- Homework #3 is due Friday at 11:50am!
- Planetarium observing is over.
- Solar observing is over.
- Nighttime observing starts tonight.

Outline

- Interesting facts.
- Temperature scales.
- How Heat is transported.
- The Earth as a Planet.
  - interior
  - plate tectonics
  - atmosphere
  - magnetic field
  - aurora

Last Lecture– Misspeak

- Pluto has about 8% of the gravity that Earth does, so a 100 pound person would weigh 8 pounds. Or a 445 Newton person would weigh 36 Newtons. Kilogram is a measure of mass, not weight.

Last Lecture– Eros

- Where did Eros get its name?

- There are 29,074 known "minor planets," mostly asteroids and a handful of comets and other objects. Of those, only 8,830 have been named.
- Usually the discover can name the asteroid whatever they want, pending approval by the Committee for Small Body Nomenclature
- There are about 1000 discovered per month.

http://near.jhuapl.edu/iod/20000222/index.html

http://utenti.lycos.it/votantonio/traduttore.htm

The Top 7 Moons

MASS

- 1) Ganymede (0.025)
- 2) Titan (0.023)
- 3) Callisto (0.018)
- 4) Io (0.015)
- 5) Moon (0.012)
- 6) Europa (0.008)
- 7) Triton (0.004)
- Pluto (0.002)

SIZE

- 1) Ganymede (0.41)
- 2) Titan (0.40)
- 3) Callisto (0.38)
- 4) Io (0.28)
- 5) Moon (0.27)
- 6) Europa (0.25)
- 7) Triton (0.21)
- Pluto (0.18)

Jupiter Saturn Neptune

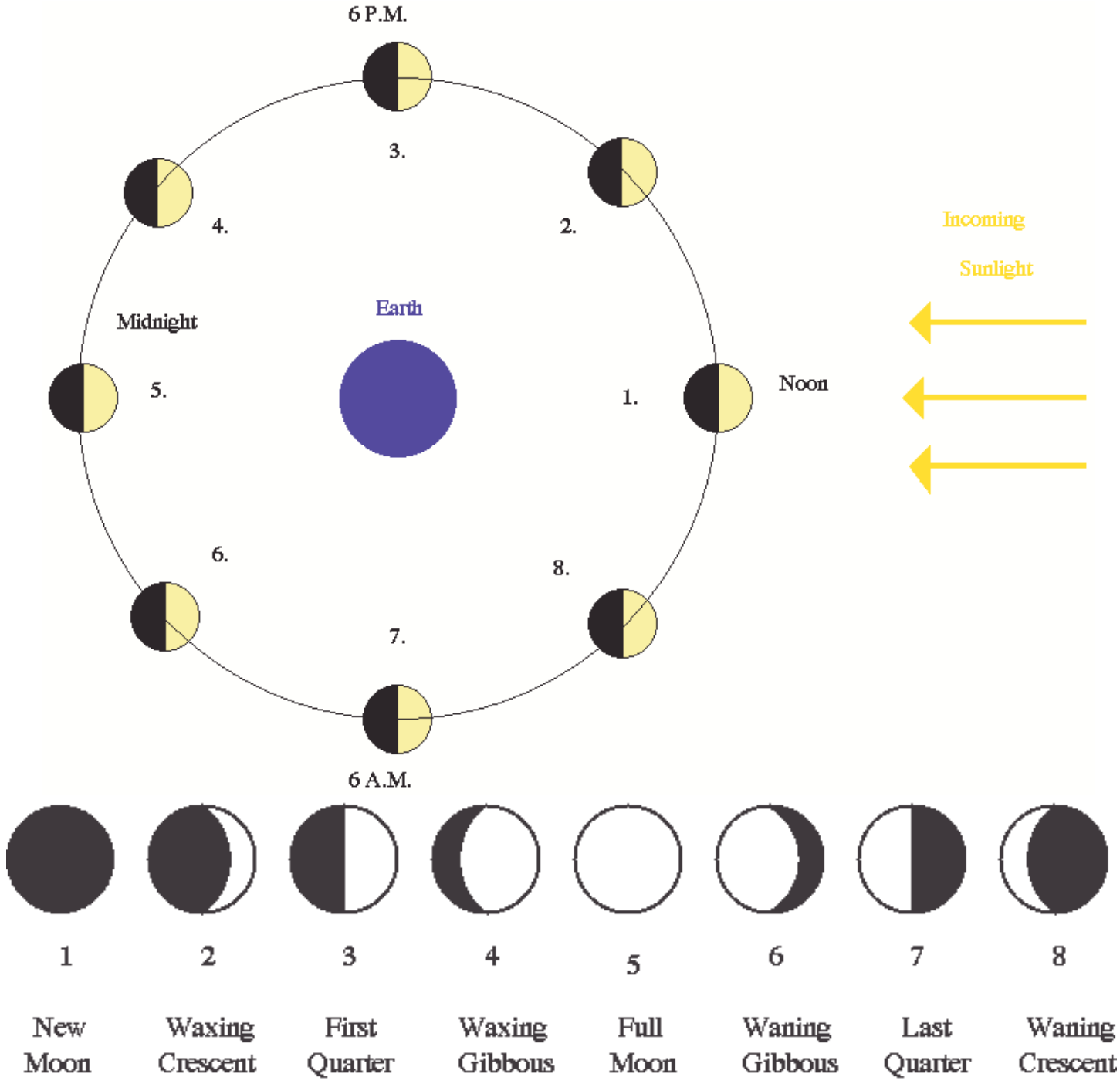
In Earth units!

