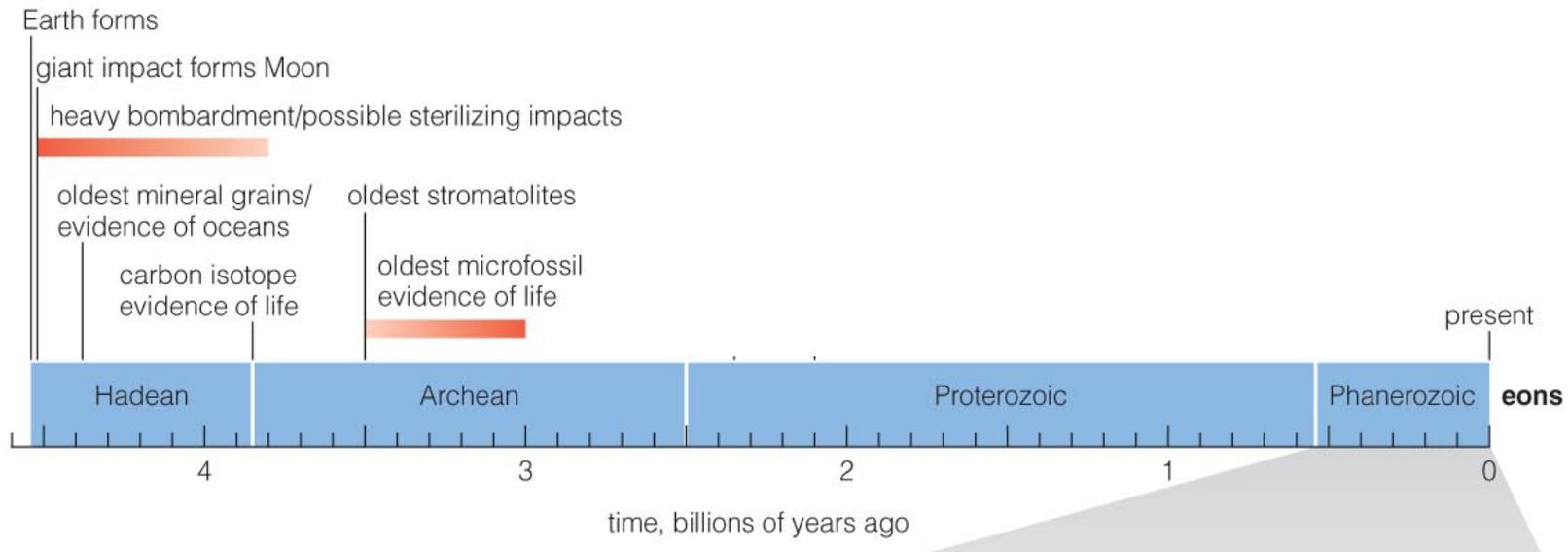
4.4 Billion year old Zircon



Earth was temperate and had water 4.4 billion years ago!

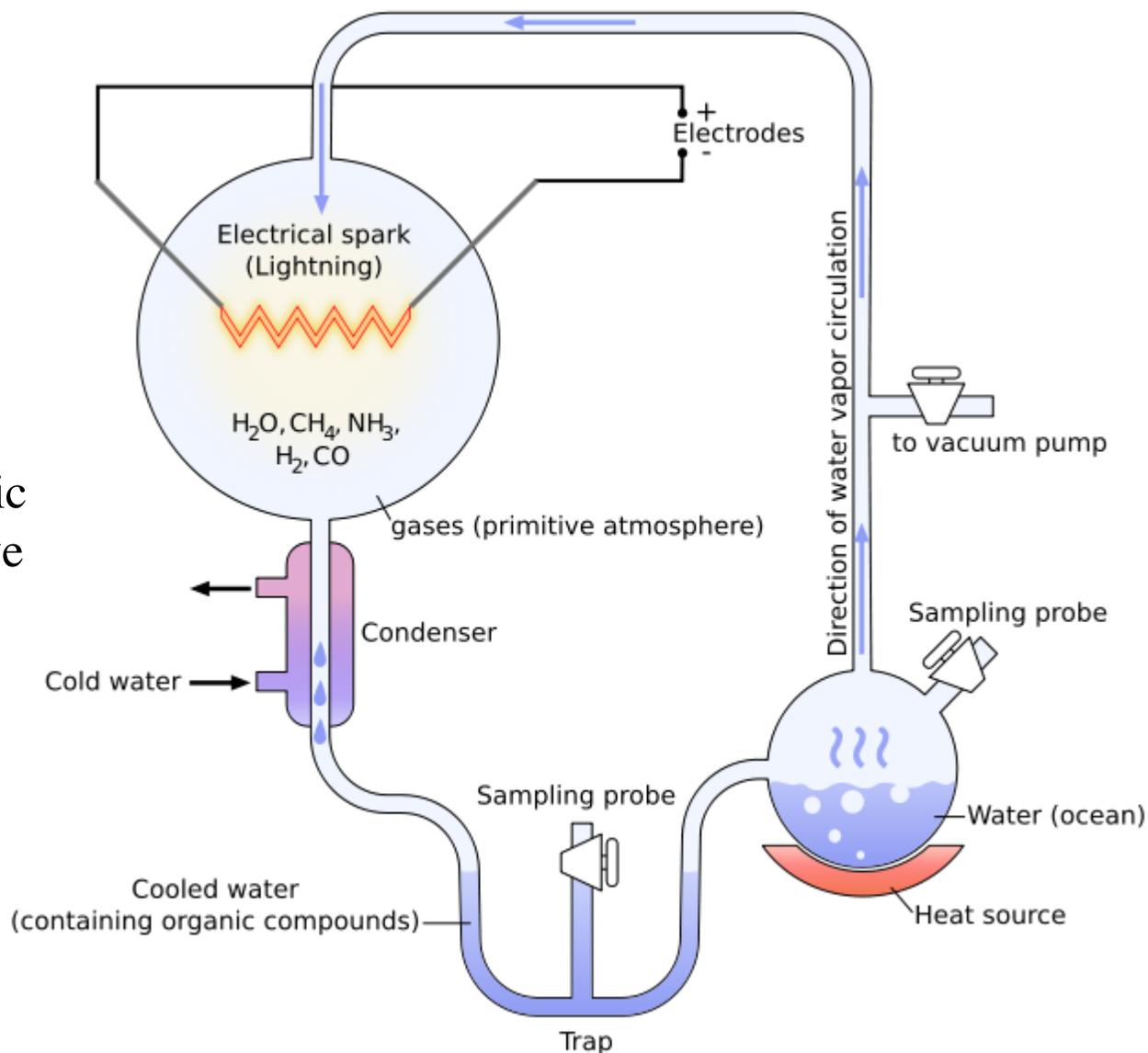


EVOLUTION OF LIFE ON EARTH



Making Organic Molecules : Miller & Urey

Famous 1953 experiment to test the hypothesis of Oparin and Haldane that organic compounds were synthesized from inorganic precursors on the primitive Earth. Energy input could have taken many forms.



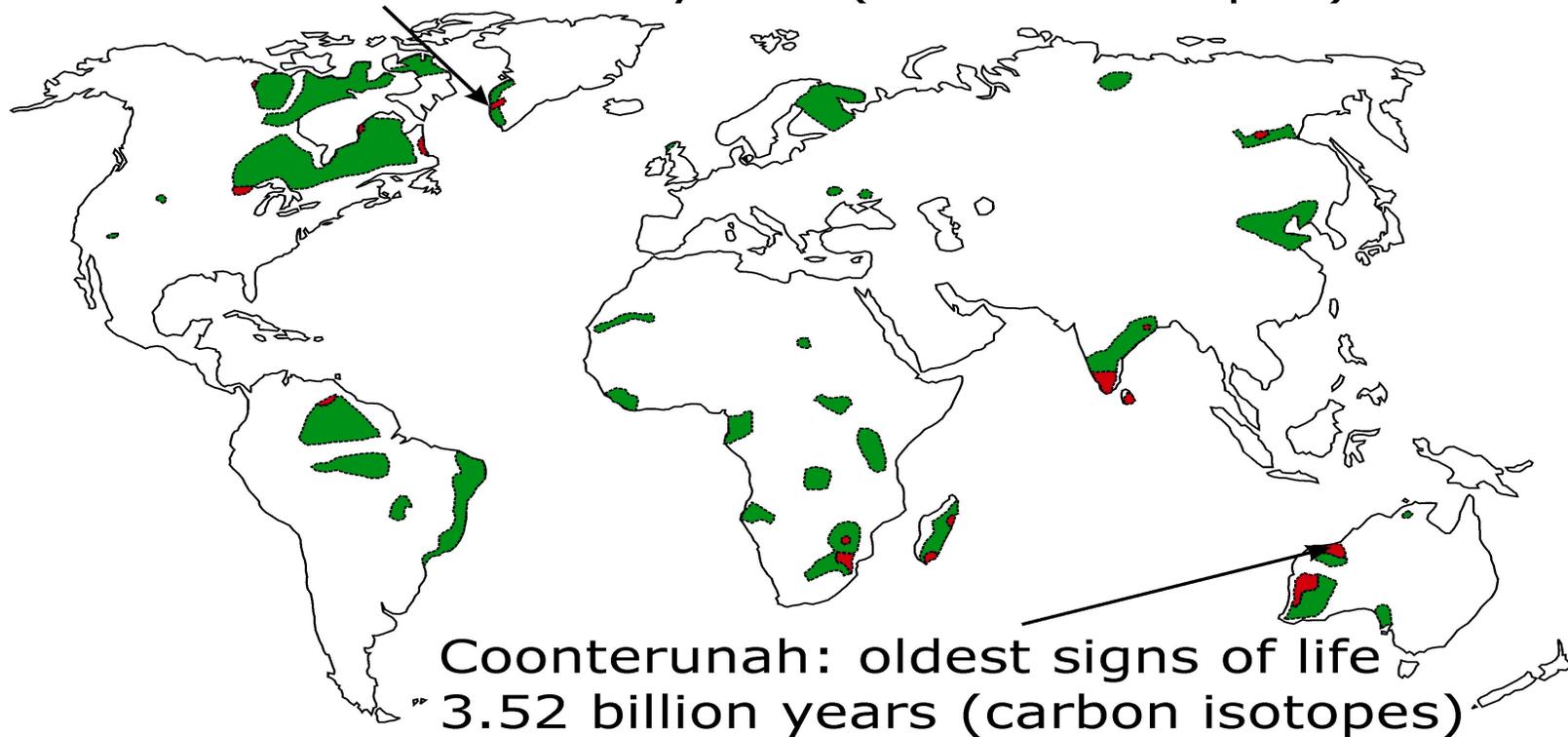
Types of evidence of early life

- **MICROFOSSILS:** preserved remains of microbial bodies
- **STROMATOLITES:** preserved remains of microbial activities
- **ISOTOPIC FRACTIONATIONS:** preserved remains of microbial metabolism
- **BIOMARKERS:** preserved remains of microbial molecules
- **BIOMINERALS:** preserved remains of microbial mineralization

Oldest Evidence of Life?

