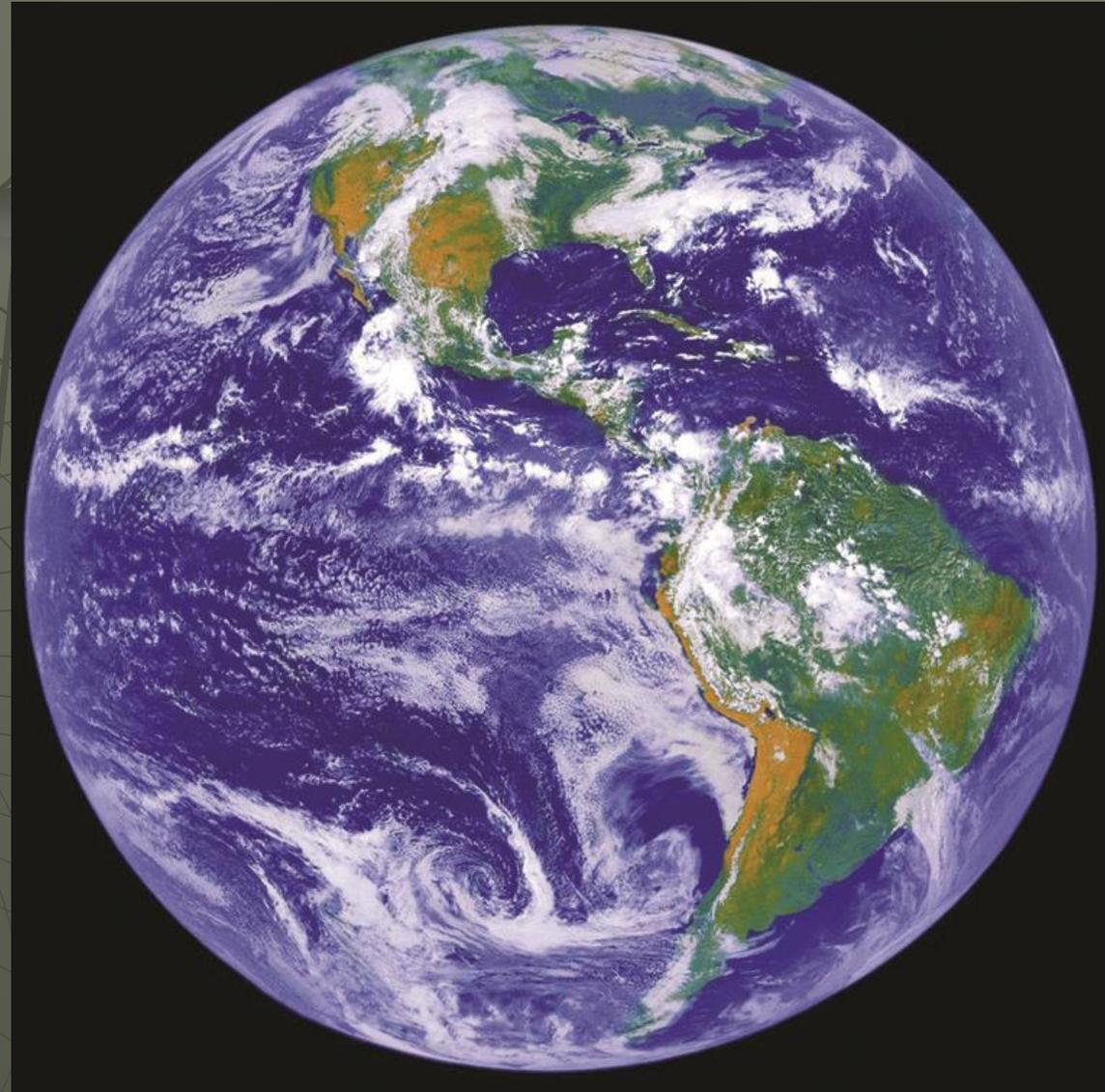


Earth!

- ◆ Objectives:
 - Interior and plate tectonics
 - Atmosphere and greenhouse effect

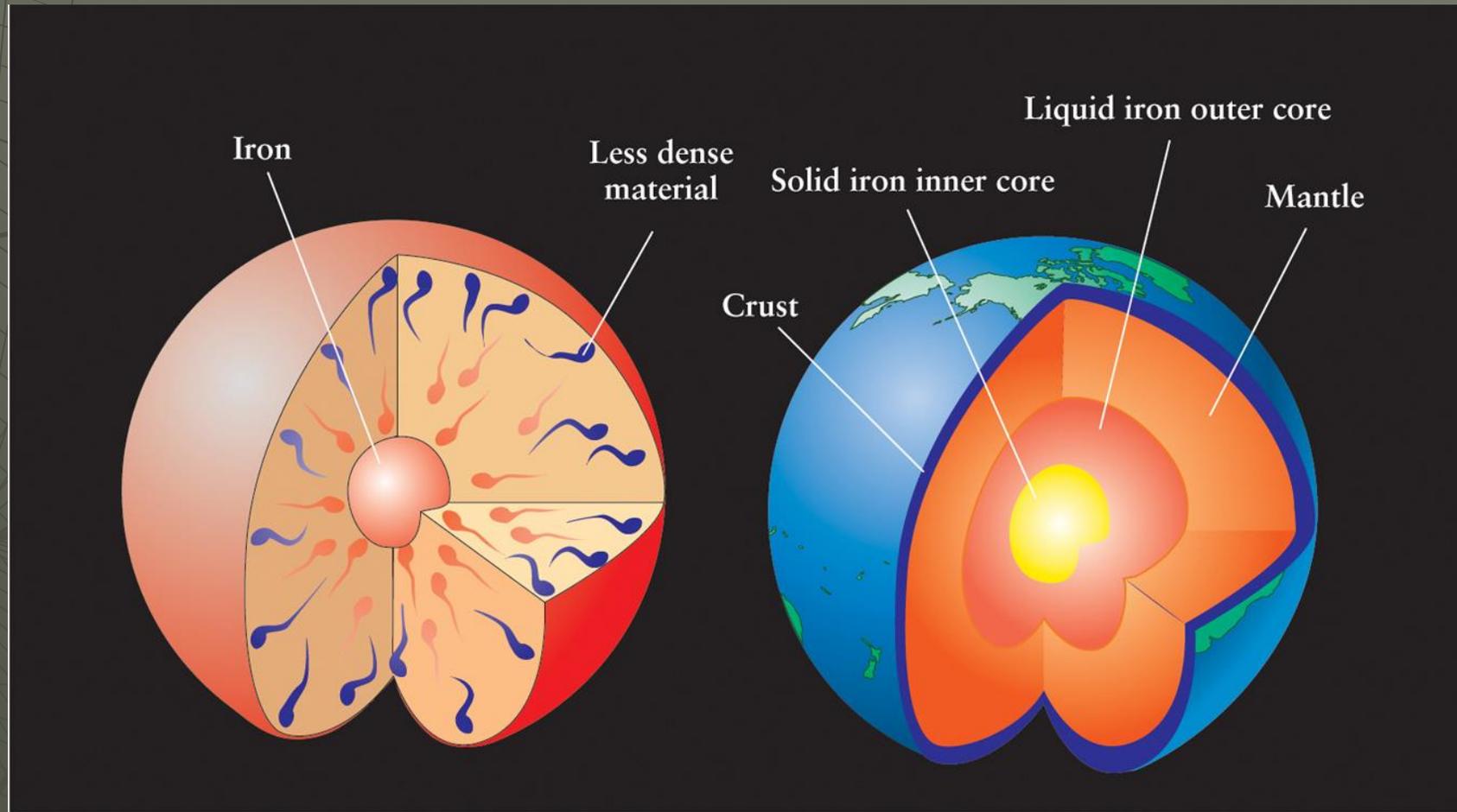


Earth...Fun Facts

1. Only body with *liquid* water on the surface.
2. Most massive terrestrial body in solar system
3. Only terrestrial planet with a large moon
4. Geothermally alive, with a dynamic atmosphere, surface being reshaped

What is it made of?!

- ◆ Mostly Iron (Fe)
- ◆ Surface or Core?
 - A: Core
- ◆ Why is the Core made of Fe?



(a) During differentiation, iron sank to the center and less dense material floated upward

(b) As a result of differentiation, Earth has the layered structure that we see today

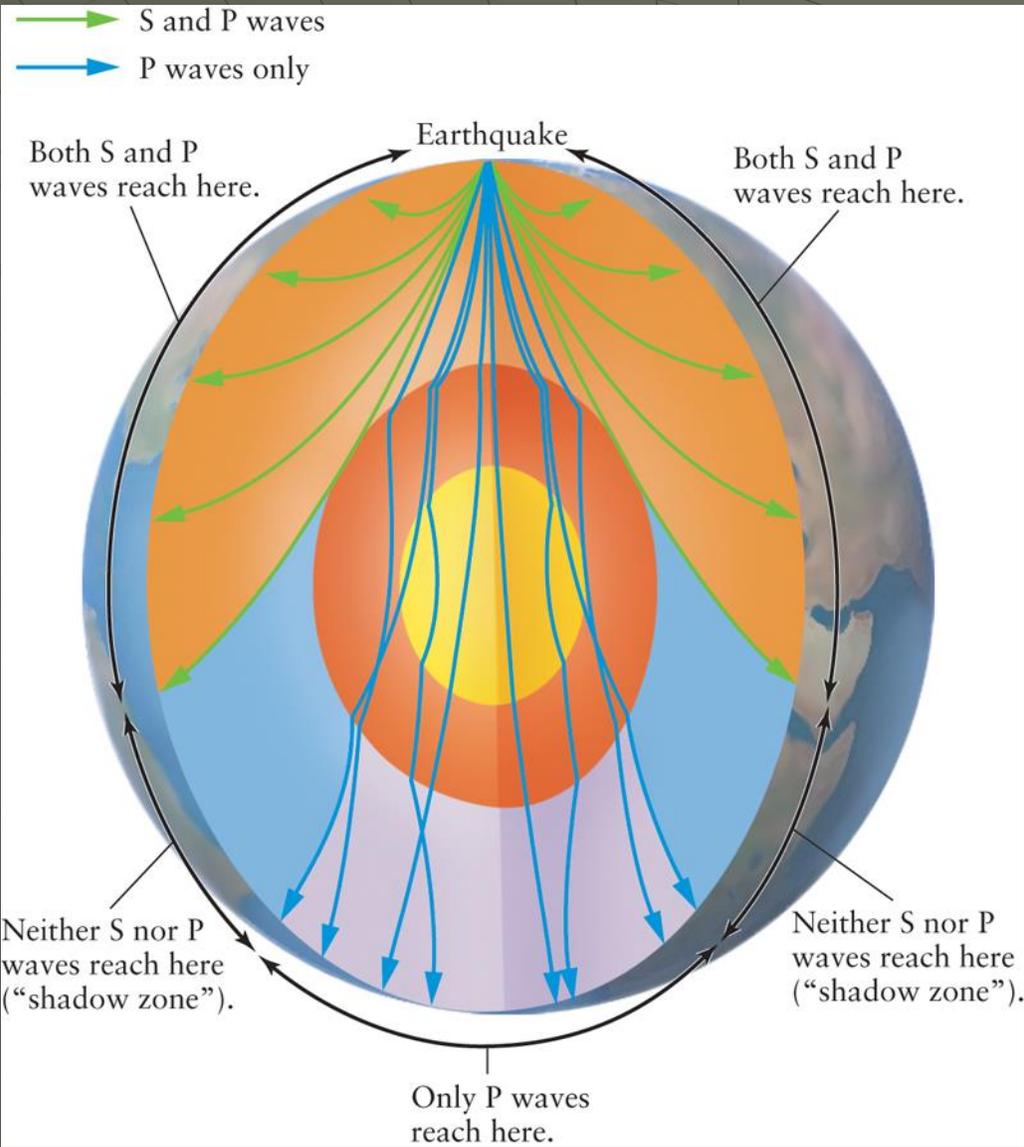
Differentiation

- ◆ What happens when you put a rock in a glass of water?
 - A: it sinks to the bottom
- ◆ What happens when you have a layer of dense rock on top of a layer of less dense rock?
 - A: it sinks to the bottom

