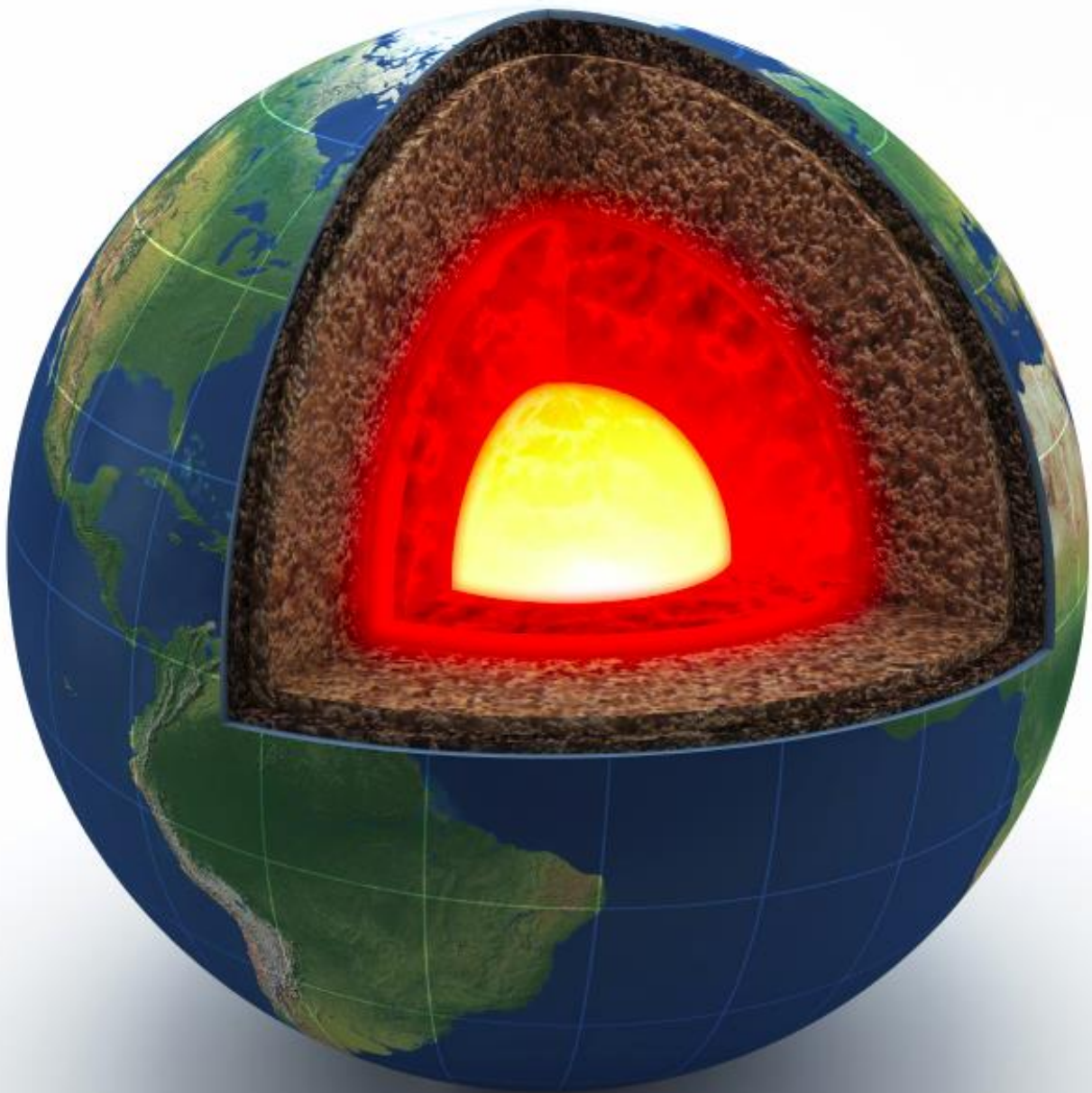
