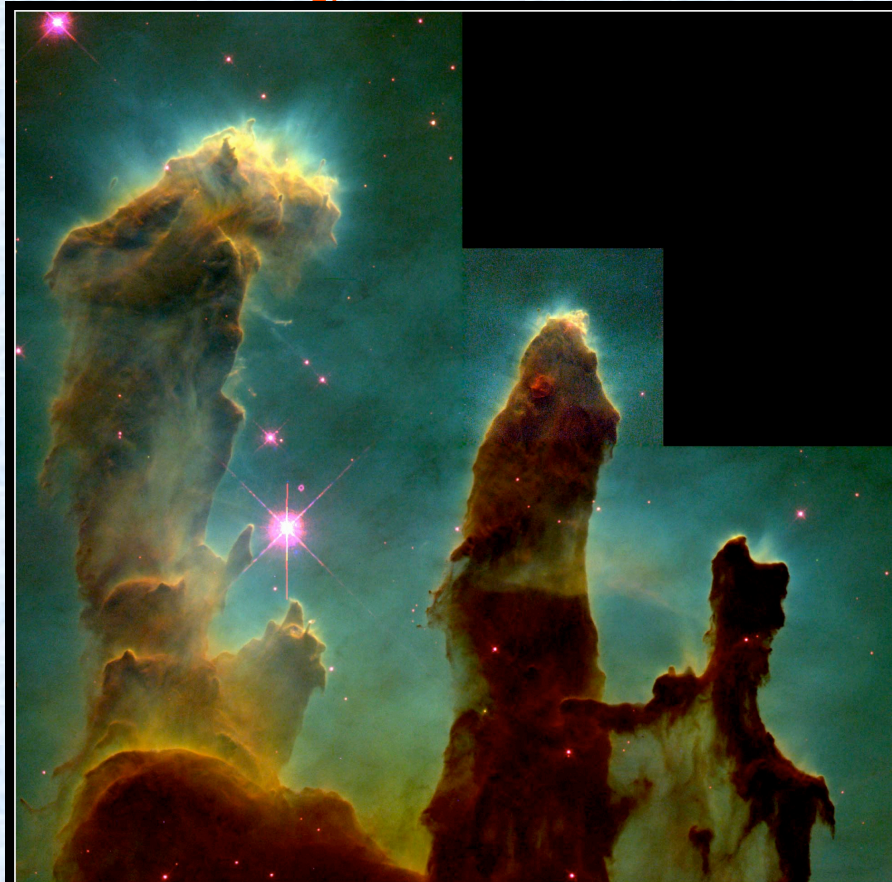


# Astronomy 1 – Winter 2011



**Gaseous Pillars in M16 • Eagle Nebula**  
Hubble Space Telescope • WFPC2

PRC95-44a • ST ScI OPO • November 2, 1995 • J. Hester and P. Scowen (AZ State Univ.), NASA

Lecture 12; February 2 2011

# Previously on Astro-1

- Solar System Formation: the nebular hypothesis.
- The Sun:
  - formed by gravitational contraction of the center of the nebula.
- Terrestrial planets:
  - formed through accretion of dust particles into planetesimals, then into larger protoplanets.
- Jovian planets:
  - Began as rocky protoplanetary cores, similar in character to the terrestrial planets. Gas then accreted onto these cores.
  - Alternatively, they formed directly from the gases of the solar nebula. In this model the cores formed from planetesimals falling into the planets.

# Homework – Due 02/09/11

- On your own: answer all the review questions in chapters 9 and 11
- To TAs: answer questions 9.29 9.35 9.39  
11.51 11.64 11.73



# Today on Astro-1

- **The Earth's Energy Sources:**
  - Solar energy
  - Rotational Energy of the Earth and the Earth-Moon system, though tidal forces.
  - Internal residual heat of the Earth
  - Radioactivity in the Earth's crust
- **The Earth's interior**
  - Inner and outer core made of Iron
  - Mantel made of iron rich minerals
- **Plate tectonics**
  - The crust moves due to the internal circulation of heat from the core to the mantel
  - Resopnsible for Earthquakes, Volcanism and Movement Continents



Look again at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every "superstar," every "supreme leader," every saint and sinner in the history of our species lived there – on a mote of dust suspended in a sunbeam.

The Earth is a very small stage in a vast cosmic arena. Think of the rivers of blood spilled by all those generals and emperors so that, in glory and triumph, they could become the momentary masters of a fraction of a dot. Think of the endless cruelties visited by the inhabitants of one corner of this pixel on the scarcely distinguishable inhabitants of some other corner, how frequent their misunderstandings, how eager they are to kill one another, how fervent their hatreds.

Our posturings, our imagined self-importance, the delusion that we have some privileged position in the Universe, are challenged by this point of pale light. Our planet is a lonely speck in the great enveloping cosmic dark. In our obscurity, in all this vastness, there is no hint that help will come from elsewhere to save us from ourselves.

The Earth is the only world known so far to harbor life. There is nowhere else, at least in the near future, to which our species could migrate. Visit, yes. Settle, not yet. Like it or not, for the moment the Earth is where we make our stand.

It has been said that astronomy is a humbling and character-building experience. There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known.



Image: Earth as seen by Voyager

Words: Carl Sagan, *Pale Blue Dot*

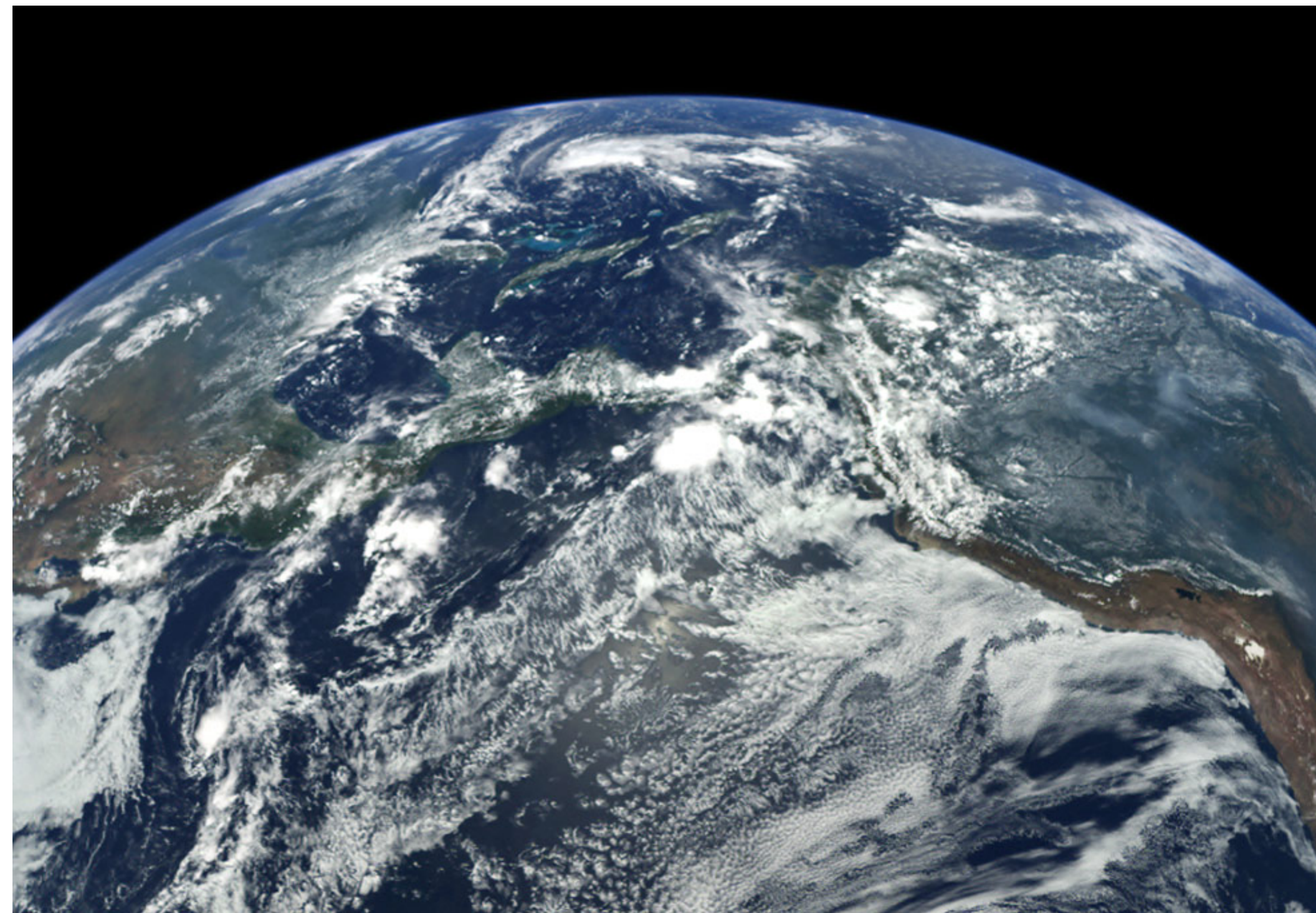


“While almost everyone is taught that the Earth is a sphere with all of us somehow glued to it by gravity, the reality of our circumstance did not really begin to sink in until the famous frame-filling Apollo photograph of the whole Earth — the one taken by the Apollo 17 astronauts on the last journey of humans to the Moon.”