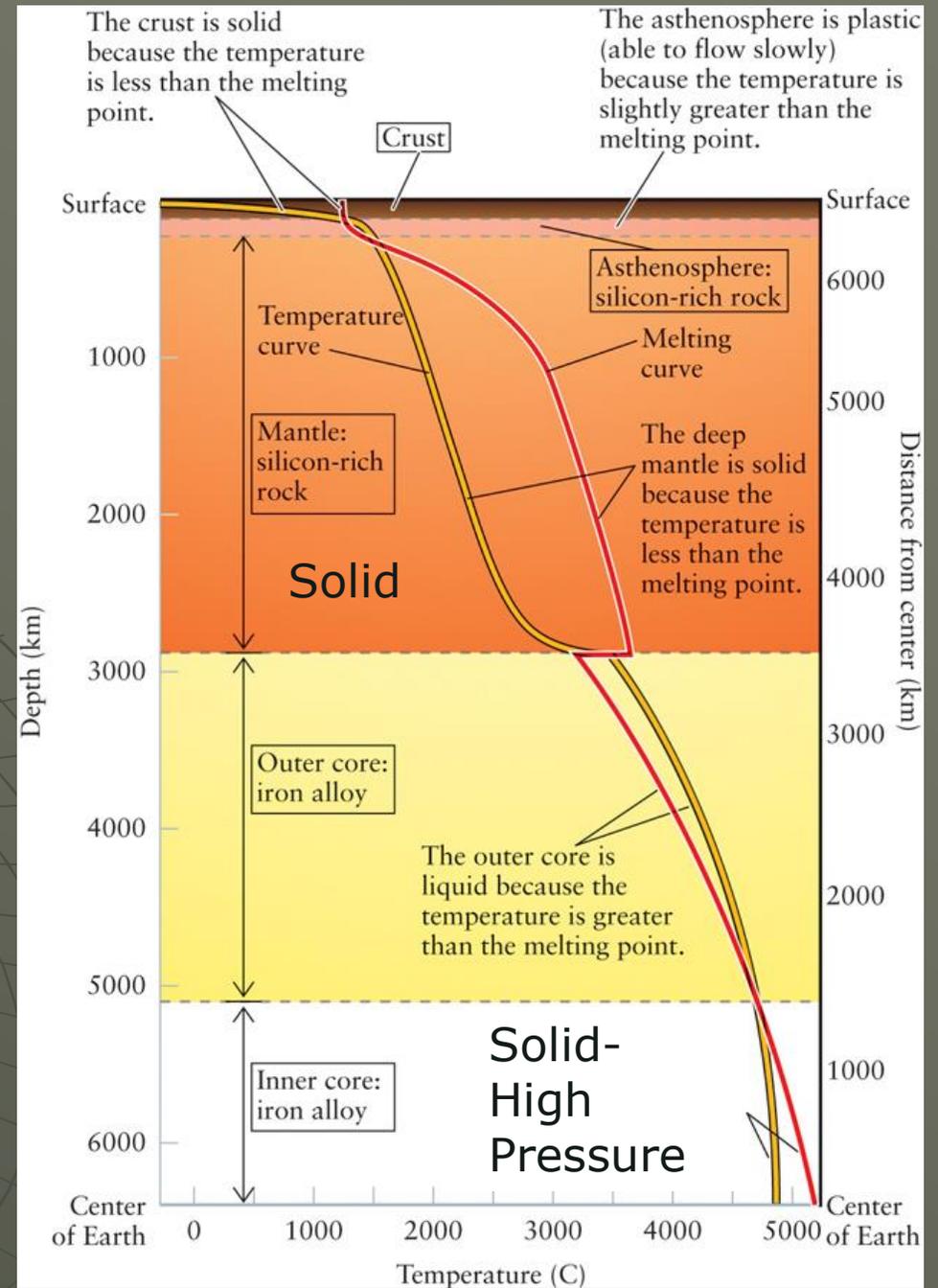
S waves: Longitudinal waves (damped by liquid)