Akilia & Isua: oldest evidence of life?

~3.85-3.7 billion years (carbon isotopes)



 Early Archean rocks (>3.0 Ga)

 Late Archean rocks (2.5-3.0 Ga)

Stromatolites

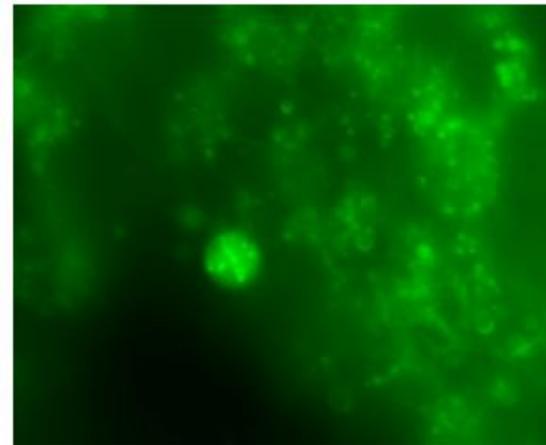
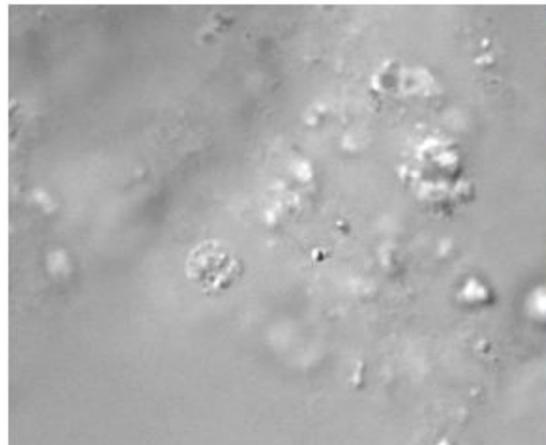


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Oldest life – 3.5 billion years ago – evidence from colonies of microbes. Stromatolites are successful forms of life whose descendants still inhabit Earth.

Clay stimulates vesicle formation becomes trapped inside

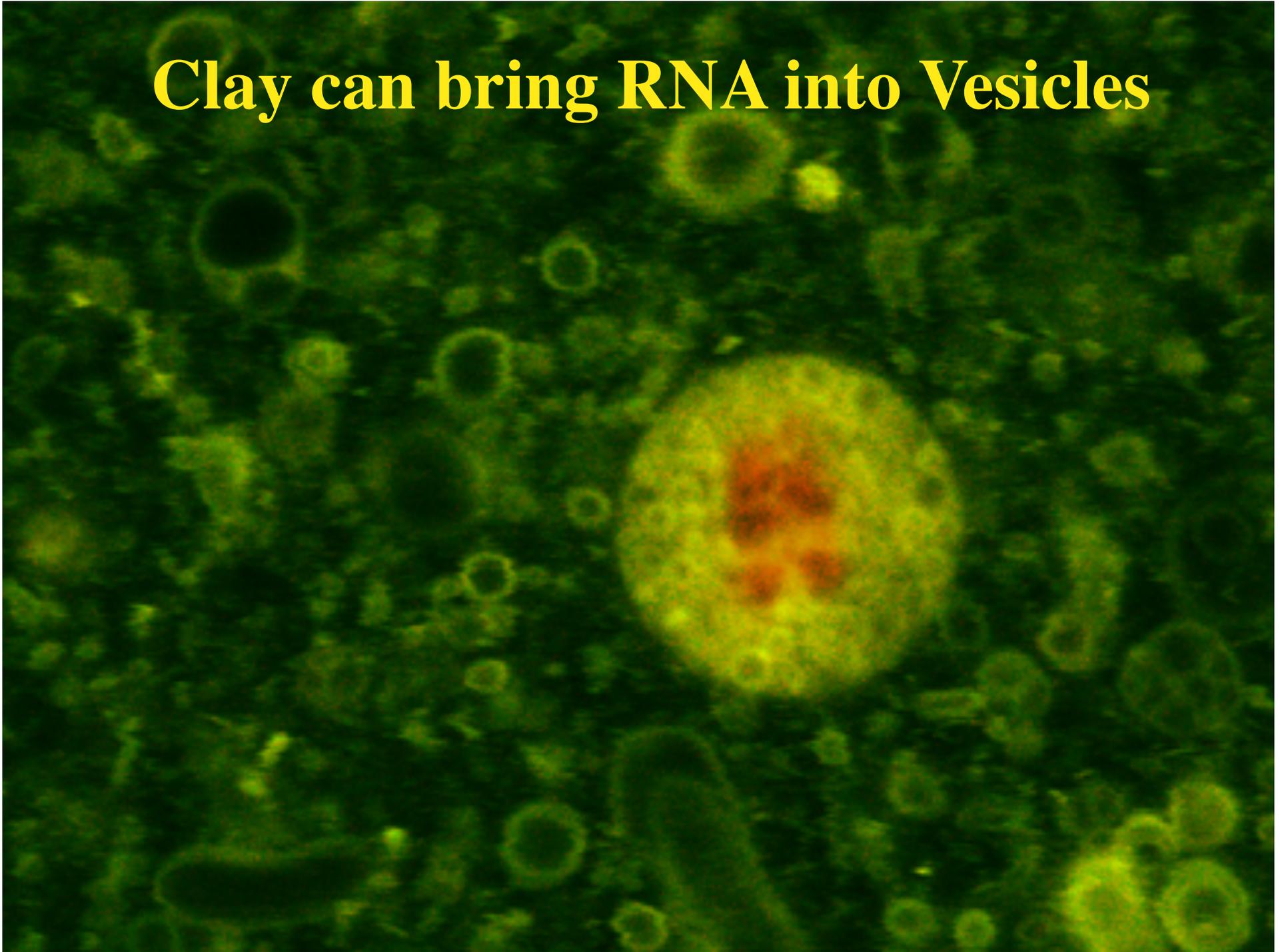
Clay:Nomarski
Optics



Vesicles;
Fluorescence
Filter



Clay can bring RNA into Vesicles



This Research Shows That:

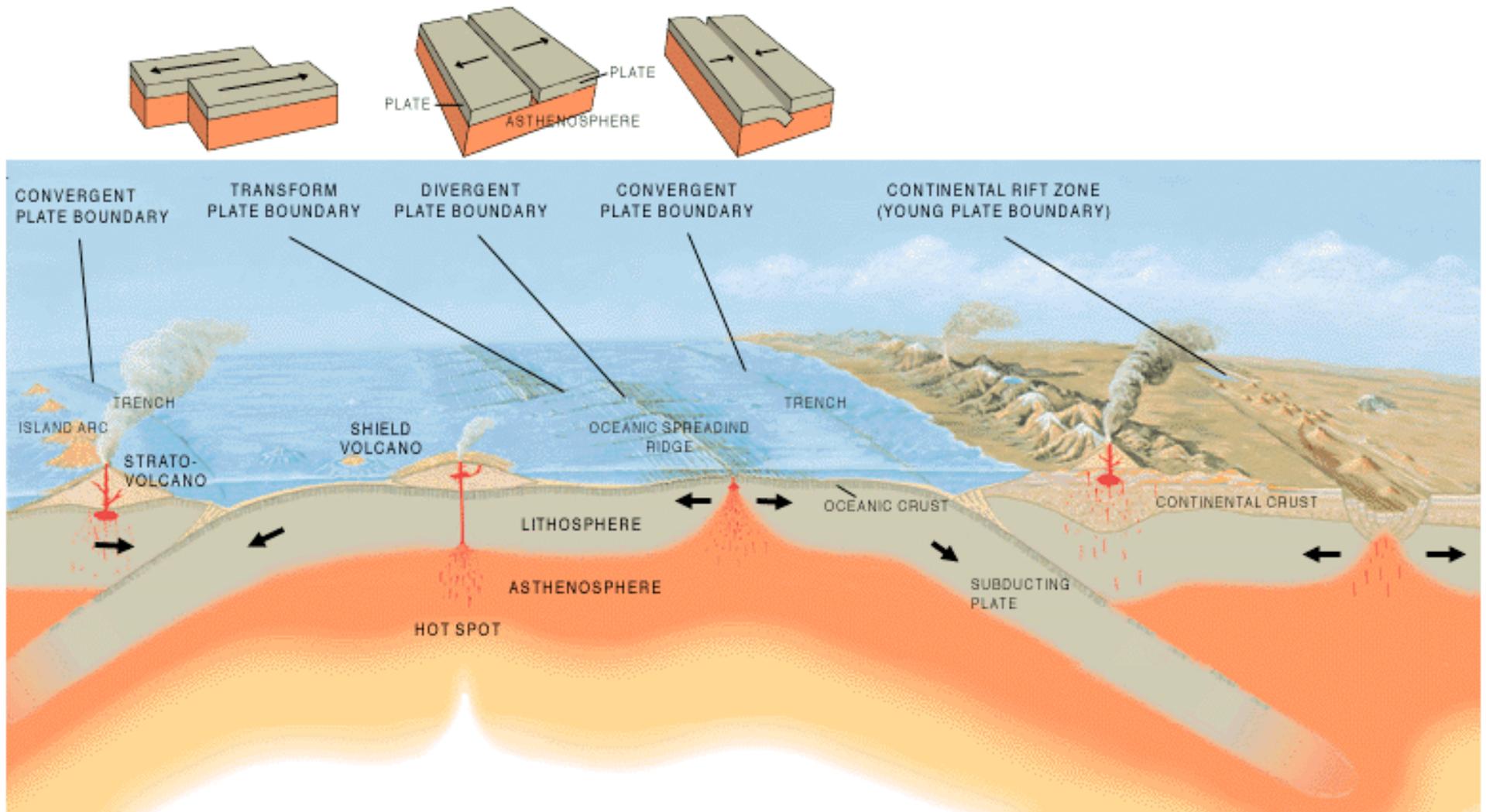
**Complex molecules (RNA fragments)
form naturally or on clay substrates**