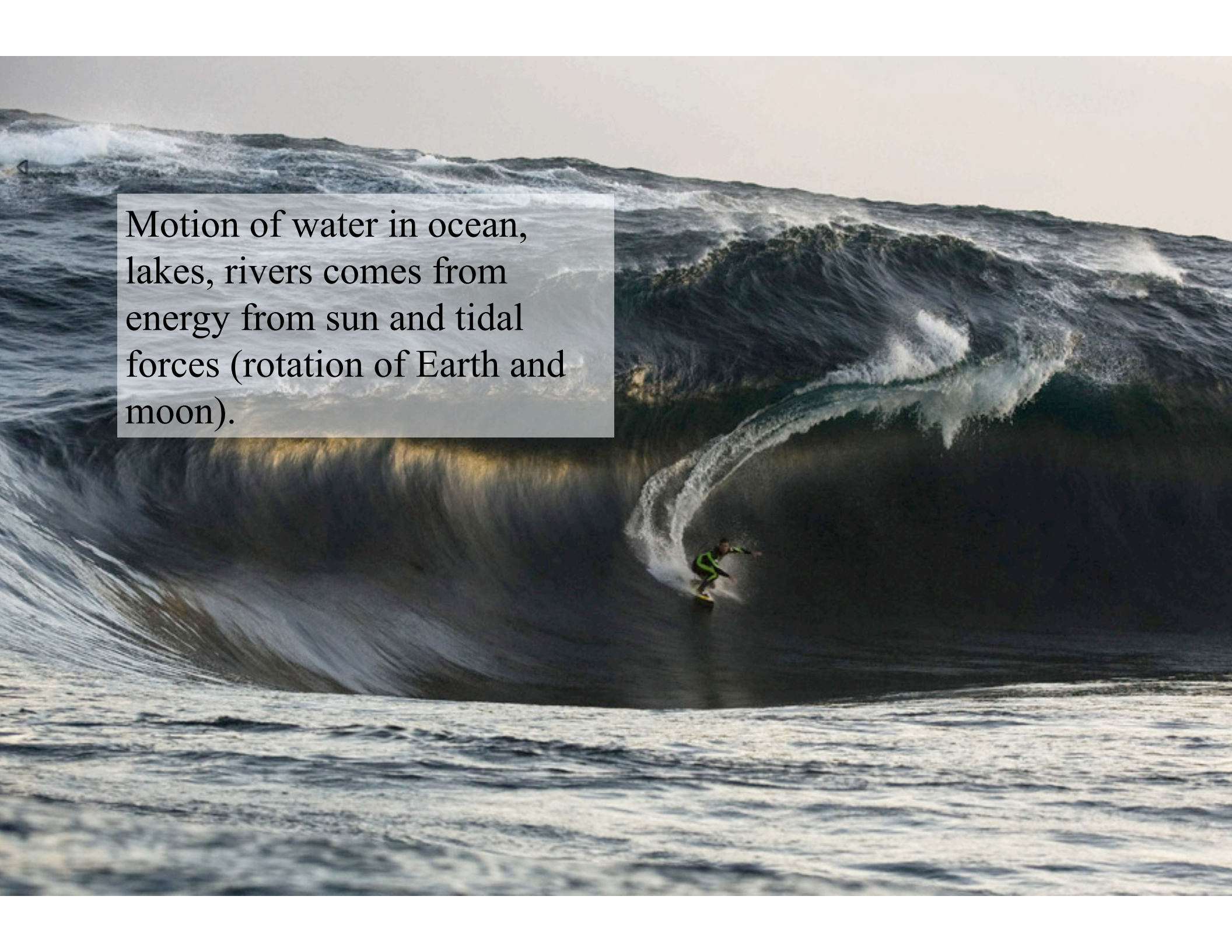
-- Carl Sagan in *Pale Blue Dot*










A large, powerful ocean wave is breaking, creating a massive wall of water. A surfer in a green wetsuit is riding the base of the wave, carving a path through the water. The sky is overcast, and the water is a deep, dark blue. The wave's crest is white with foam, and the overall scene is dynamic and energetic.

Motion of water in ocean, lakes, rivers comes from energy from sun and tidal forces (rotation of Earth and moon).

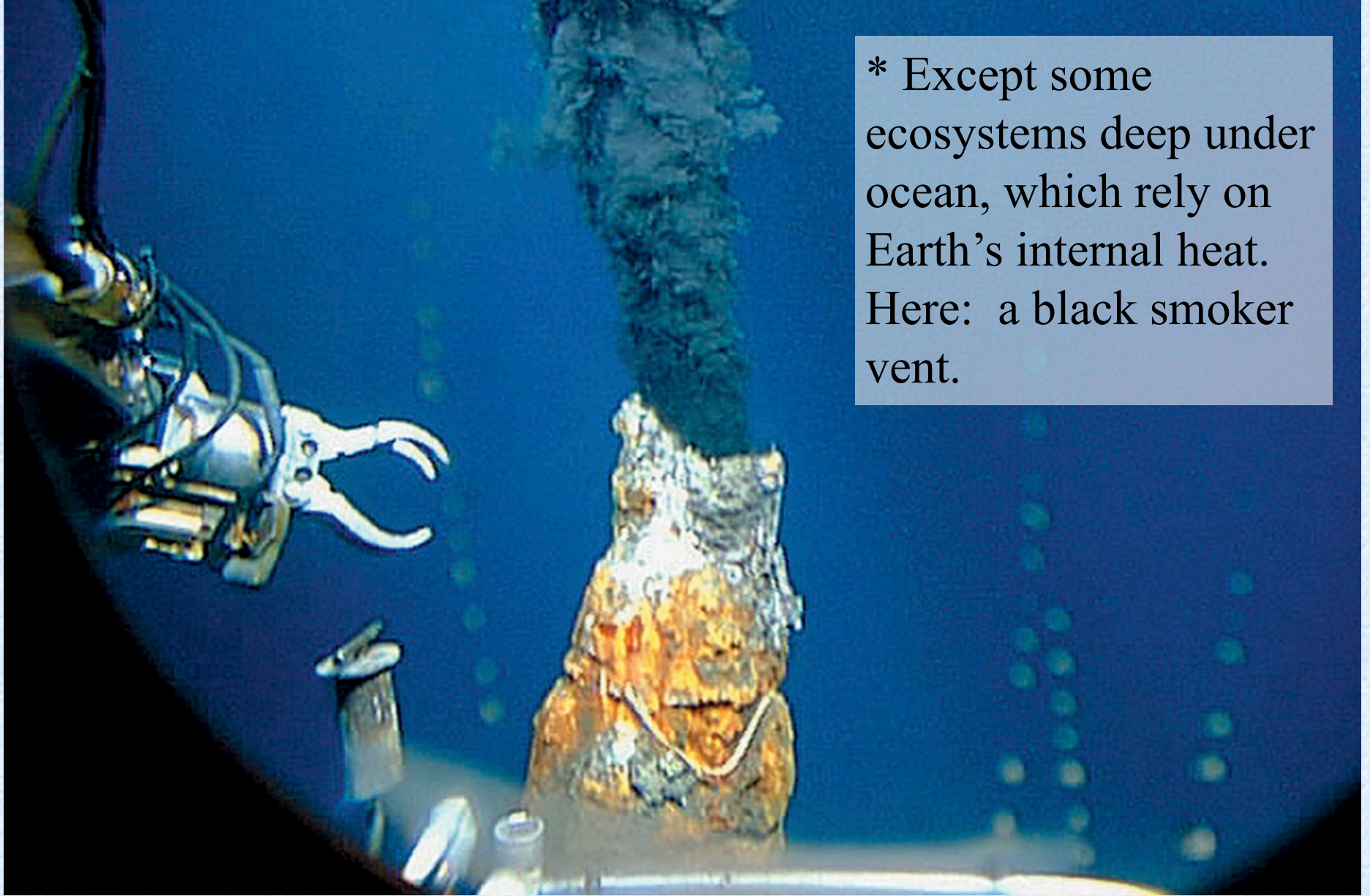


A photograph showing a whale breaching the ocean surface in the foreground. In the background, an offshore oil rig is visible on the horizon. The sky is clear and blue. A semi-transparent text box is overlaid on the right side of the image.

Energy for life comes  
from the sun\*

Off the coast of Santa Barbara. Source: [boston.com/bigpicture](http://boston.com/bigpicture)





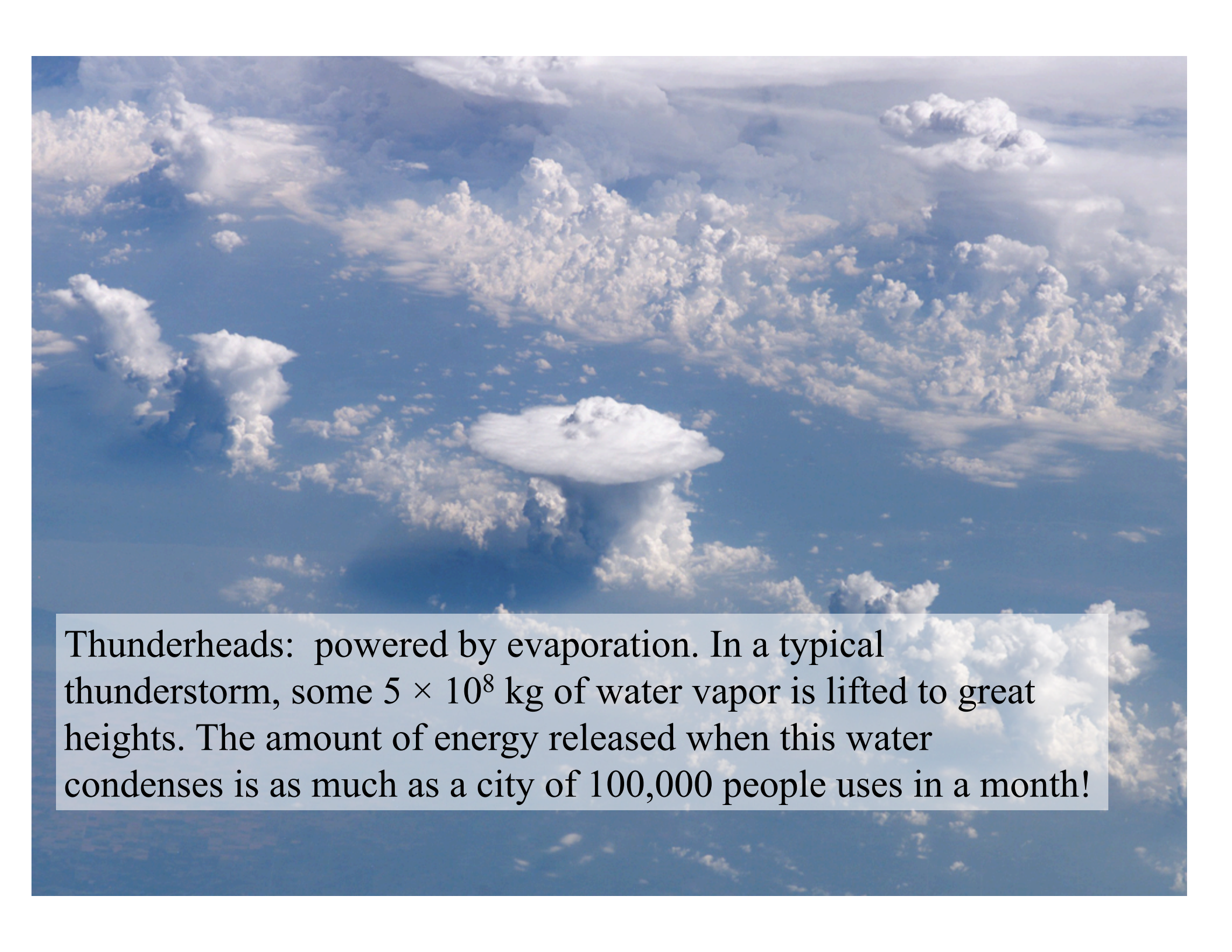
\* Except some ecosystems deep under ocean, which rely on Earth's internal heat. Here: a black smoker vent.



Energy for  
atmospheric motion  
comes from the sun.







Thunderheads: powered by evaporation. In a typical thunderstorm, some  $5 \times 10^8$  kg of water vapor is lifted to great heights. The amount of energy released when this water condenses is as much as a city of 100,000 people uses in a month!