Moon Phases

When will the first-quarter Moon rise, approximately?

1. 6 AM
2. midnight.
3. 6 PM
4. noon.

http://www.accd.edu/sac/ce/scobee/1stqtr.jpg


6 P.M.
3.
2.
4.
Midnight
Earth
Incoming
Sunlight
5.
1.
Noon
6.
8.
7.
6 A.M.
1
2
3
4
5
6
7
8
New Moon
Waxing Crescent
First Quarter
Waxing Gibbous
Full Moon
Waning Gibbous
Last Quarter
Waning Crescent


6 P.M.
3.


Earth

Incoming
Sunlight

What is Stuff?

- One of the biggest questions has been: What is stuff made out of?

- We know that things can be broken into small bits that defines the stuff– Atoms.

- Feynman-"..all things are made of atoms– little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another."

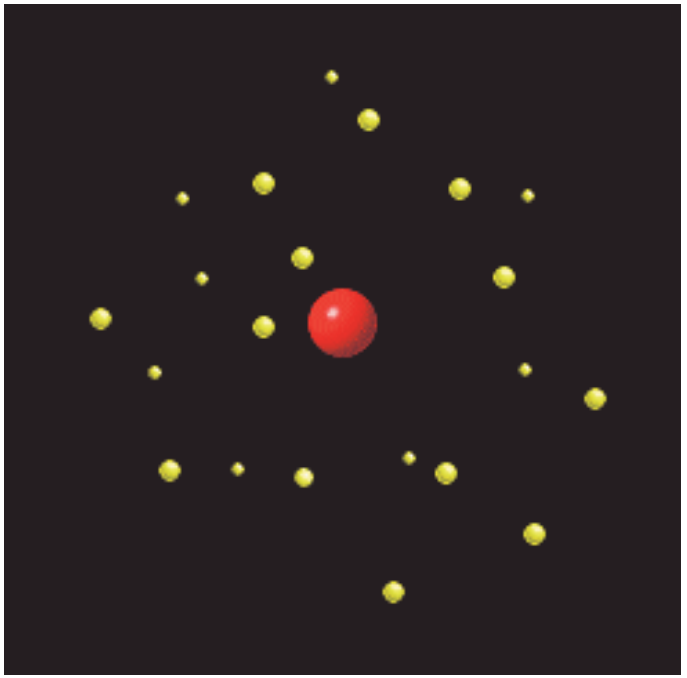
Atoms In Perspective

- Imagine yourself on a beach. You see the smallest grain of sand that you can find– stuck between your toes. How many atoms does it have? More than…

1. All the people in this room?
2. All the people in the Memorial Stadium during a Football game.
3. The population of Chicago.
4. The population of the World.

Atoms

- Remember that they are mostly empty space.



http://www.miamisci.org/af/sln/phantom/spectroscope.html

Temperature

- By measuring temperature, we are measuring the average kinetic energy of an object
  - Sort of the jiggling of the molecules. A high temperature $\Rightarrow$ higher energy and faster

- Three commonly used temperature scales:
  - Fahrenheit
  - Celsius
  - Kelvin

But there are more.