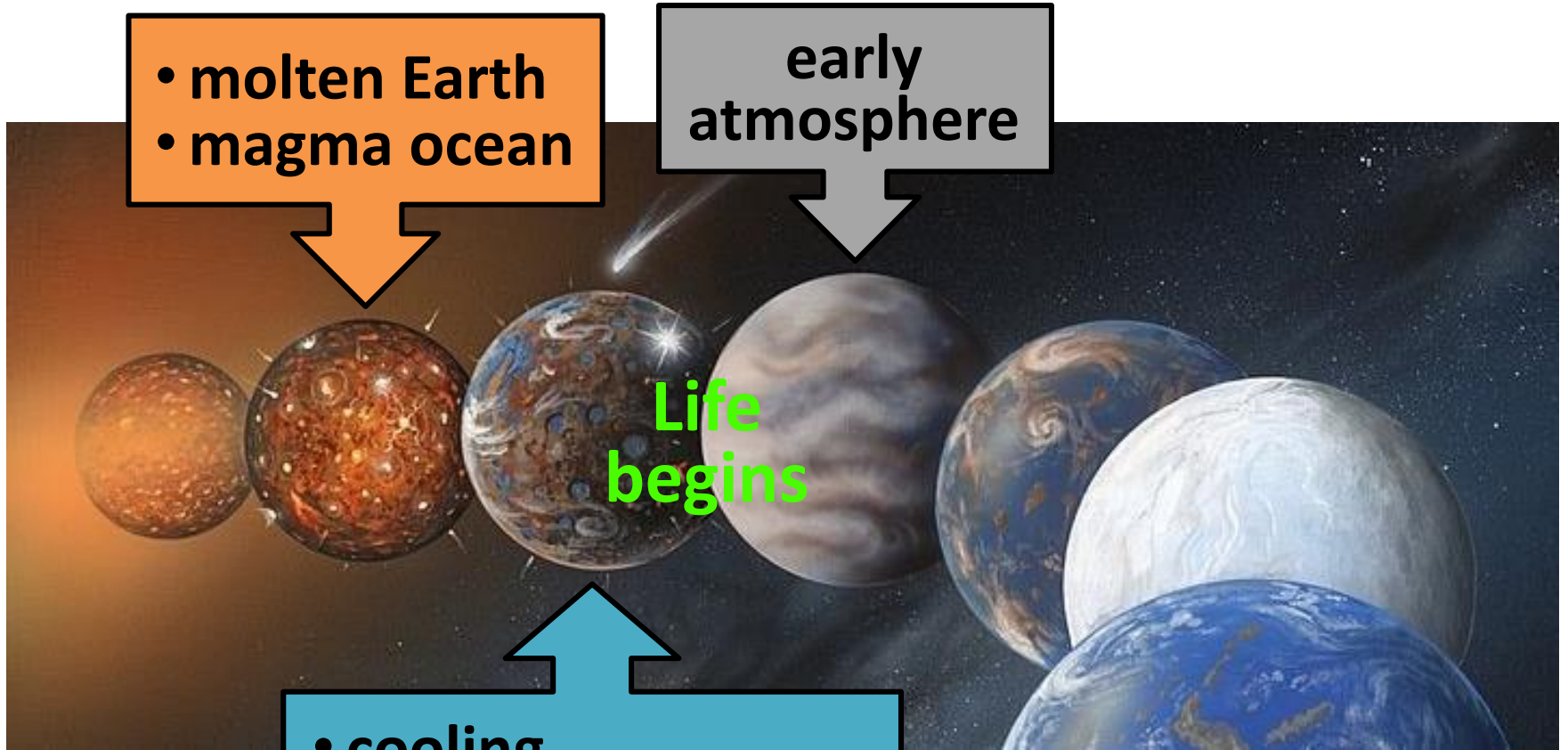