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

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

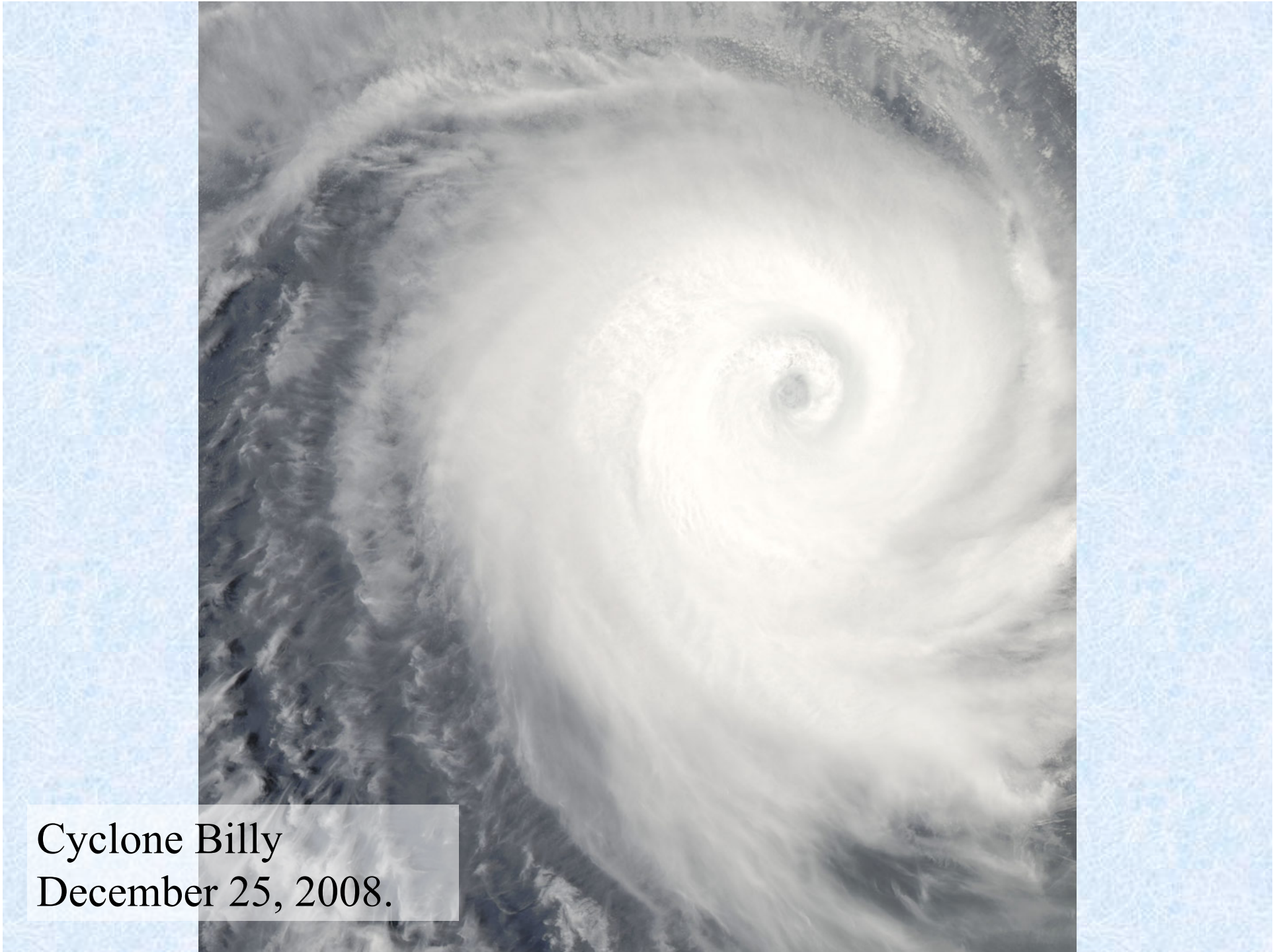


**3. ... warms, and rises again.**

Figure 9-5  
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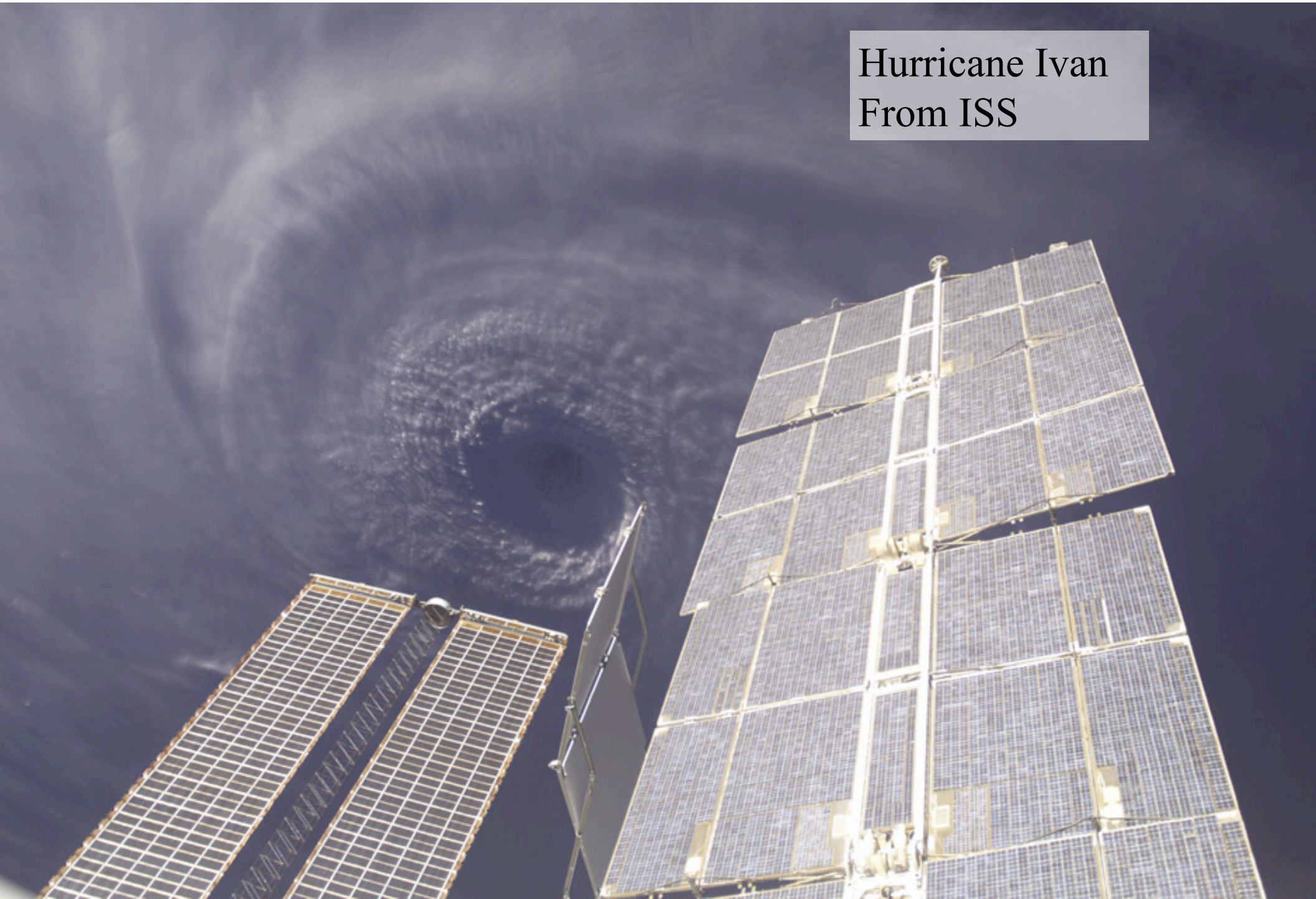




Cyclone Billy  
December 25, 2008.



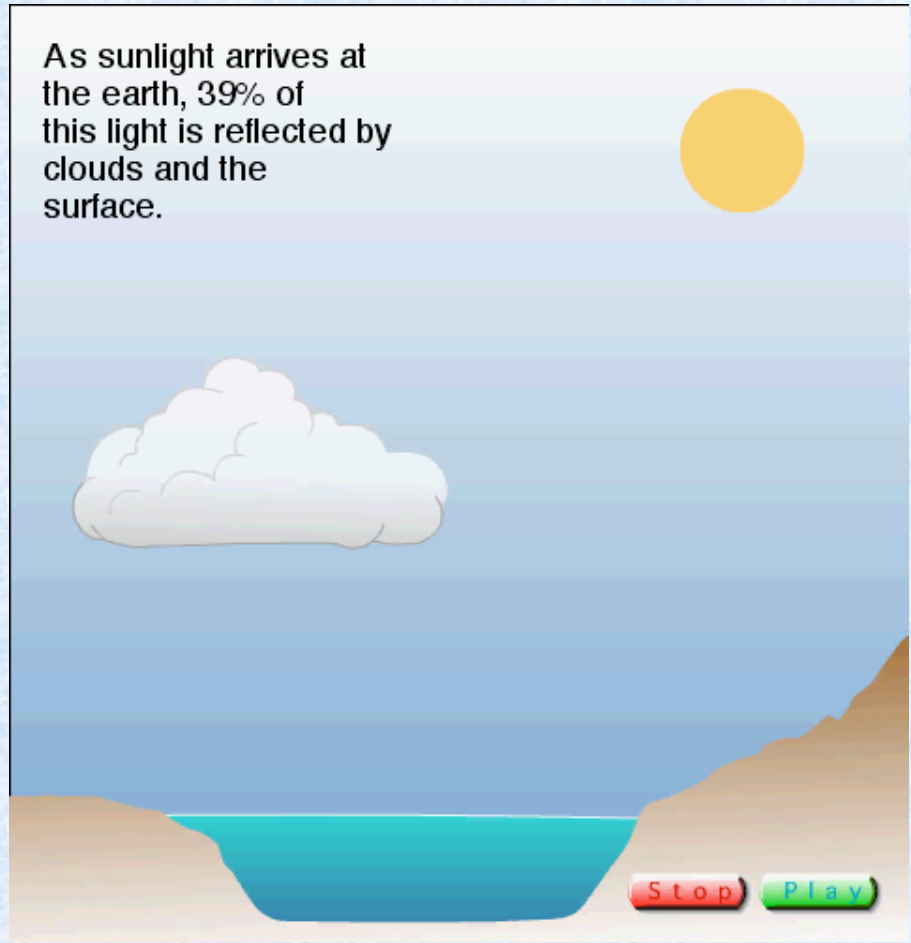
Hurricane Ivan  
From ISS





The temperature at the Earth should be 254 K ( $-19^{\circ}\text{C} = -2^{\circ}\text{F}$ ), but instead the Earth's average temperature is  $14^{\circ}\text{C}$  ( $57^{\circ}\text{F}$ ). What is going on?