**Vesicles (simple cell containers) form
readily and concentrate bio-polymers**

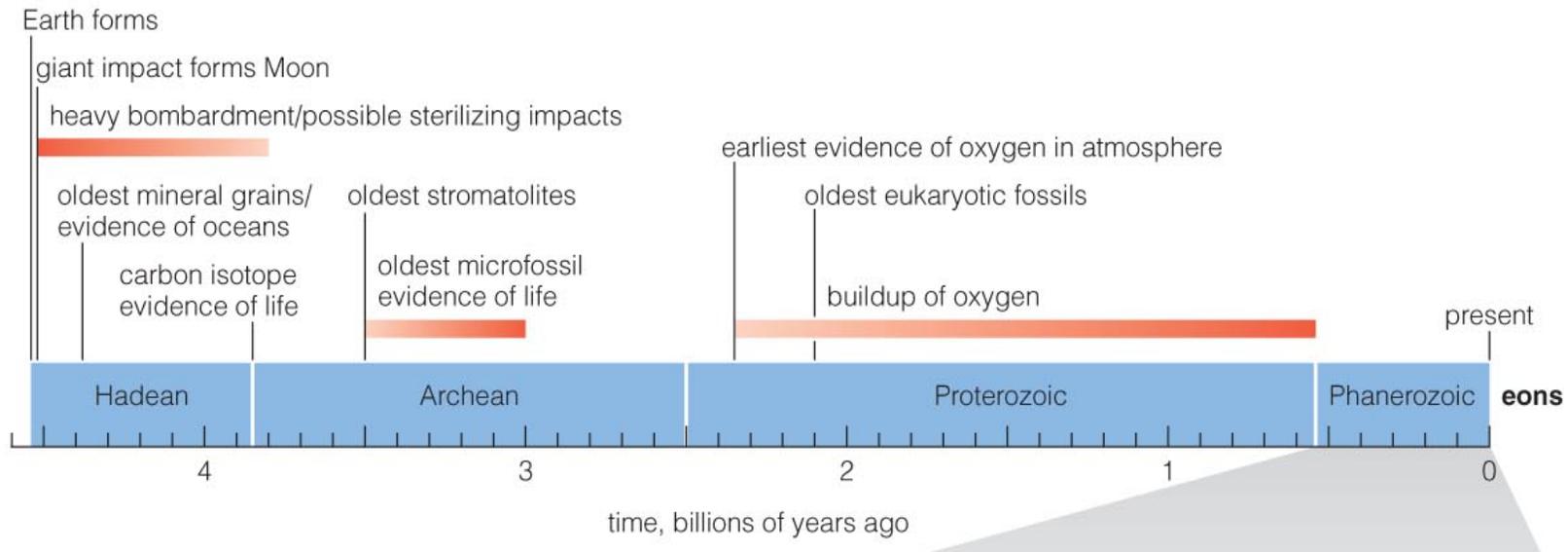
**Chemical natural selection will act to
to increase biochemical complexity**

Plate Tectonics

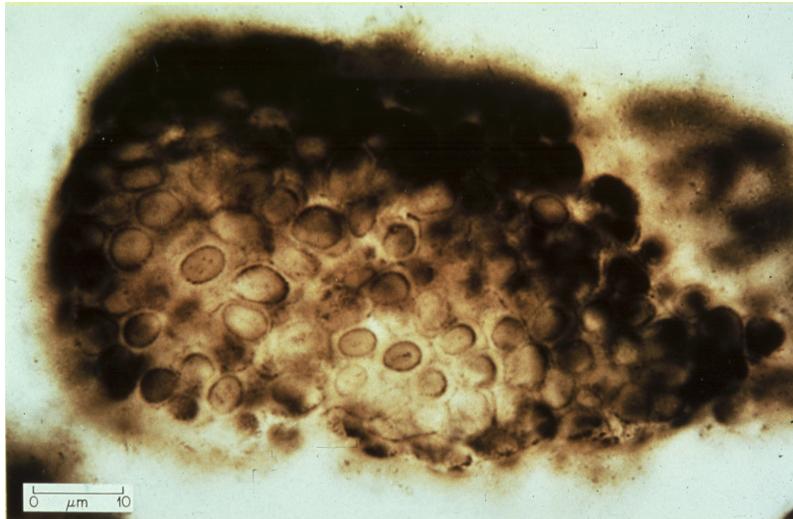
- Likely operating for last ~3.2 billion years