Fahrenheit (1714)

- From Gabriel Daniel Fahrenheit (German physicist)
- First to use the metal mercury
- Zero was lowest temperature he could reach (freezing point of a mixture of ice and salt)
- Freezing point of water is 32 degrees F
- Water Boils at 212 degrees F

- Advantage: human scale

Celsius (1742)

- From Anders Celsius (Swiss astronomer)
- Zero was set to freezing point of water
- 100 degrees was set to the boiling point of water

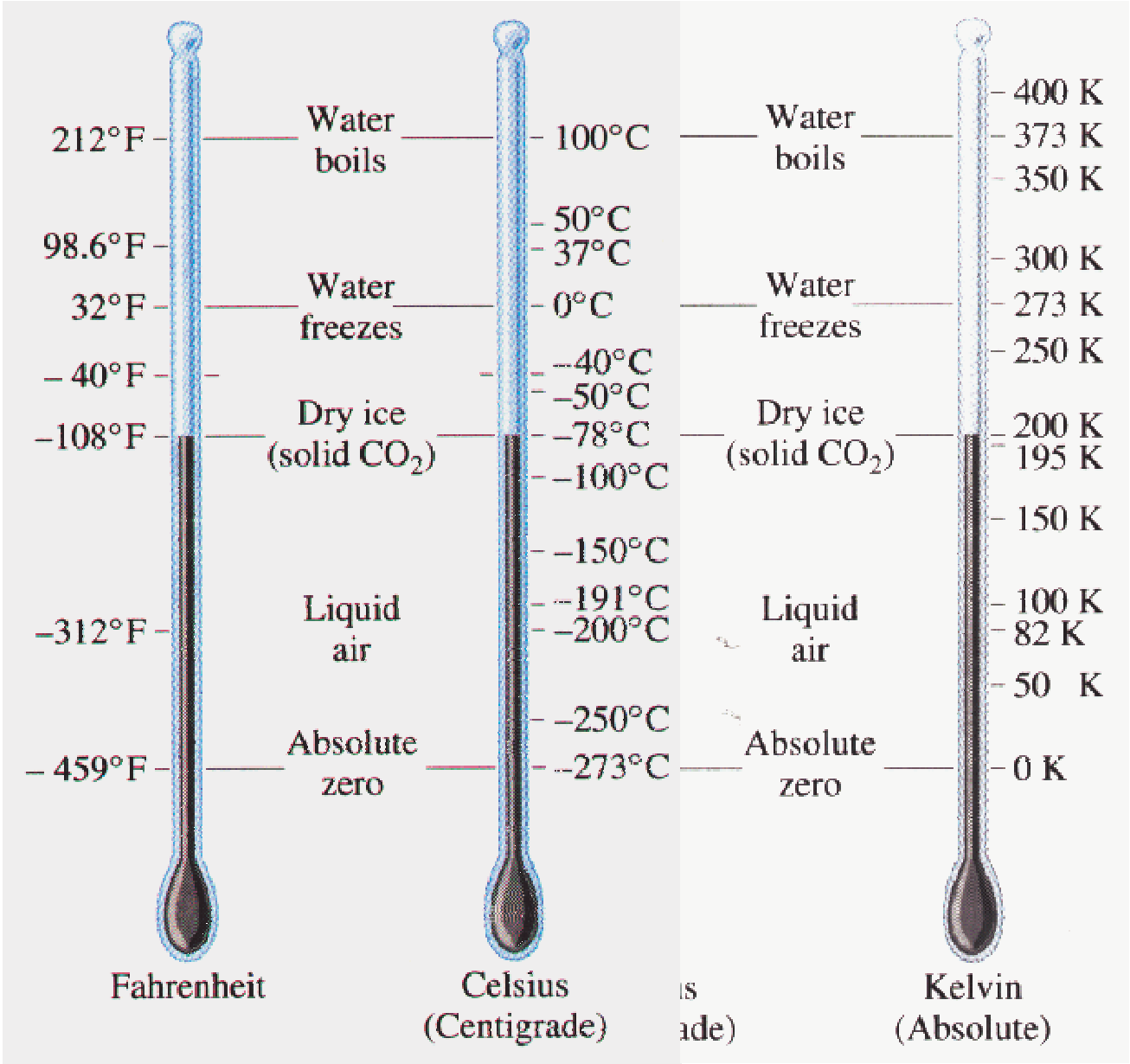
- Larger steps than Fahrenheit scale
- 1 F° = 5/9 C°