# The Greenhouse effect





# The Greenhouse effect

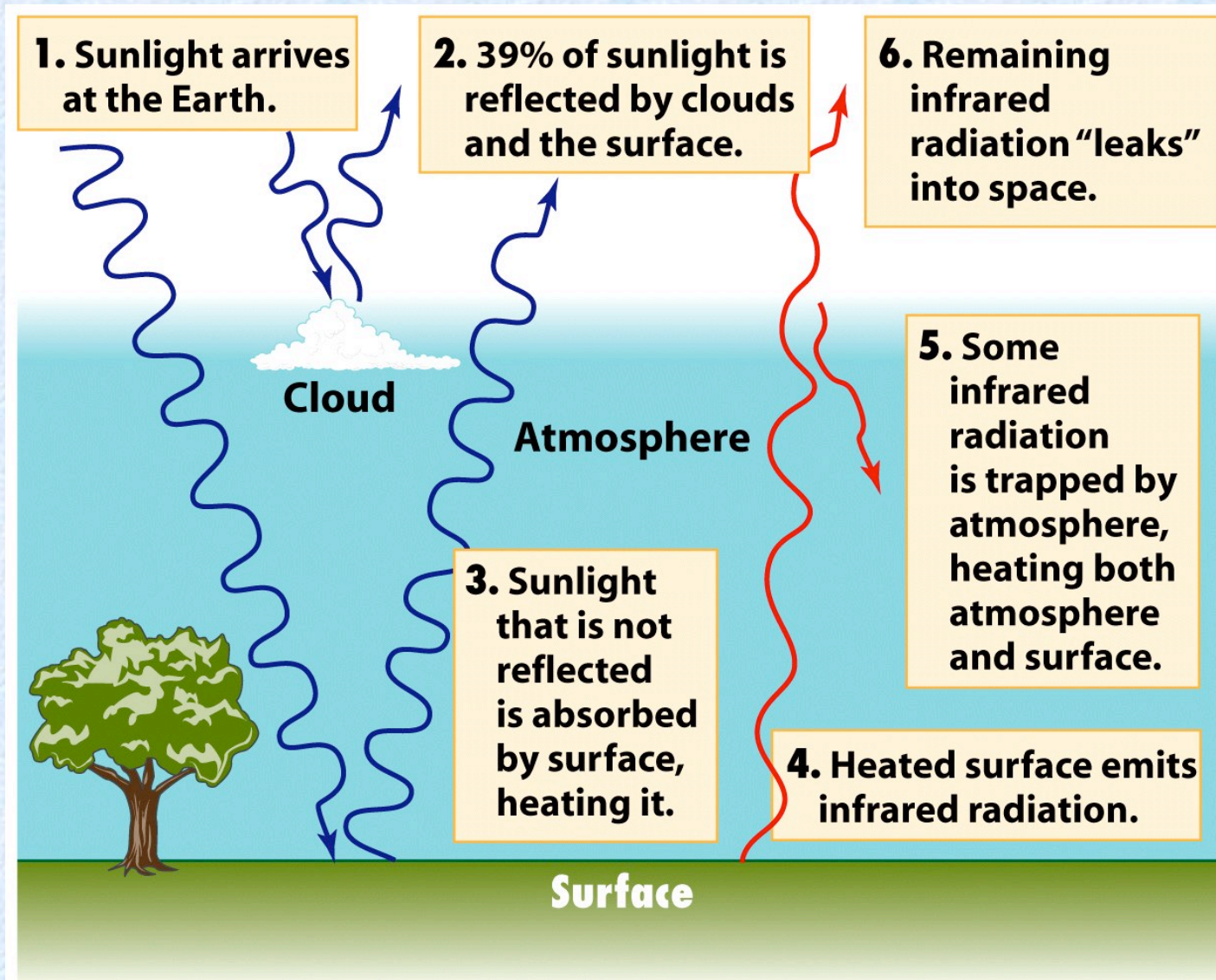


Figure 9-6  
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## Question 12.1 (iclickers!)

- What is the main mechanism by which the lower atmosphere of Earth is heated
  - A) Sunlight heats Earth's surface and the resultant heat is transferred to the atmosphere by infrared radiation and convective gas motions
  - B) Conduction carries heat from the Earth's interior to the surface where conduction in the lower atmosphere transfers this heat to the higher layers
  - C) Friction between the winds in the atmosphere and the mountain ranges and land masses of Earth
  - D) Absorption of sunlight by molecules of the gases in the atmosphere




A night sky over a mountain range. The sky is dark with many stars and the Milky Way galaxy visible. A bright, glowing object is labeled 'Moon'. The Milky Way is labeled 'Milky Way'. The mountain range is labeled 'Everest'.

Milky Way

Moon

The energy to reshape Earth's surface comes from the Earth's internal heat: left over from formation of solar system and bombardment by planetesimals, comets, etc!

Everest



Mt. Redoubt, Alaska,  
March 31, 2009.





Llaima Volcano  
January 2008



Chaiten Volcano, Chile  
May 2008





Earthquake in L'Aquila,  
Italy April 7 2009.





Earthquake in L'Aquila, Italy  
April 7 2009.





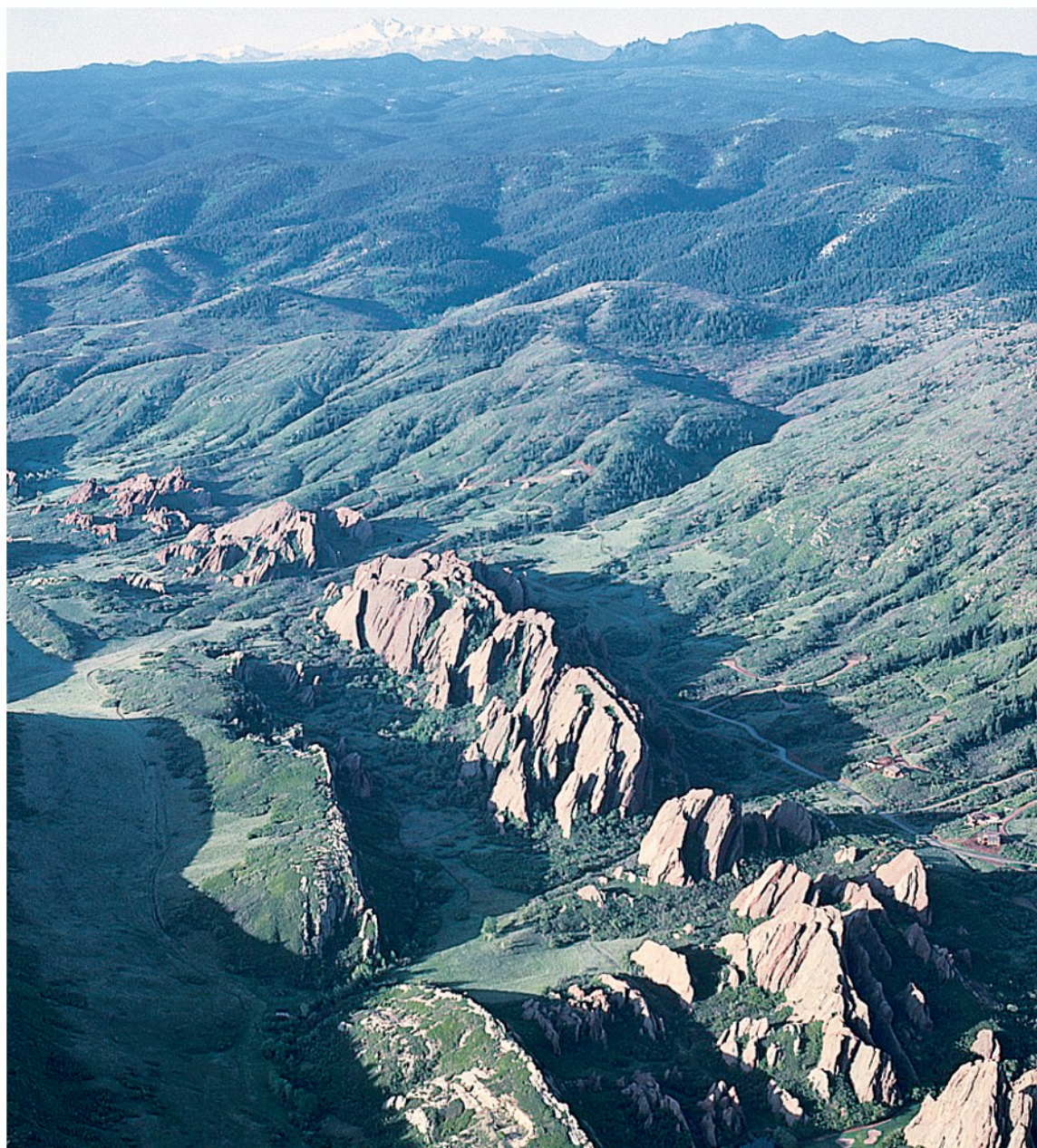
Earthquake in Haiti  
January 12 2009





2004 Tsunami.





These tan-colored ridges, or hogbacks, in Colorado's Rocky Mountains were once layers of sediment at the bottom of an ancient body of water. Forces within the Earth folded this terrain and rotated the layers into a vertical orientation. The layers were revealed when wind and rain eroded away the surrounding material.

**Figure 9-3**  
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**2. Over millions of years, layers of sediments built up over that rock. The most recent layer—the top—is about 250 million years old.**



