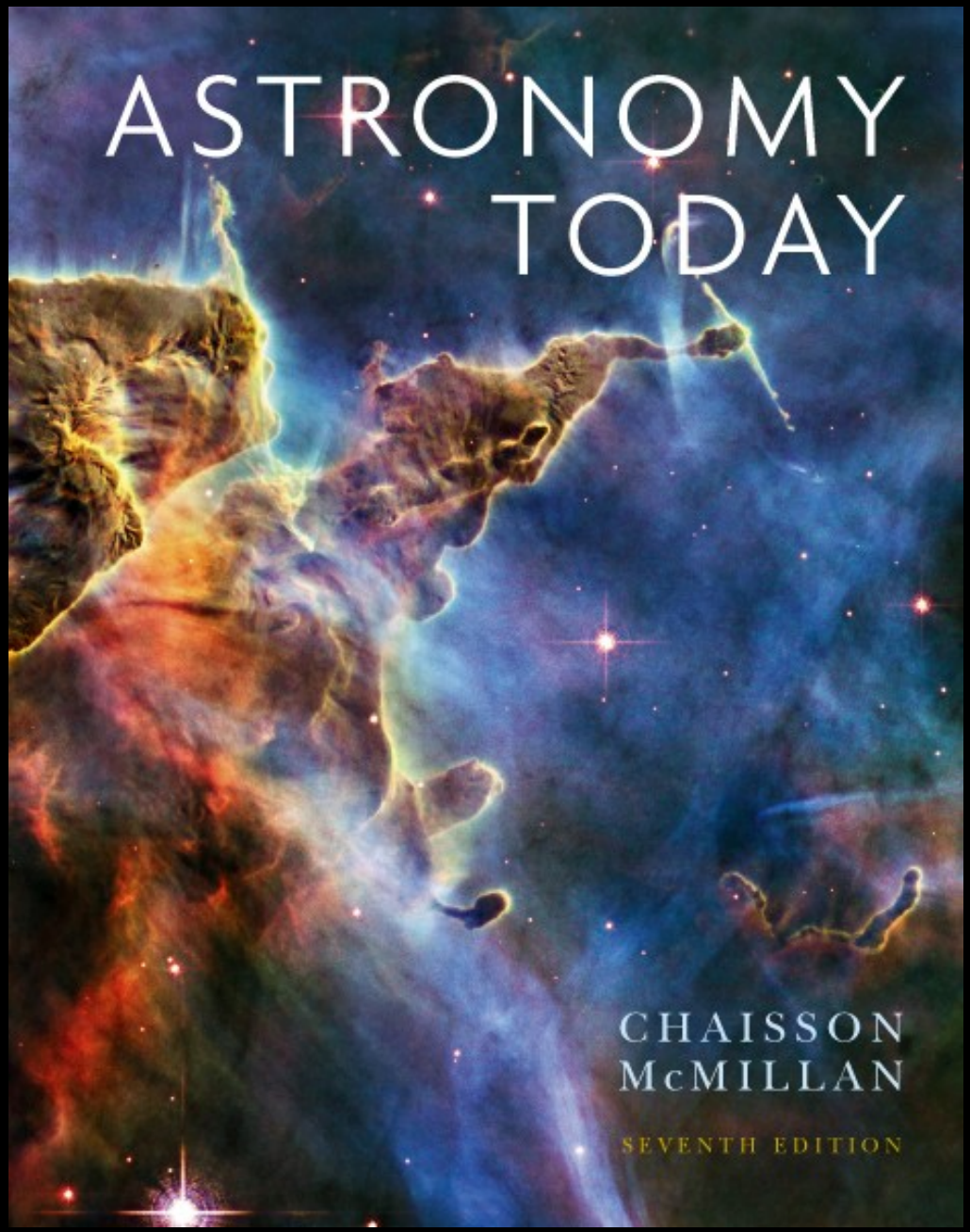


Lecture Outlines

Chapter 7

Astronomy Today

7th Edition

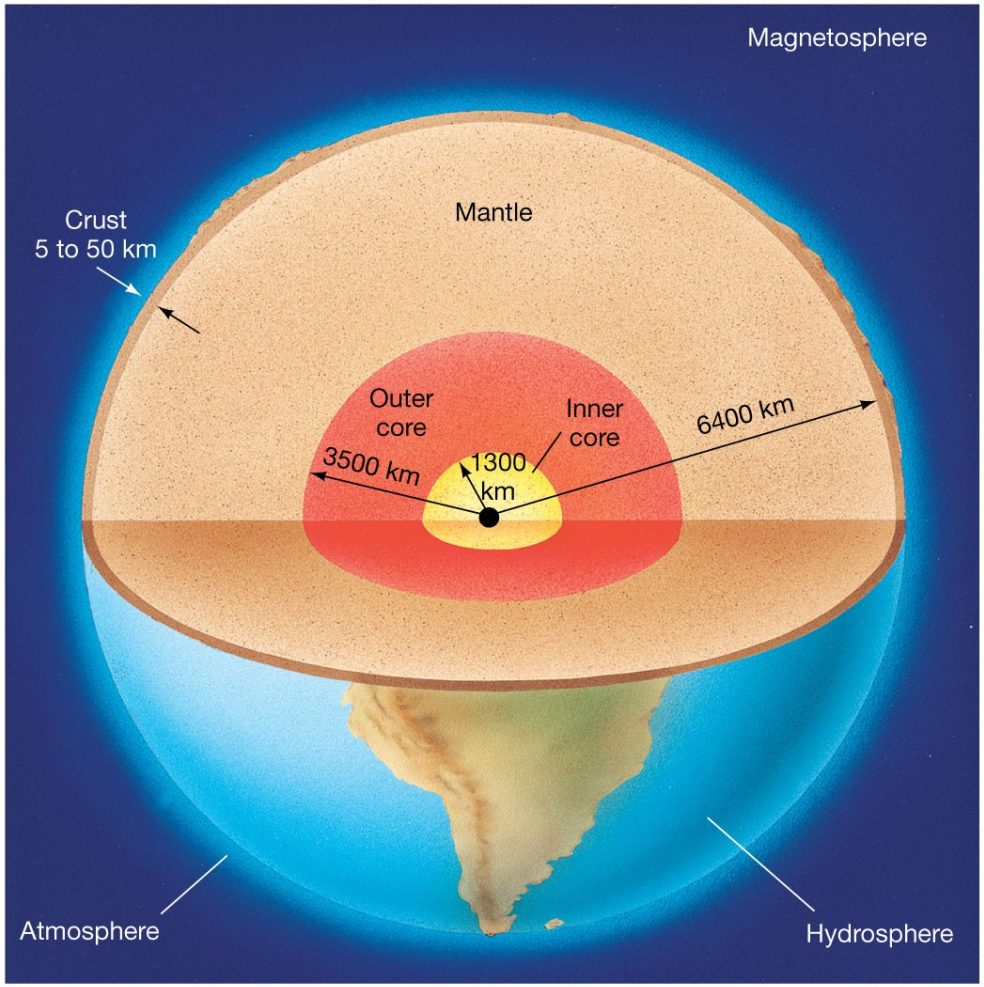
Chaisson/McMillan

Chapter 7
Earth

Units of Chapter 7

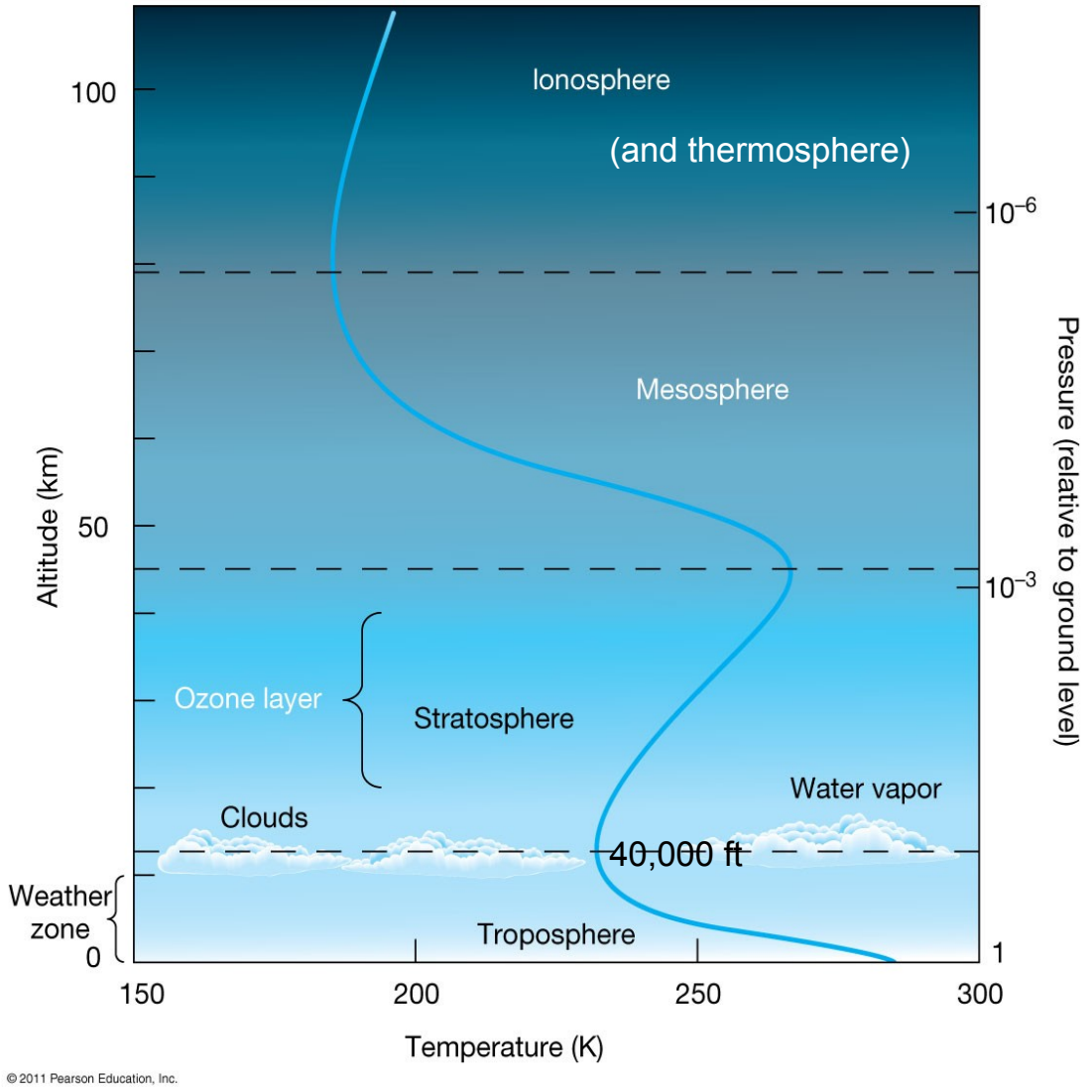
7.1 Overall Structure of Planet Earth

- **Two-part core**
- **Mantle**
- **Thin crust**
- **Hydrosphere (oceans)**
- **Atmosphere**
- **Magnetosphere**



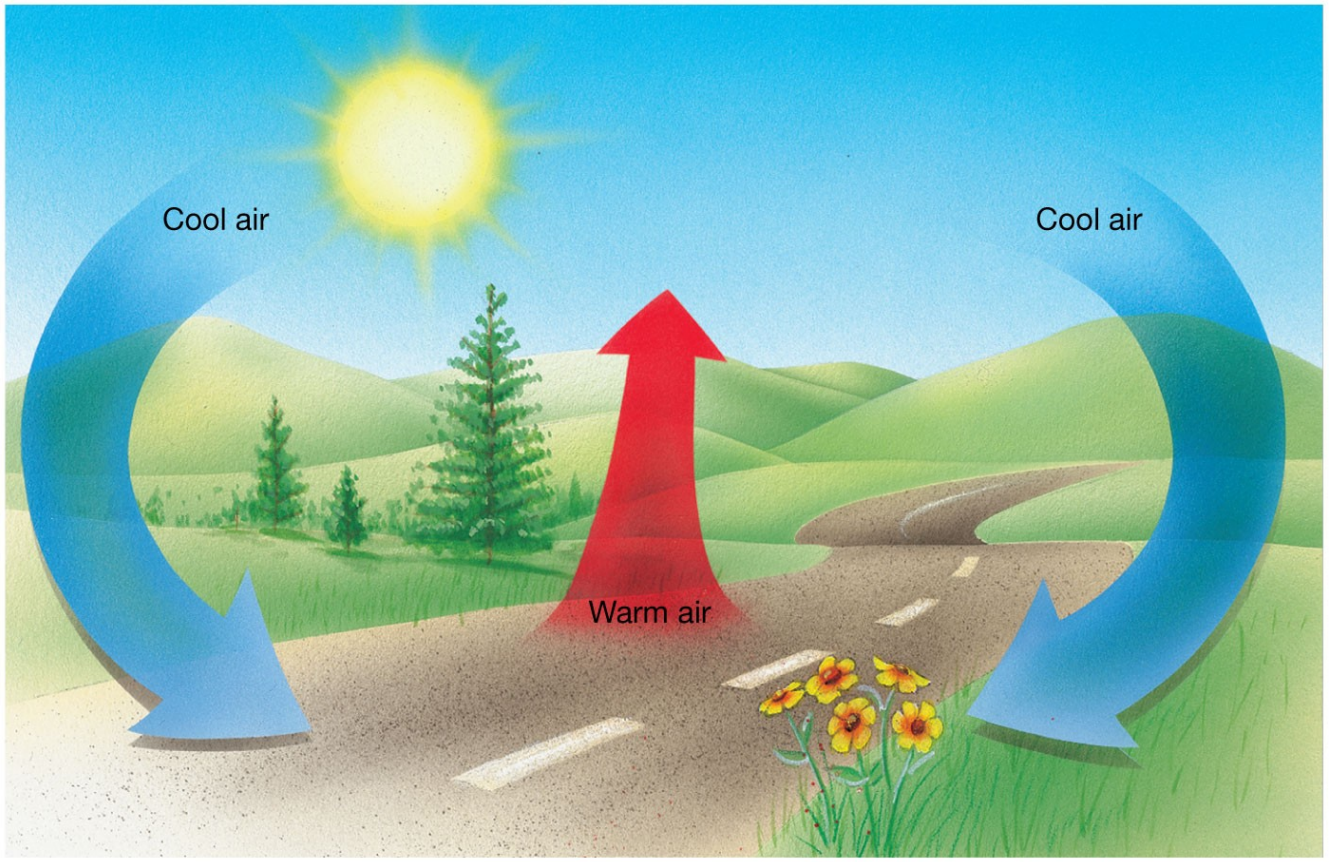
7.2 Earth's Atmosphere

- **The blue curve shows the temperature at each altitude**
- **Troposphere is where most of our weather occurs. It is where convection occurs when the temperature gradient is steep.**