No S waves → liquid layer

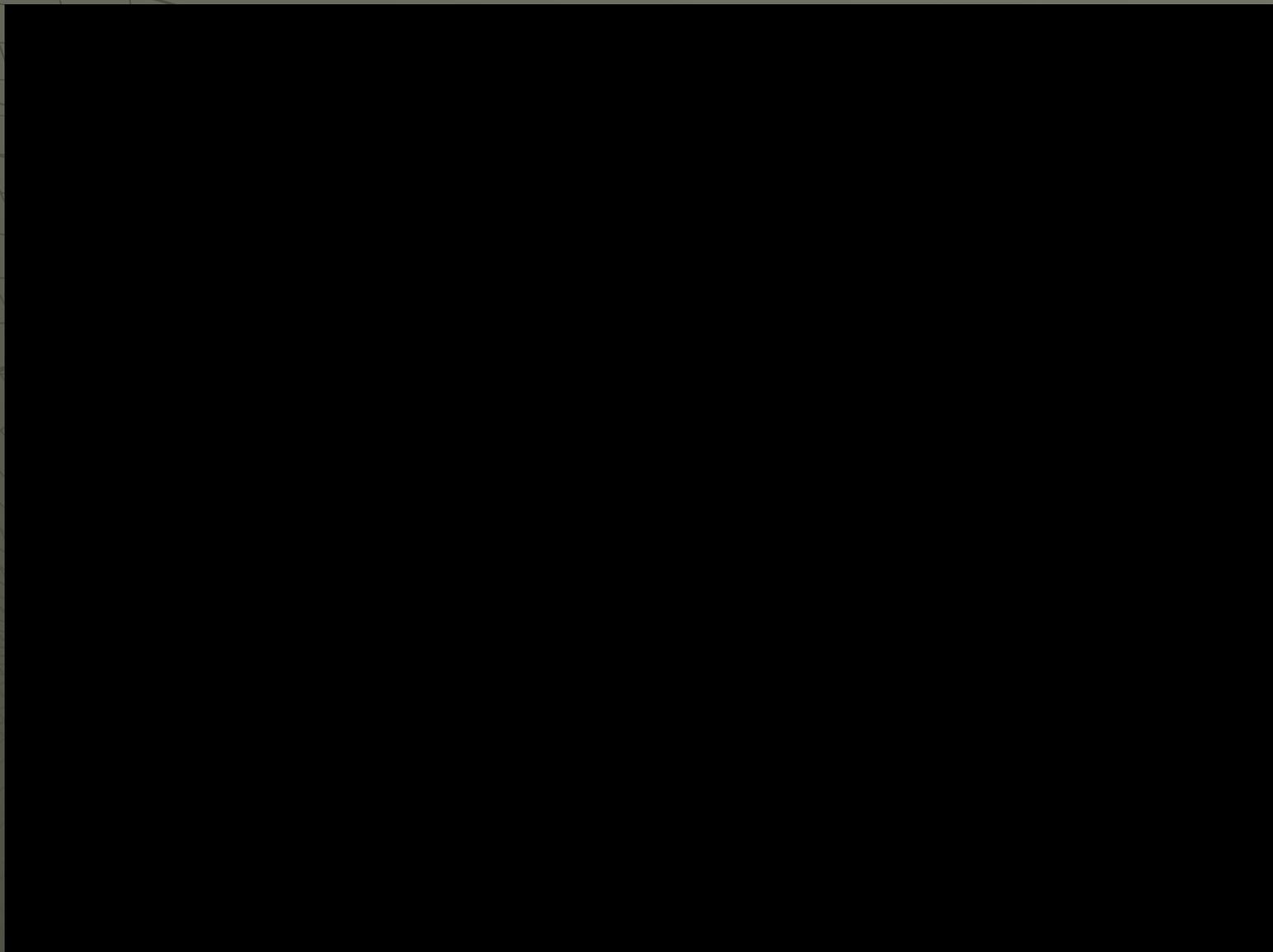
P waves: compression waves



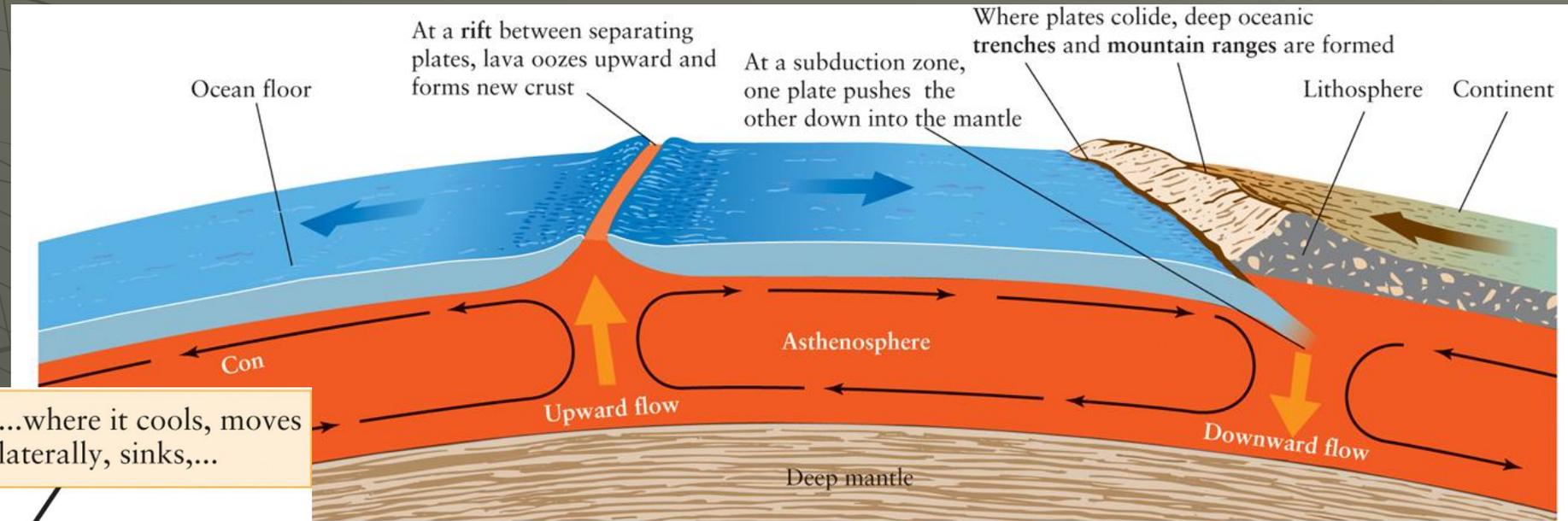
Major Layers



Seismic Waves



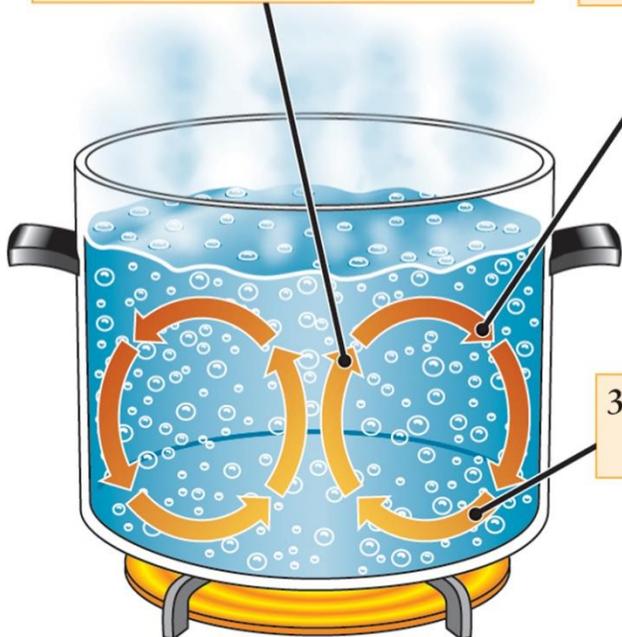
Convection



1. Convection moves hot water from the bottom to the top...

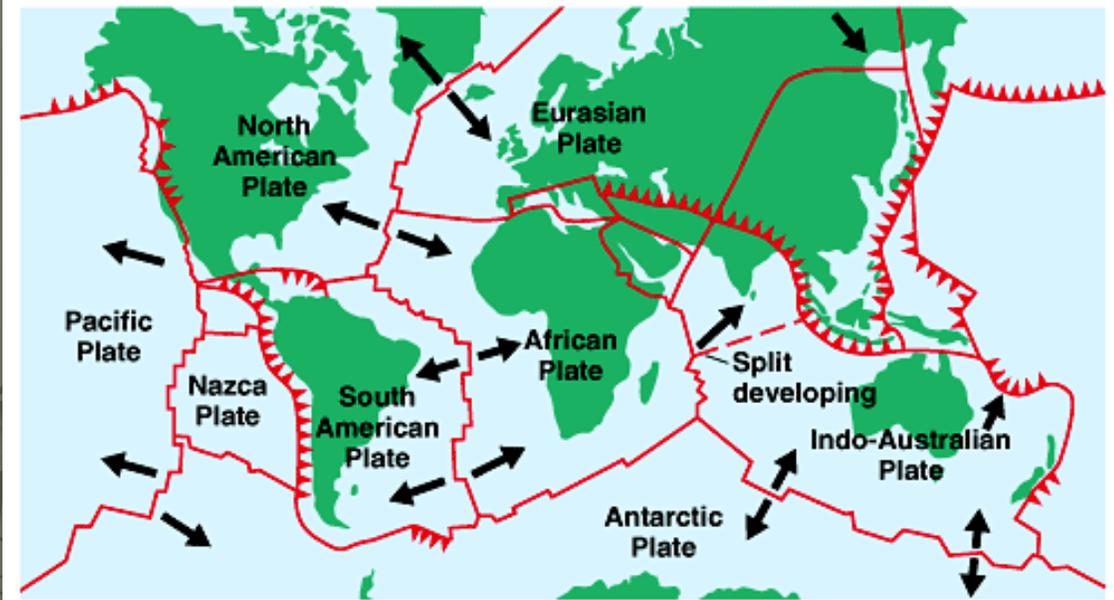
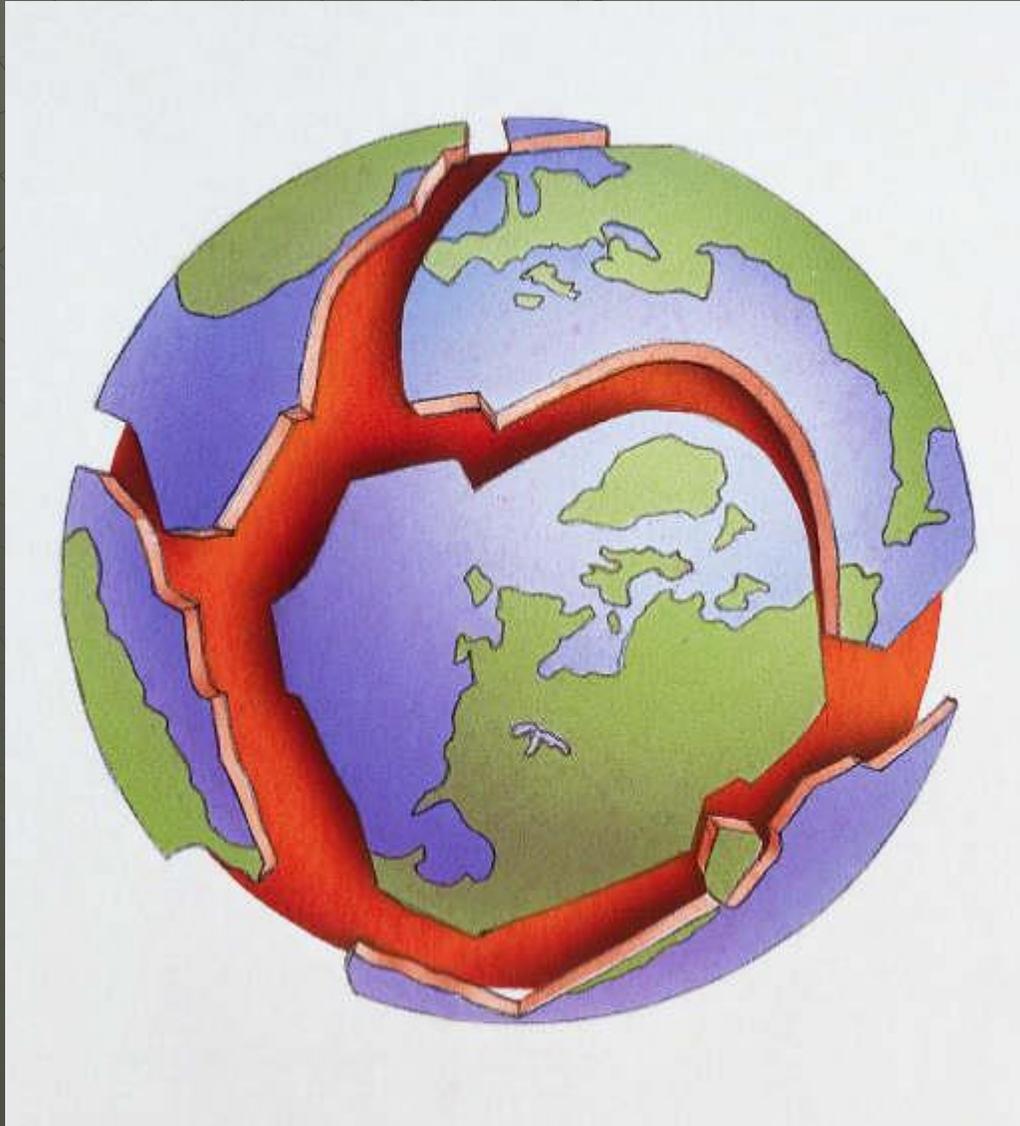
2. ...where it cools, moves laterally, sinks,...

3. ... warms, and rises again.

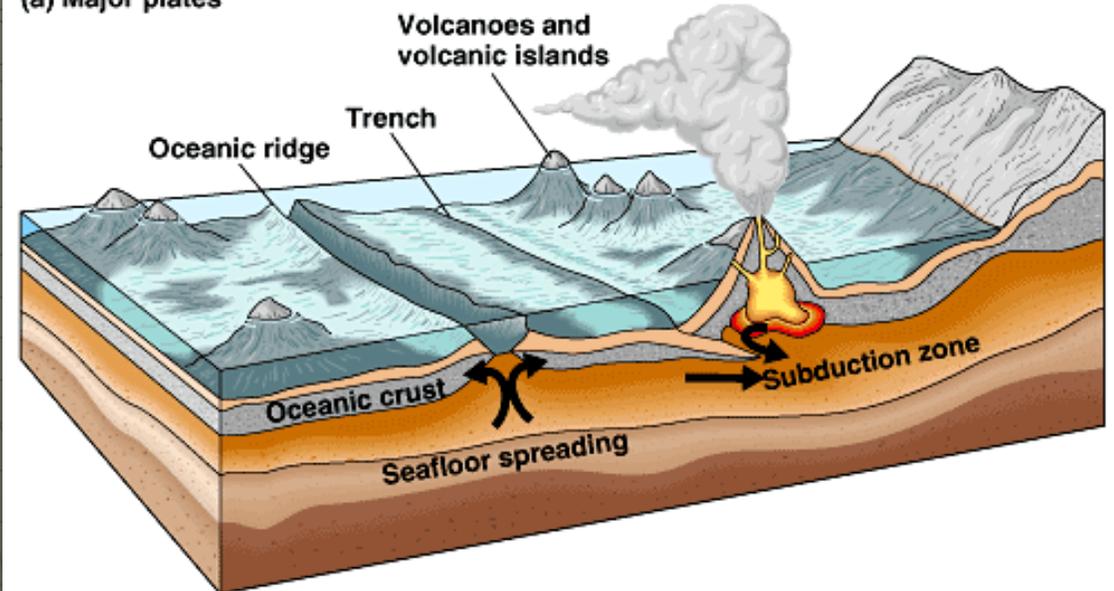


- **Convection:** transfer of heat through the collective movement of material.
- Hot material on bottom expands (less dense) and rises
- Cold material on top contracts (more dense) and sinks