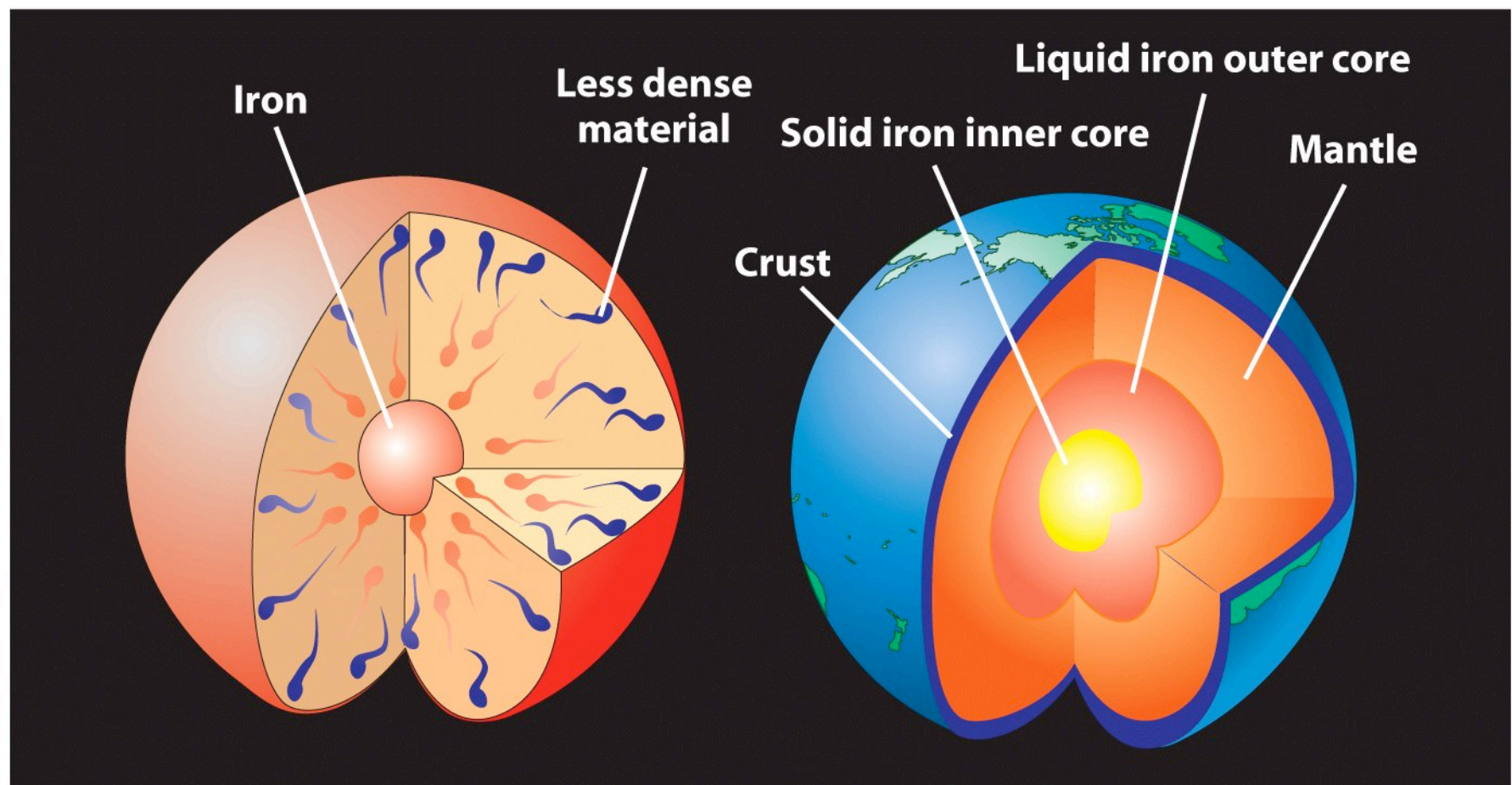
**1. The rocks at the bottom of the Grand Canyon are 1.7-2.0 billion years old.**

Figure 9-4

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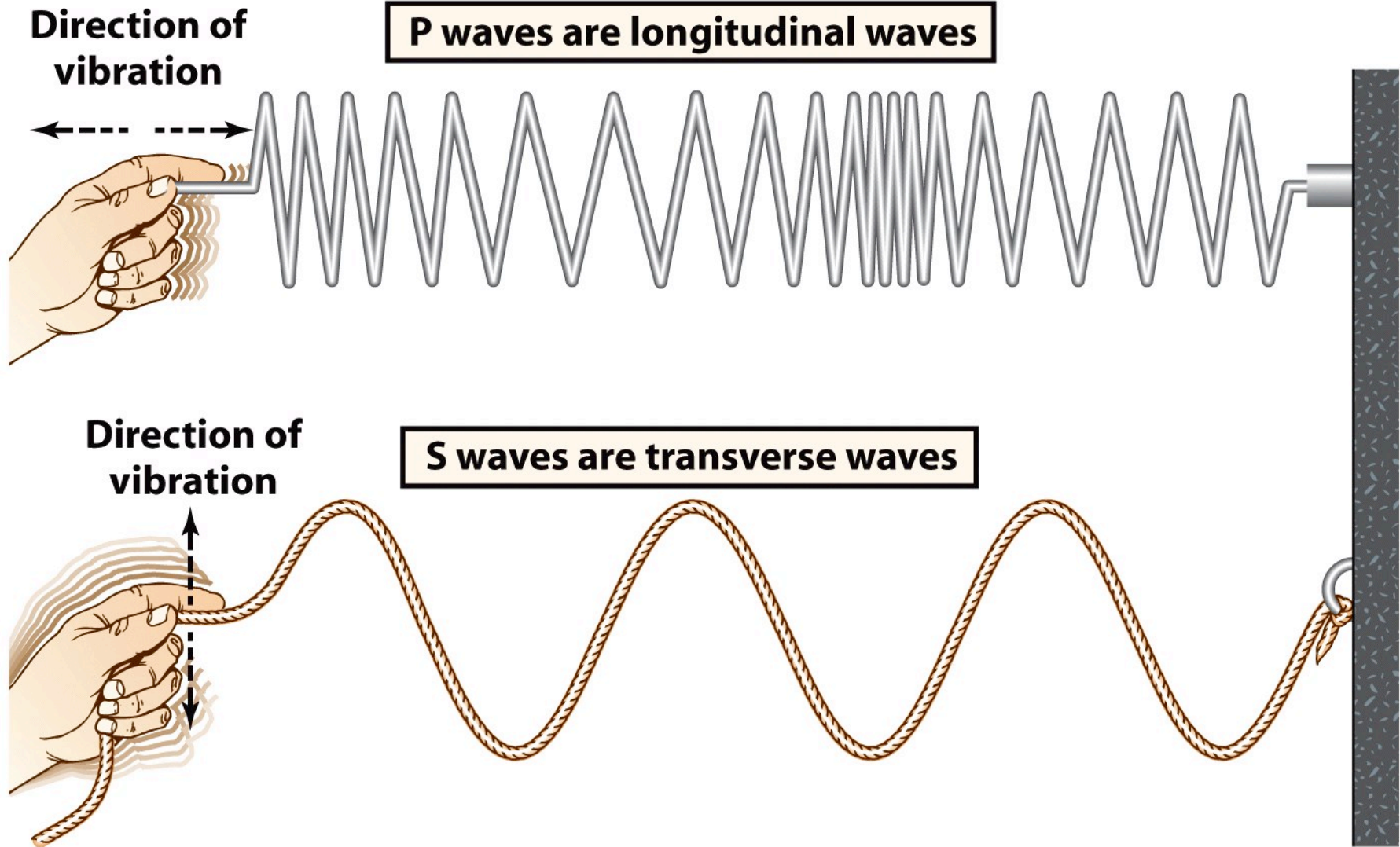
When earth was molten, heavy stuff sank to center. Eventually the iron core and outer crust solidified.



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

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





**Figure 9-8**  
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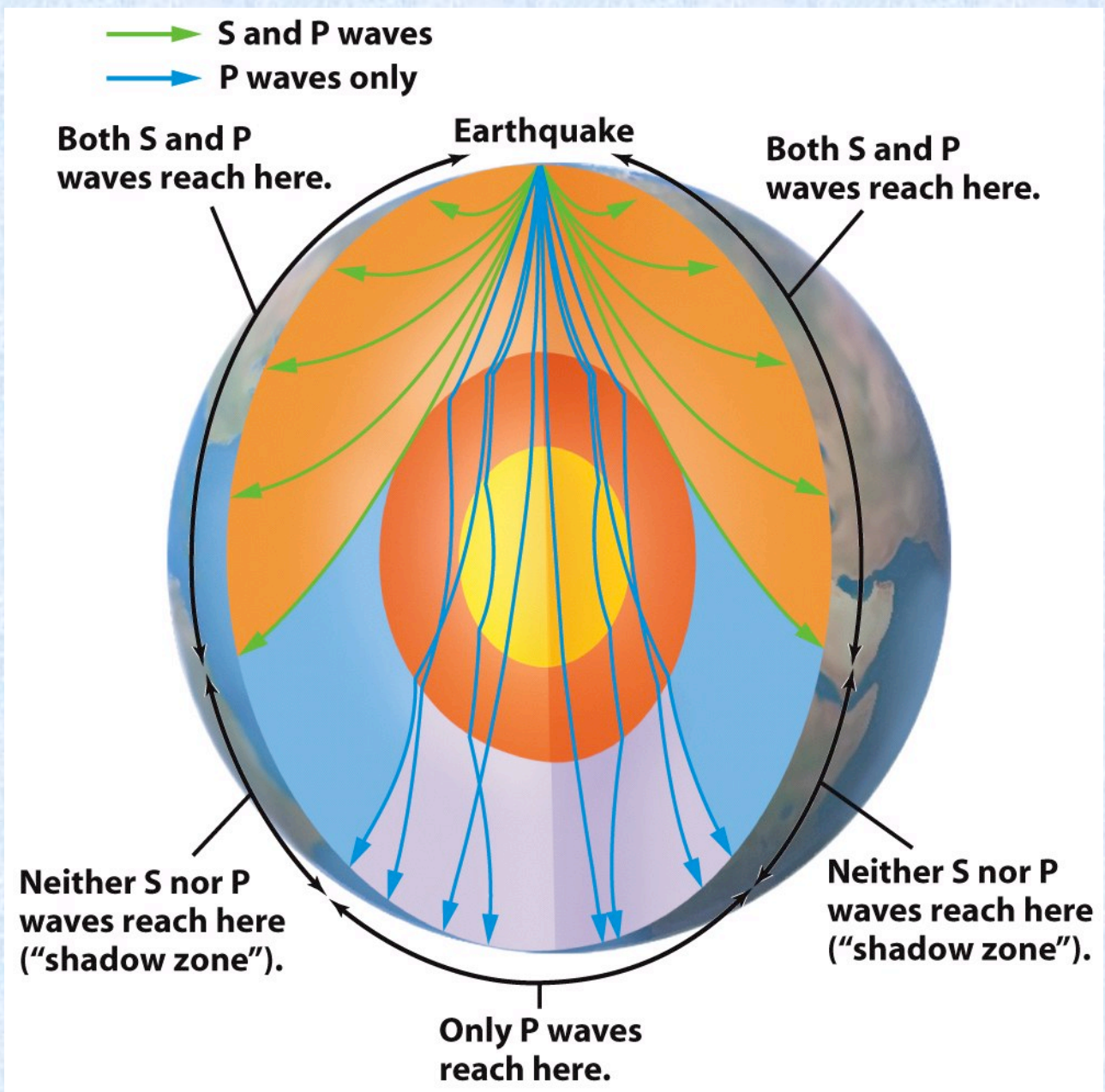


Figure 9-9  
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**Table 9-3 The Earth's Internal Structure**

<b>Region</b>	<b>Depth Below Surface (km)</b>	<b>Distance From Center (km)</b>	<b>Average Density (kg/m<sup>3</sup>)</b>
<b>Crust (solid)</b>	0–5 (under oceans) 0–35 (under continents)	6343–6378	3500
<b>Mantle (plastic, solid)</b>	from bottom of crust to 2900	3500–6343	3500–5500
<b>Outer core (liquid)</b>	2900–5100	1300–3500	10,000–12,000
<b>Inner core (solid)</b>	5100–6400	0–1300	13,000