Kelvin (1848)

- From William Thomson Kelvin (UK Physicist)
- Set 0 K to absolute zero (where molecular energy is a minimum)
- Used same increment as Celsius scale (just add 273 degrees)
- Mostly widely used scale in science (makes equations simpler)

http://www.schoolscience.co.uk/content/5/physics/bama/aerosch2pg3.html

Temperature Scale Comparison



Heat Transport

- Heat passes from warmer to colder objects
- If there are several objects in contact, the warm ones become cooler and the cool ones become warmer
  - They tend to reach a common temperature
- This equalization of temperature happens in three ways:

Conduction, Convection, and Radiation

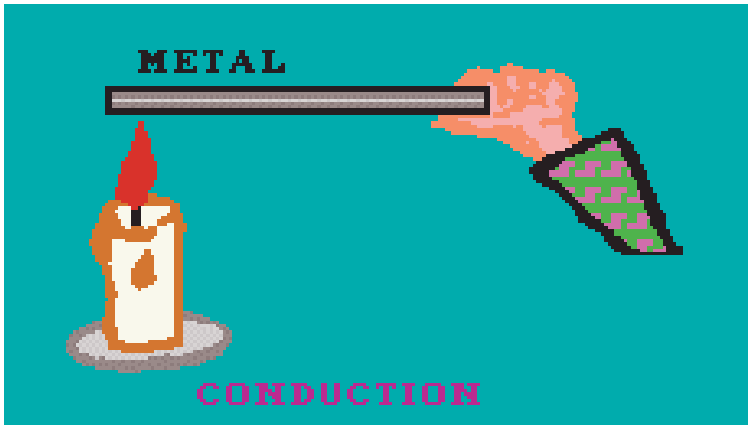
Heat **Conduction**

- With your bare feet, step on a rug. Then step on a tile floor. Which feels colder? Why?

- Since the tile is a better conductor of heat, it will conduct heat away from your foot. Making it feel cold.

Heat **Conduction**

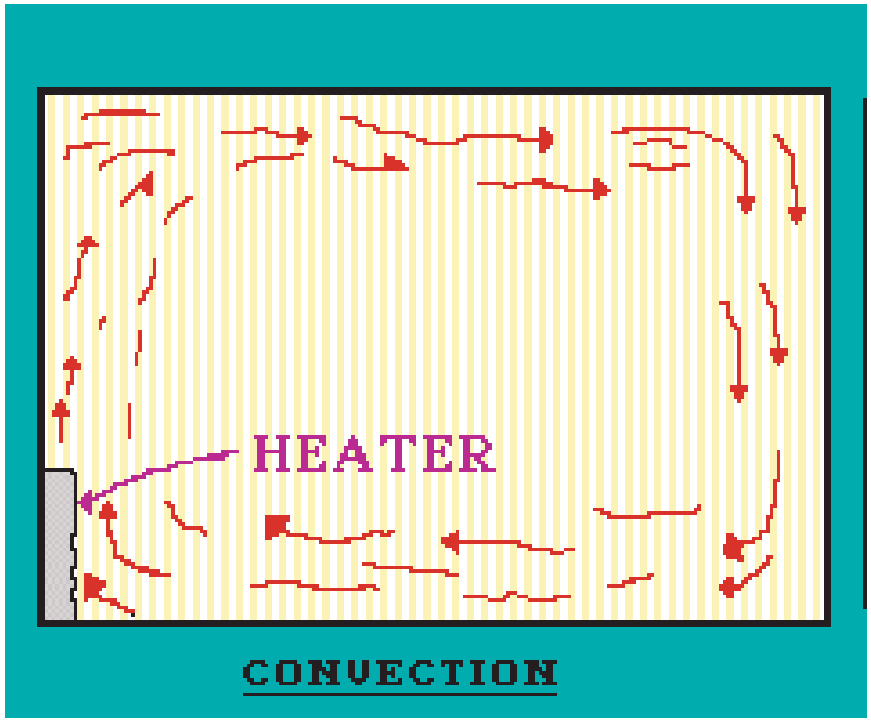
- Hold one end of a metal bar in a flame. It will quickly become too hot to hold.