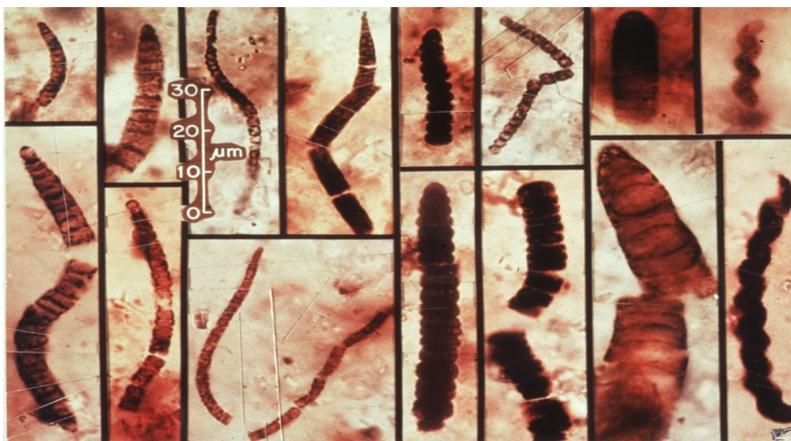
EVOLUTION OF LIFE ON EARTH



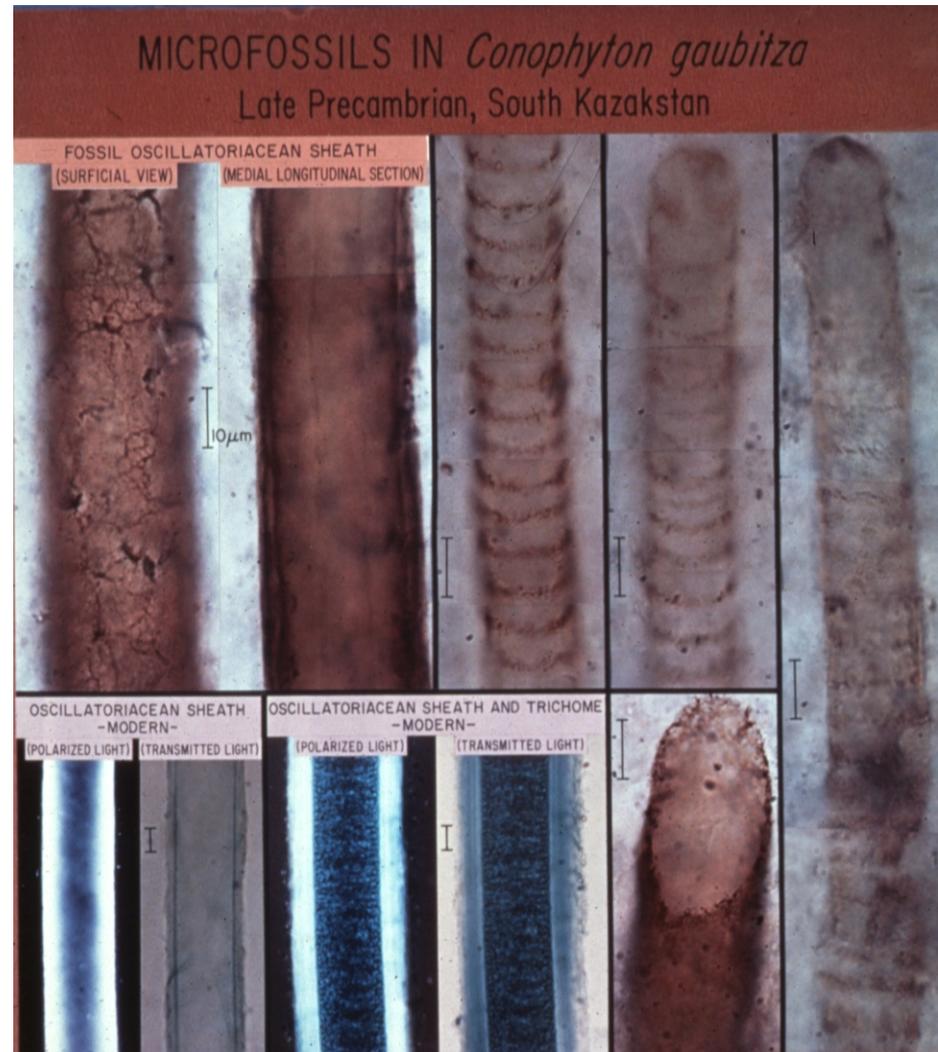
Cyanobacterial microfossils

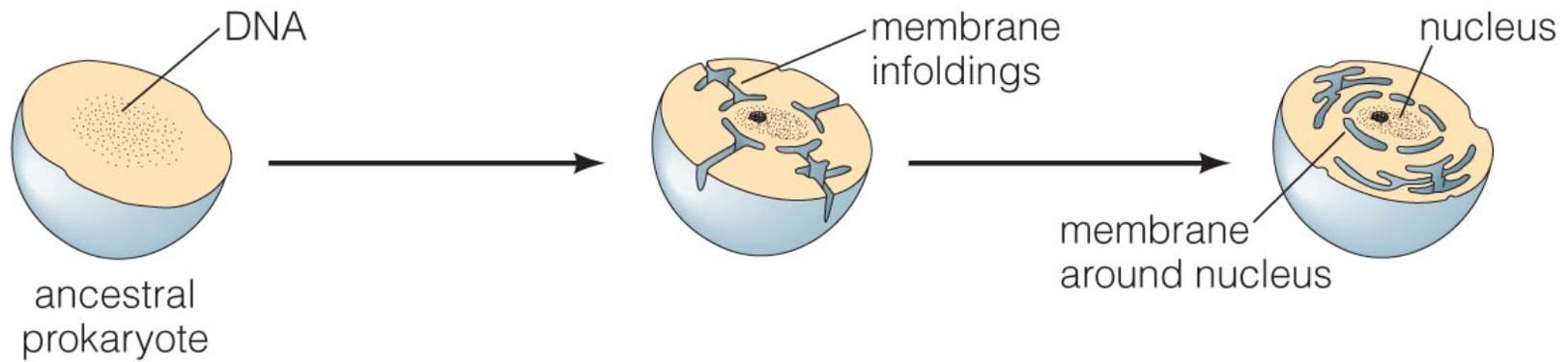


Eoentophysalis -- N.W.T., CANADA -- 2.0 Ga

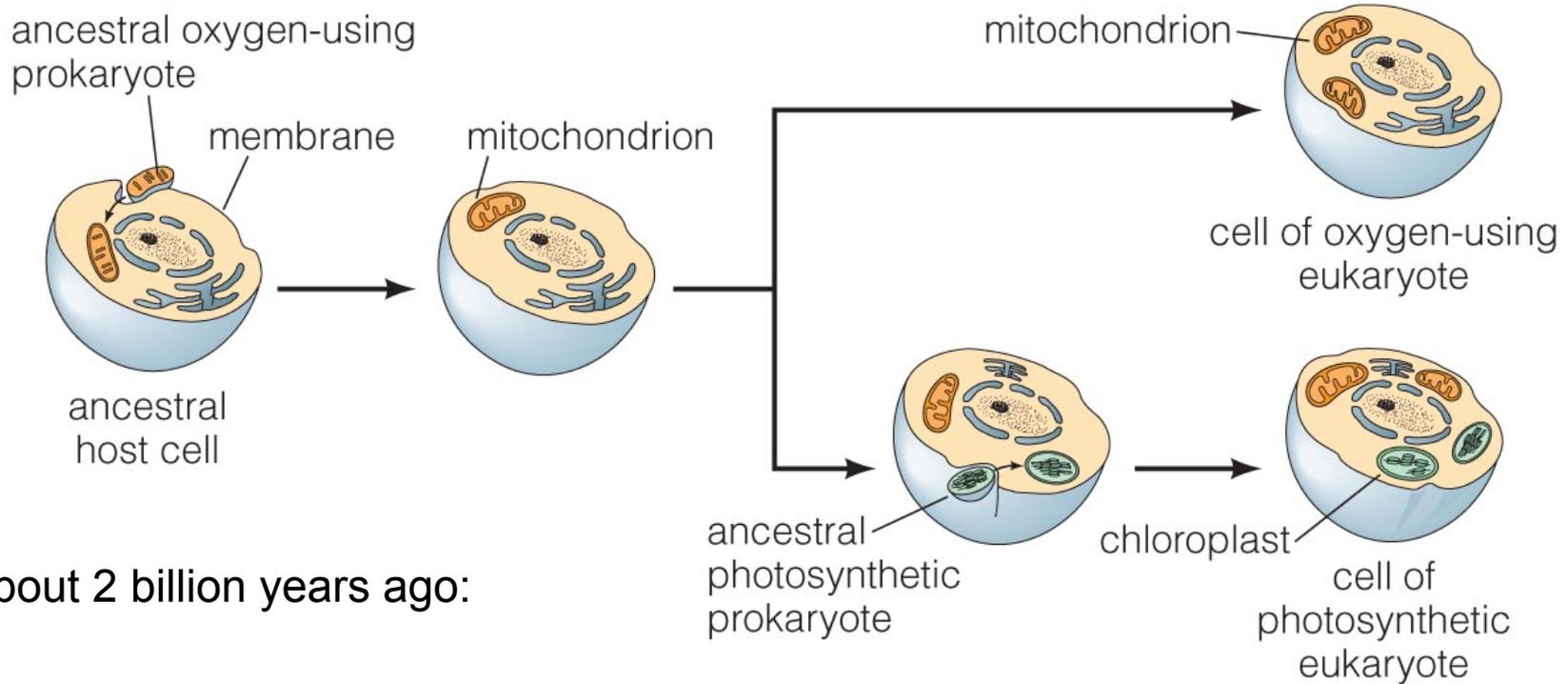


BITTER SPRINGS FORMATION -- CENTRAL AUSTRALIA -- 850 Ma



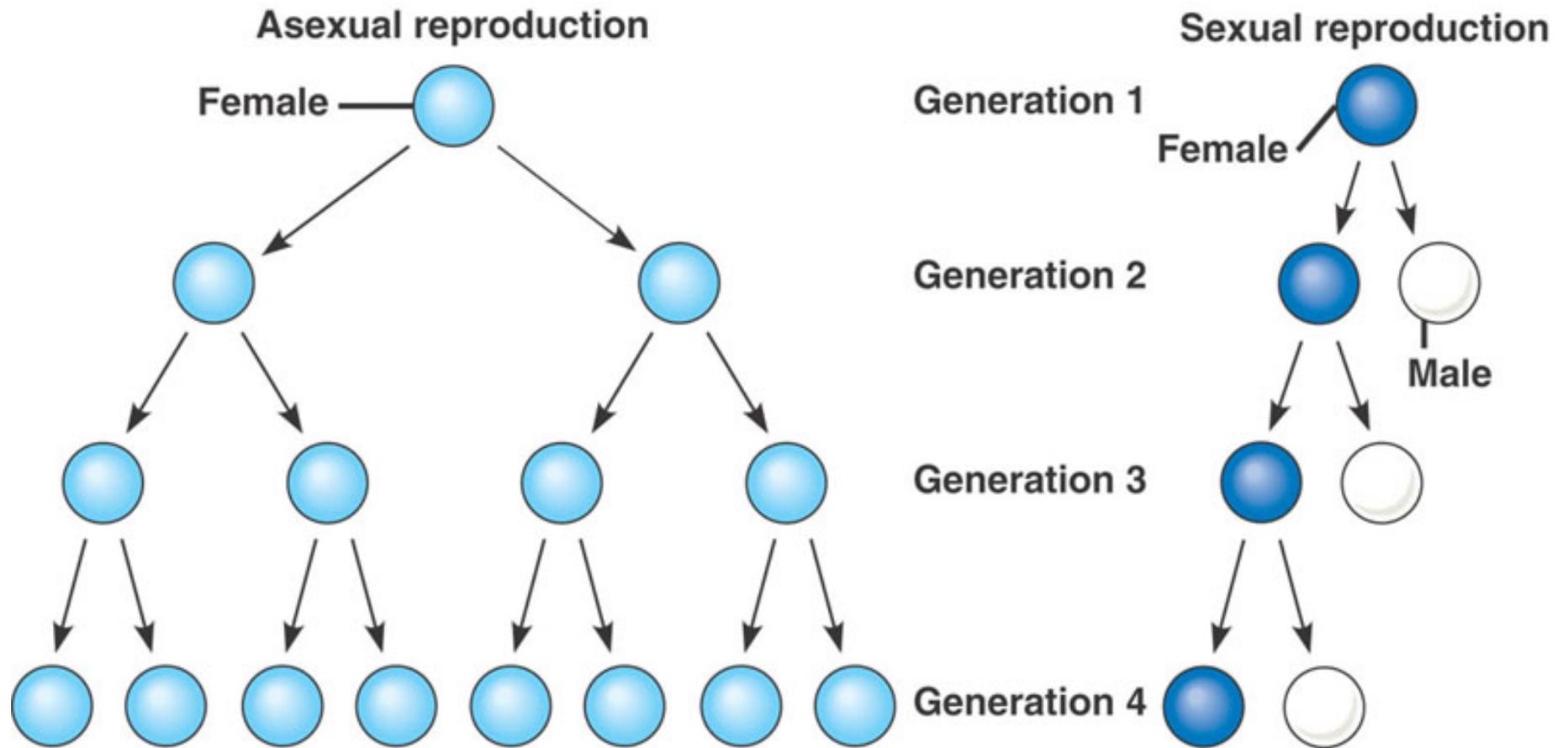


a Some large prokaryotes may have developed specialized membrane infoldings that compartmentalized certain cell functions, ultimately leading to the creation of a cell nucleus.