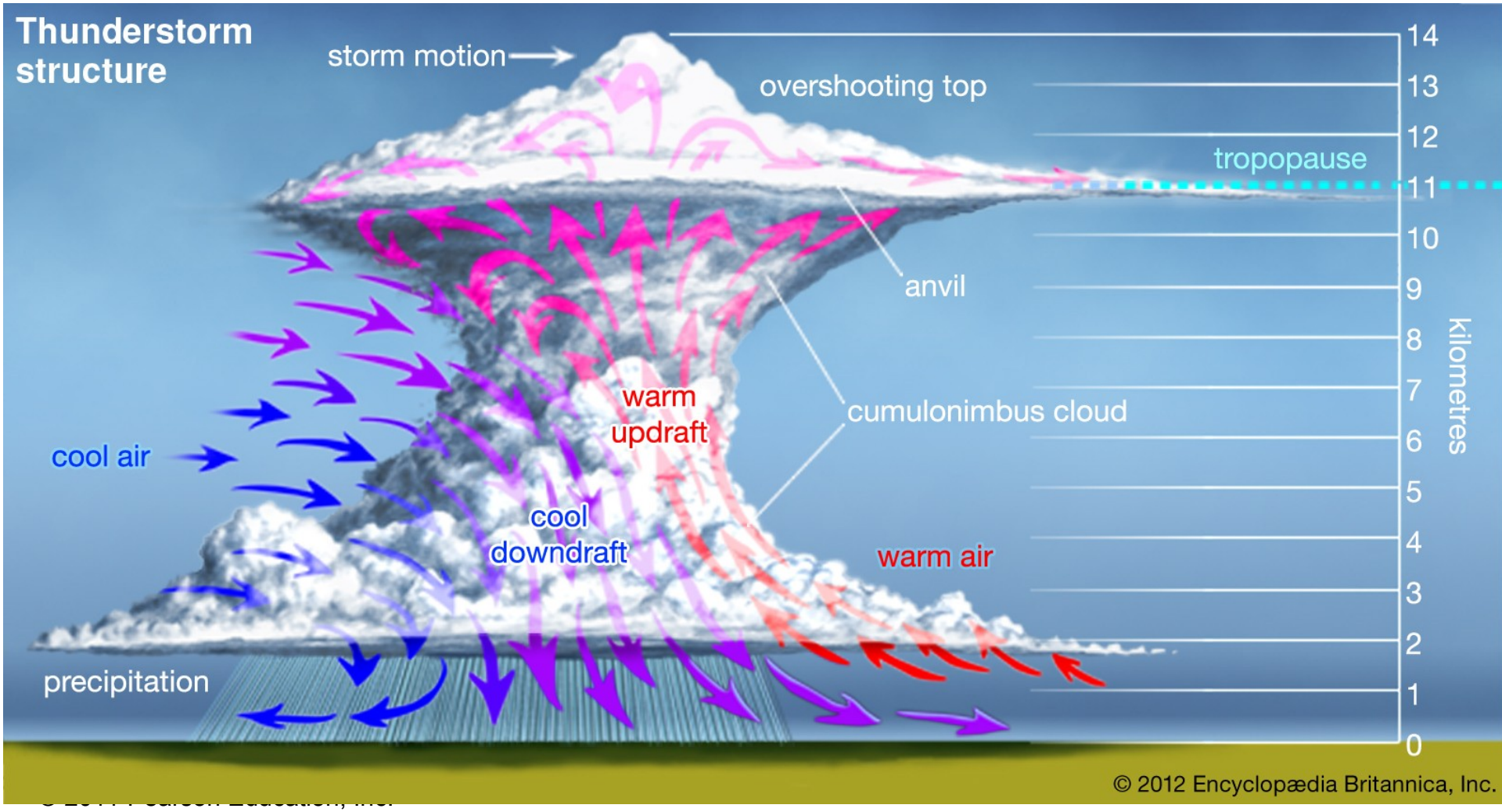
7.2 Earth's Atmosphere

Convection depends on warming of ground by the Sun



7.2 Earth's Atmosphere

Convection builds cumulus clouds.



7.2 Earth's Atmosphere

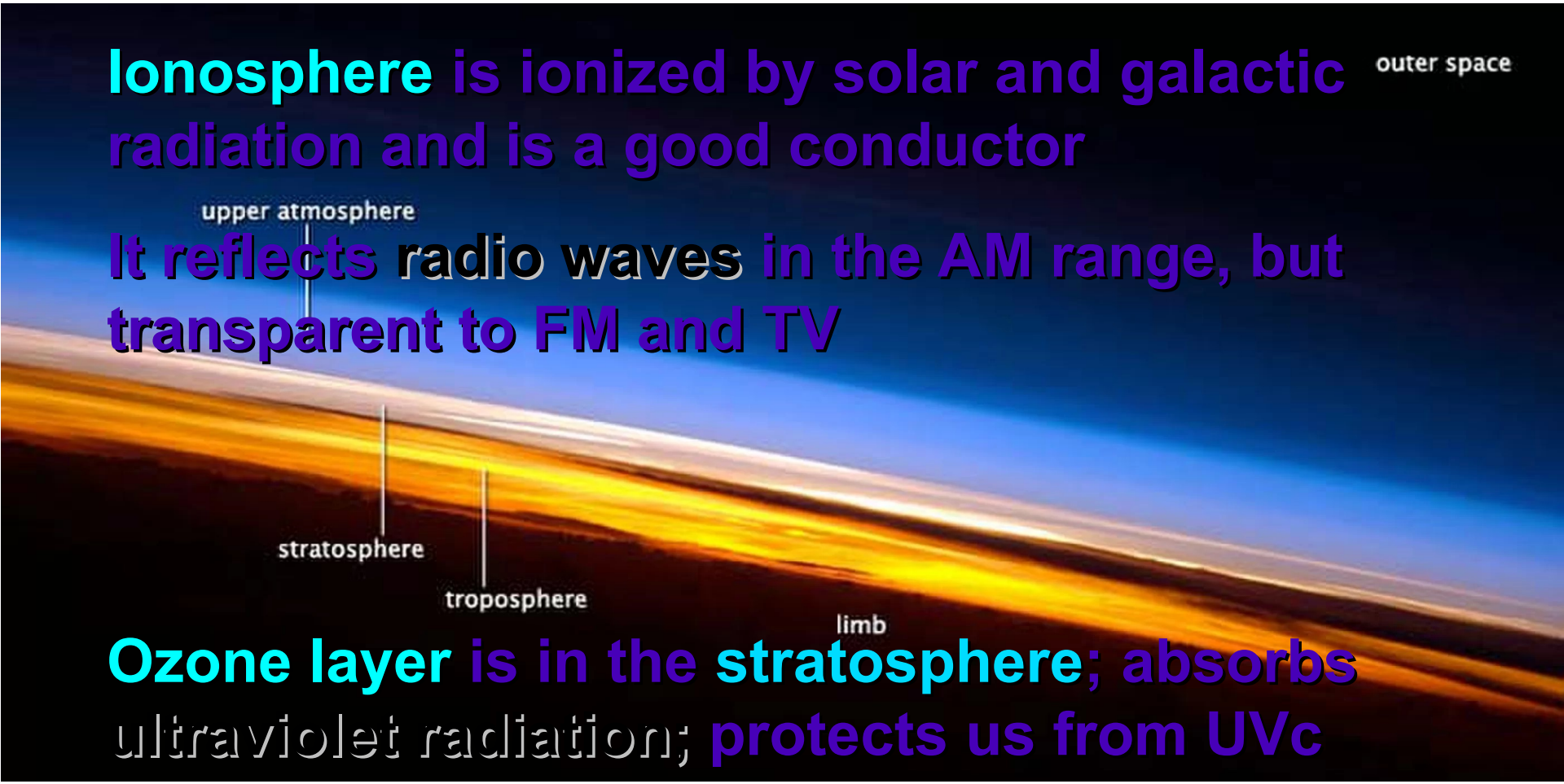
The Stratosphere and Mesosphere can sometimes produce clouds.

Noctilucent clouds

(See also nacreous clouds, and PMCs)

Photo by Graeme Whipps

7.2 Earth's Atmosphere



Ionosphere is ionized by solar and galactic radiation and is a good conductor

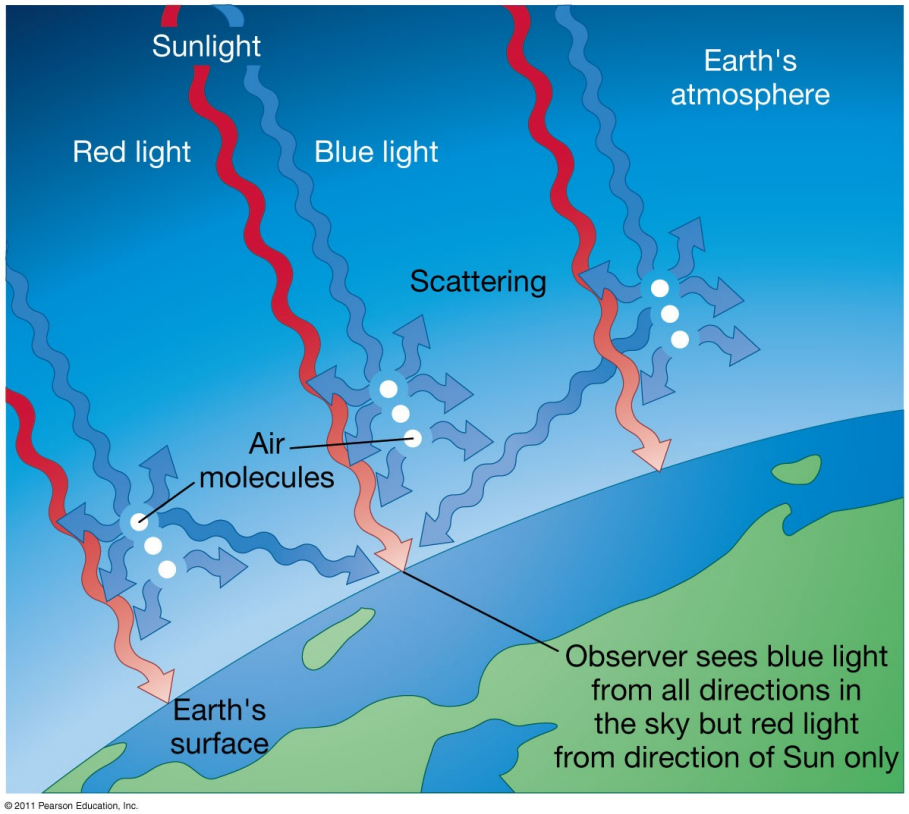
It reflects radio waves in the AM range, but transparent to FM and TV

Ozone layer is in the **stratosphere**; absorbs ultraviolet radiation; protects us from UVc

More Precisely 7-1: Why Is the Sky Blue?

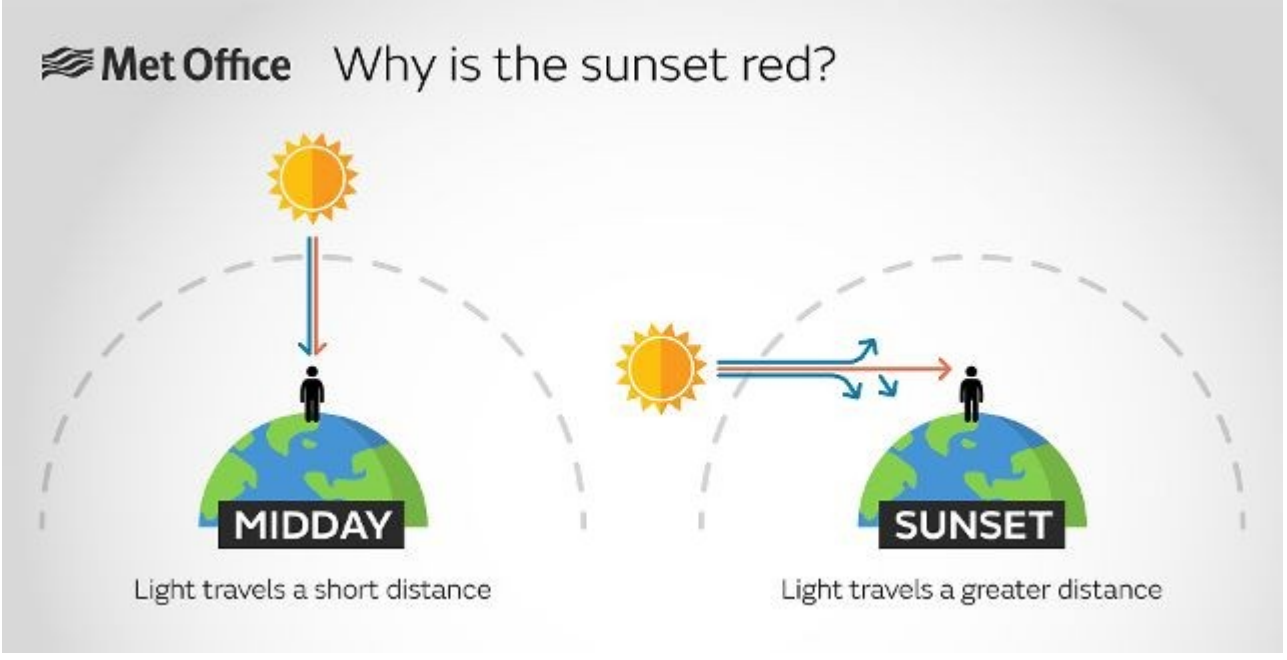
Scattering of light by air depends on the wavelength of the light—the wavelength of blue light is closer to the size of air molecules, so it is scattered most strongly.