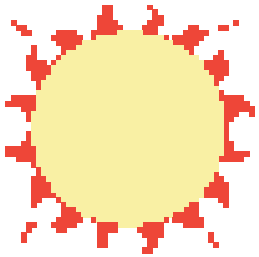


- Hold one end of a stick in a flame. You can have the stick catch fire and still you can hold the stick.

Heat **Convection**

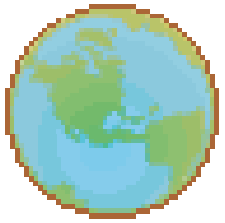
- Main method for liquids and gases to transmit heat via flows or currents
- Examples:



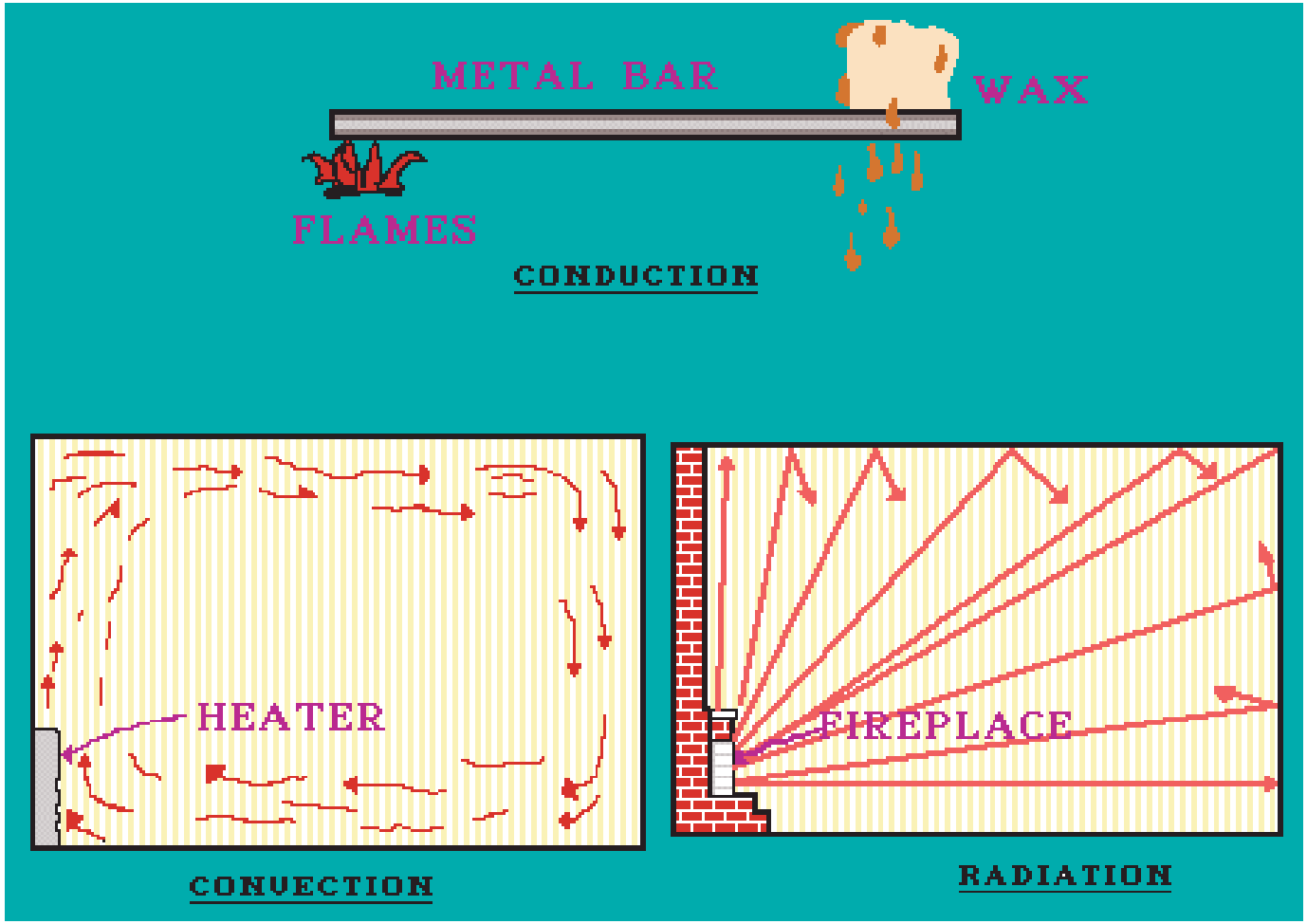


Heat **Radiation**

- How does the Sun's heat reach the earth?
  - There is vacuum between us so no conduction or convection
  - And the atmosphere is a poor conductor too
- It is emitting electro-magnetic waves, and especially infrared radiation. All matter releases radiant energy. Hotter matter releases more radiant energy than cooler matter.