**I
N
S
I
D
E**



**E
A
R
T
H**

Earth Evolution



- molten Earth
- magma ocean

early atmosphere

Life begins

- cooling
- crust formation
- volcanic outgassing
- comet impacts

“A planet and its life will co-evolve”

Earth's Layers

➤ Inner core

- R = 1300 km
(0-800 mi)

➤ Outer core

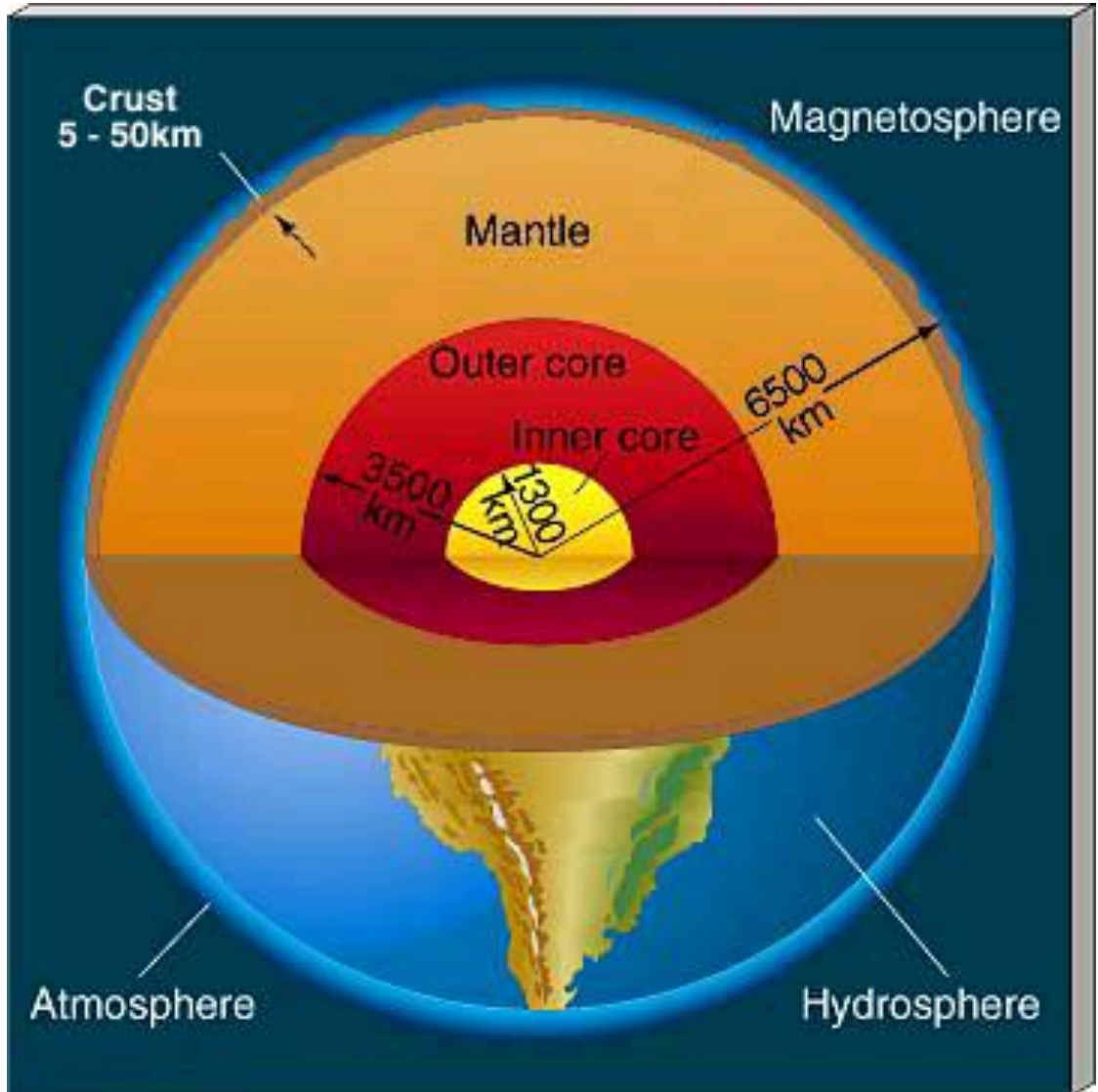
- 1300-3500 km
(800-2200 mi)

➤ Mantle

- 3500-6400 km
(2200-4000 mi)

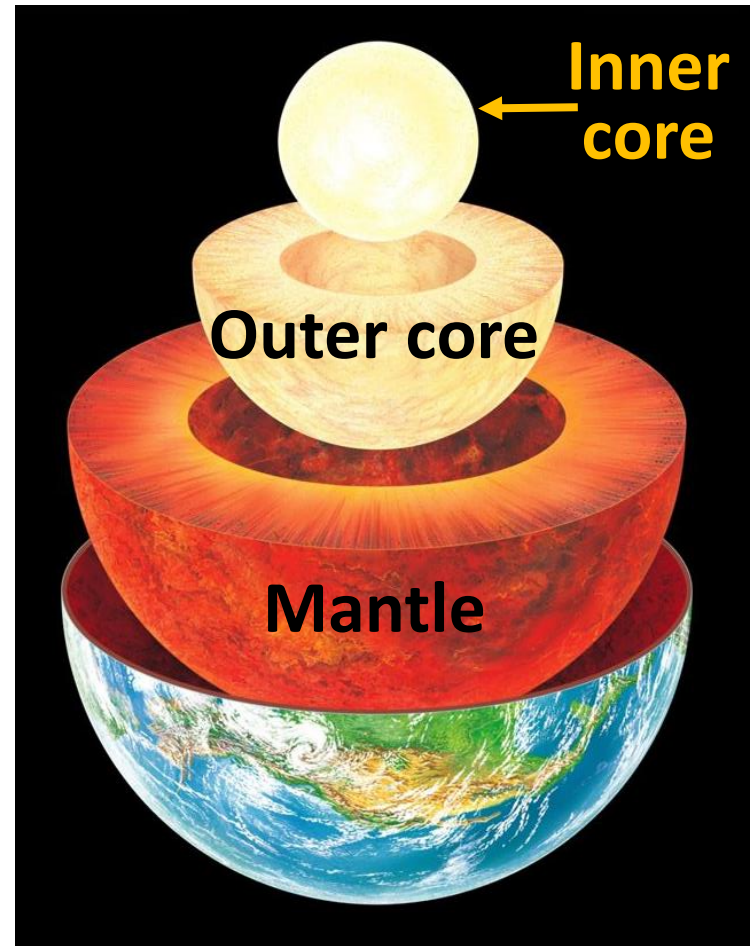
➤ Crust

- tops mantle
- 5-50 km thick
(3-25 mi)