Table 9-3

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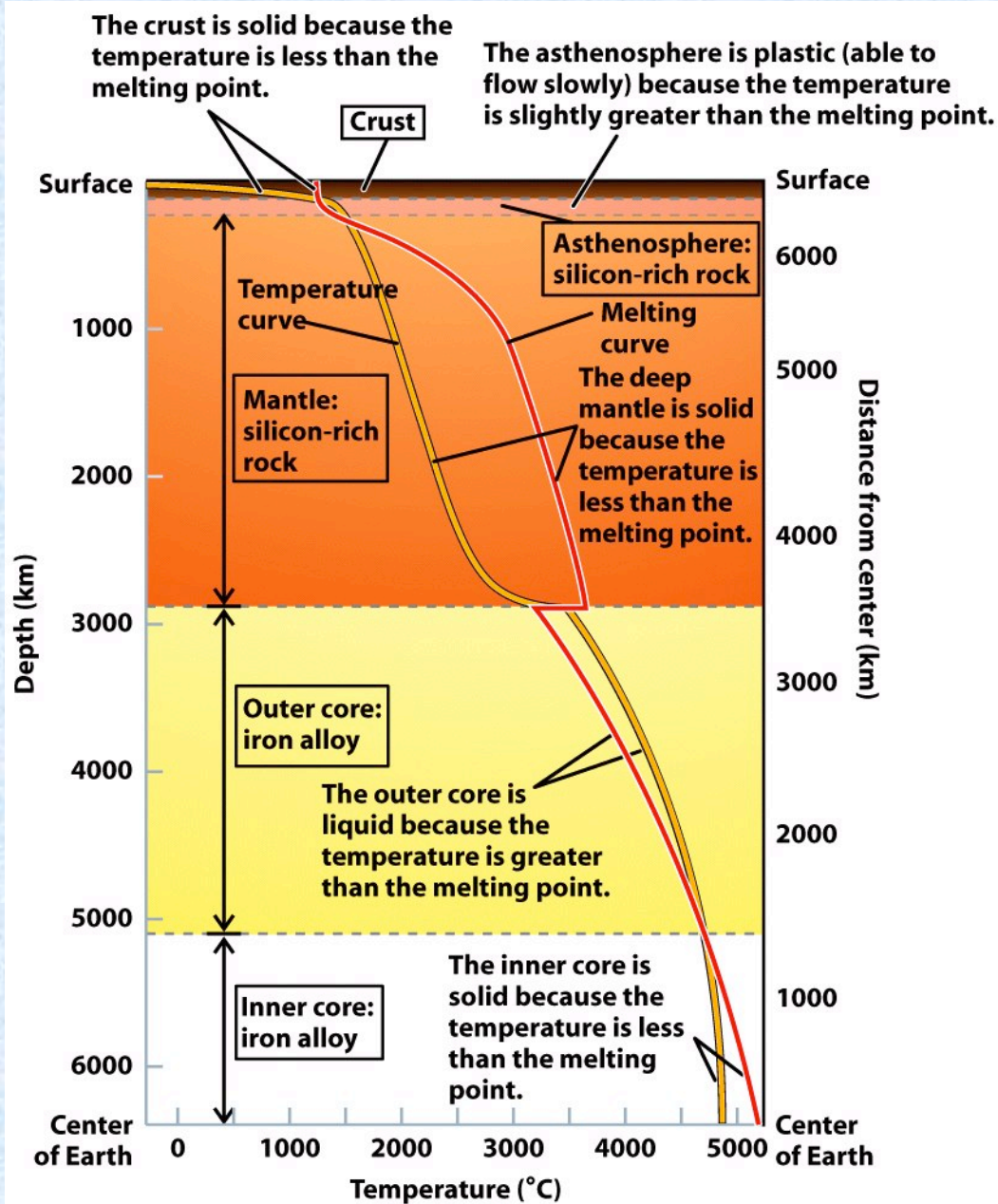


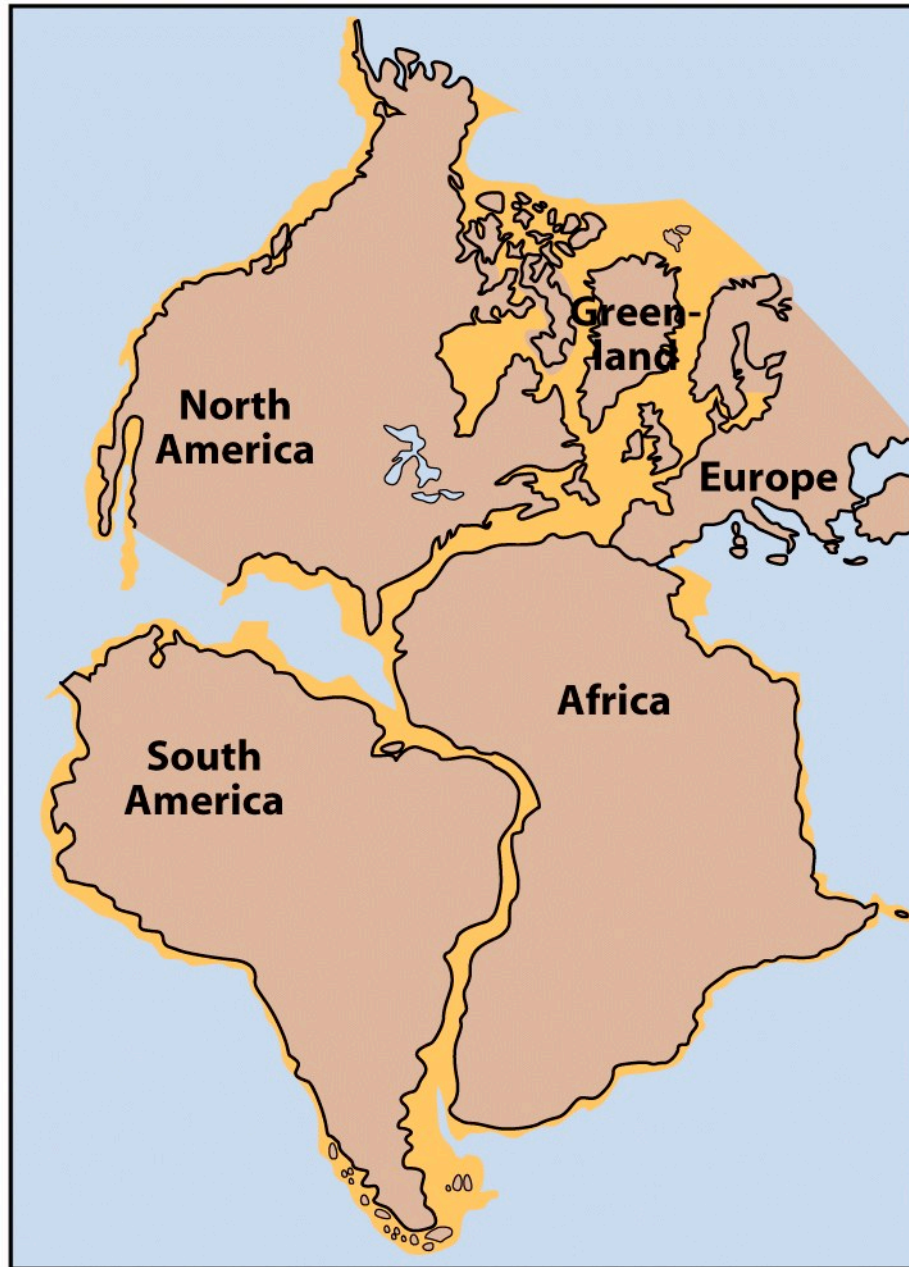
Figure 9-10  
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## Question 12.2 (iclickers!)

- The main reason that deep P and S seismic waves do not travel in straight lines inside Earth is that
  - A) Earth is spherical, and the waves follow the shape of the surface of Earth
  - B) They cannot travel through molten regions, and thus reflect back toward the surface of Earth
  - C) They reflect and scatter off numerous irregularities and faults inside Earth
  - D) Their speed changes with changing density, causing the waves to refract





Africa, Europe, Greenland, North America, and South America fit together remarkably well. The fit is especially convincing if the edges of the continental shelves (shown in yellow) are used, rather than today's shorelines. This strongly suggests that these continents were in fact joined together at some point in the past.

Figure 9-11  
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# 237 million years ago: the supercontinent Pangaea



Figure 9-12a  
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# 152 million years ago: the breakup of Pangaea