Plate Tectonics



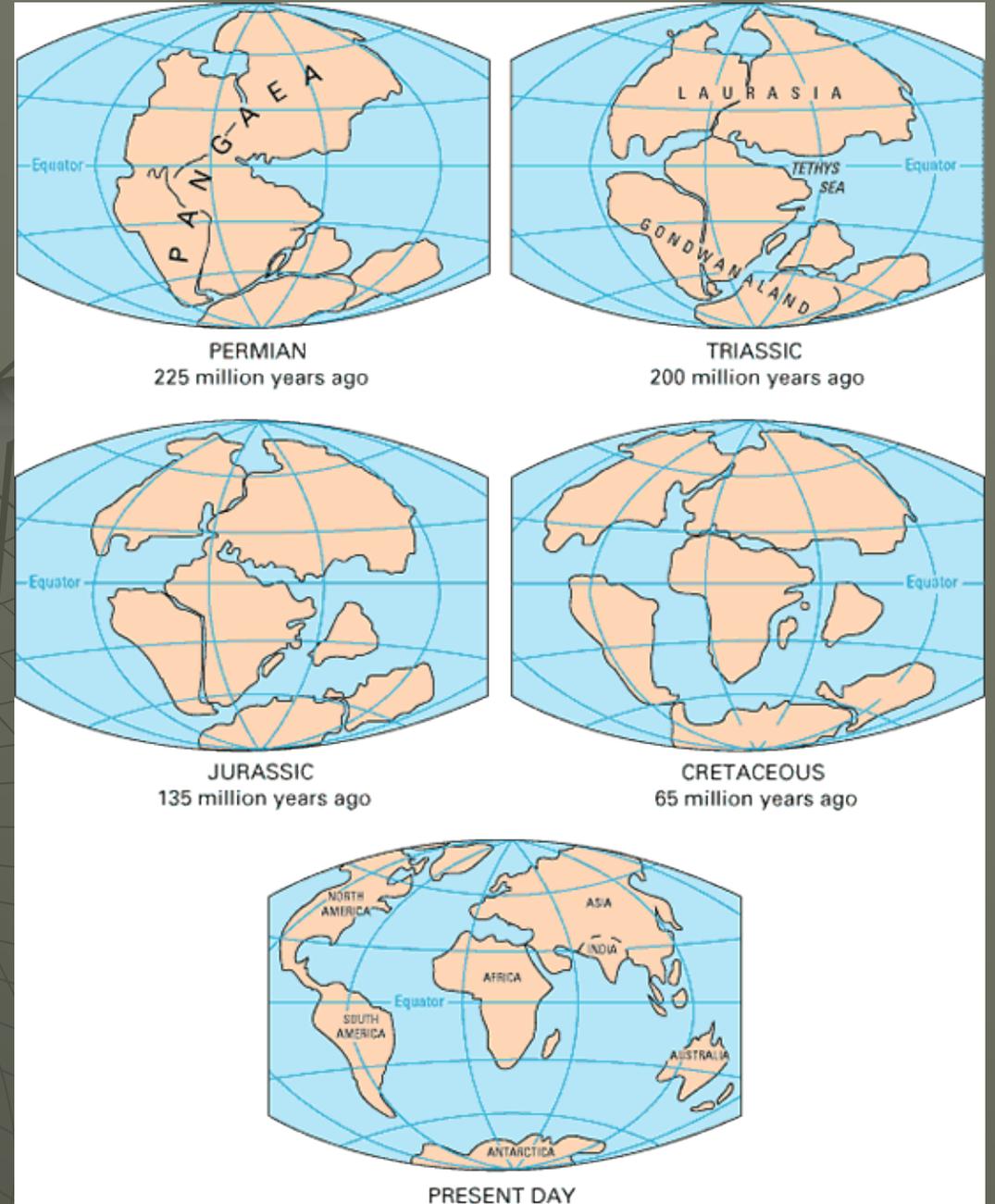
(a) Major plates



(b) Events at plate boundaries

Pangaea

- Continents move \sim few cm/year



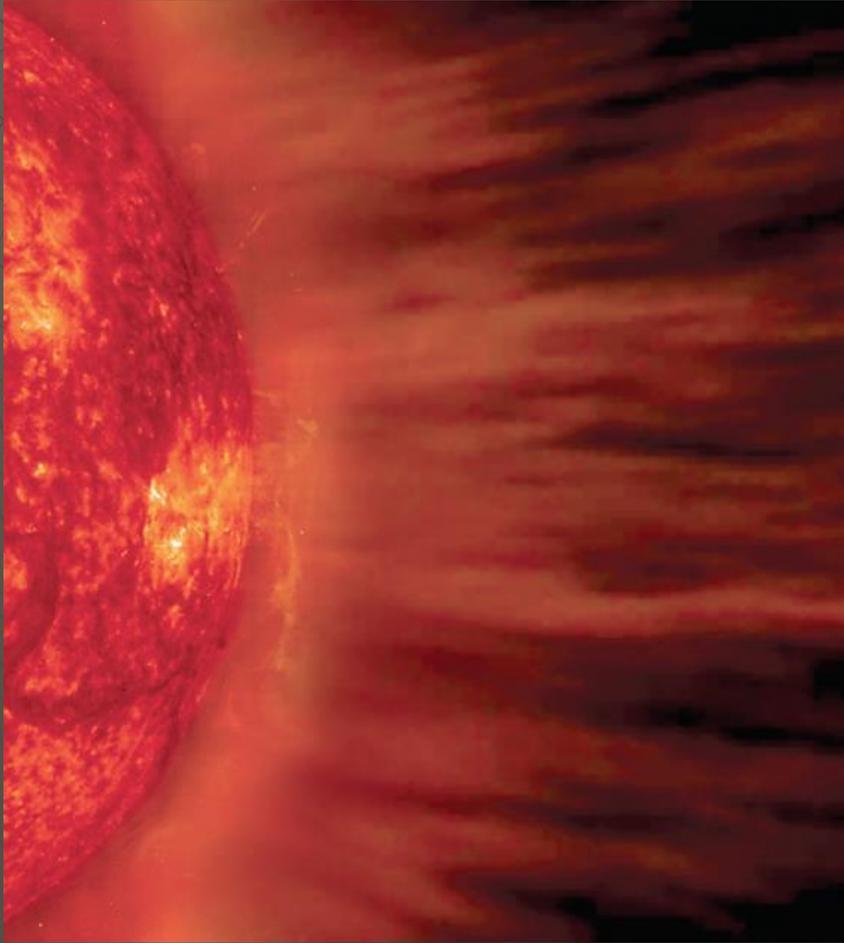
- ◆ How did the Earth form with a dense iron core and low-density crust?
 - A. Iron particles collapsed out of the solar nebula first, and lighter material accreted onto it.
 - B. While Earth was still molten, denser material sank to the center while lighter material rose to the surface.
 - C. Impacts from lower-density asteroids covered the early Earth with a lighter crust.
 - D. Pressure from the outer layers of Earth compressed the core, forcing it to become denser.

- ◆ Scientists on the planet Zoraxx have seismic-wave stations all over the planet. Whenever a planetquake occurs, both S and P waves are detected on the opposite side of the planet. This tells us that
 - A. the planet has no iron core.
 - B. the planet is completely solid.
 - C. the density of the planet smoothly increases with distance.
 - D. planetquakes work differently on Zoraxx than they do on Earth.

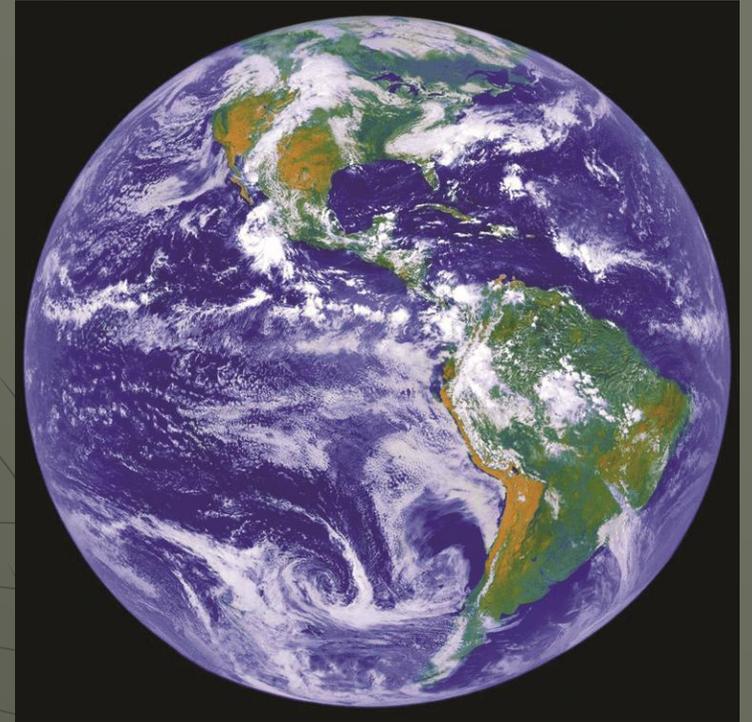
LT

- ◆ Earth's Changing Surface
 - Pg 99

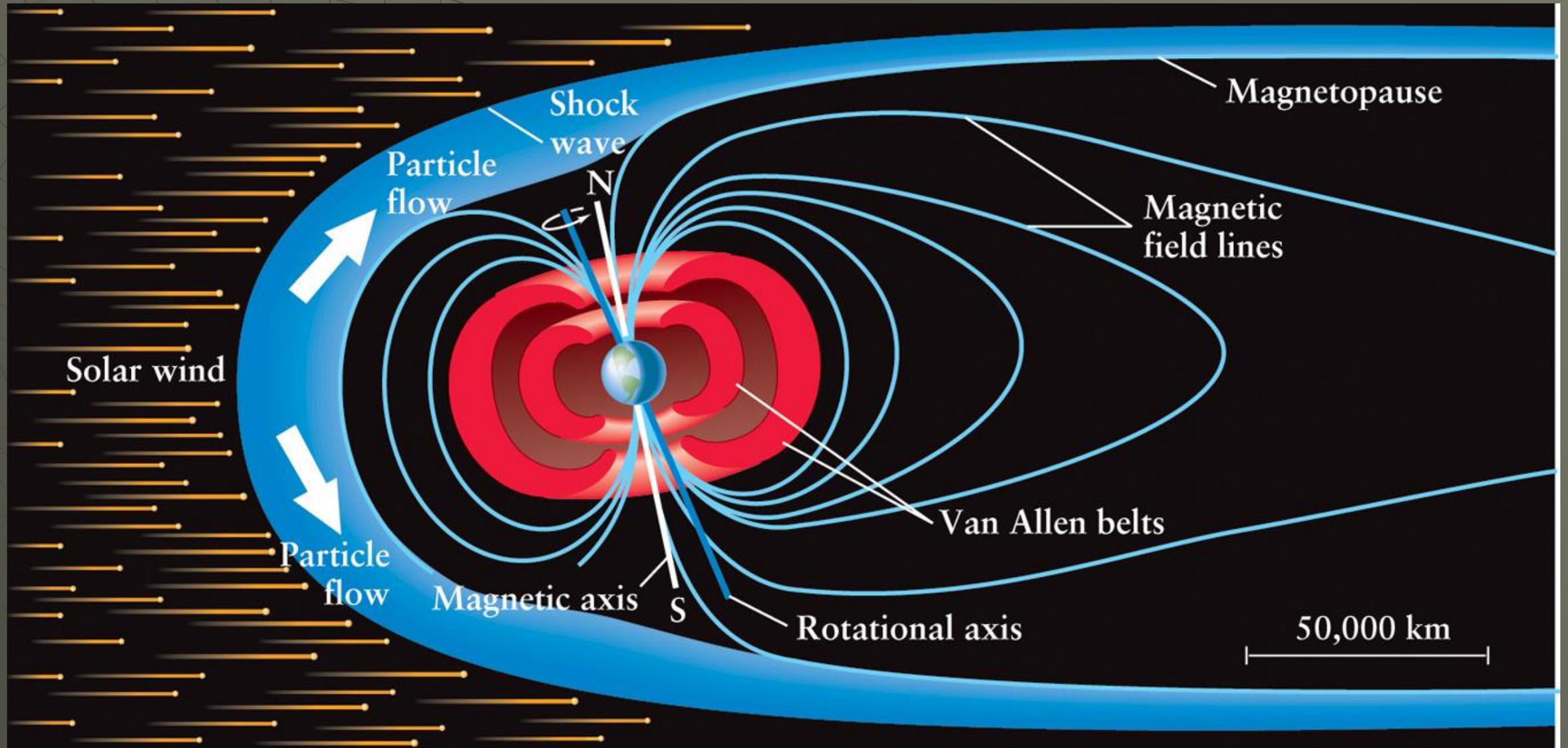
Why don't We get hit with Sun's Wind?



Death Rays!!!