The Core

- 16% of Earth's volume
- Two sections:
 - inner core
 - total diameter ~2600 km (larger than Mercury!)
 - $T \sim 6,000\text{-}7,000\text{ K}$ ($>10,000^\circ\text{F}$)
 - solid, very dense
 - nickel-iron alloy
 - grows ~1 mm per year
 - outer core
 - ~2250 km thick
 - liquid
 - $T \sim 4,000\text{-}6,000\text{ K}$ ($\sim 6,700\text{-}10,300^\circ\text{F}$)
 - primarily iron with some nickel and sulfur
 - convection of liquid metals creates the Earth's magnetic field



The Mantle

- 2900 km thick
- ~84% of Earth's volume

- Three regions:

- lower region

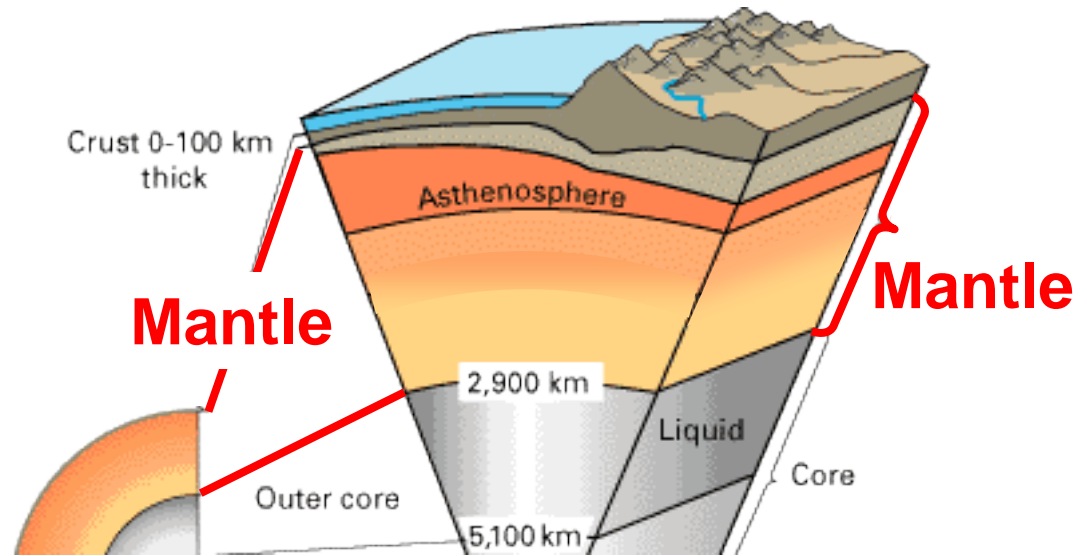
- dense, **solid** (due to *enormous pressure!*)
- temperatures between ~2000-3,500 K (~3,100-5,800°F)

- upper region (*asthenosphere*, “weak” sphere)

- has reduced pressures and rock strength
- **plastic rock** (at pressures and temperatures found in this region, mantle rock **can deform and flow slowly**).

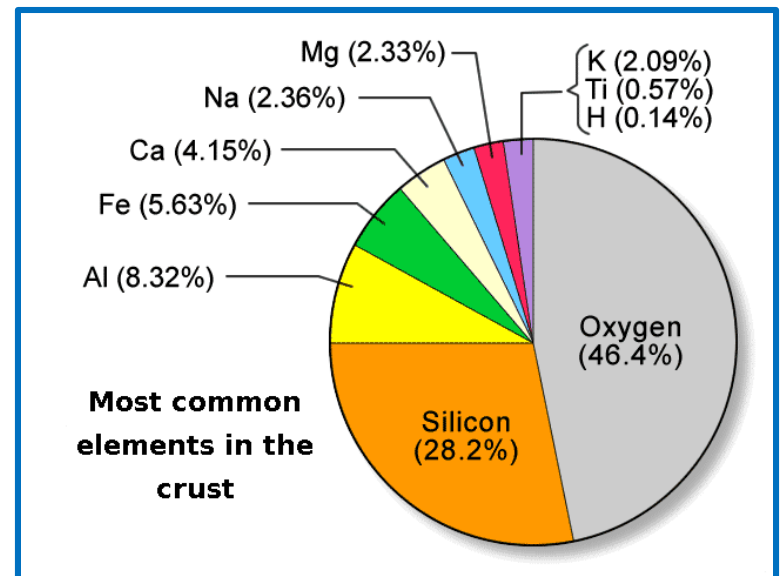
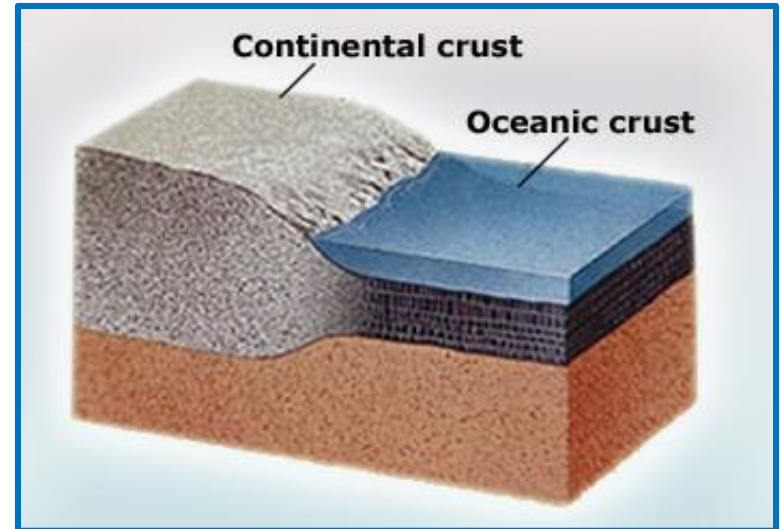
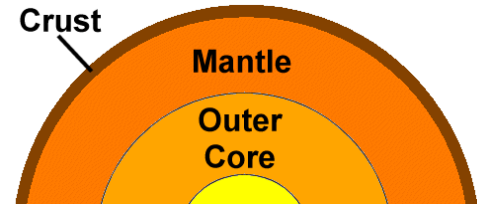
- uppermost region