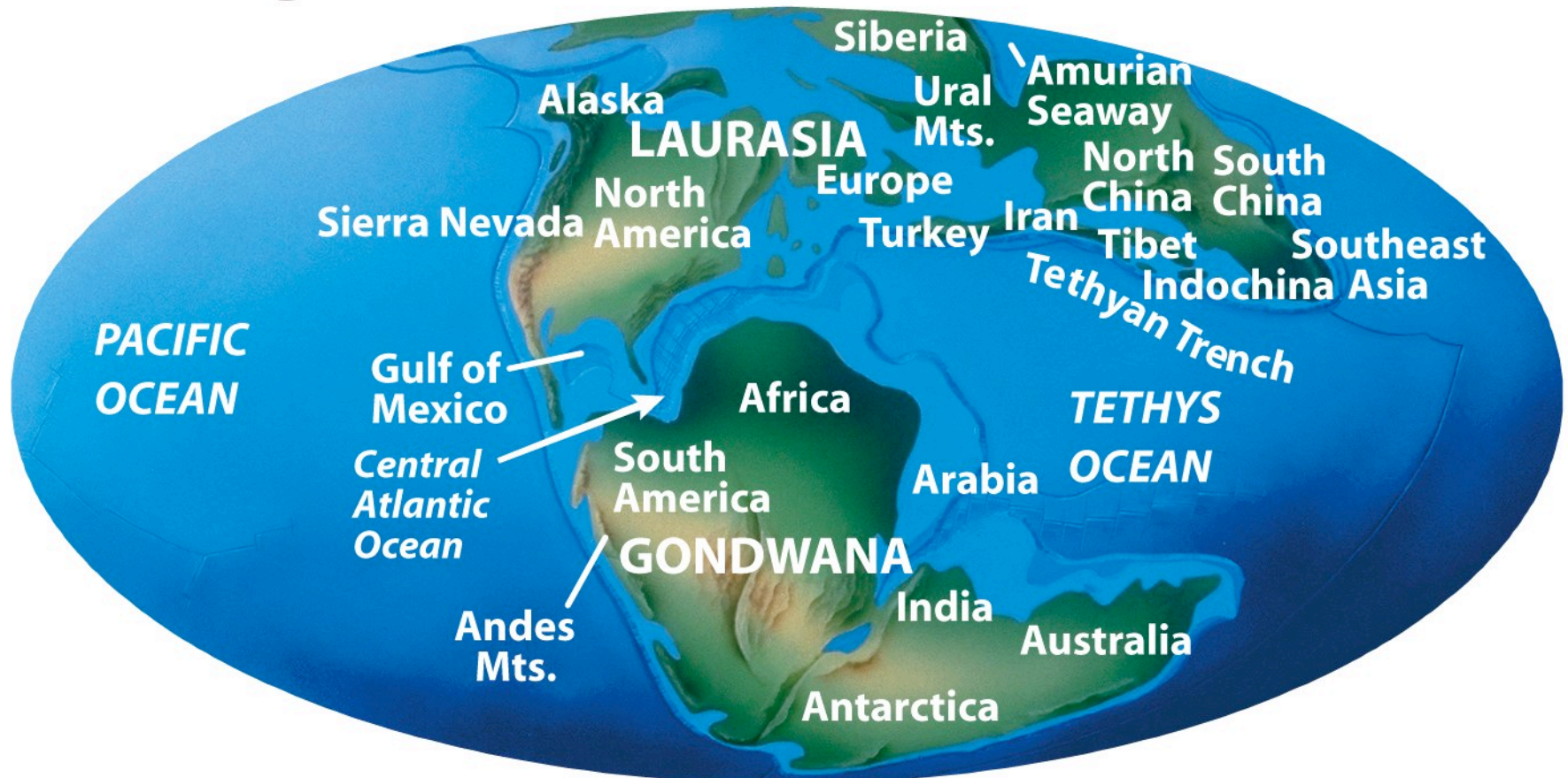


Figure 9-12b  
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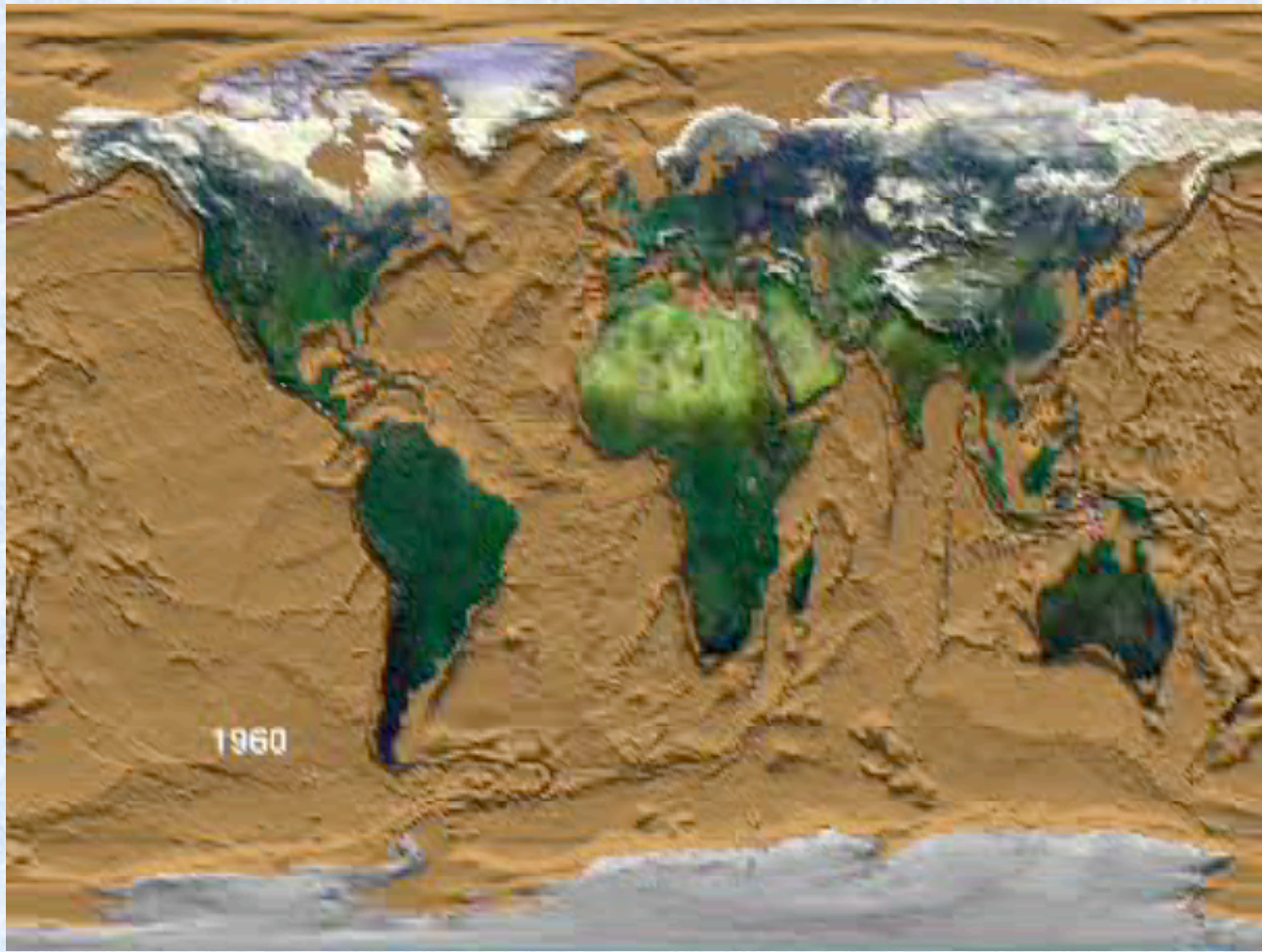


# The continents today



Figure 9-12c  
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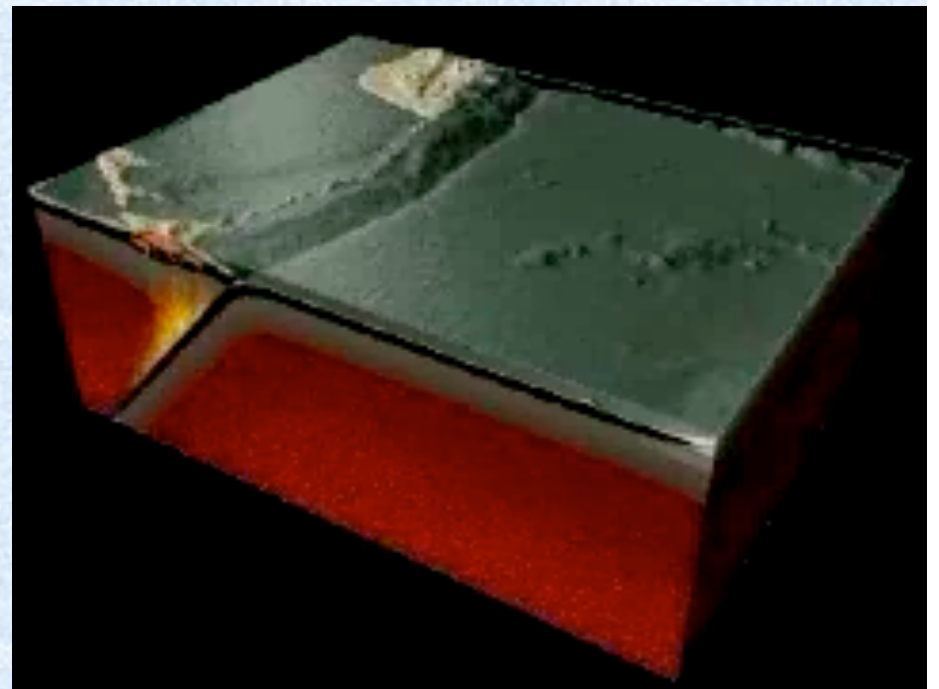
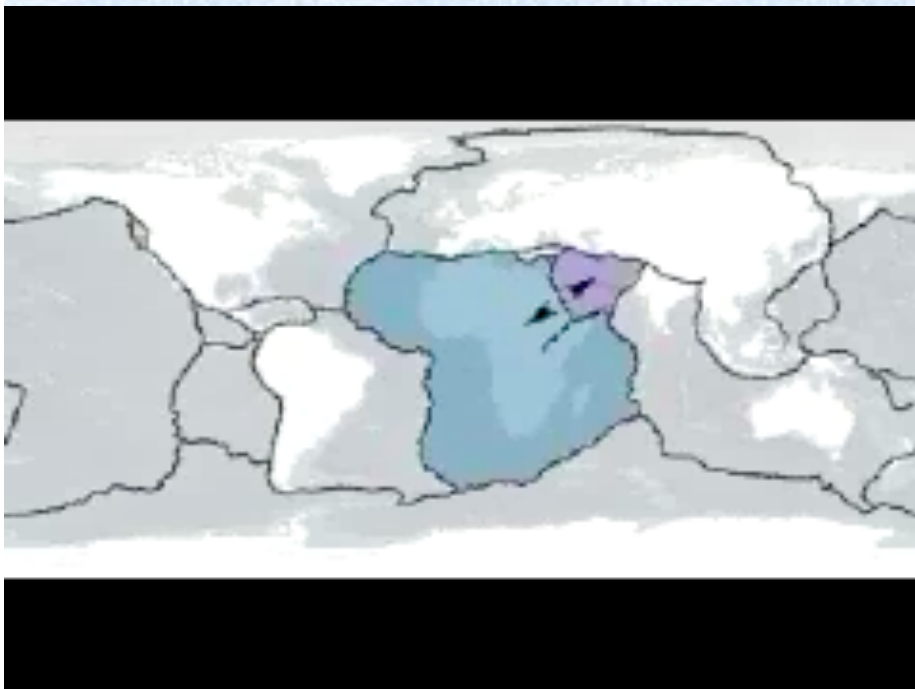
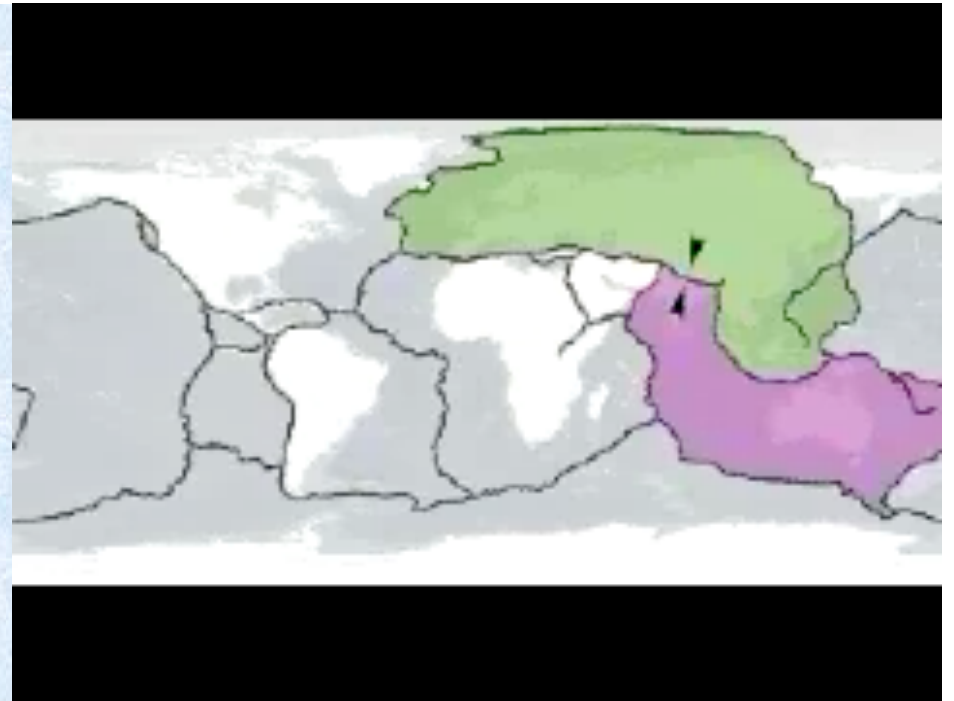
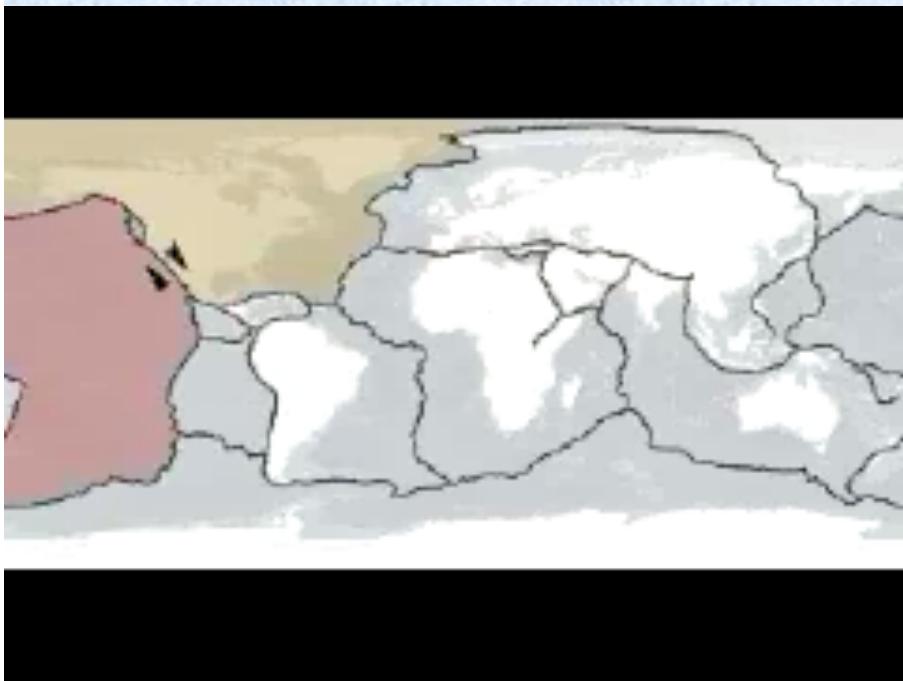