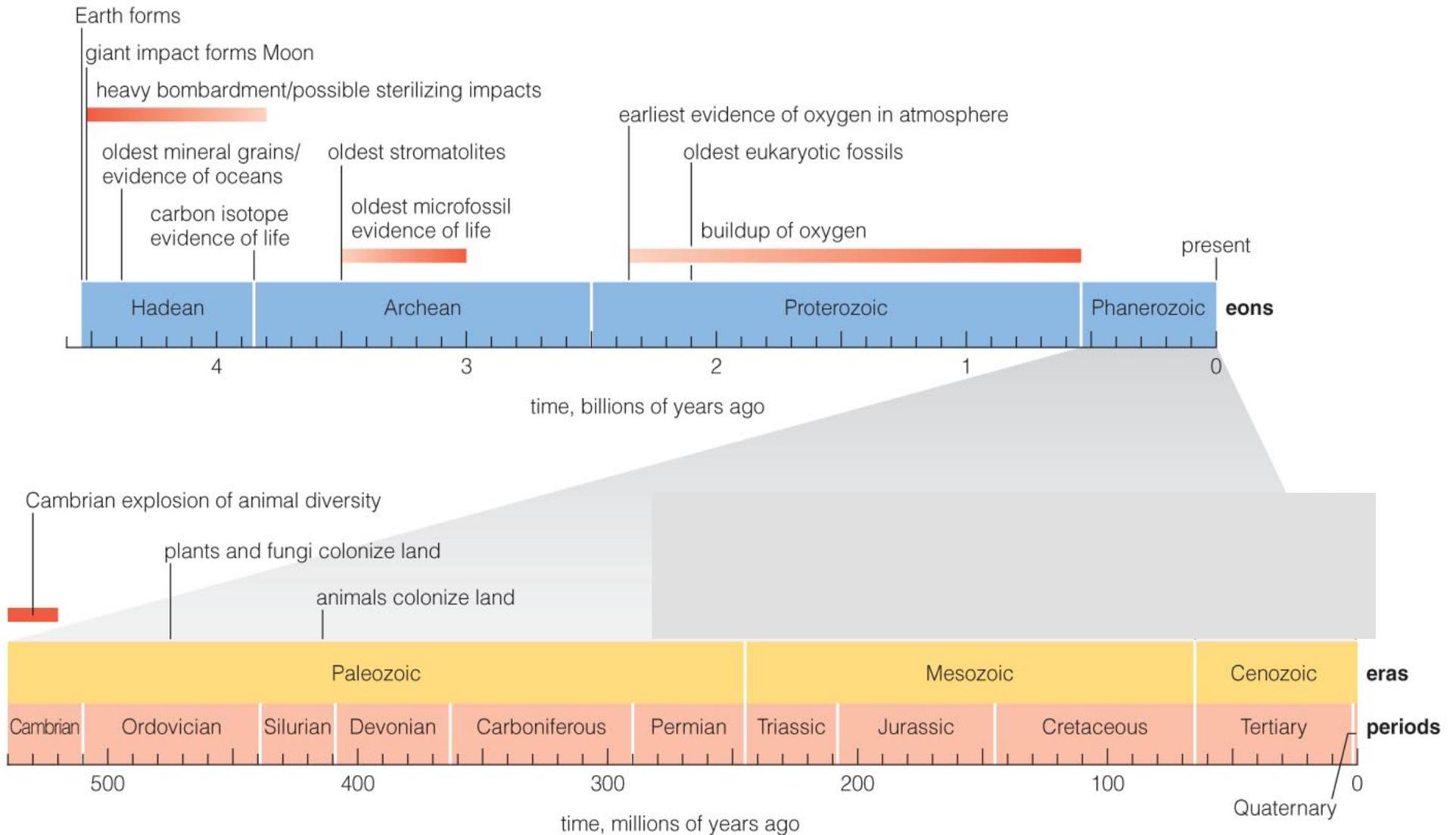
About 2 billion years ago:

b Mitochondria and chloroplasts may have evolved as small prokaryotes invaded a larger host cell, forming a symbiotic relationship.



The invention of sexual reproduction 1.2 billion years ago – apart from being a generally good thing – acts to accelerate evolution by mixing genetic material.

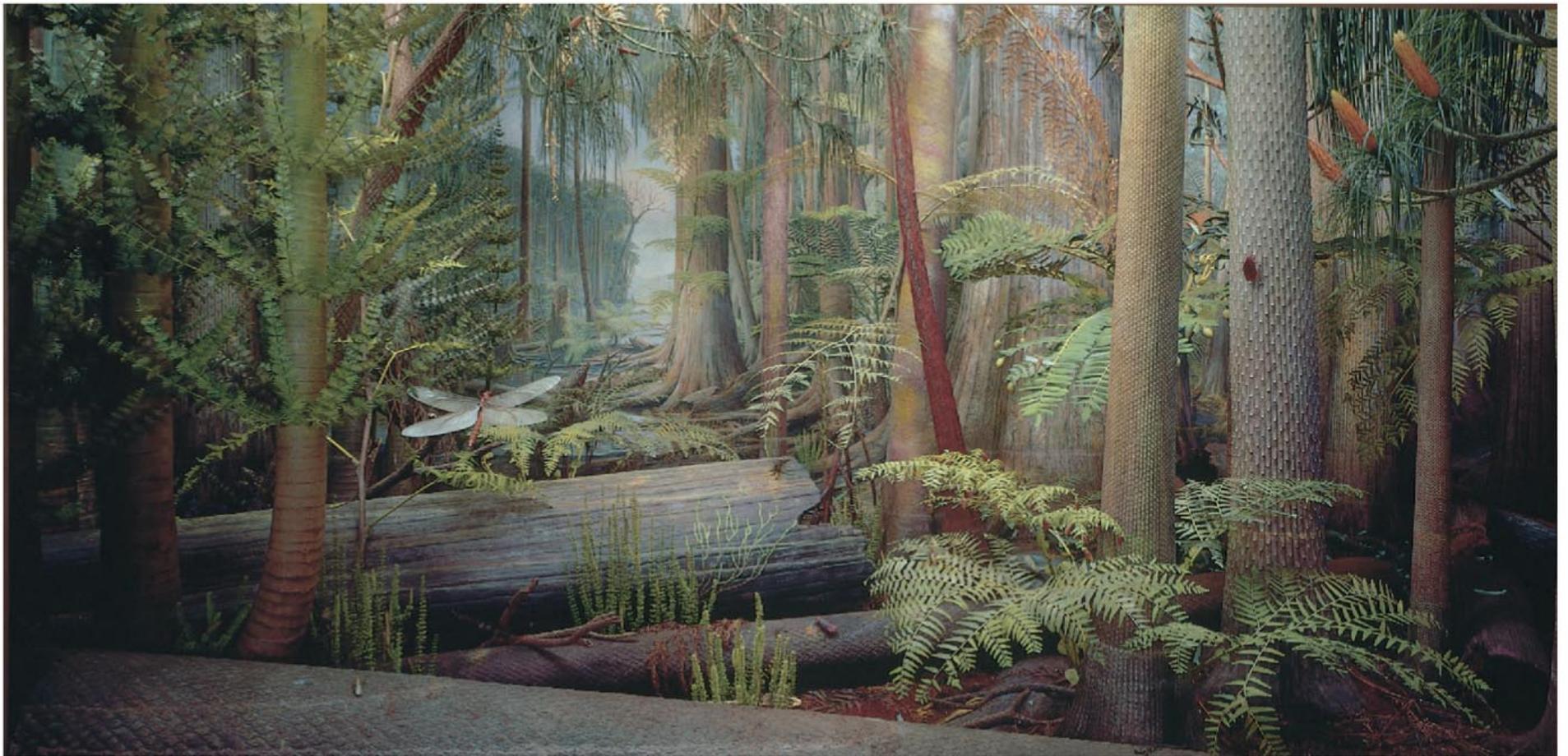
EVOLUTION OF LIFE ON EARTH



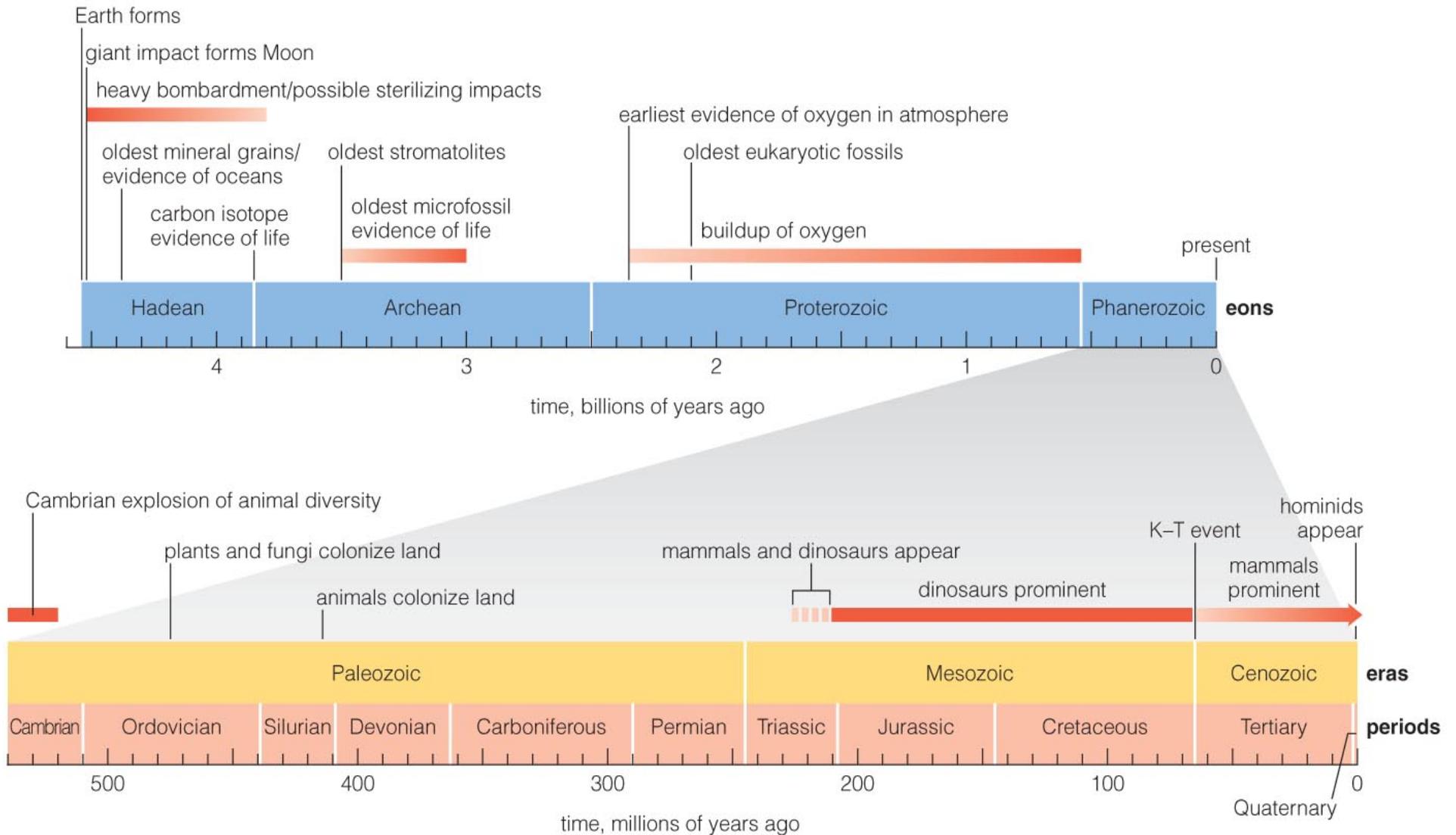


After 3 billion years of no lifeform larger than the head of a pin, there is an explosion of diversity in the oceans 550 My ago – the Cambrian explosion.