Scattering ~ $1/\lambda^4$



More Precisely 7-1: Why Is the Sky Blue?

When the Sun is close to the horizon, its light must pass through more air and dust to reach us. With the blue light greatly diminished, the Sun looks orange or red.

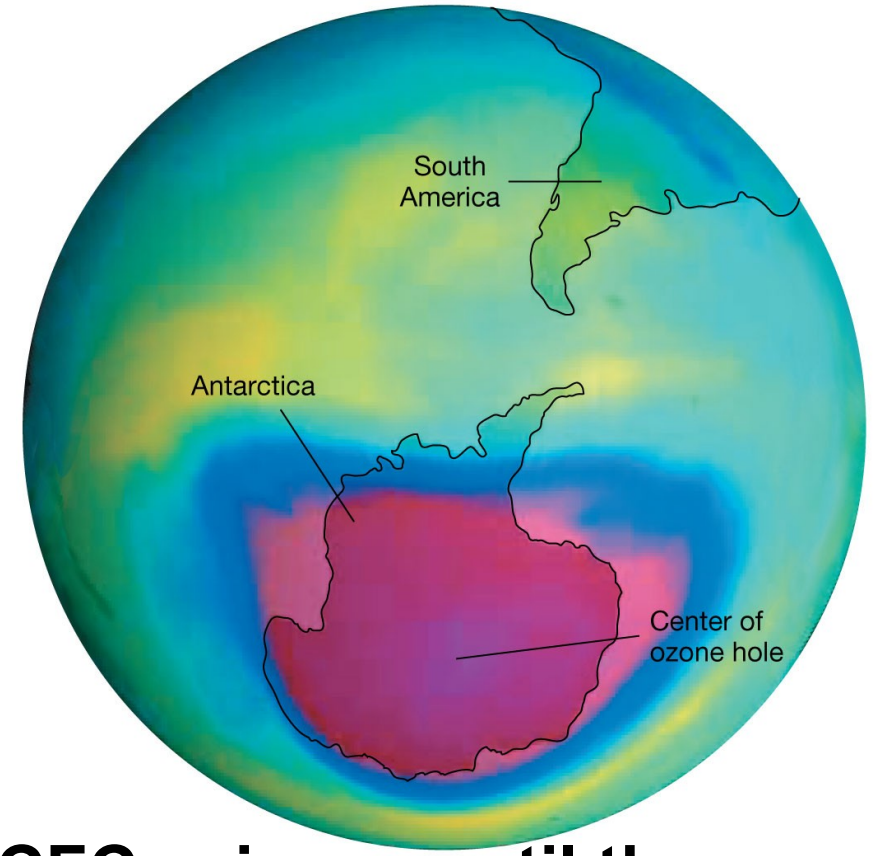


7.2 Earth's Atmosphere

Chlorofluorocarbons (CFCs) have damaged the ozone layer, resulting in ozone hole.

Fortunately, regulations restricting the use of CFCs have helped the problem.

Freon replaced by R-410A

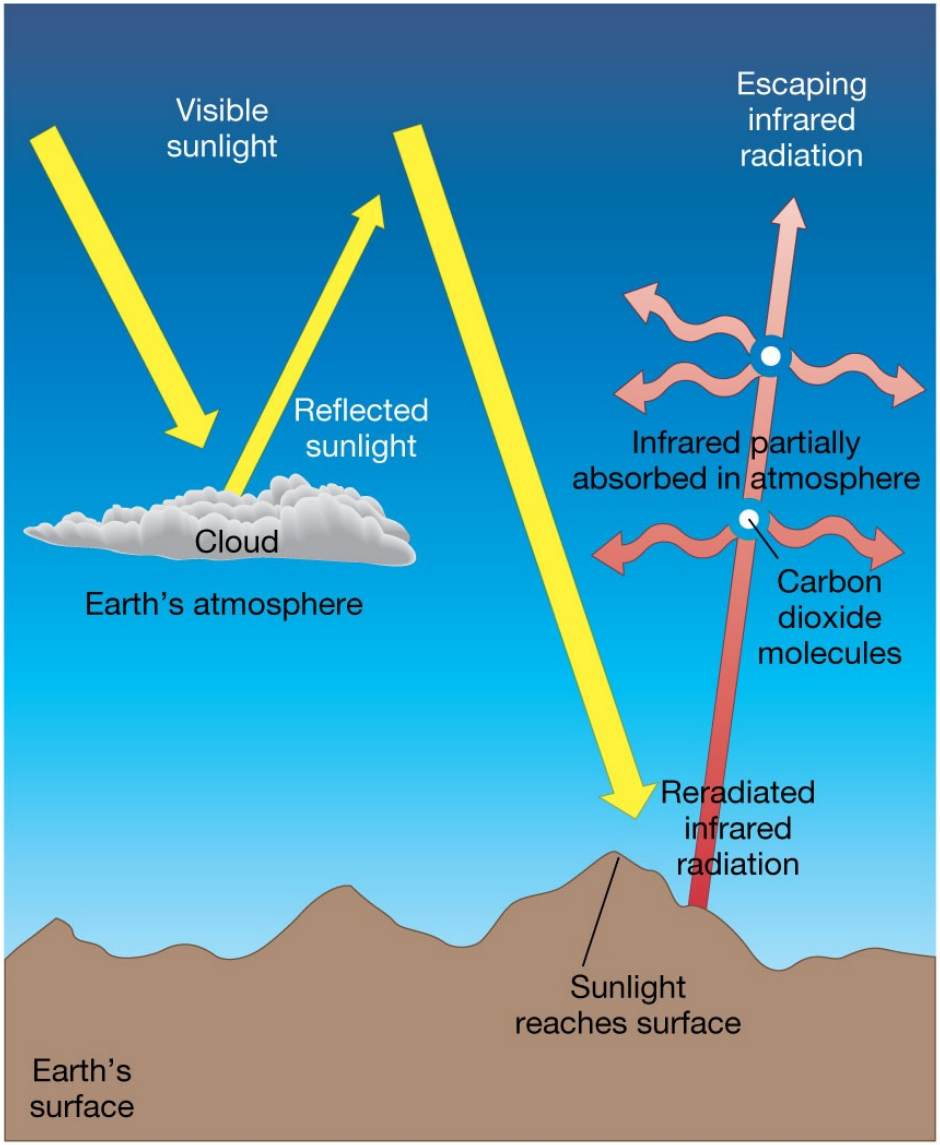


Dupont tried to question anti-CFC science until they patented an alternative ... and abruptly began condemning CFCs.

7.2 Earth's Atmosphere

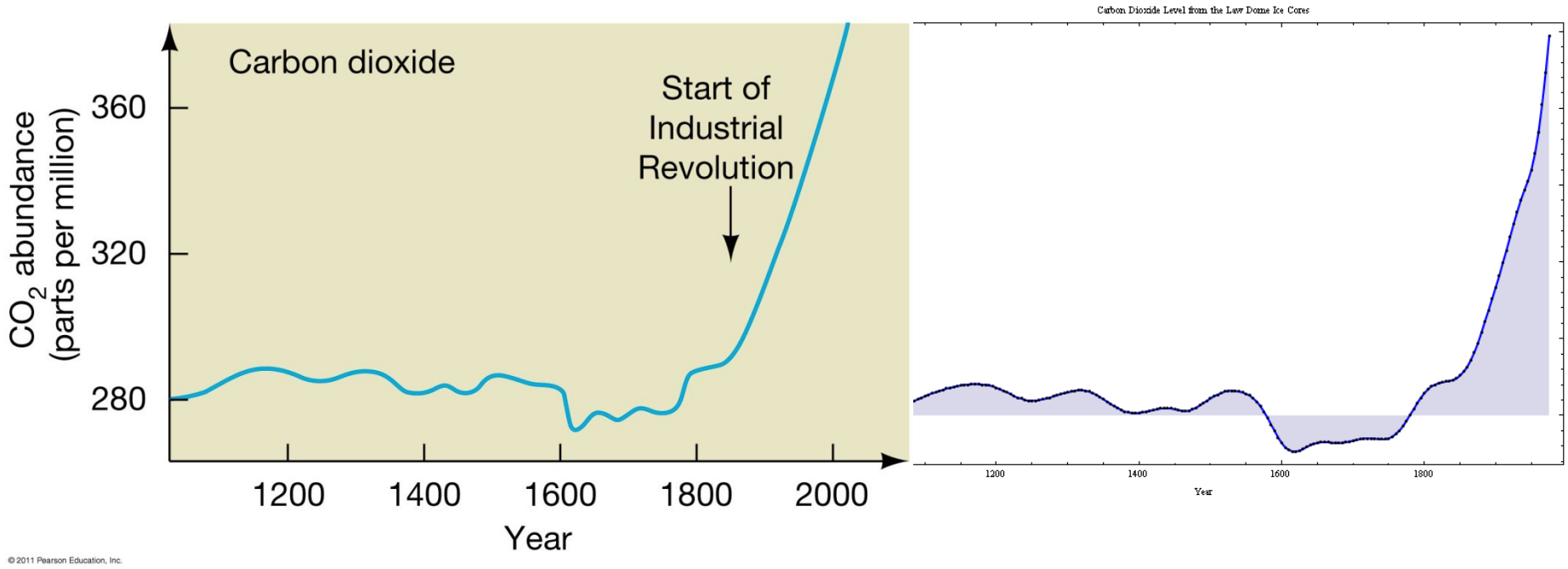
The greenhouse effect refers to the way the reradiated IR (upward red arrow) is partly redirected back down to Earth.

The H_20 and CO_2 molecules absorb IR and then re-emit it in all directions.



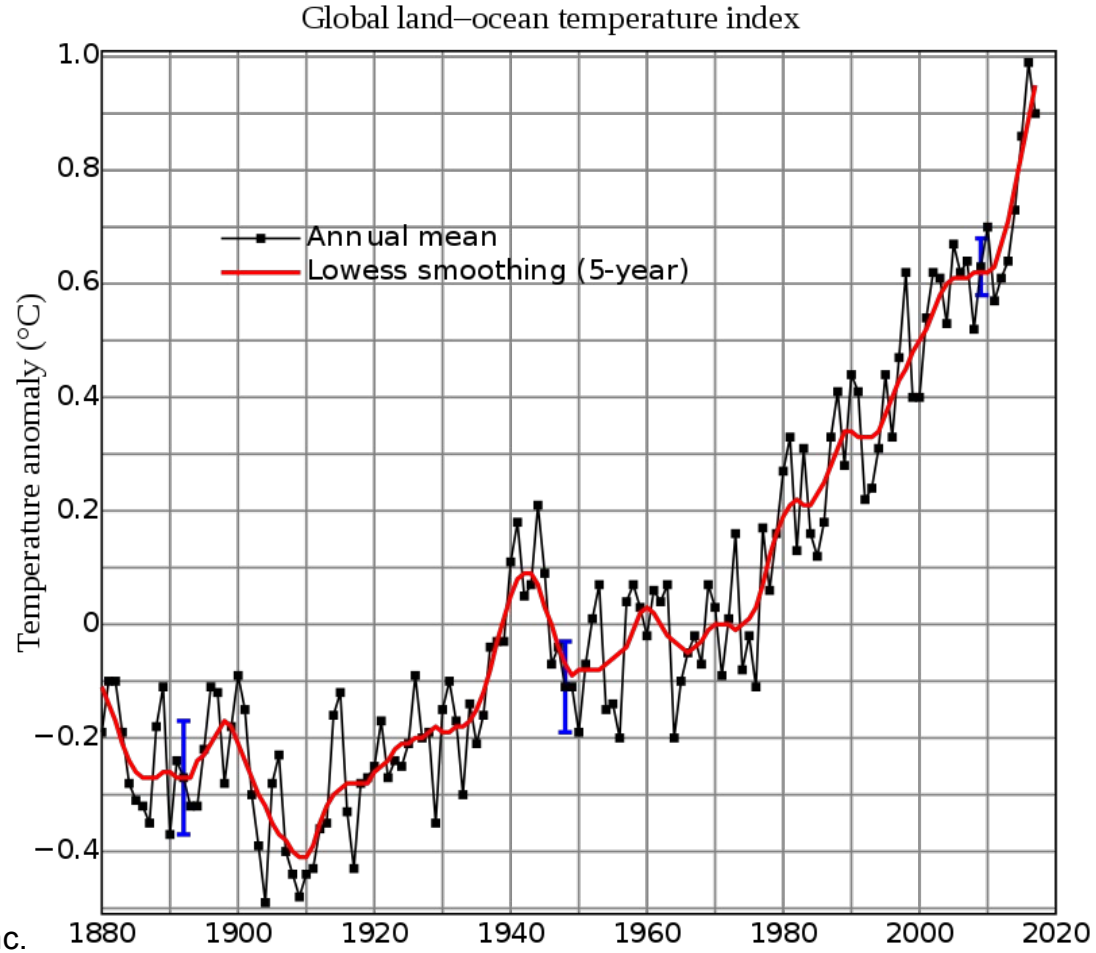
Discovery 7-1: The Greenhouse Effect and Global Warming

One result of modern society has been to increase CO_2 levels in the atmosphere. The increase in CO2 is clear and the correlation with the burning of fossil fuels *suggests* an <u>anthropogenic</u> (man-made) cause.