- **solid**; temperatures between 750-1200 K (~900-1,700°F)



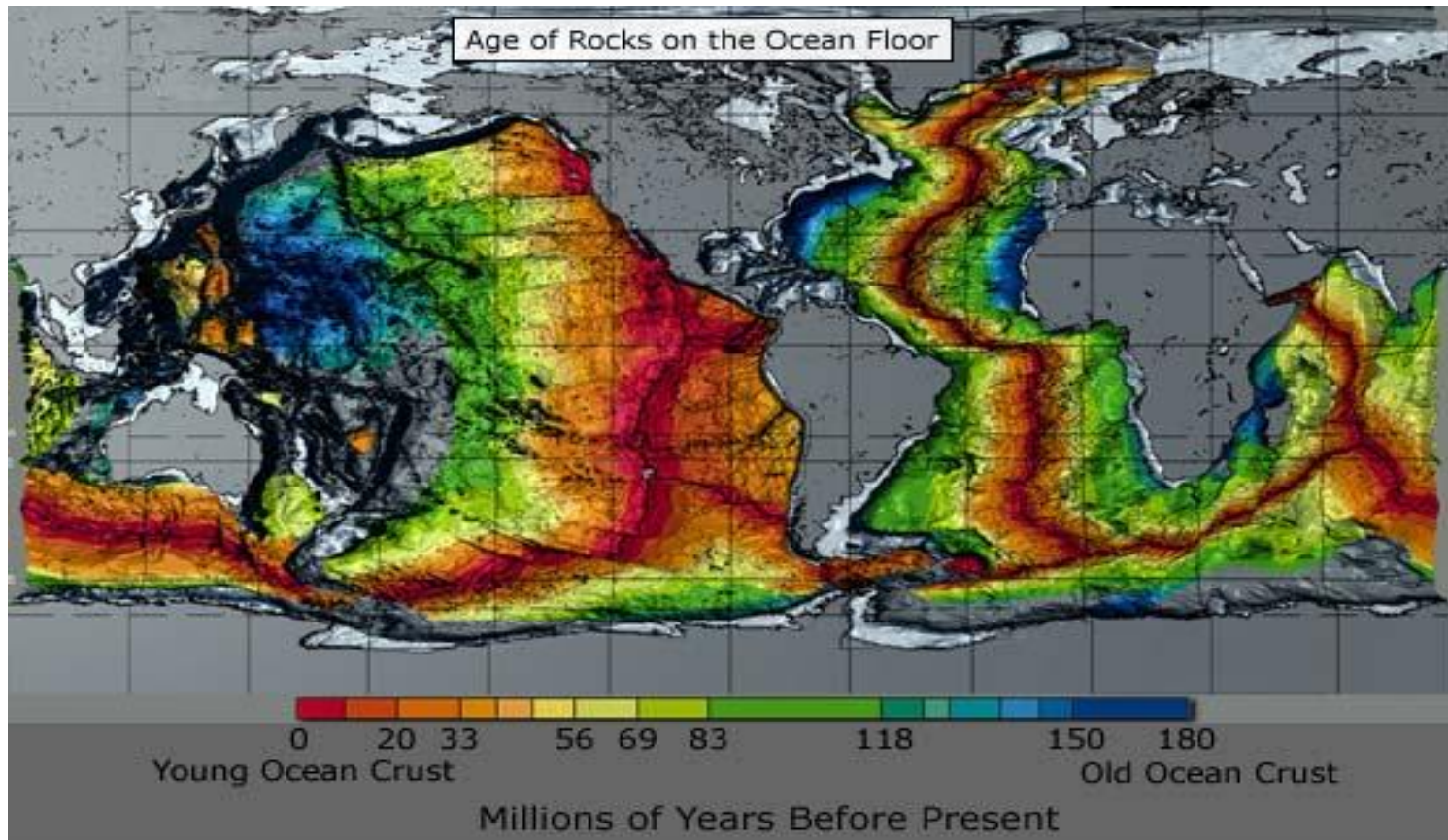
The Crust

- <1% of Earth's mass
- Solid
- Two types:
 - oceanic crust
 - 55% of the surface
 - 6 to 10 km thick
 - composed of basalts
 - relatively young (<200 MYO)
 - continental crust
 - 45% of the surface
 - 70% by volume
 - 25 to 70 km thick