Heat **Transfer**

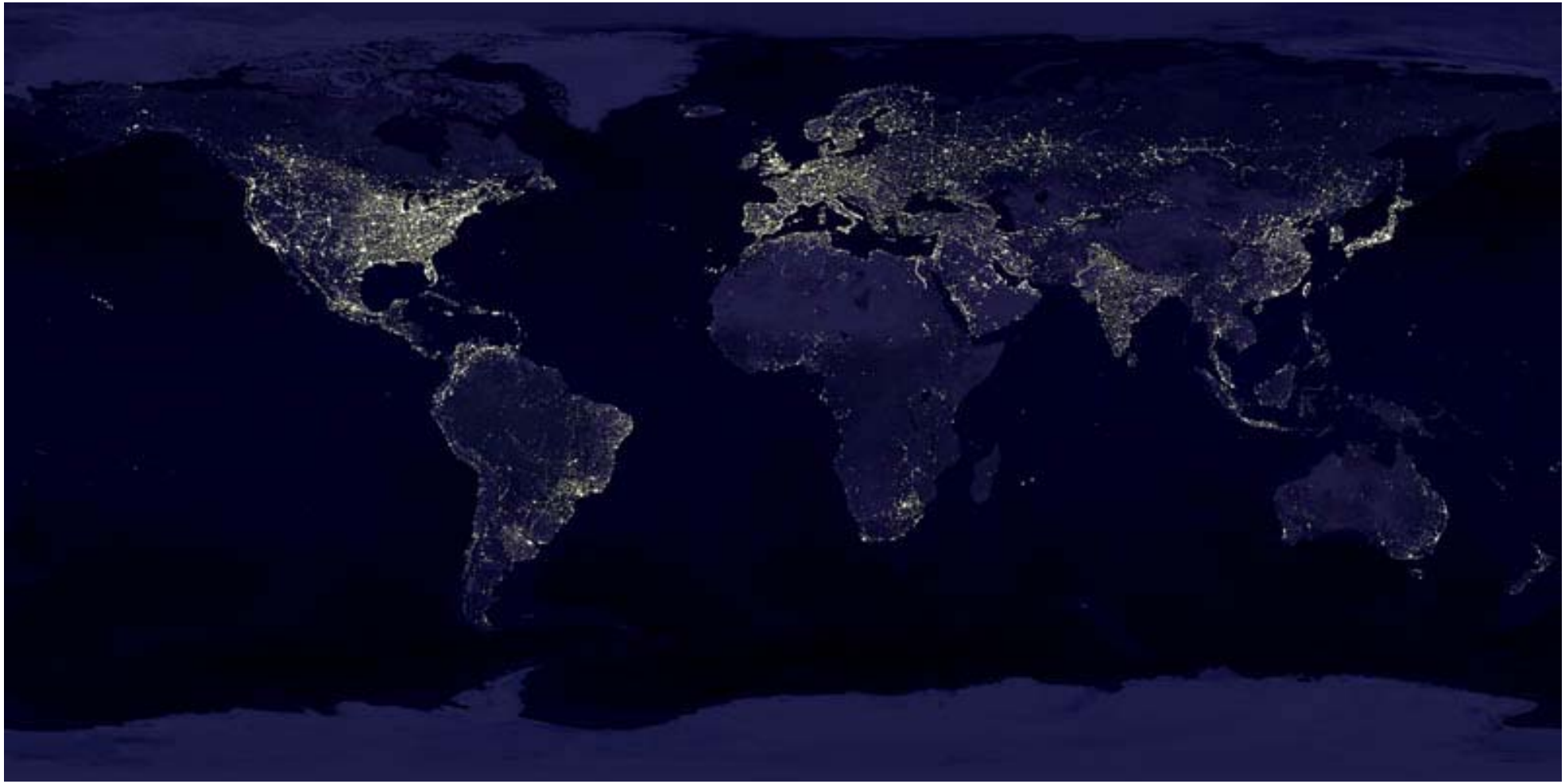


Earth as a Planet

If you were an astronomer on Mars looking at Earth though your telescope, what aspect or feature would you get excited about first? Excited enough to write a paper about it.