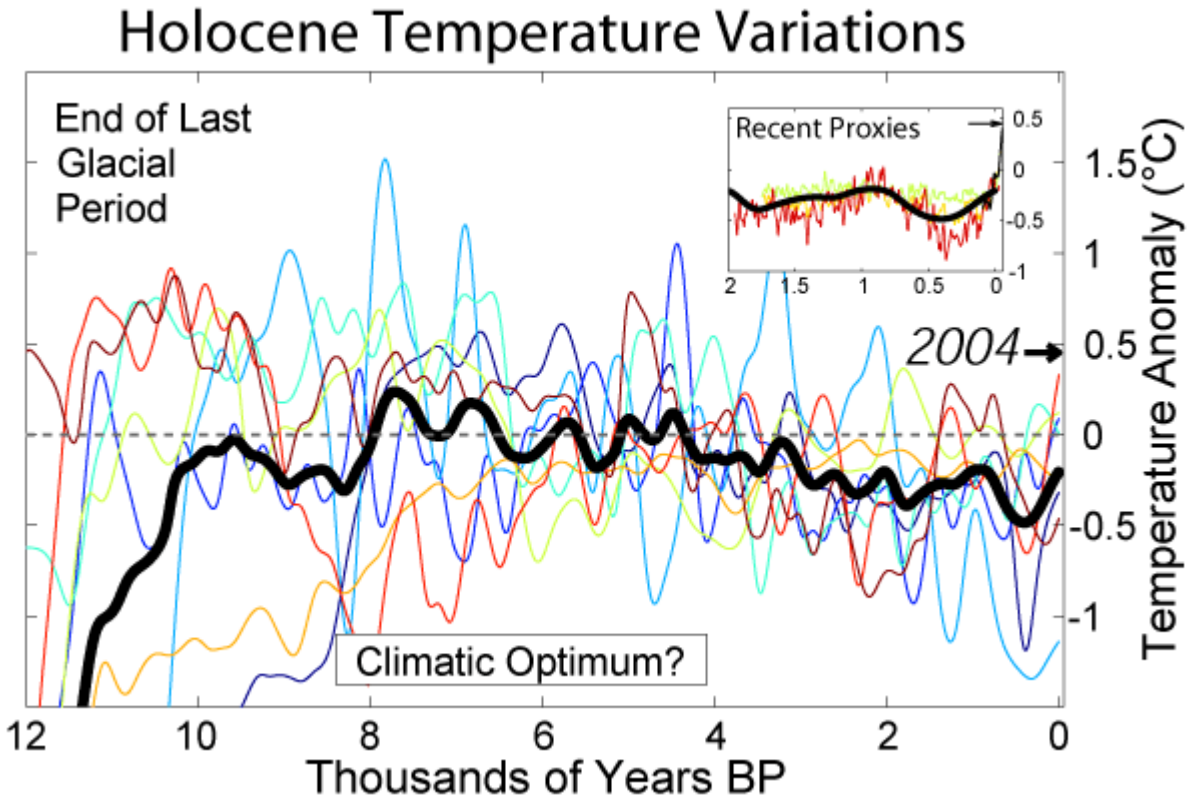
Discovery 7-1: The Greenhouse Effect and Global Warming

A corresponding small (~1°C) but significant increase in global average temperature has been seen as well.



Discovery 7-1: The Greenhouse Effect and Global Warming

The causes of temp change are many, but climate scientists are in >97% agreement that we have <u>AGW</u>.



"Deniers" claim that the increase in T is a part of Earth's natural cycles.

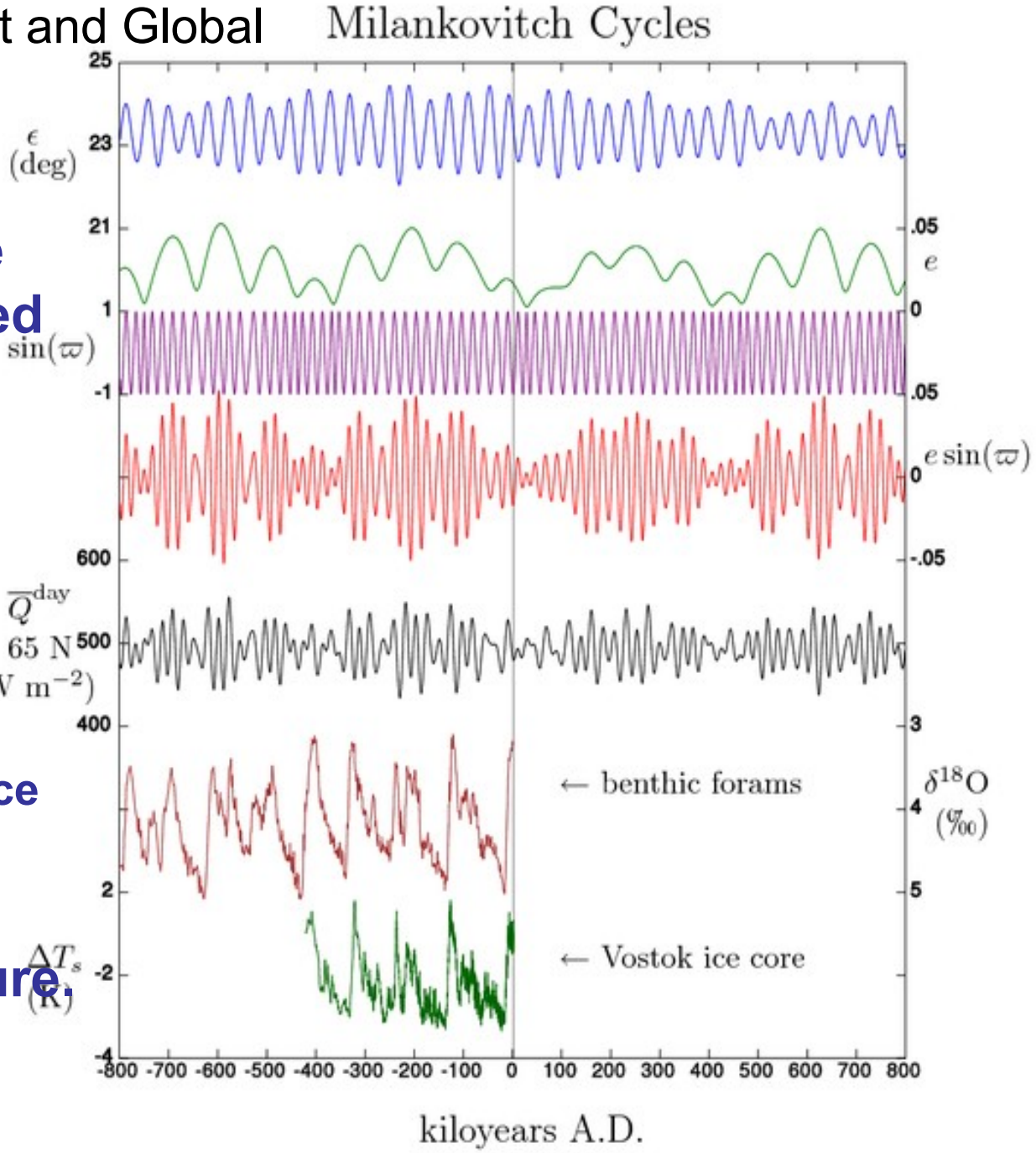
The Greenhouse Effect and Global Warming

The natural cycles in climate related to the Earth's orbit are called Milankovitch Cycles.

Shown are:

Obliquity
Eccentricity
Longitude of perihelion
Precession index
Insolation on Sum.Solstice

Proxies for sea level and global temperature.



Discovery 7-1: The Greenhouse Effect and Global Warming

Some possible consequences of global warming:

- **Rise in sea level**
- **More severe weather**
- **Crop failures (as climate zones change)**
- **Expansion of deserts**
- **Spread of tropical diseases away from the tropics**

Factors that should **positively** reinforce Global Warming (i.e., make things worse)

Higher temperatures means that more water will be in the vapor state (adding to the Greenhouse effect) than the liquid state.

As oceans warm, they can hold less dissolved CO_2, so more CO_2 is added to the atmosphere.

As snow and ice are lost, the Earth's surface becomes more absorptive of sunlight (decreased albedo) adding to more heating.

Factors that should **positively** reinforce Global Warming (cont.)

- **Some ecosystems will loose plant life with increasing Temps, and with less plants, there can be less CO_2 consumption by those plants.**

- **Higher temps result in more methane being released from permafrost, peat bogs, and methane clathrate on the sea floor.**

- **As glaciers and ice shelves melt we loose a temperature "buffer" - thermal energy will go into increasing temperature instead of melting.**

Factors that should negatively reinforce Global Warming (i.e., make things better)

The hotter the Earth, the more it radiates away IR. This is the Stefan-Boltzmann equation (Ch. 4), where Luminosity ~ T^4.

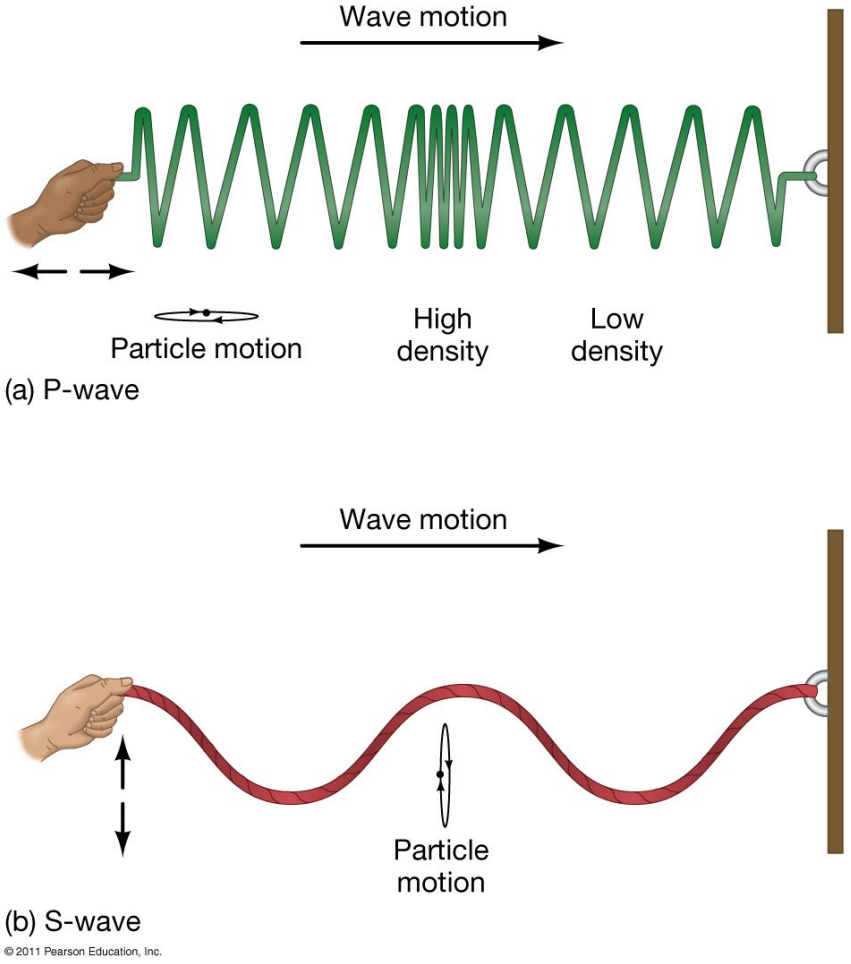
Some regions (eg. northern latitudes) may be able to support MORE plant life which can then take more CO_2 out of the atmosphere.

More moisture in the atmosphere could mean more cloud cover. Clouds increase the average albedo (reflectivity) of the Earth so that it absorbs less light from the Sun.

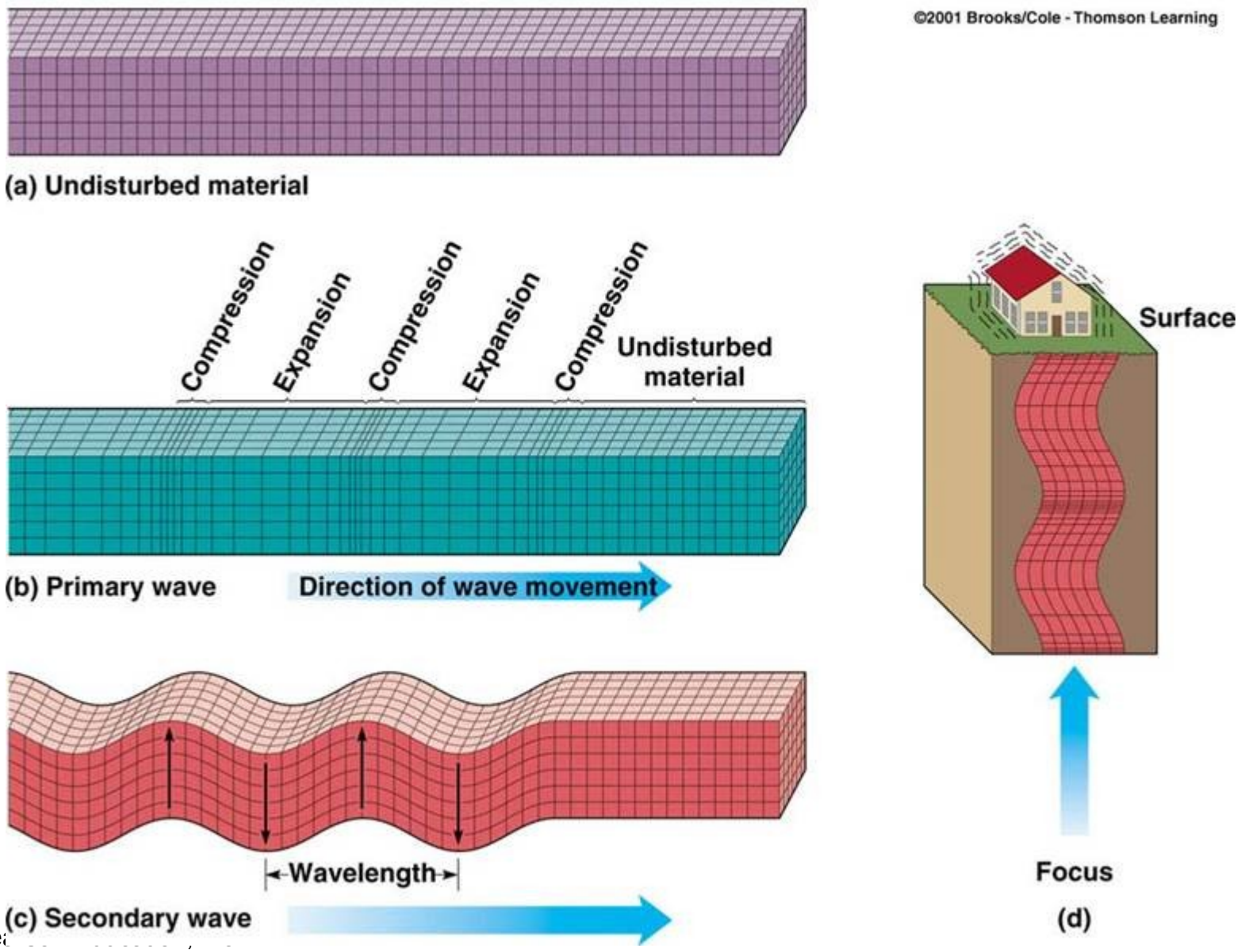
More can be learned about global warming from Venus ...