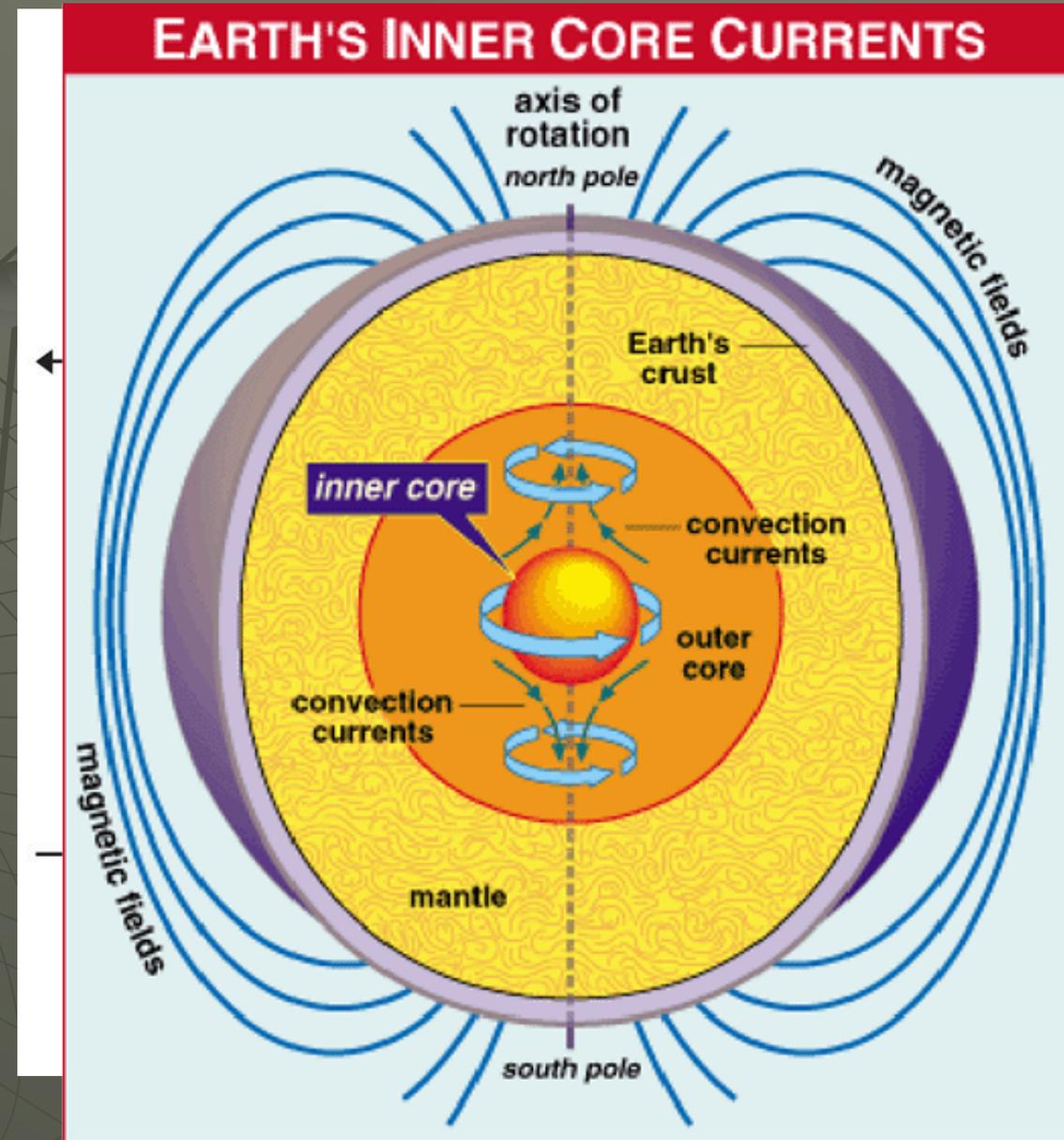


Magnetosphere

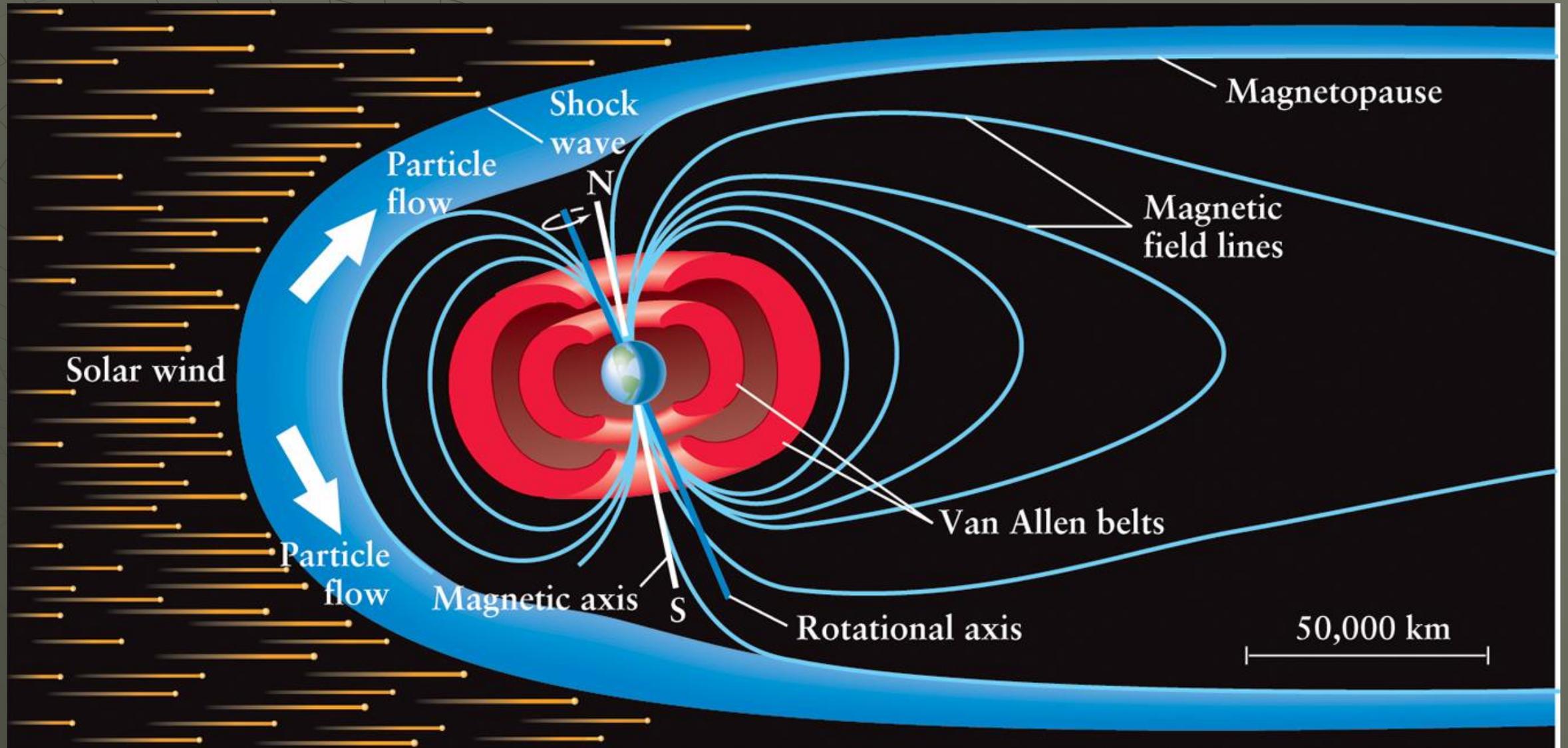


Dynamo

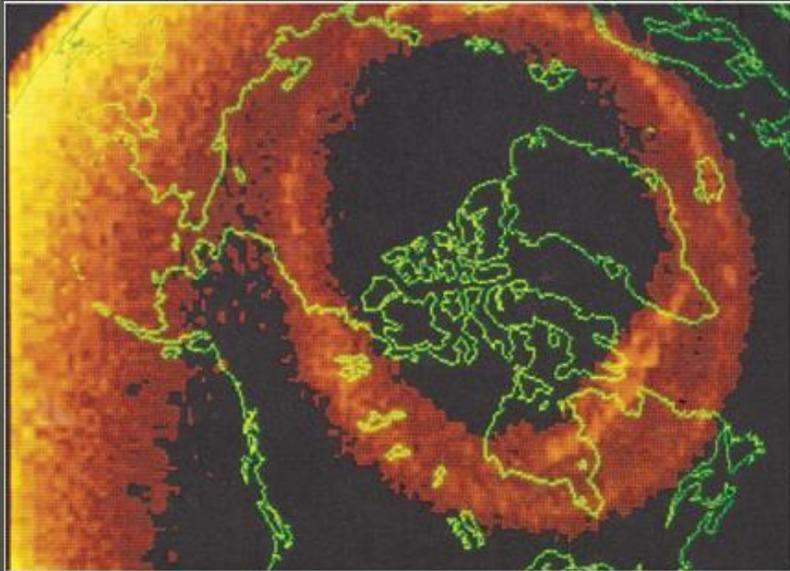
- ◆ Moving charged particles create a magnetic field
- ◆ Demo electromagnet
- ◆ Outer Core is molten lava which has free electrons
- ◆ The Earth's outer core produces a magnetic field



Magnetosphere



Aurora



(a)



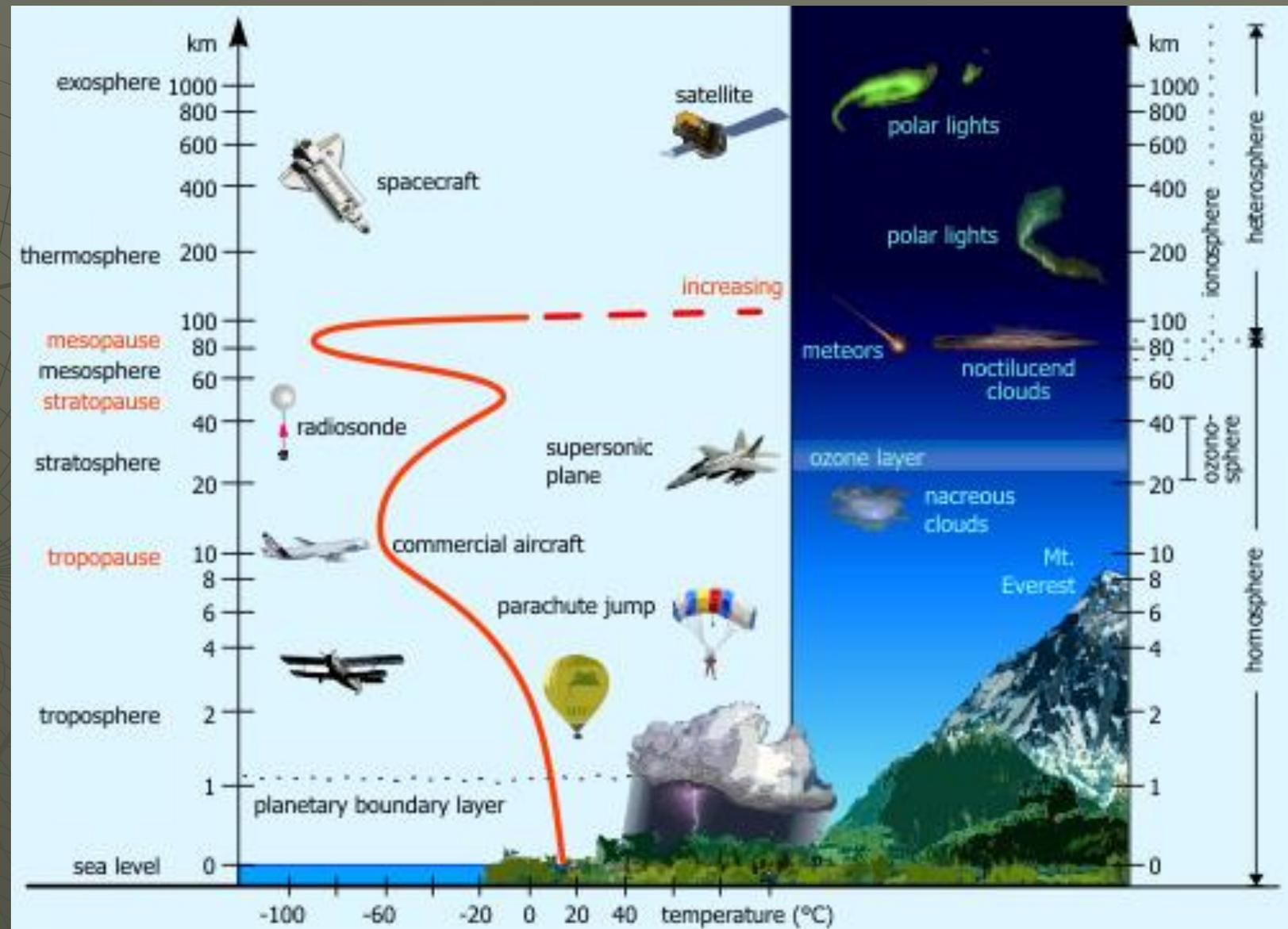
(b)