Life moves onto the land 400 My ago and adapts to a much wider range of ecological niches. Evolution of plants raises the oxygen content of the atmosphere.



EVOLUTION OF LIFE ON EARTH





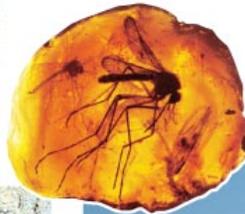
a A dinosaur bone preserved in sandstone in Dinosaur National Monument, which straddles Utah and Colorado.



d This 40-million-year-old leaf still retains organic material, including DNA.



b A 190-million-year-old petrified (stone) tree in Arizona.



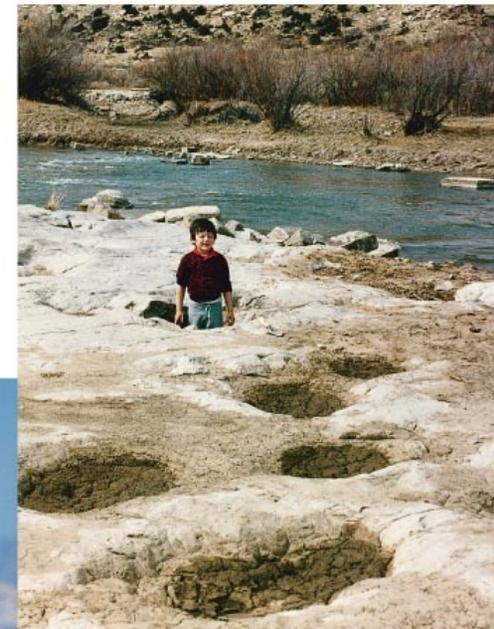
e An insect preserved in hardened tree resin (often called *amber*).



f These tusks belong to a whole 23,000-year-old mammoth discovered in Siberian ice in 1999.



c These 375-million-year-old impressions are casts of dead organisms (called ammonites) made when minerals filled the empty space left after the organism decayed.



g This boy is standing in a 150-million-year-old dinosaur track in Colorado.