7.3 Earth's Interior

Probed using Seismic waves:
Earthquakes produce both pressure and shear waves.
Pressure (P) waves are longitudinal and will travel through both liquids and solids.
Shear (S) waves are transverse and will not travel through liquid, as liquids do not resist shear forces.
Wave speed depends on the density of the material.

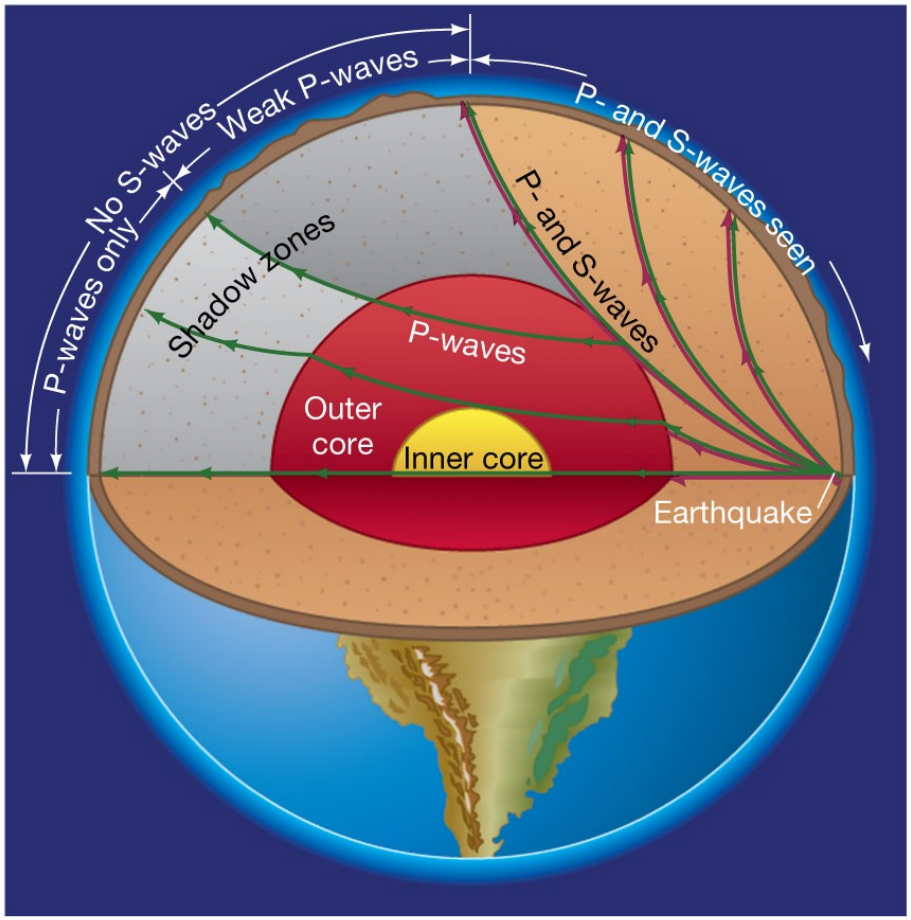


7.3 Earth's Interior



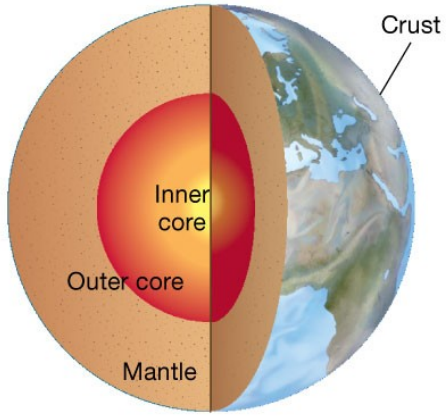
7.3 Earth's Interior

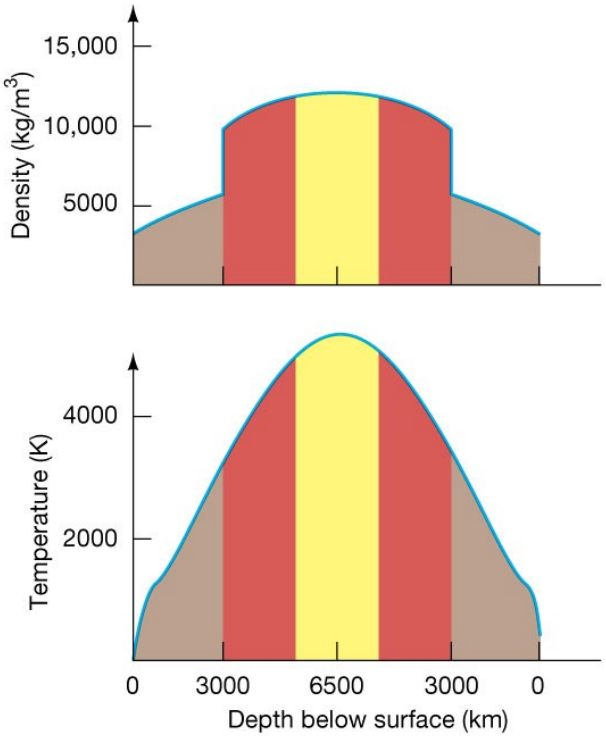
We can use the pattern of reflections during earthquakes to deduce the interior structure of Earth



7.3 Earth's Interior

Currently accepted model





7.3 Earth's Interior

Mantle is much less dense than core

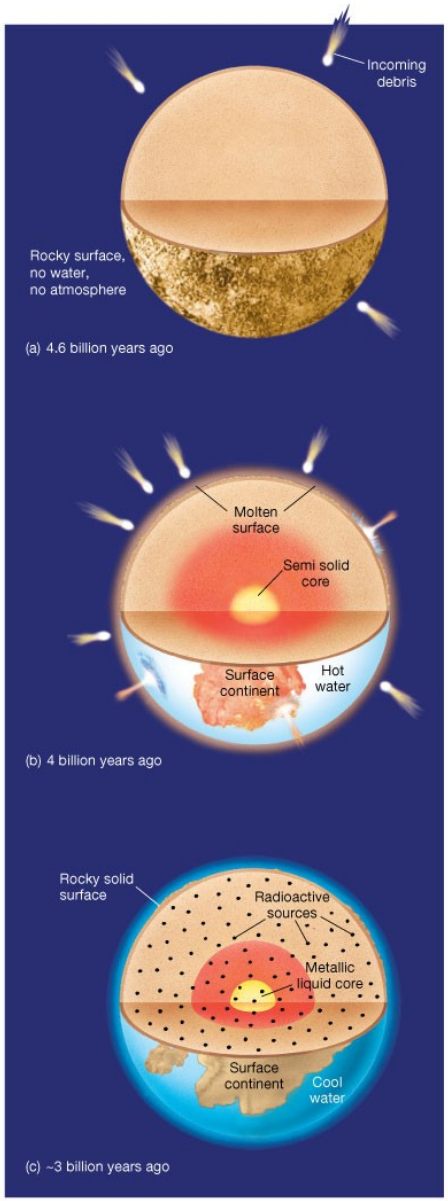
Mantle is rocky; core is metallic—iron and nickel

Outer core is liquid; inner core is solid, due to pressure

Volcanic lava comes from mantle, allows analysis of composition

7.3 Earth's Interior

History: Earth was probably molten when formed and remelted due to bombardment by space debris. Heavier materials sank to the center. Radioactivity provides a continuing source of heat.



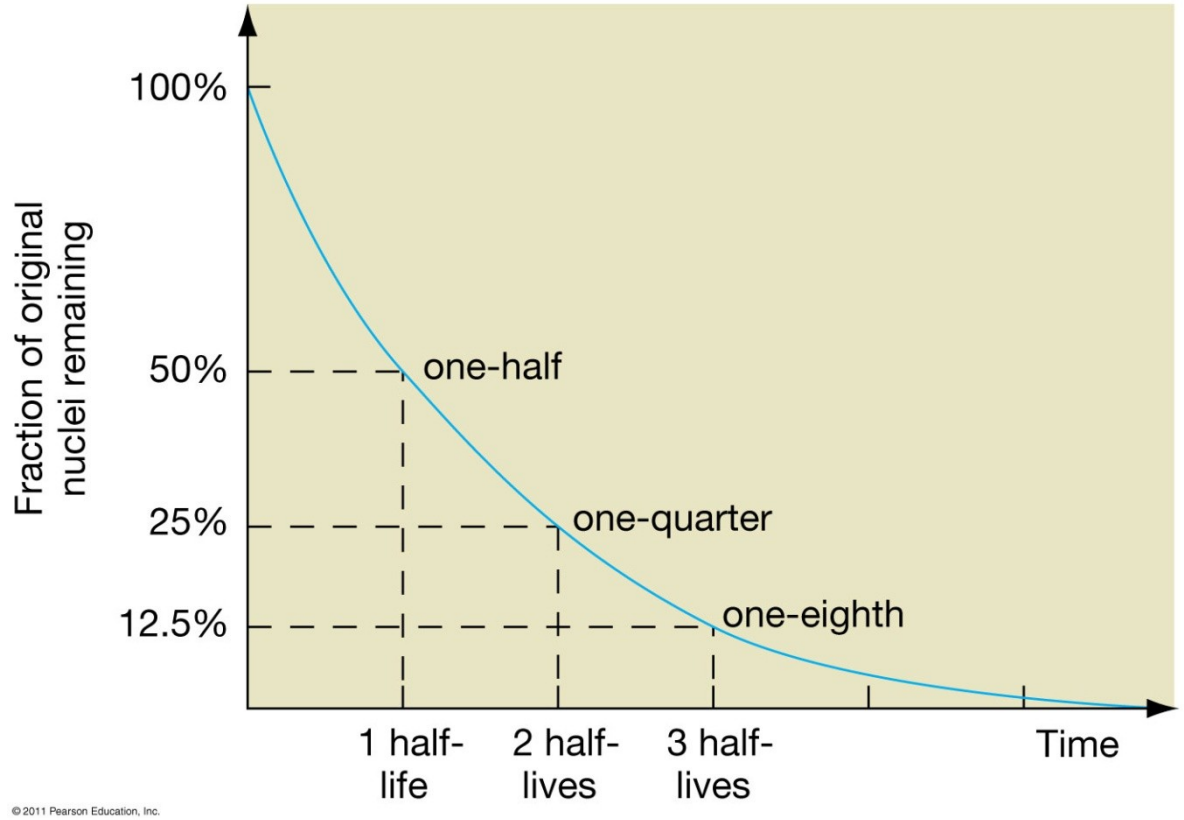
More Precisely 7-2: Radioactive Dating

The number of protons in an atom's nucleus determines which element it is. However, there may be different isotopes of the same element, with the same number of protons but different numbers of neutrons. Many of these isotopes are unstable and undergo radioactive decay. This decay is characterized by a half-life T:

Fraction of material remaining = $(1/2)^{t/T}$

More Precisely 7-2: Radioactive Dating

This plot shows the fraction of the original sample remaining as a function of time



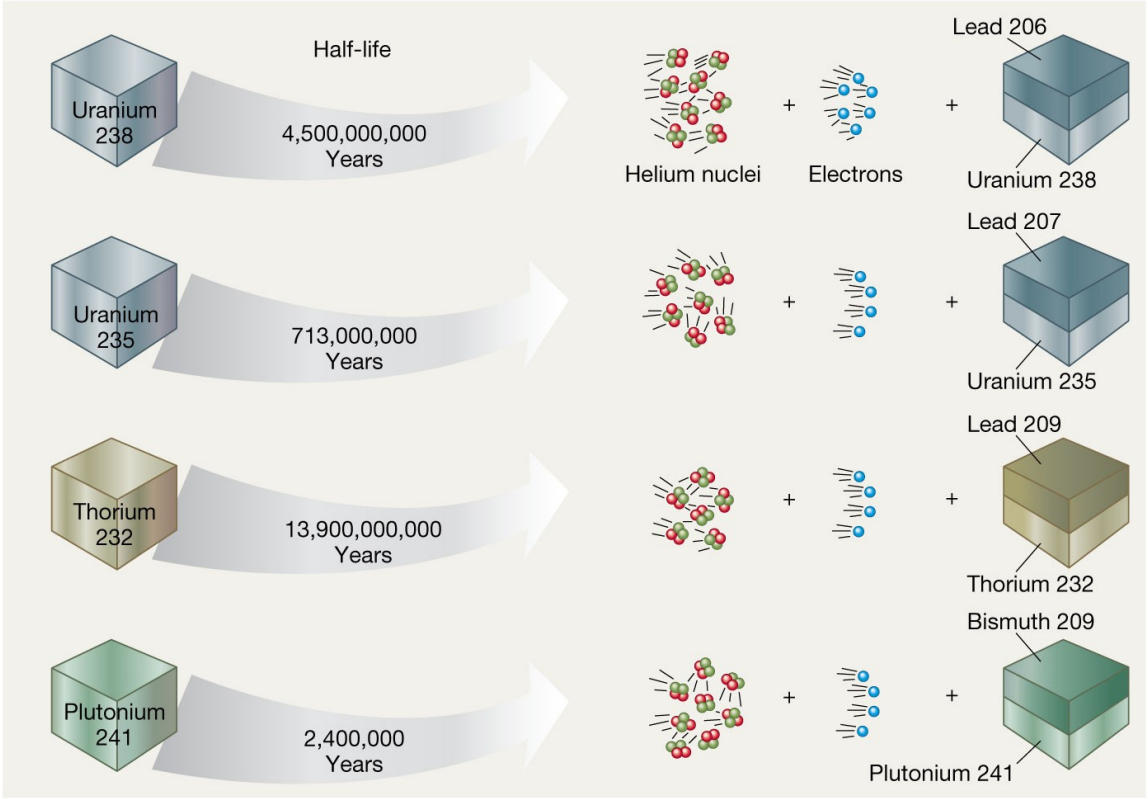
More Precisely 7-2: Radioactive Dating

Half-lives have been measured in the laboratory for almost all known isotopes. Knowing these, we can use them for determining the age of samples by looking at isotope ratios.