(c)

Atmosphere

- **Exosphere:** Outer edge
- **Ionosphere:** Ionized by Sun's radiation
- **Thermosphere:** Molecules are heated by the Sun's radiation
- **Mesosphere:** Where meteors burn up (higher density)
- **Stratosphere:** Ozone layer
- **Troposphere:** 80% of the atmosphere's mass and interacts with the surface

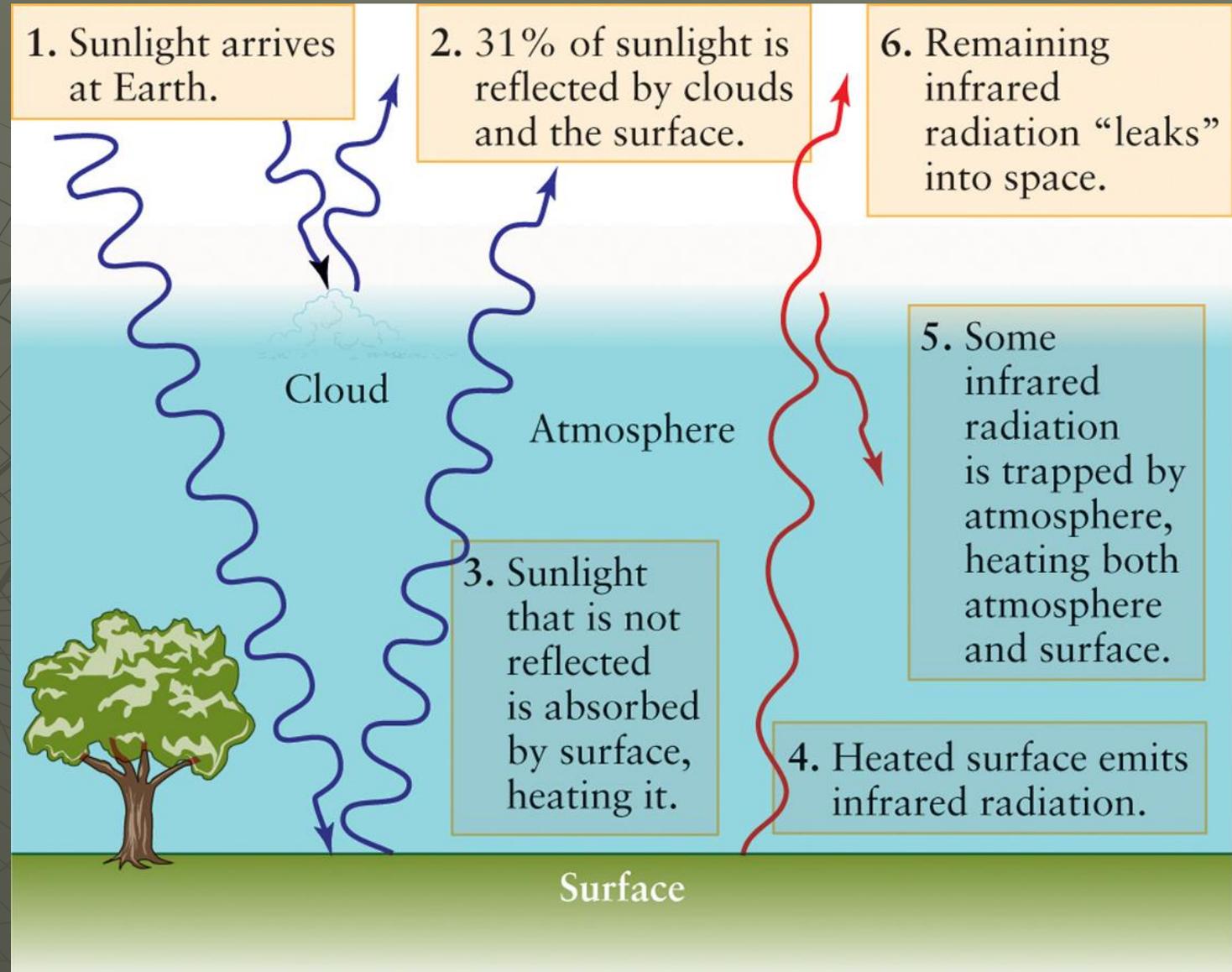


Sun's Affect

- ◆ The Sun is the principle energy source for the Earth
- ◆ The Earth absorbs some and re-emits back into space
- ◆ And reflects some (**albedo**: how reflective a planet is)
- ◆ We can measure the amount of energy absorbed (431 W/m²) and reflected (30%), and can predict Earth's average temp: Flux (W/m²) = σT^4 (black body radiation)
- ◆ -19° C (-2° F) !!!! (Laramie...maybe)
- ◆ Why don't we freeze to death?

Greenhouse Effect

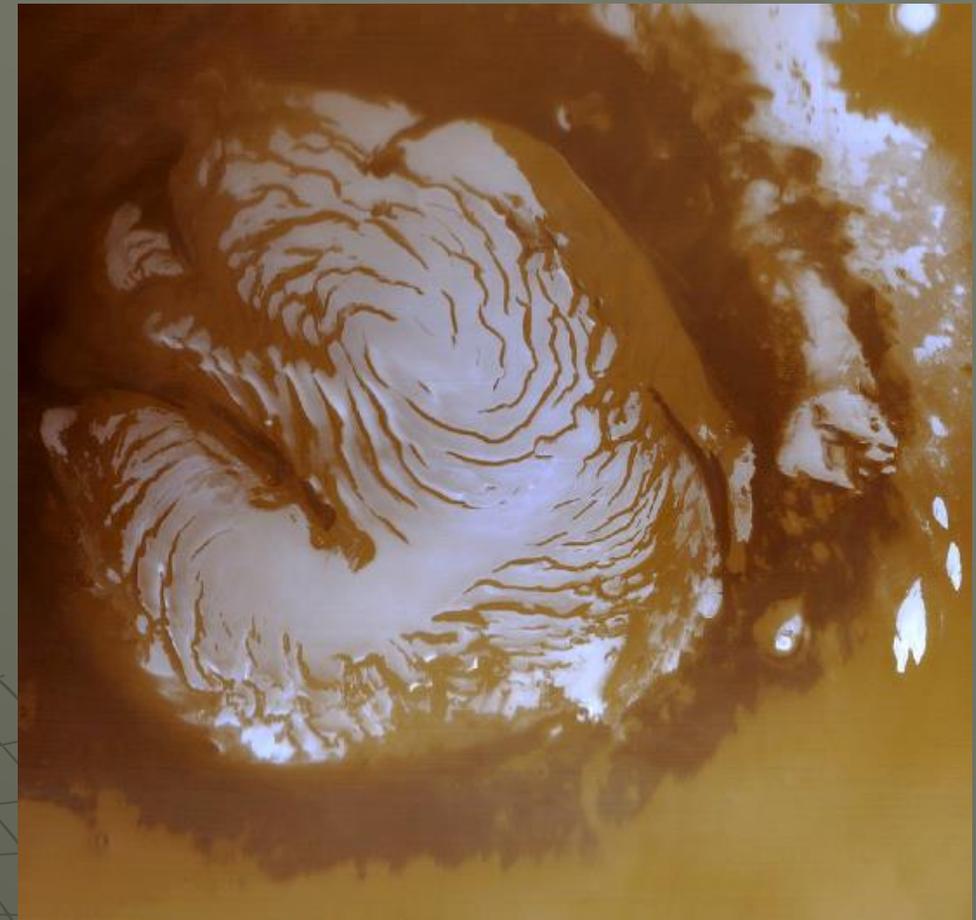
- Some molecules are good at absorbing infrared light (or heat):
 - CO₂
 - H₂O
 - CH₄
- These are **greenhouse gasses**.
- They remit in all directions:
 - Toward space
 - Back to Earth (further heating the planet)
- **Greenhouse gases are transparent to visible light**
- **But absorb and re-emit IR heat**



Runaways!

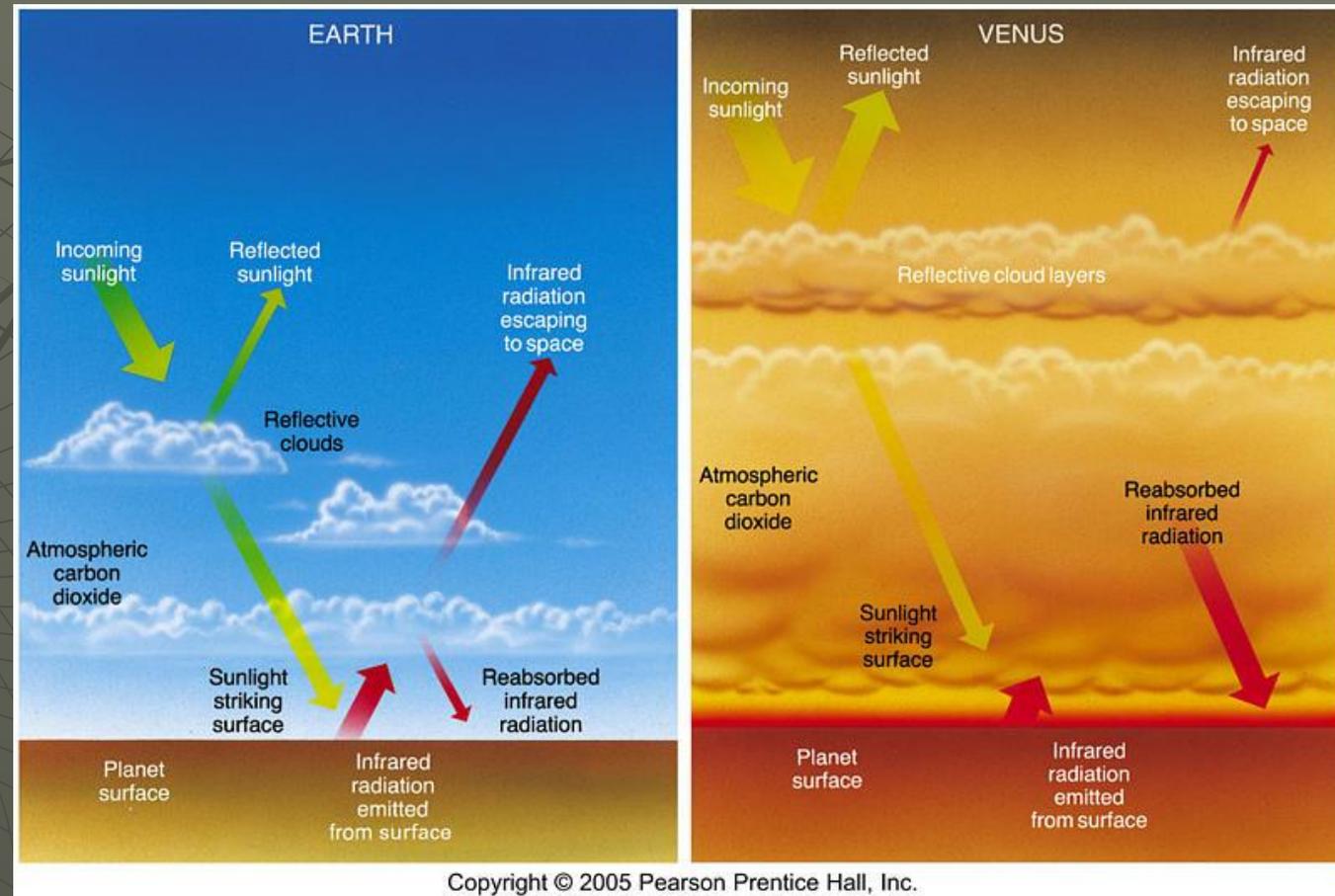
- ◆ Cold runaway – Mars

- Mars has 1/3 the mass of Earth
- **Barely has an atmosphere**
- Less CO₂ and H₂O = less greenhouse
- Colder = more CO₂ and H₂O frozen into the surface
- The colder it is = the more gas trapped in the surface
- And so on....
- **Mars reradiates most of its absorbed energy back into space!**