 - granites (less dense)
 - mostly old (up to 3.5-4 BYO)



Age of Oceanic Crust

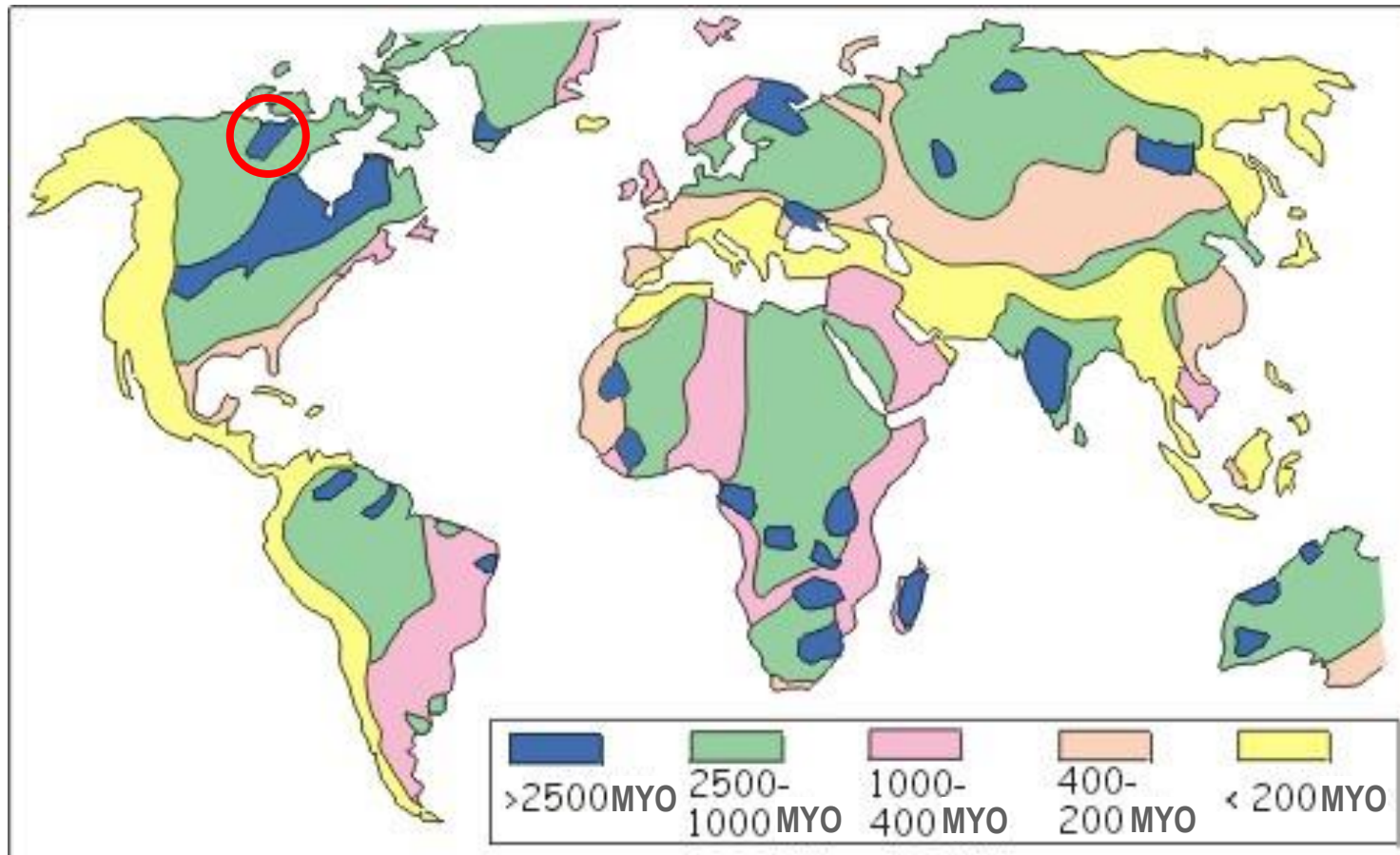
By analyzing **radioactive minerals in igneous rocks** (*those formed through the cooling and solidification of magma or lava*), scientists can tell how much time has passed since rocks solidified from lava - **the age of a rock**.