The most useful isotope for dating rock samples is uranium-238, which has a half-life of 4.5 billion years, comparable to the age of the Earth.

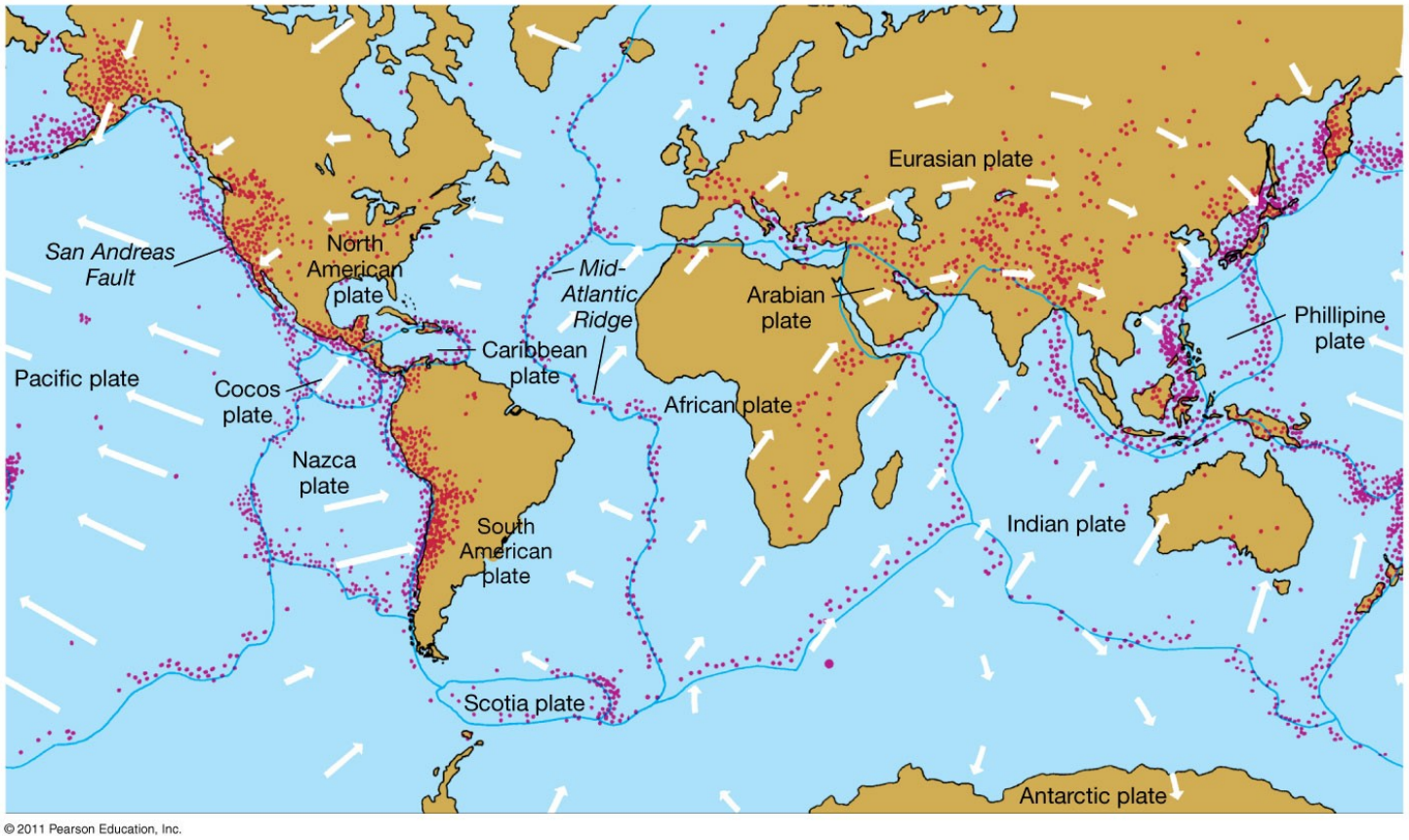
More Precisely 7-2: Radioactive Dating

The dating process involves measuring the ratio between the parent nucleus and the daughter nucleus (lead-206 in the case of uranium-238)



7.4 Surface Activity

Continental drift: Entire Earth's surface is covered with crustal plates, which can move independently



13 plates labeled here. 7 continents.

7.4 Surface Activity

At plate boundaries, earthquakes and volcanoes occur

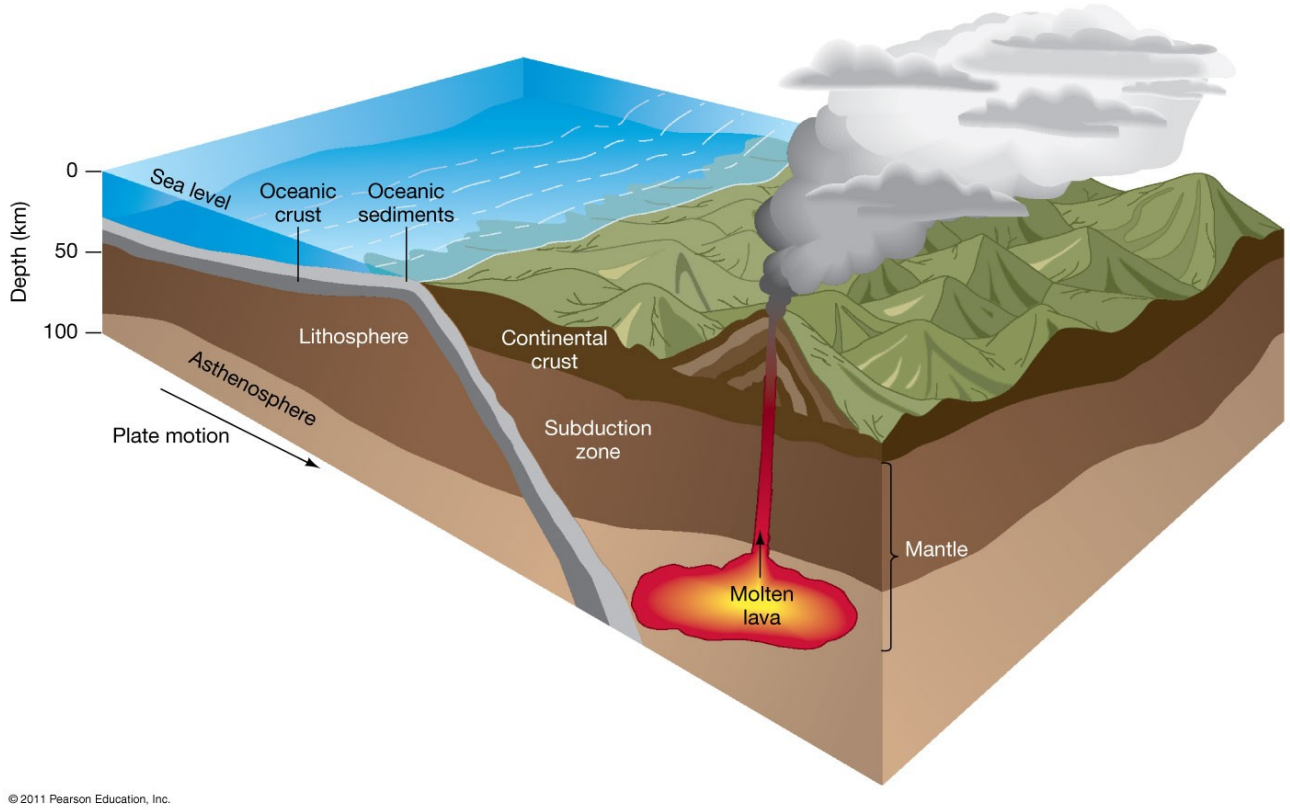
(a)

(b)

(c)

7.4 Surface Activity

Earth's upper mantle, near a plate boundary; this is a subduction zone, where one plate slides below another



7.4 Surface Activity

A plate colliding with another can also raise it, resulting in very high mountains

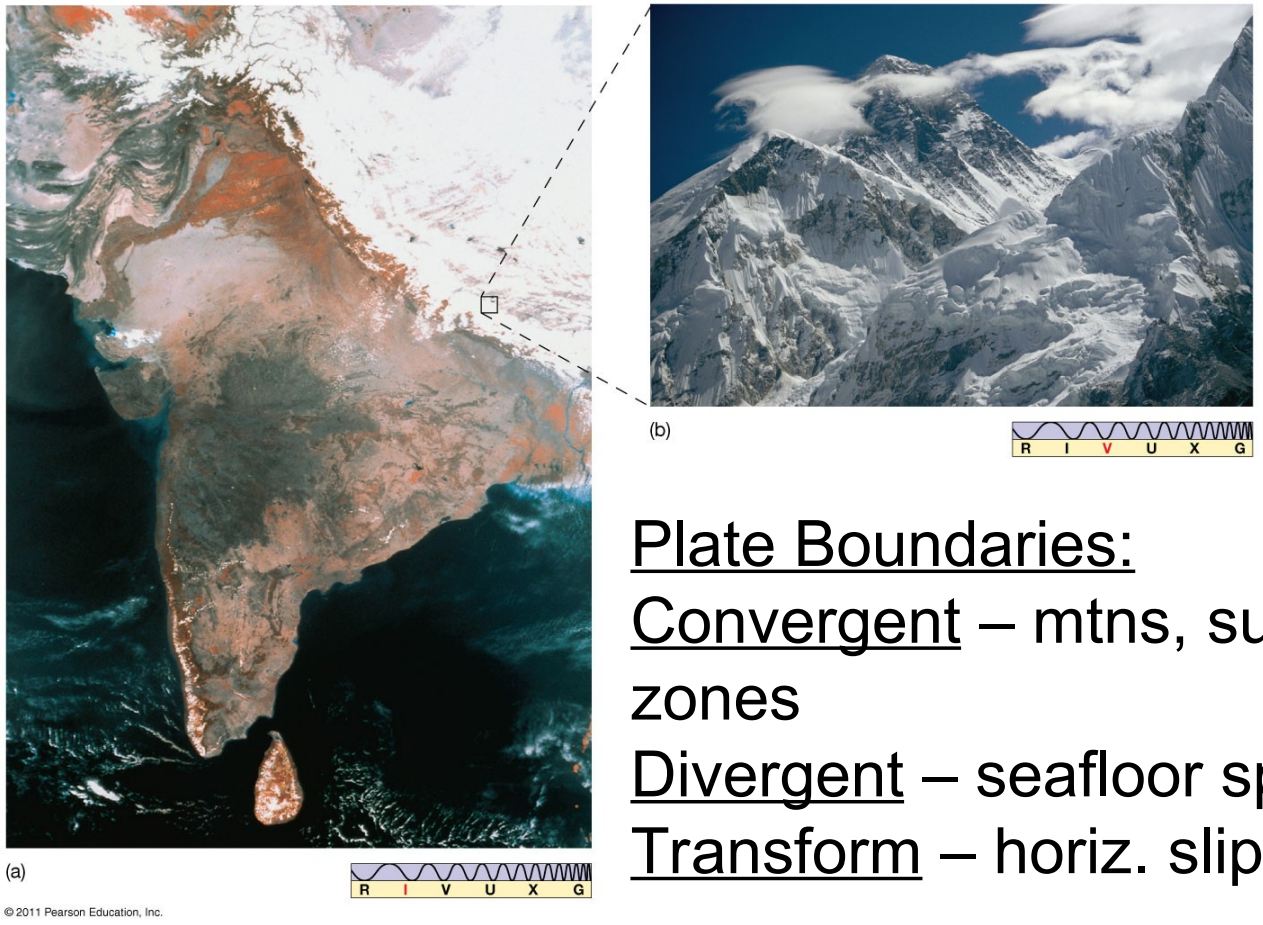


Plate Boundaries:

Convergent – mtns, subduction zones

Divergent – seafloor spreading

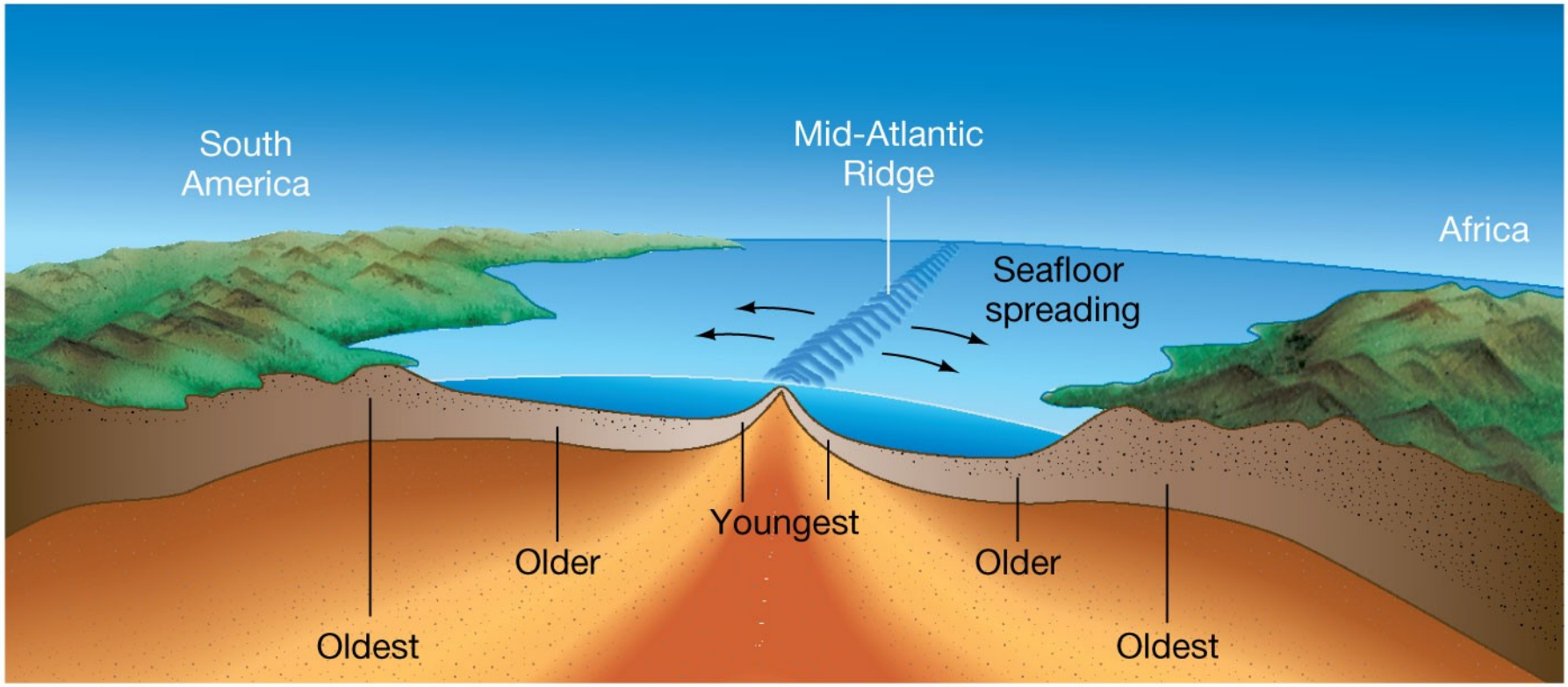
Transform – horiz. slipping

7.4 Surface Activity

Plates can also slide along each other, creating faults where many earthquakes occur

7.4 Surface Activity

Finally, plates can move away from each other, creating rifts

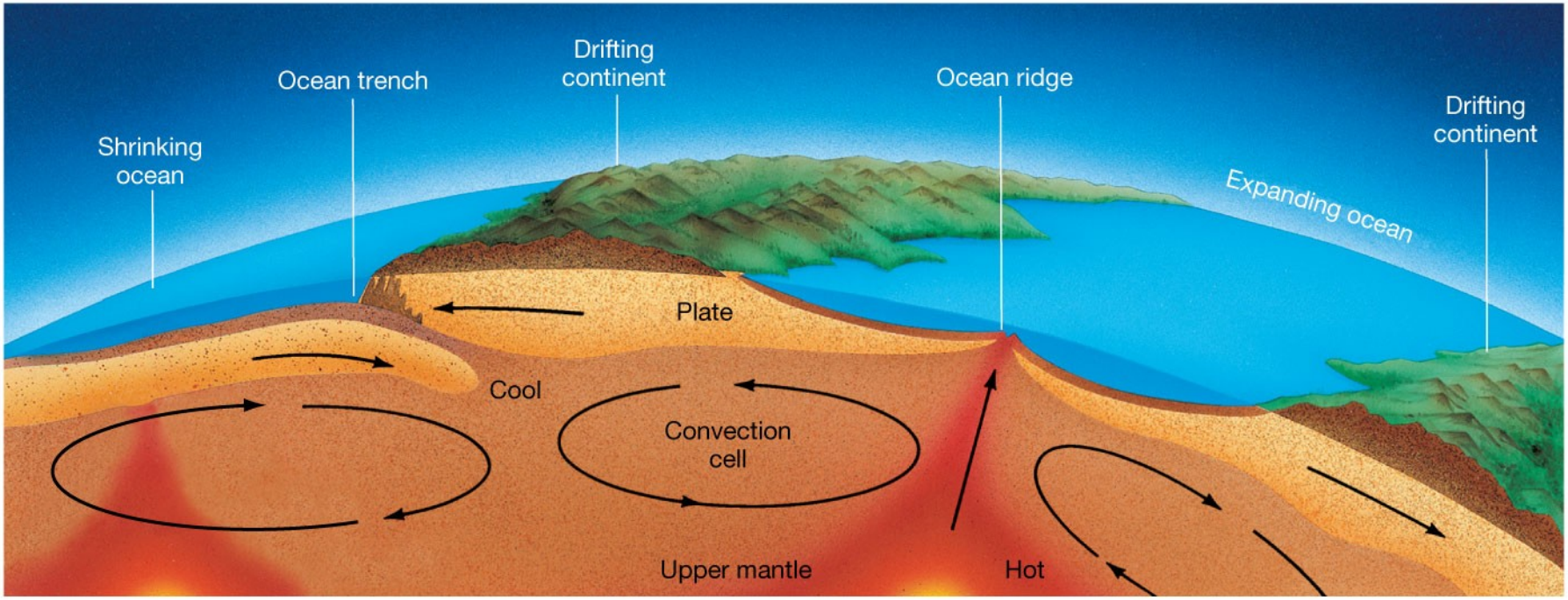


7.4 Surface Activity

The new crust created at rift zones preserves the magnetic field present at the time it solidified. From this, we can tell that magnetic field reversals occur about every 500,000 years.

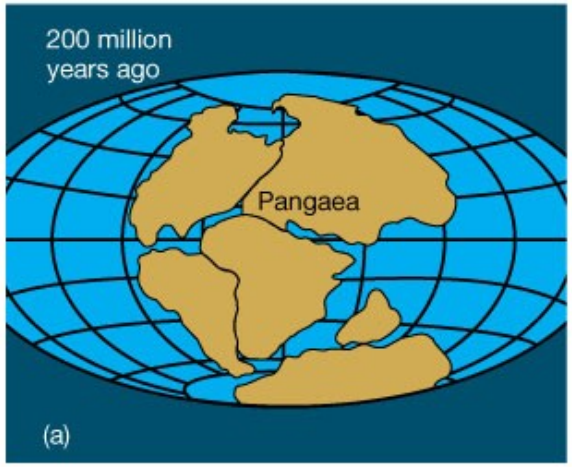
7.4 Surface Activity

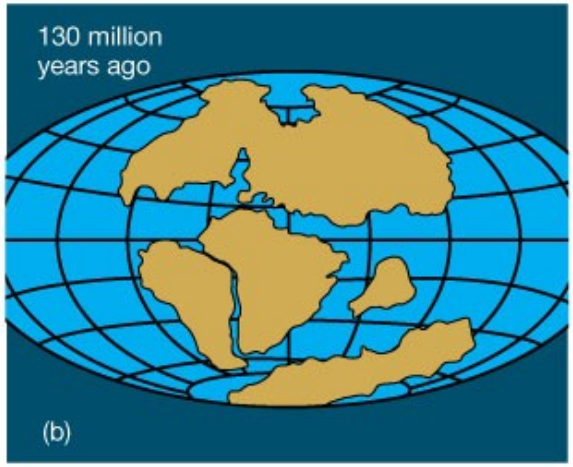
Plate motion is driven by **convection**

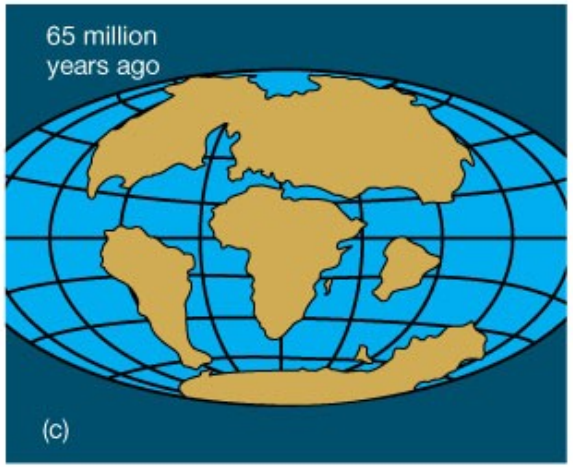


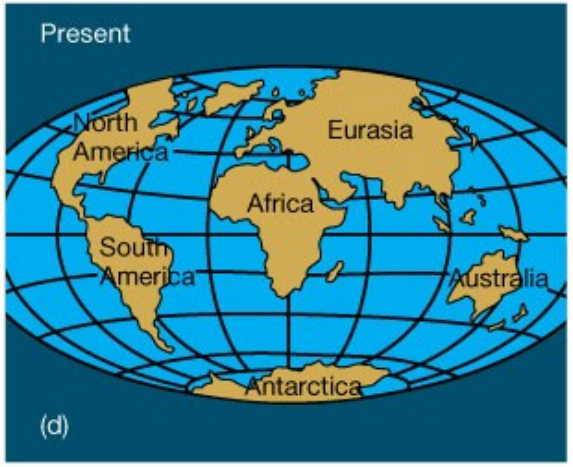
7.4 Surface Activity

If we follow the continental drift backward, the continents merge into one, called Pangaea









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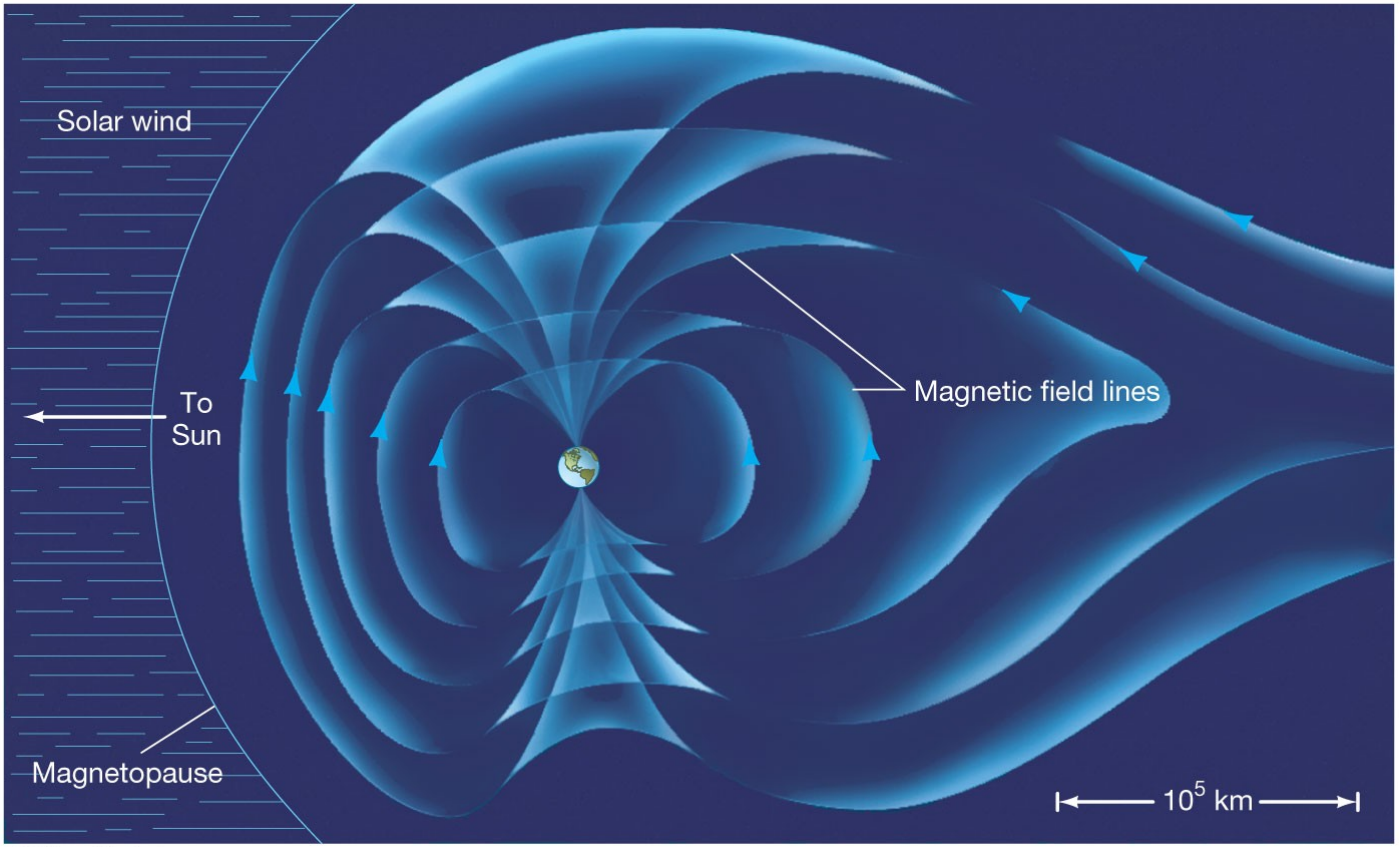
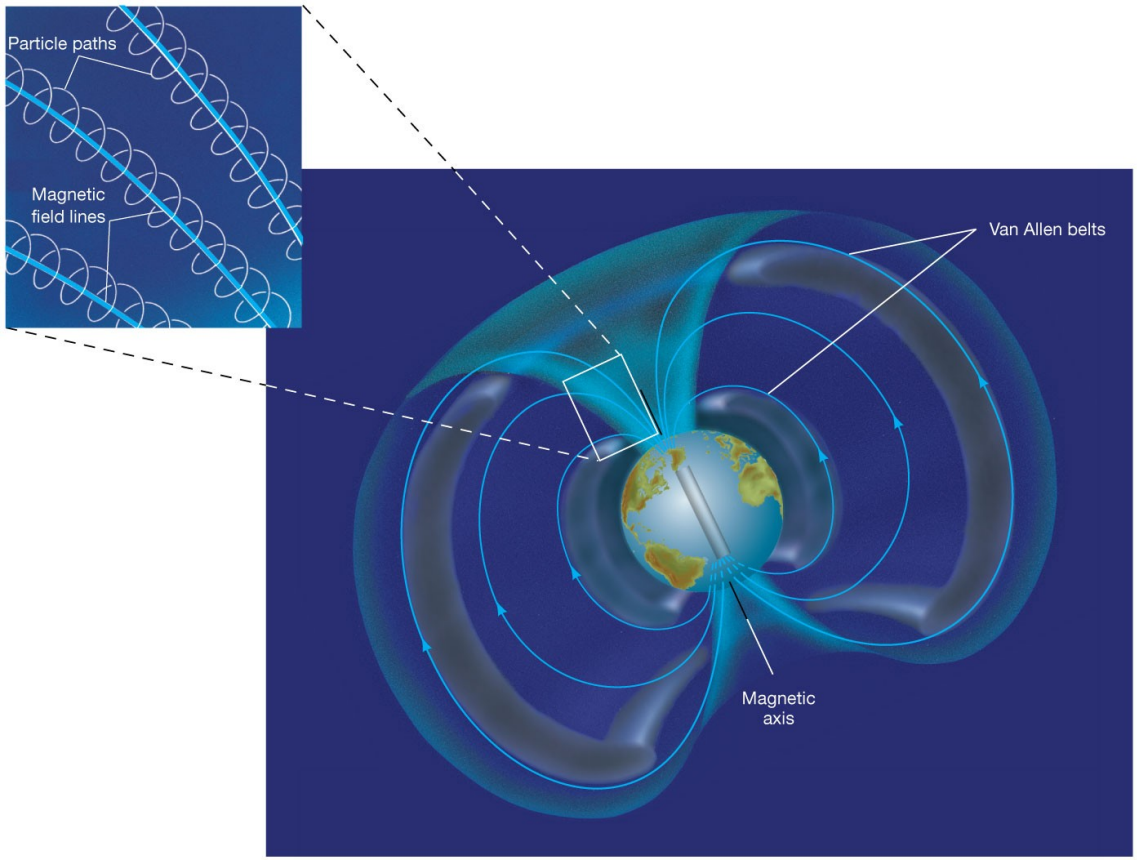
7.5 Earth's Magnetosphere