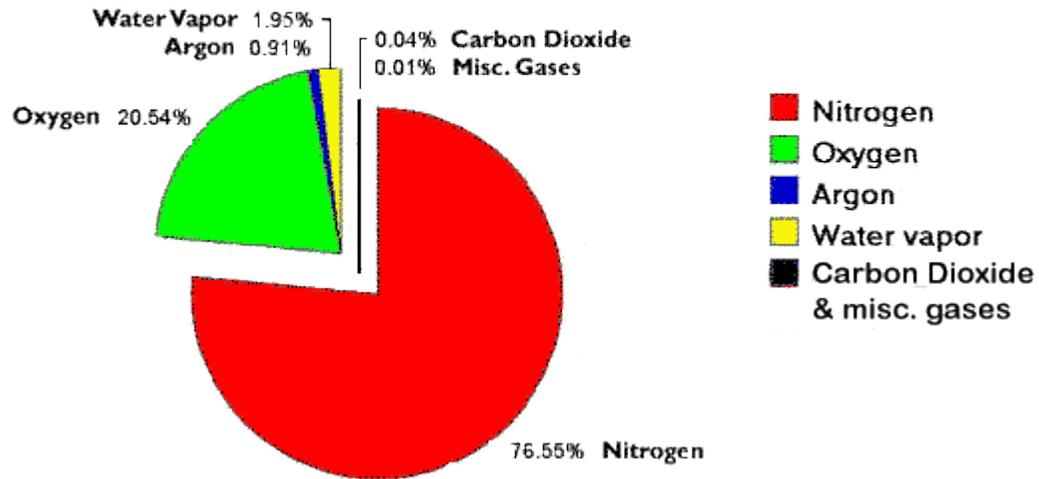
Runaways!

- ◆ Warm runaway – Venus
 - More greenhouse gases = more absorbed heat is sent back to the surface
- ◆ The hotter it is the more greenhouse gases are released into the atmosphere
- ◆ More greenhouse gases...
- ◆ And so on



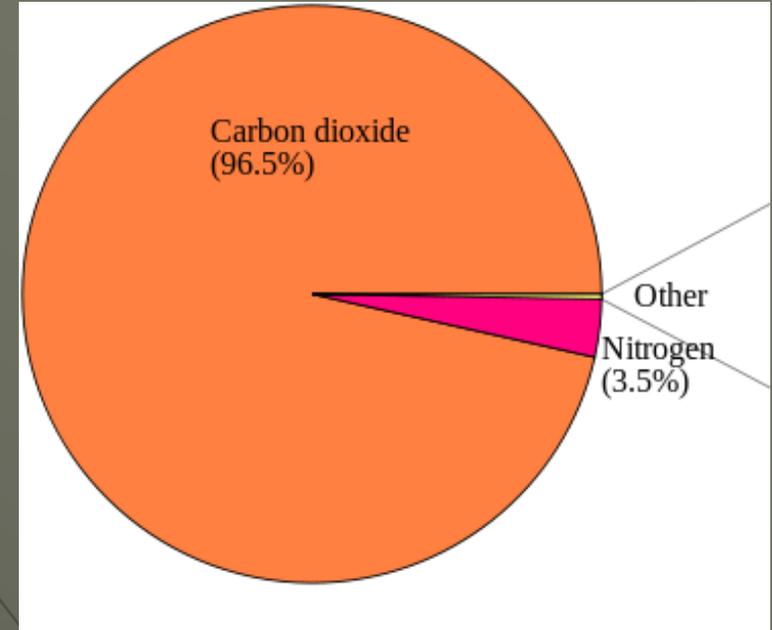
Comparison

The Gases That Comprise Earth's Atmosphere



Mars: too small to really have an atmosphere

Venus & Mars



Venus

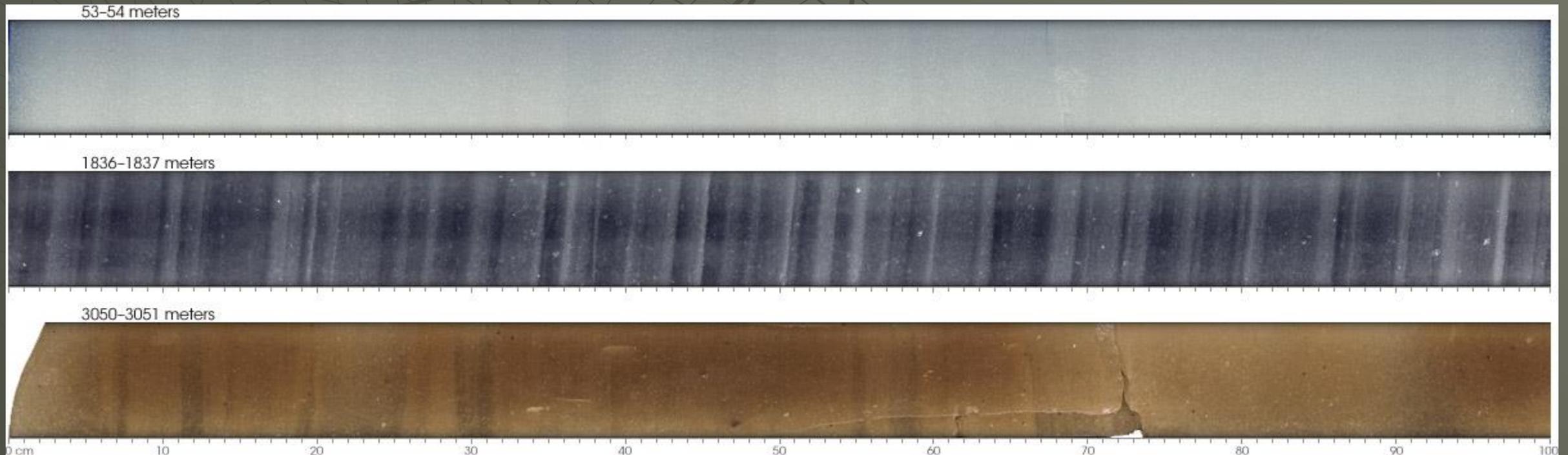
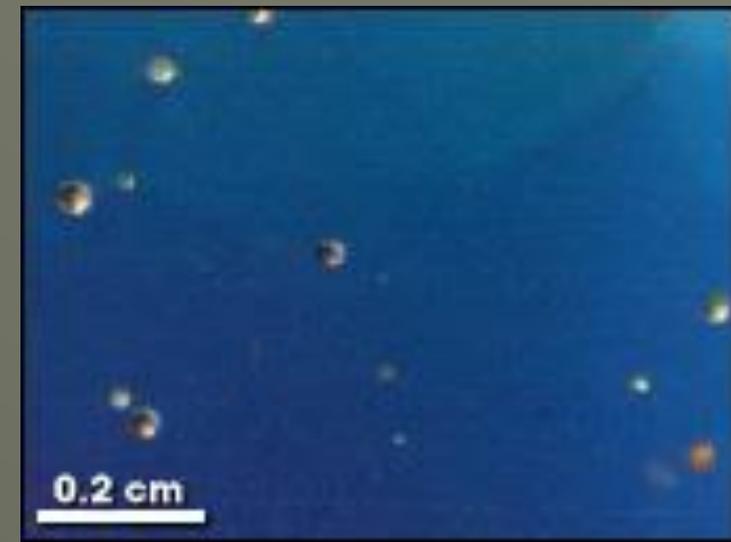
Earth

Mars

Surface temperature	450°C	13°C	-53°C
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Earth's Past Climate

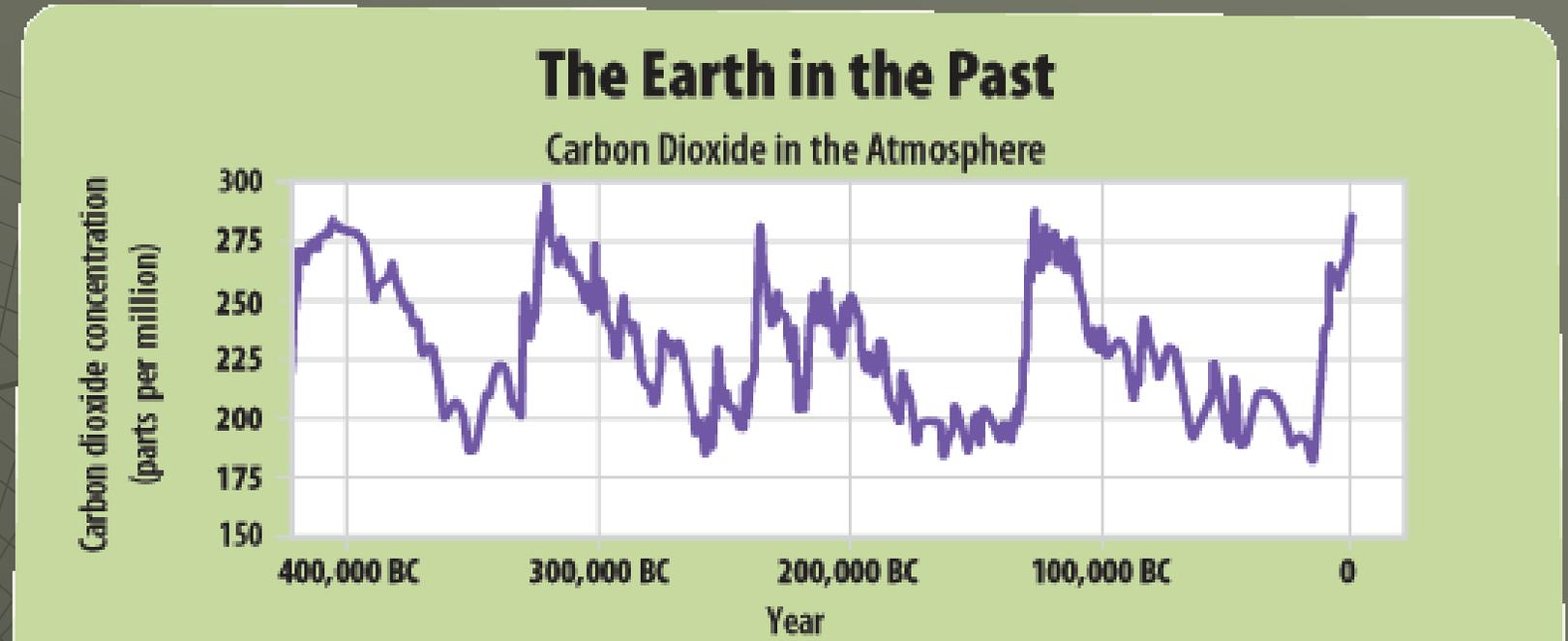
- ◆ **Climate:** general weather conditions over an extended period of time.
- ◆ **Ice Cores, past 600,000 years**