Plate Tectonics

Late Cambrian 514 Ma

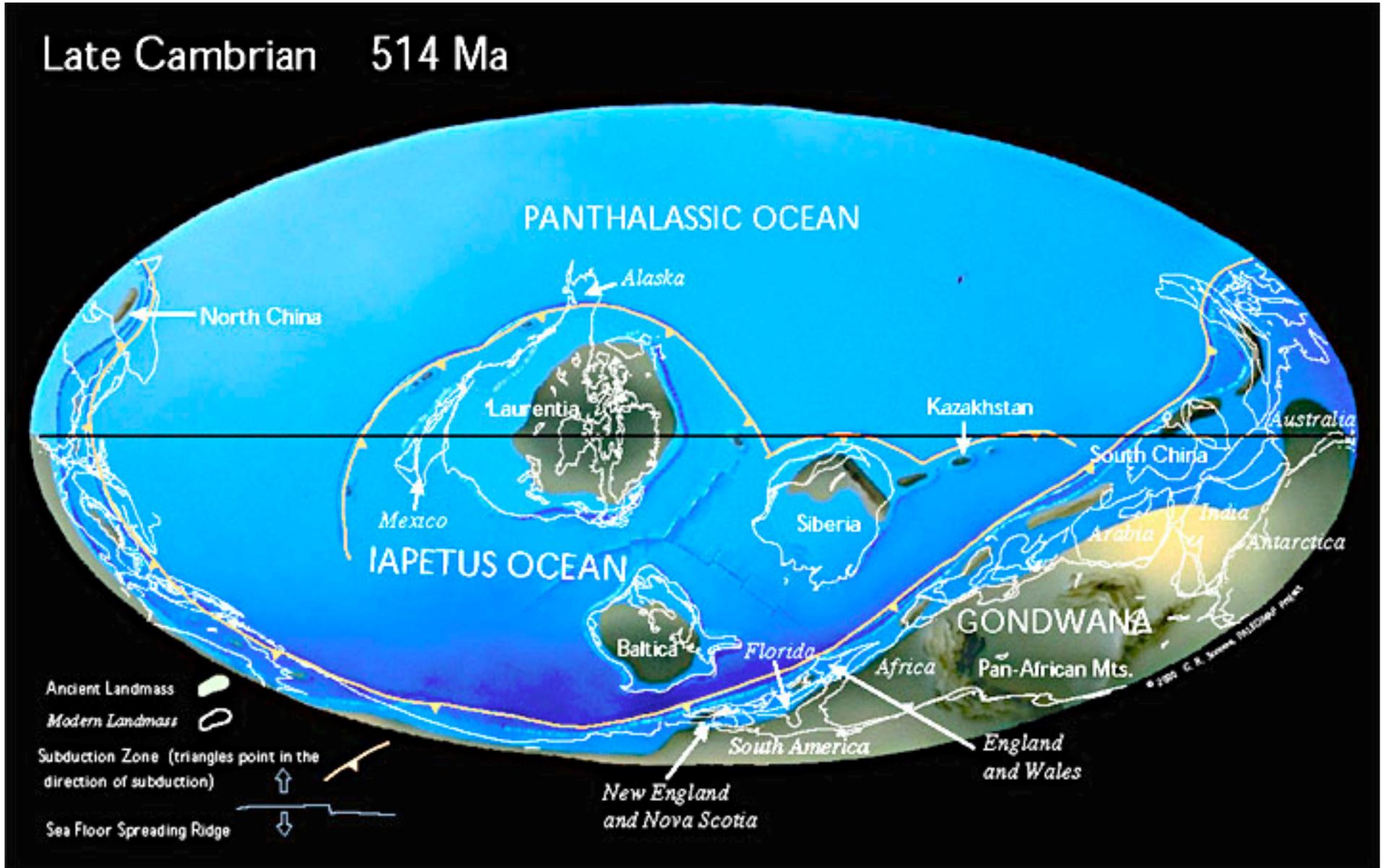


Plate Tectonics

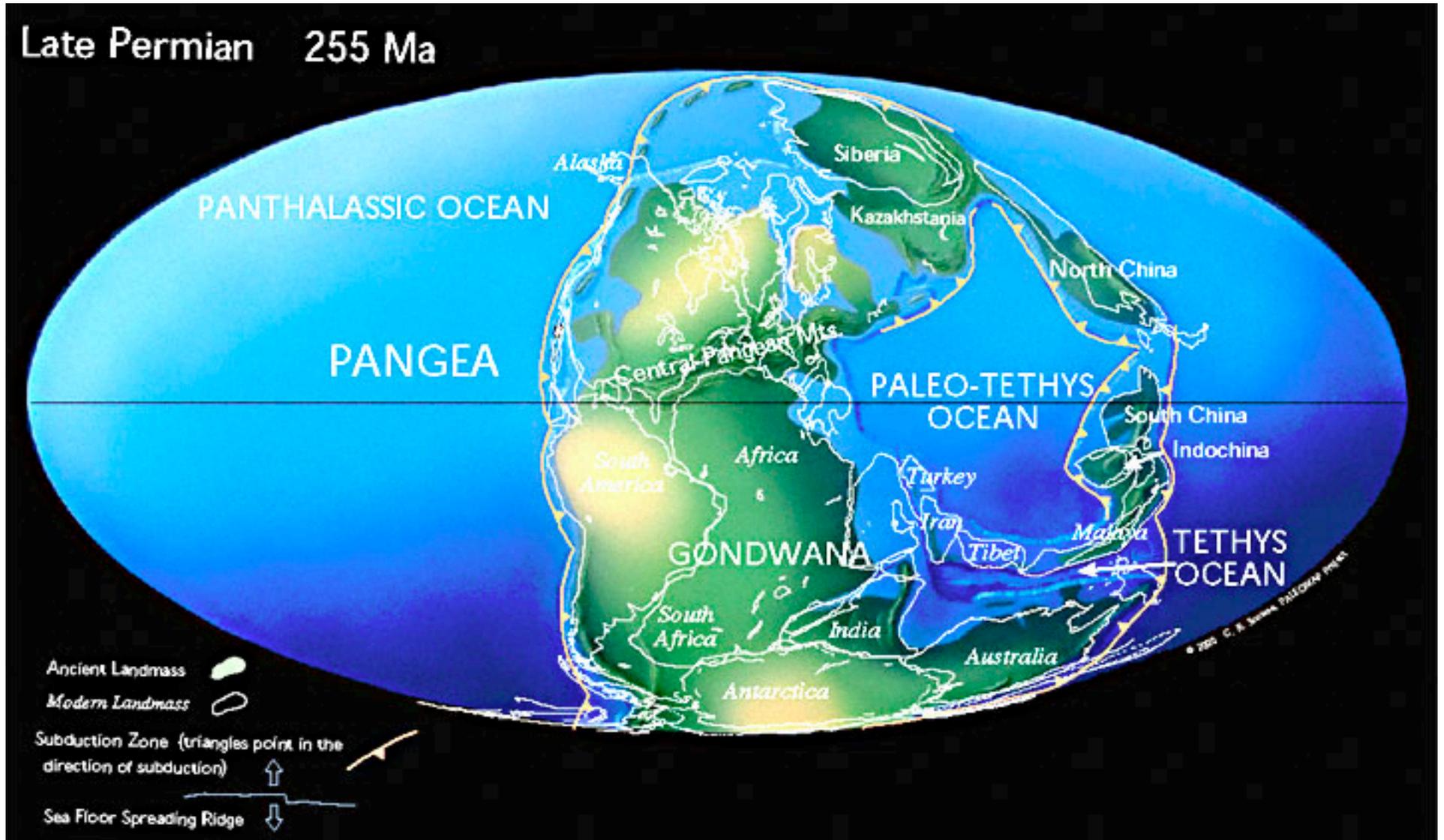


Plate Tectonics

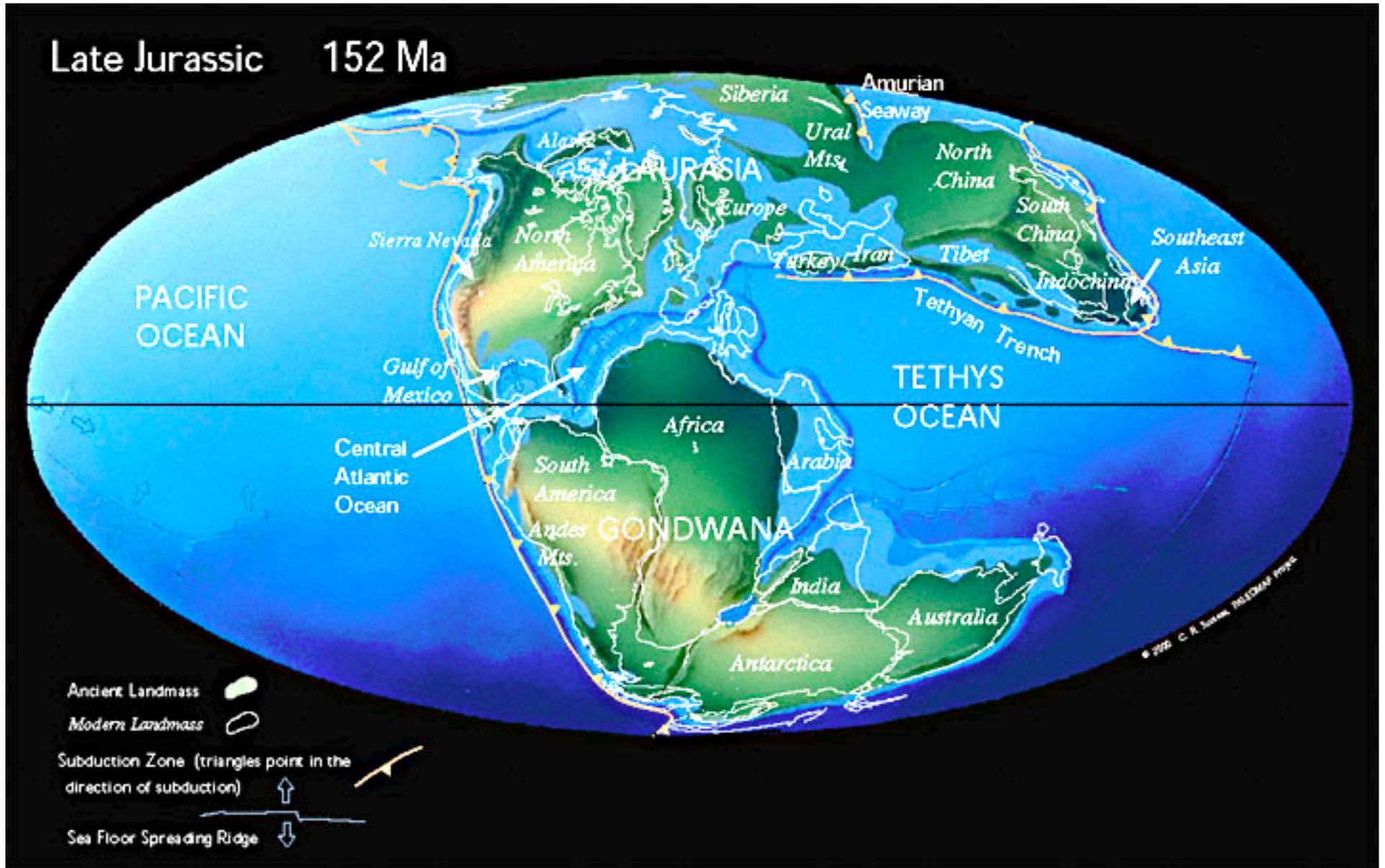


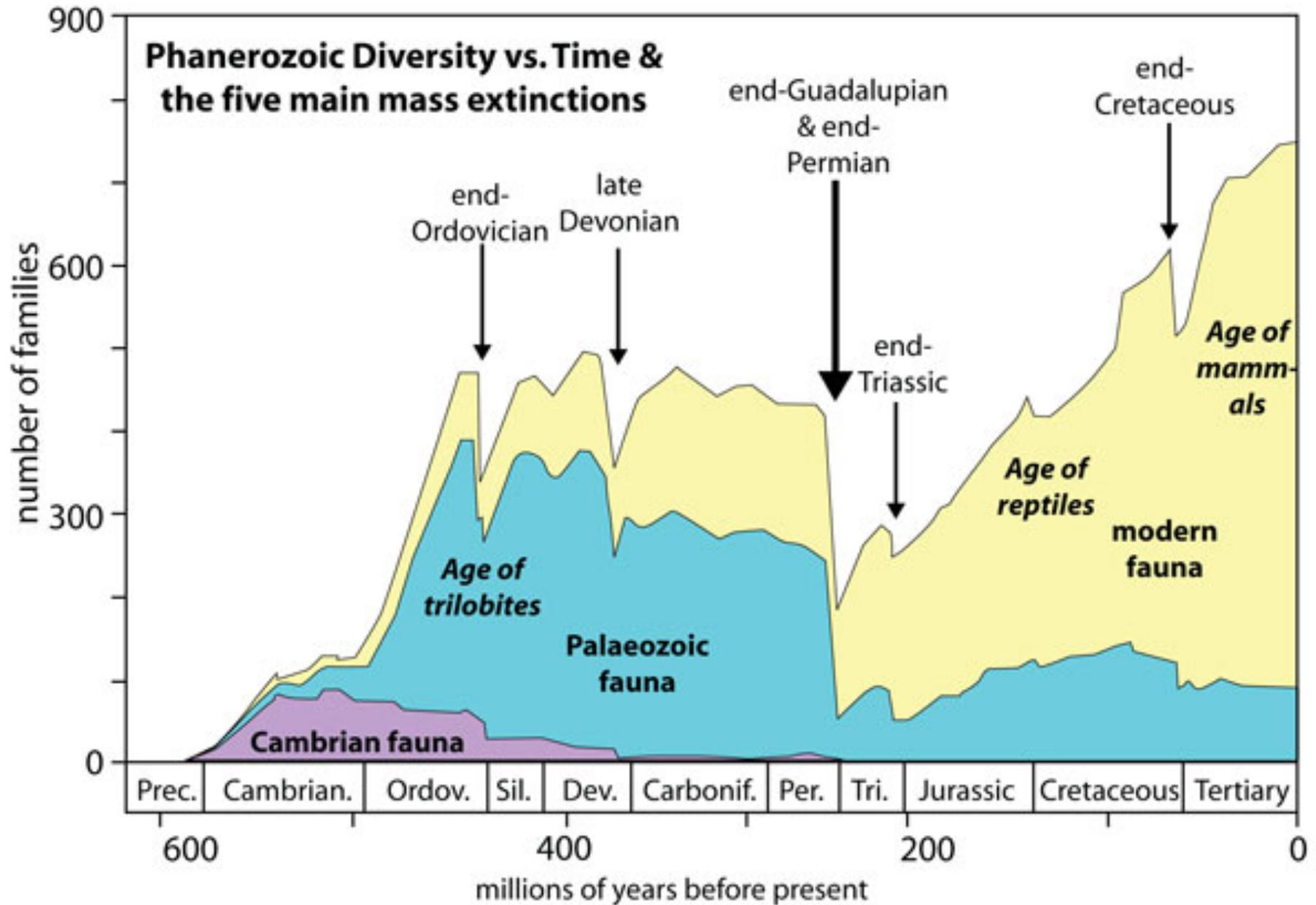
Plate Tectonics

Future World + 250 Ma



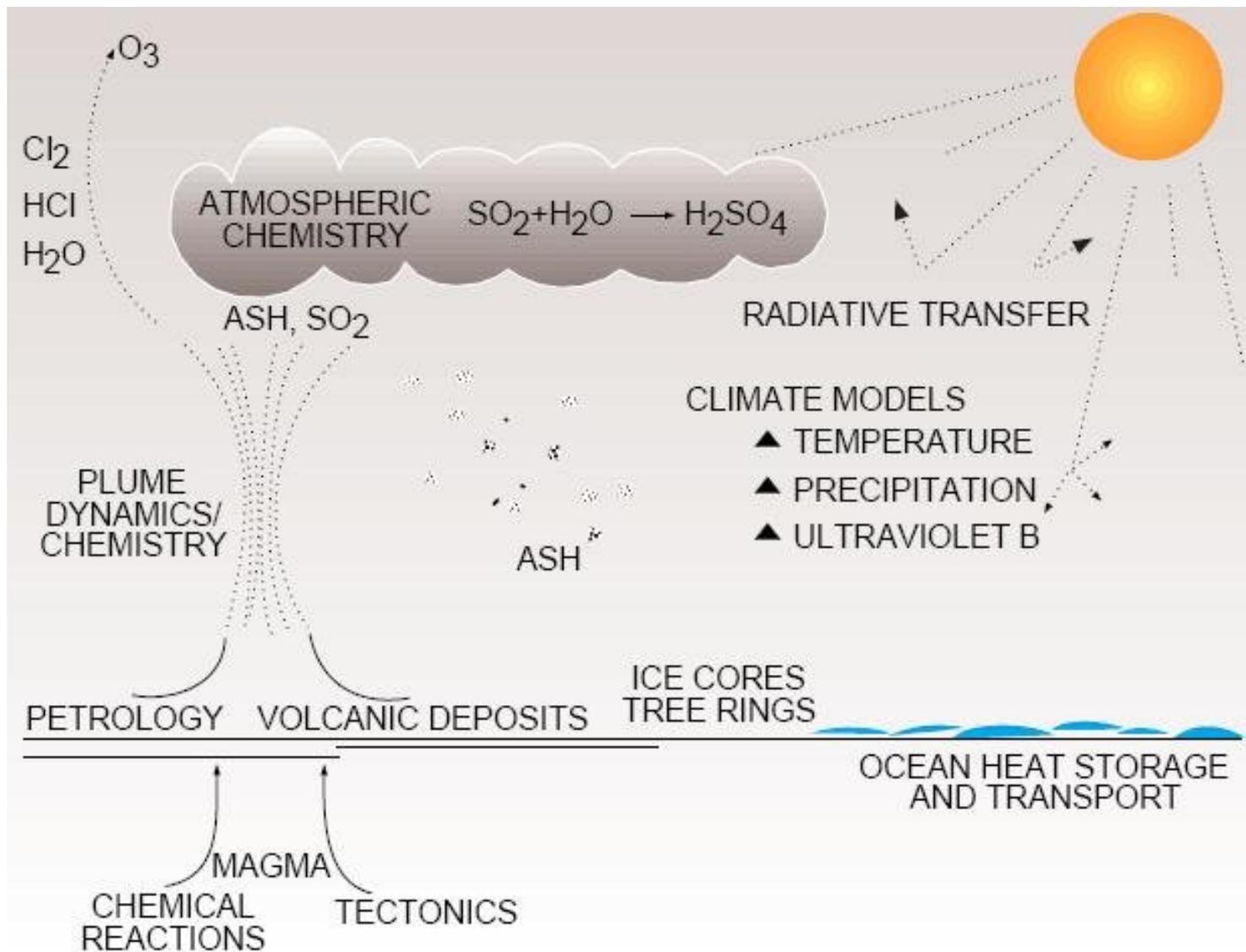
- Ancient Landmass 
- Modern Landmass 
- Subduction Zone (triangles point in the direction of subduction) 
- Sea Floor Spreading Ridge 

Extinction History





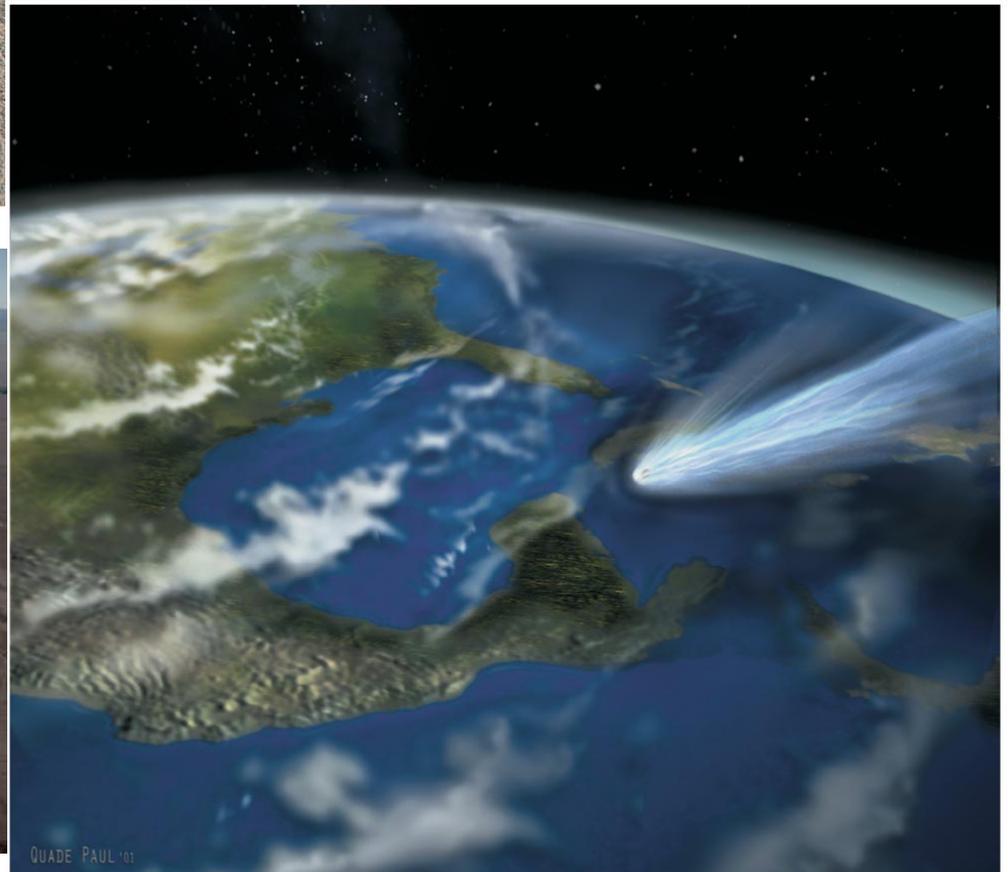
Drastic climate change and ecological catastrophe can occur every 100,000 years or so due to supervolcanos. They blot out the Sun for decades.



A layer rich in iridium and soot tells us a huge impact occurred at this point in geological (and biological) history.

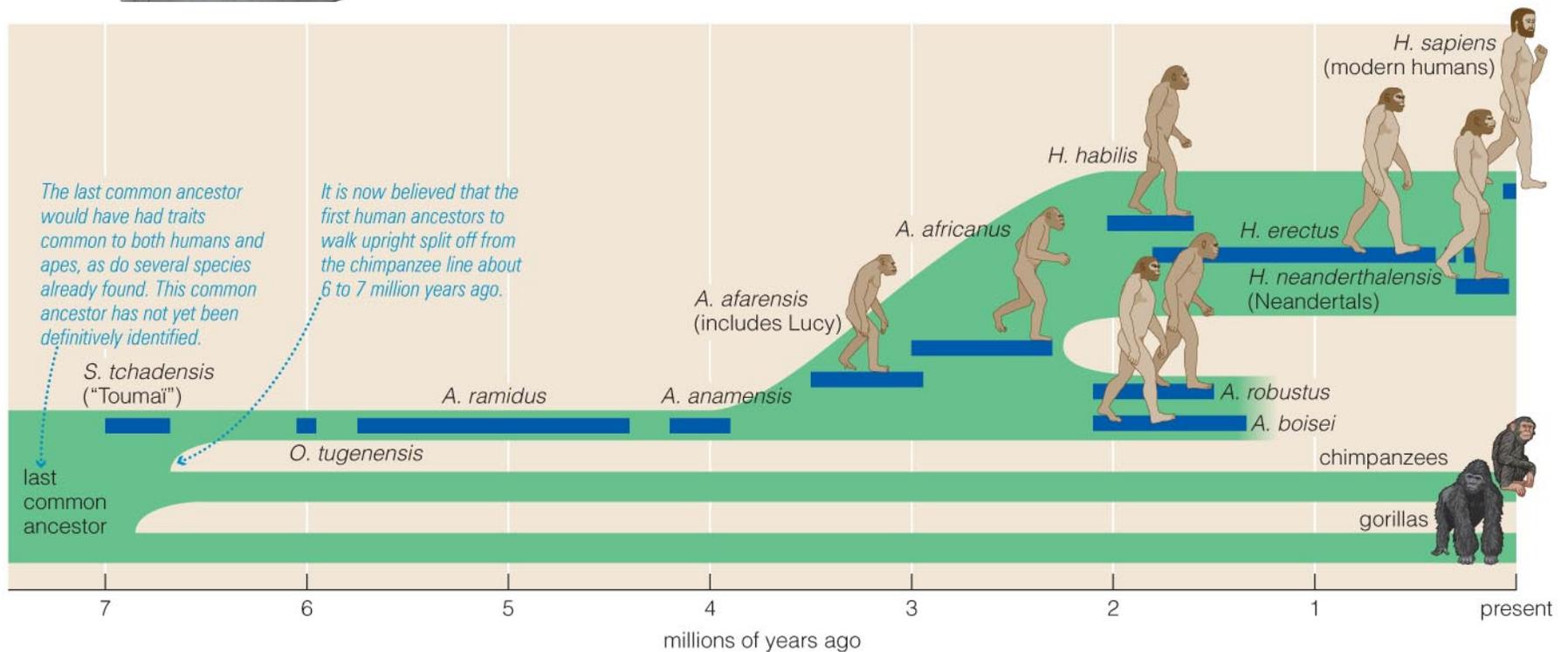


A major impact event likely caused the mass extinction 65 million years





After four billion years of life on Earth, homo sapiens emerged to dominate the planet and venture into space. Was this just a fluke or did something like this happen anywhere else on distant planets?



Astrobiological Implications

- Earth had life soon after its origin, and maybe within 100 million years, under extreme conditions.
- Soon after the heavy meteorite bombardment ended, microbes as metabolically complex as now were widespread and abundant.
- So life arose and diversified rapidly, and occupied an amazing array of evolutionary niches.
- Planets with early but short-lived habitable windows (e.g. Mars, Venus) could have been lively.
- Intelligence does not rapidly follow evolution of complex cells (eukaryotes), so microbial life may be abundant while intelligence is rare.