The magnetosphere is the region around the Earth where charged particles from the solar wind are trapped



7.5 Earth's Magnetosphere

These charged particles are trapped in areas called the Van Allen belts, where they spiral around the magnetic field lines



7.5 Earth's Magnetosphere

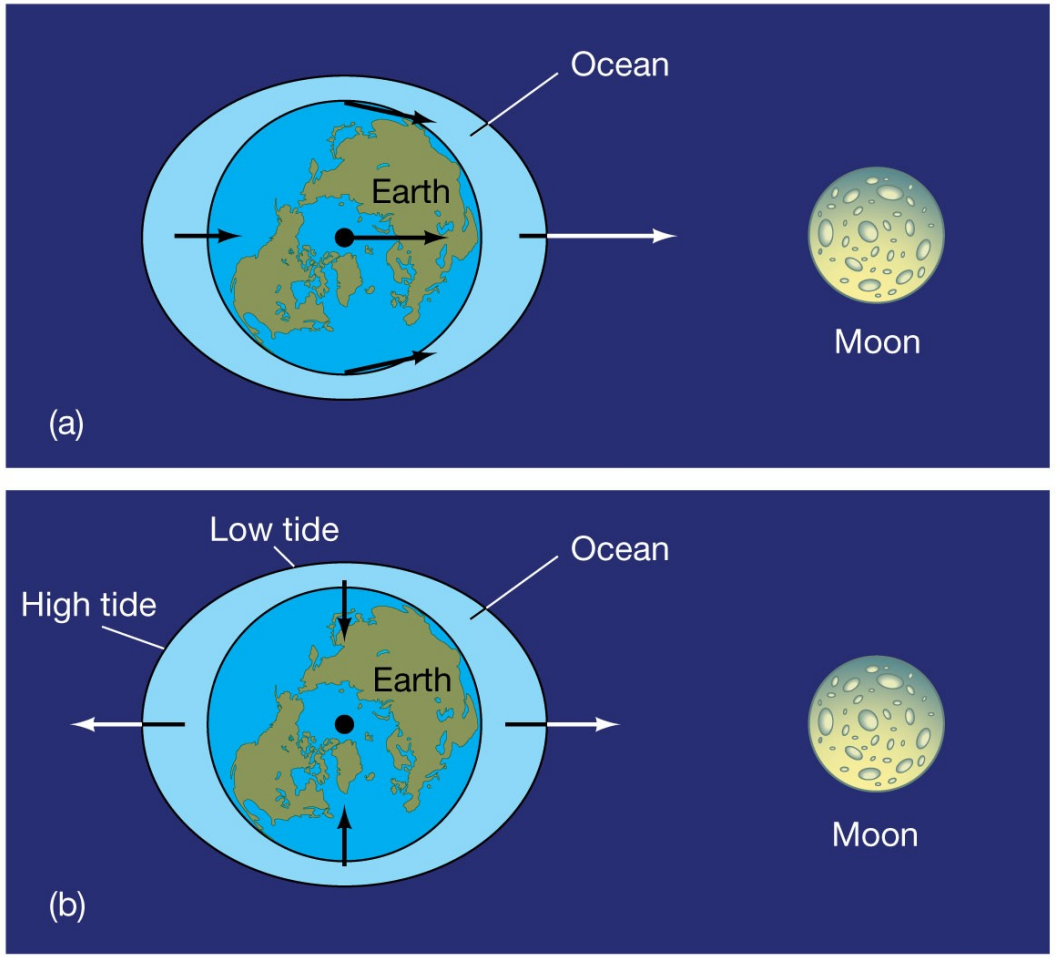
Near the poles, the Van Allen belts intersect the atmosphere. The charged particles can escape; when they do, they create glowing light called aurorae.

(a)

(b)

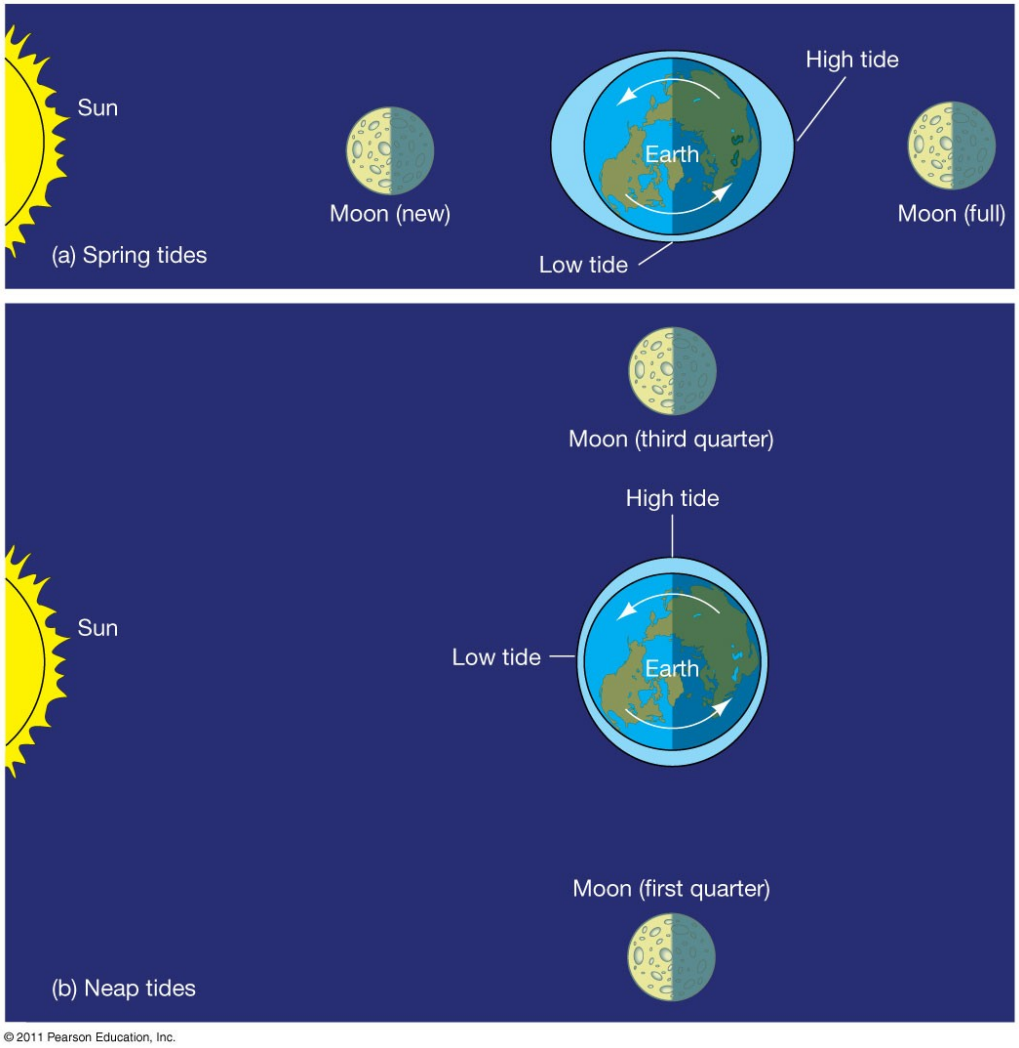
7.6 The Tides

Tides are due to the gravitational force on Earth from Moon—force on the near side of Earth is greater than force on the far side. Water can flow freely in response.



7.6 The Tides

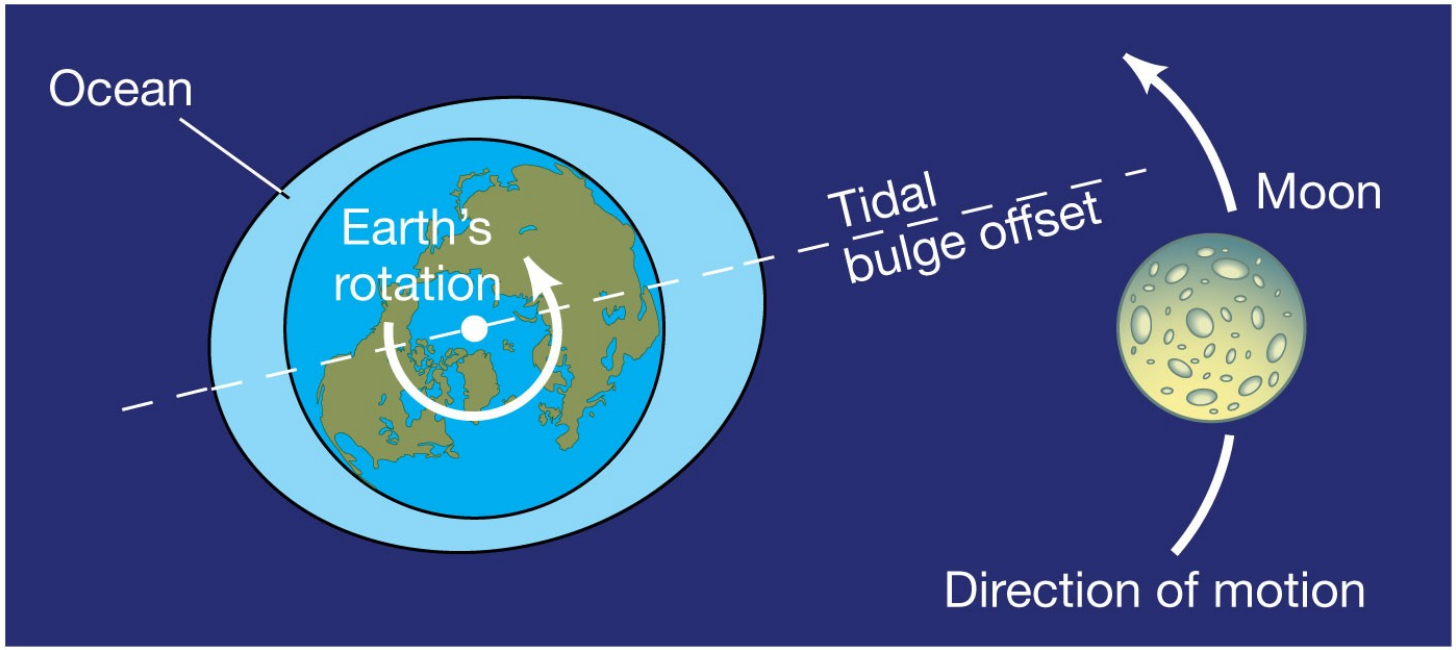
The Sun has less effect because it is farther away, but it does modify the lunar tides



7.6 The Tides

Tides tend to exert a "drag" force on the Earth, slowing its rotation.

This will continue until the Earth rotates synchronously with the Moon, so that the same side of the Earth always points toward the Moon.



Summary of Chapter 7

- **Earth's structure, from inside out: core, mantle, crust, hydrosphere, atmosphere, magnetosphere**
- **Atmosphere is mostly nitrogen and oxygen; thins rapidly with increasing altitude**
- **Greenhouse effect keeps Earth warmer than it would otherwise be**
- **Study interior by studying seismic waves**
- **Crust is made of plates that move independently**

Summary of Chapter 7 (cont.)

- **Movement at plate boundaries can cause earthquakes, volcanic activity, mountain ranges, and rifts**
- **New crust formed at rifts shows evidence of magnetic field reversals**
- **Earth's magnetic field traps charged particles from solar wind**
- **Tides are caused by gravitational effects of Moon and Sun**