Oceanic crust is seldom more than 200 million years old.

Age of Continental Crust

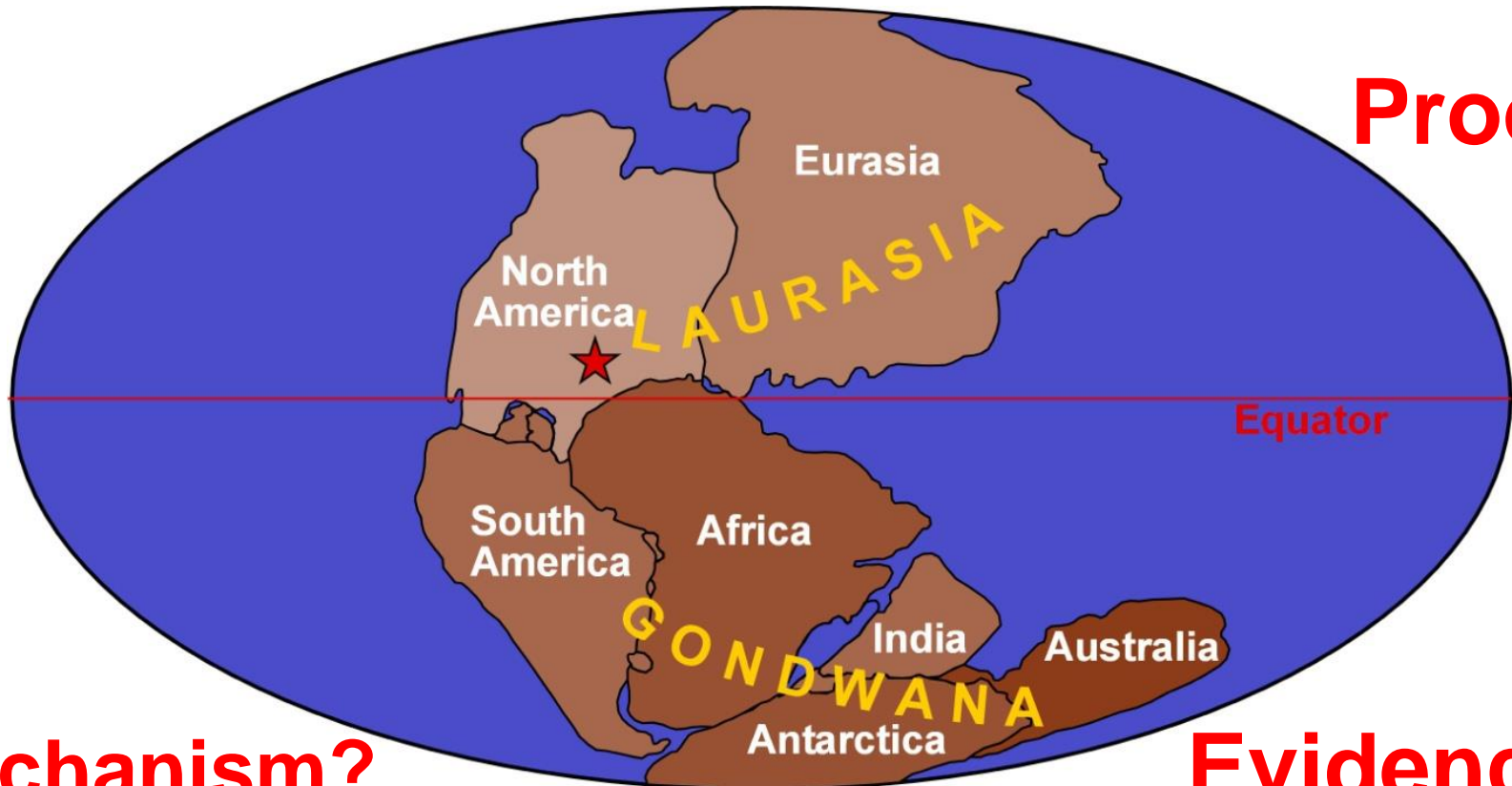
The **oldest rocks** on Earth are found **within the stable cores of the continents**. The oldest known intact crustal fragment on Earth, **Acasta Gneiss** (located in Northwest Territories, Canada), is believed to be **~4 billion years old**.



Continental Drift

- In the late 19th and early 20th centuries, geologists assumed that the Earth's major features were fixed.
- In 1912, **Alfred Wegener** proposed that up until about 200 million years ago, all of the present continents were joined together into a single super-continent later called **Pangea**.