**Figure 9-13**  
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The Mechanism of Plate Tectonics: Convection currents in the asthenosphere, the soft upper layer of the mantle, are responsible for pushing around rigid, low-density crustal plates.

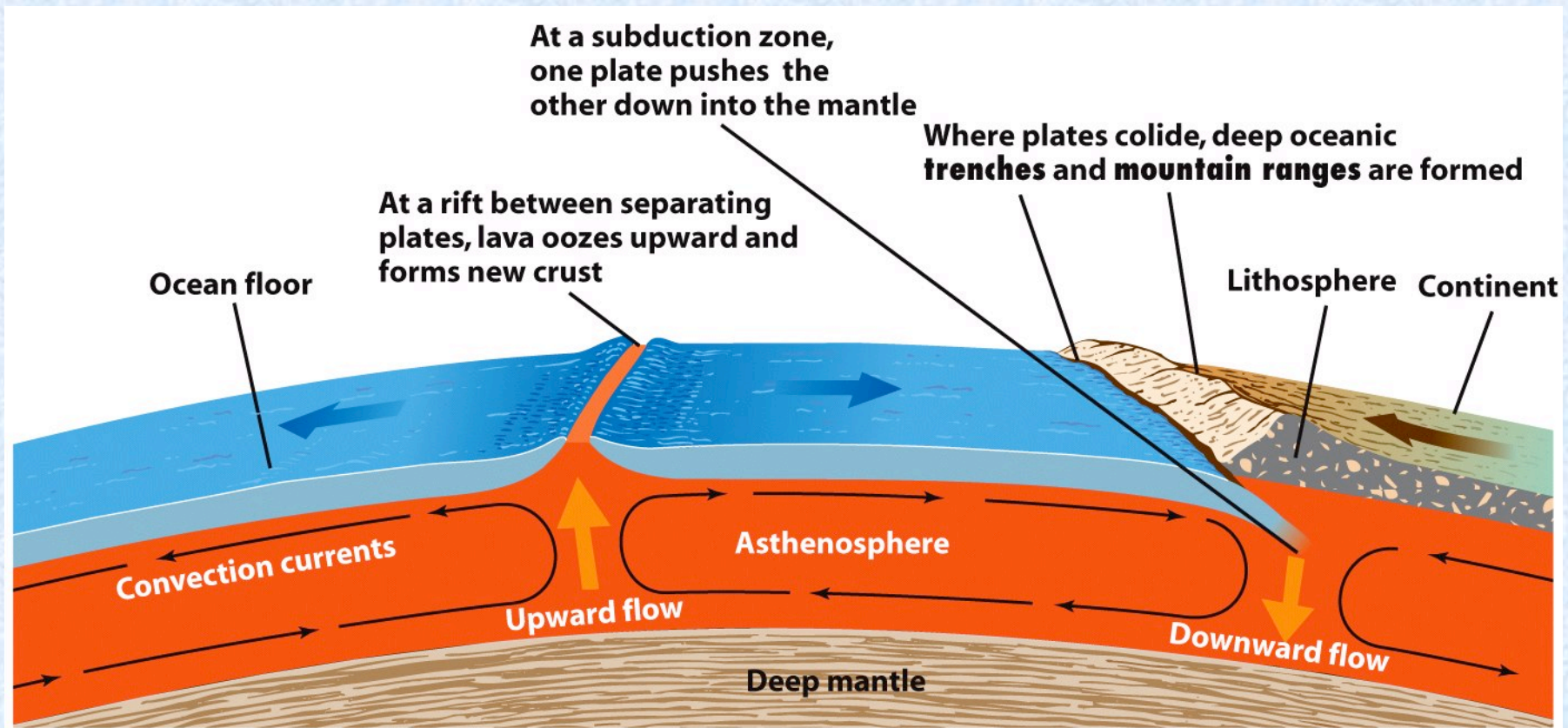


Figure 9-16  
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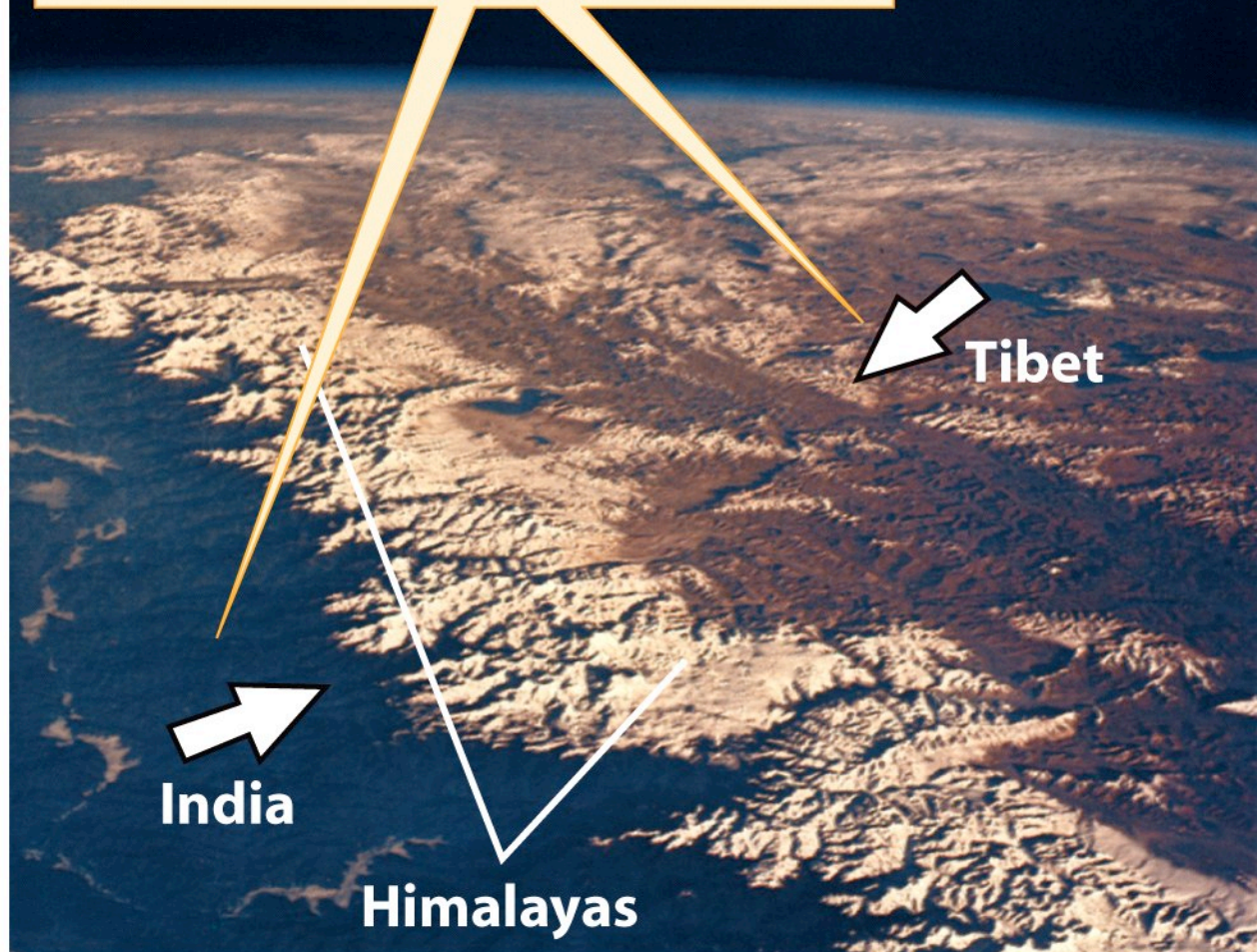
**The Red Sea is formed by the spreading apart of the African plate (at lower left) and the Arabian plate (at upper right)**



**Figure 9-17**  
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**The Himalayas are formed by the collision of the Australia-India plate (on the left) and the Eurasian plate (on the right)**



**Figure 9-18**  
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## Question 12.3 (iclickers!)

- The motion of large portions of Earth's surface, or "plates" are caused by
  - A) Tidal forces from the Moon and the Sun, acting on continental landmasses
  - B) The varying pressure of Earth's atmosphere, both daily and seasonally
  - C) Flexing of the surface due to solar heating and nighttime cooling
  - D) Convective flow of matter in Earth's interior



# Summary

- **The Earth's Energy Sources:**
  - Solar energy
  - Rotational Energy of the Earth and the Earth-Moon system, though tidal forces.
  - Internal residual heat of the Earth
  - Radioactivity in the Earth's crust
- **The Earth's interior**
  - Inner and outer core made of Iron
  - Mantel made of iron rich minerals
- **Plate tectonics**
  - The crust moves due to the internal circulation of heat from the core to the mantel
  - Resopnsible for Earthquakes, Volcanism and Movement Continents



**The End**

See you on friday!