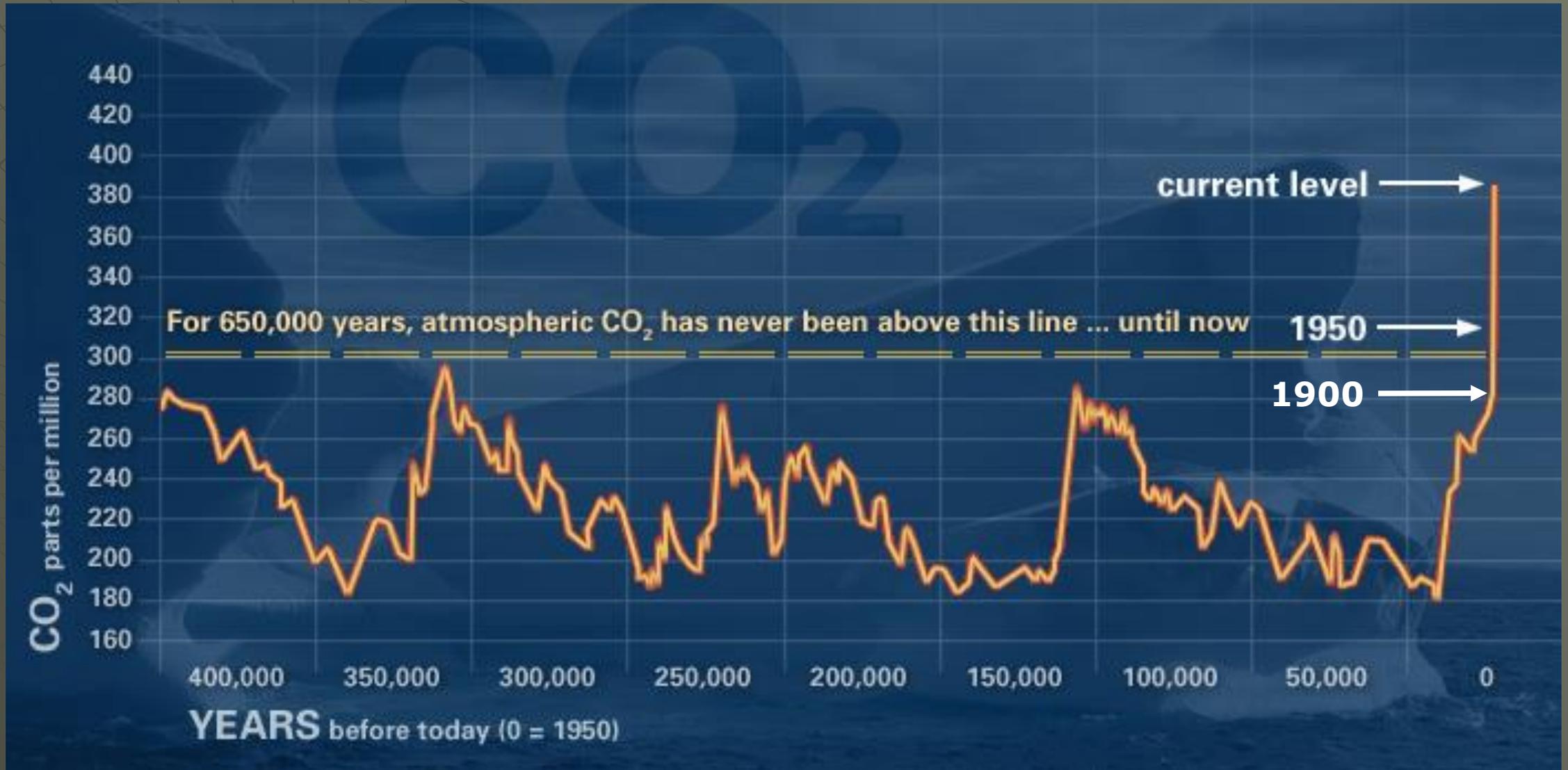
Earth's Past Climate

650,000 years ago – 1900

- Natural variations due to our orbit.
- Do you expect the Temperature to follow the CO₂ concentration?



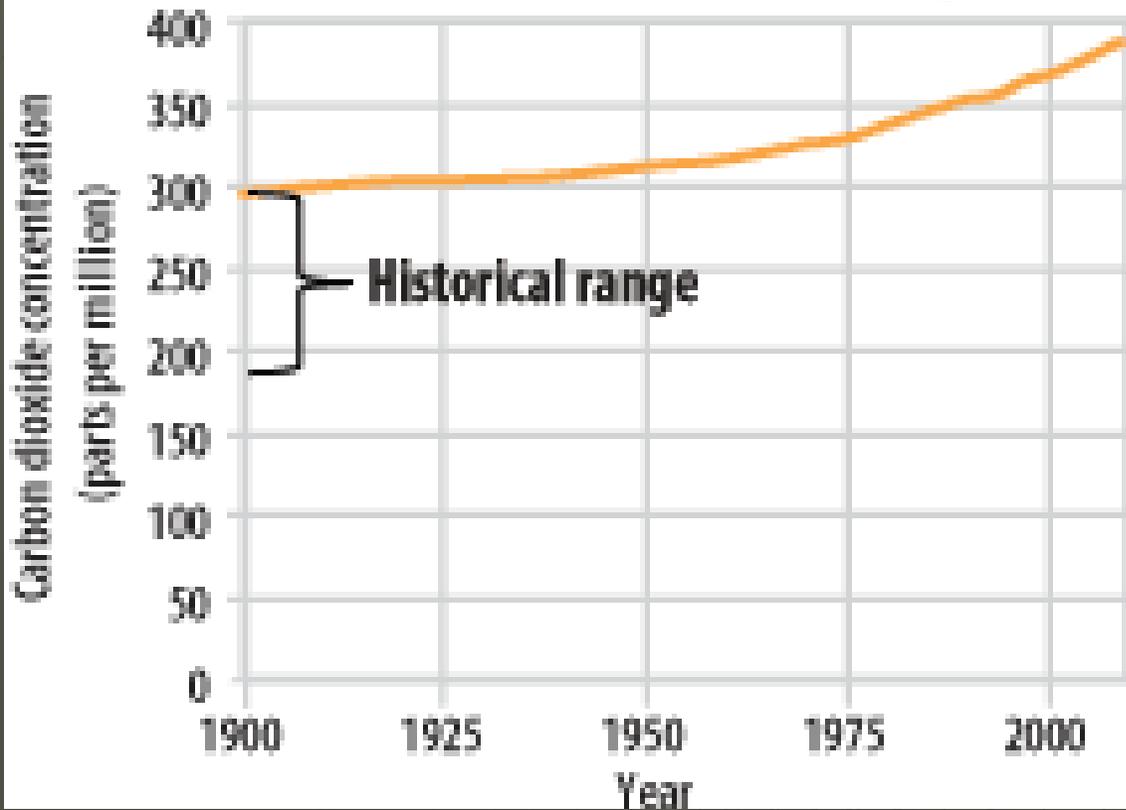
Add Data from the Last 100 years



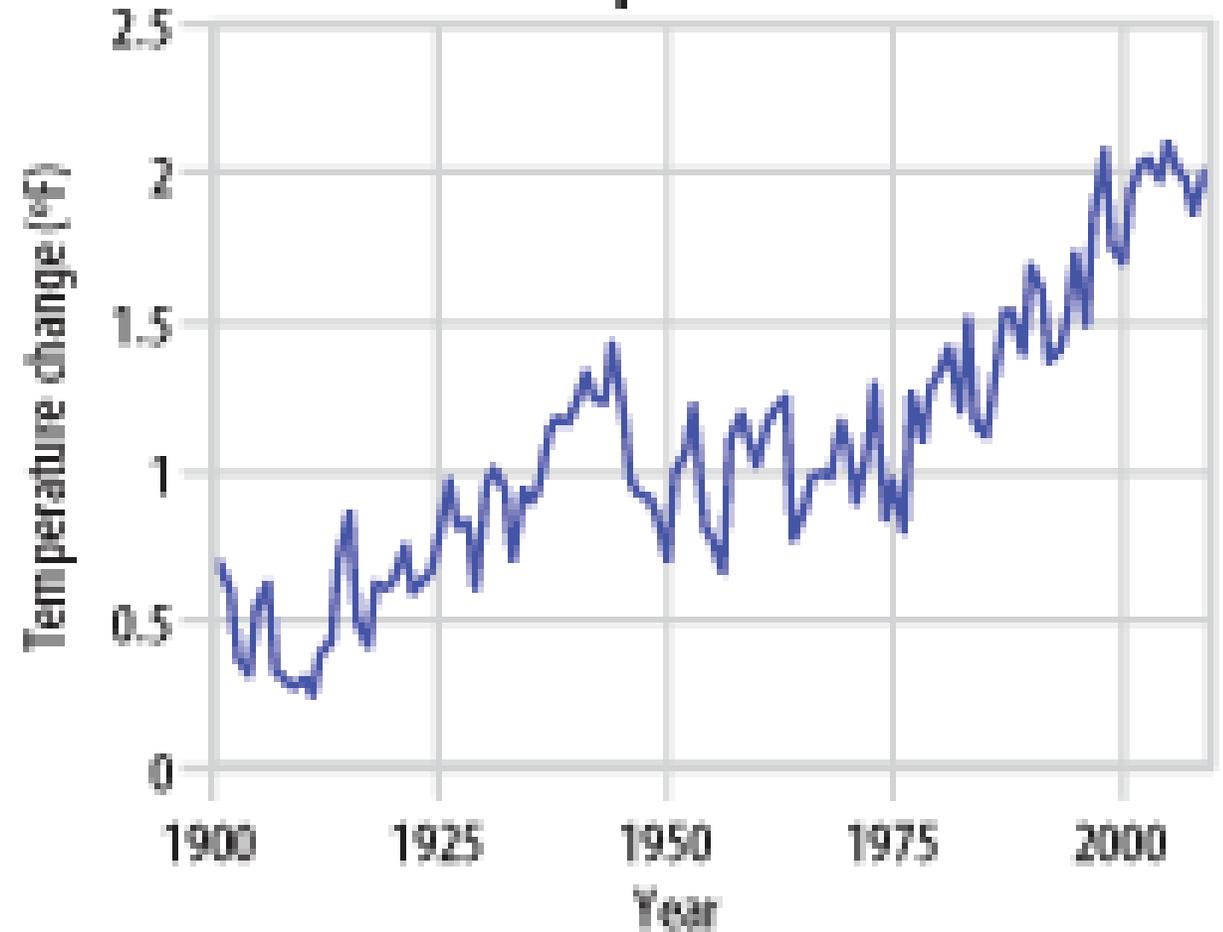
Over the past 100 years

Recent Change

Carbon Dioxide in the Atmosphere



Temperature



- ◆ What effect would an increase in Earth's albedo have on the planet?
 - A. Earth would be colder than it is now.
 - B. The liquid core would be smaller than it is now.
 - C. The magnetic field would be stronger than it is now.
 - D. Earthquakes would be more frequent than they are now.

◆ The greenhouse effect occurs because Earth's atmosphere is transparent to _____ light and partially opaque to _____ light.

- A. visible; ultraviolet
- B. ultraviolet; visible
- C. infrared; visible
- D. visible; infrared