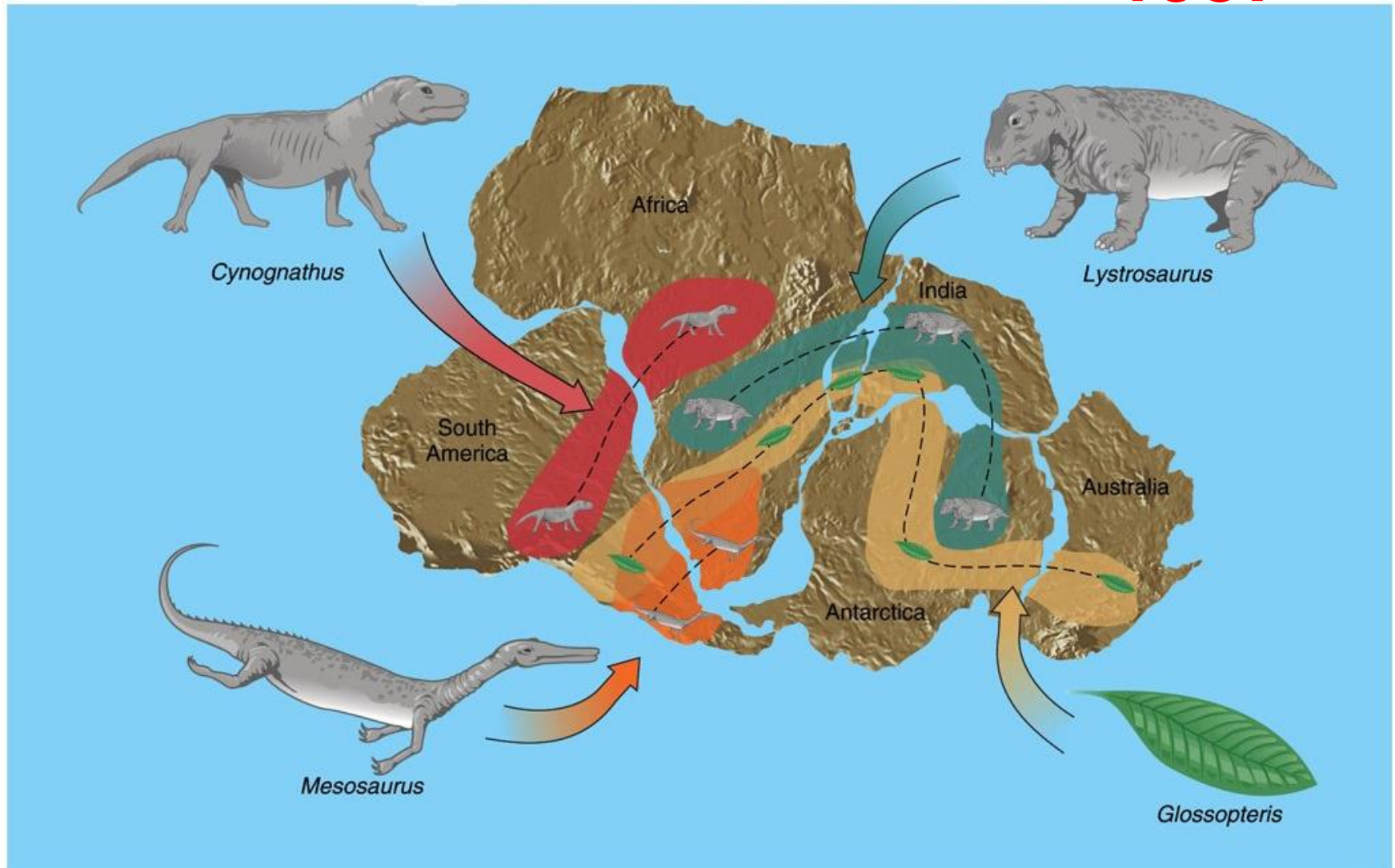
Proof?



Mechanism?

Evidence?

Continental Drift: Fossil Evidence 1937



Continental Drift: Debate

- Fifty years long lively debate started between "drifters" or "mobilists" (proponents of the theory) and "fixists" (opponents), during which the **theory of plate tectonics was born**.
- Early "weak" evidence:
 - Parts of **Scotland and Ireland** contain **rocks very similar** to those found in **Newfoundland and New Brunswick**.
 - The **Caledonian Mountains of Europe** and parts of the **Appalachian Mountains of North America** are very similar in structure and composition.
- Strong geophysical evidence:
 - **Paleomagnetism**, the rocks of different ages show a variable magnetic field direction consistent with continents movement.
 - Late 1950s and early 60s data on the **bathymetry of the deep ocean floors** and the nature of the oceanic crust; **evidence of seafloor spreading** along the *mid-oceanic ridges*.

Continental Drift Simulation

The Past

<https://www.youtube.com/watch?v=UwWWuttntio>

The Future

<https://www.youtube.com/watch?v=bQywDr-btz4>