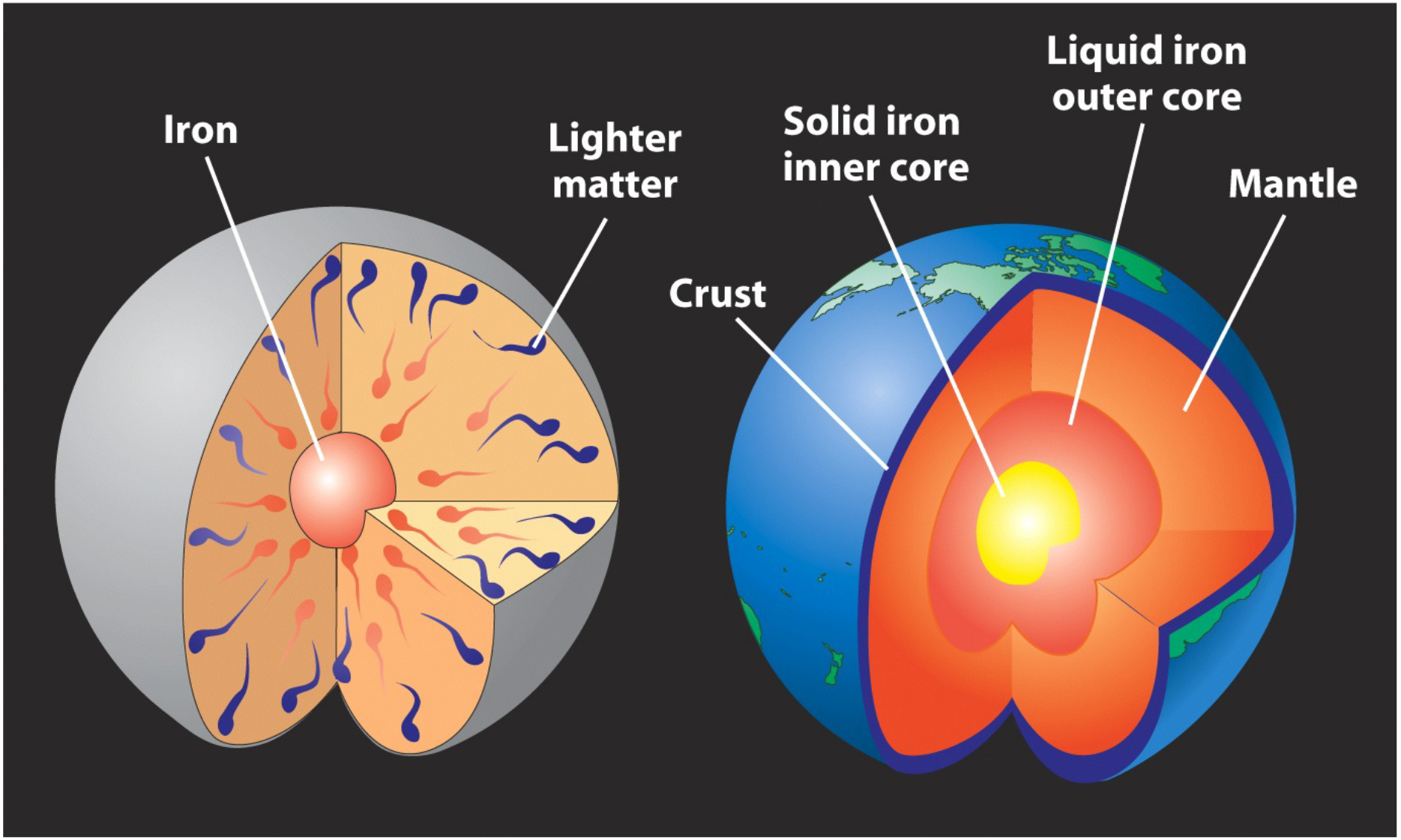
http://www.solarviews.com/cap/earth/earthafr.htm

Lights Around the World



http://www.solarviews.com/cap/earth/earthlights.htm

Planetary Differentiation

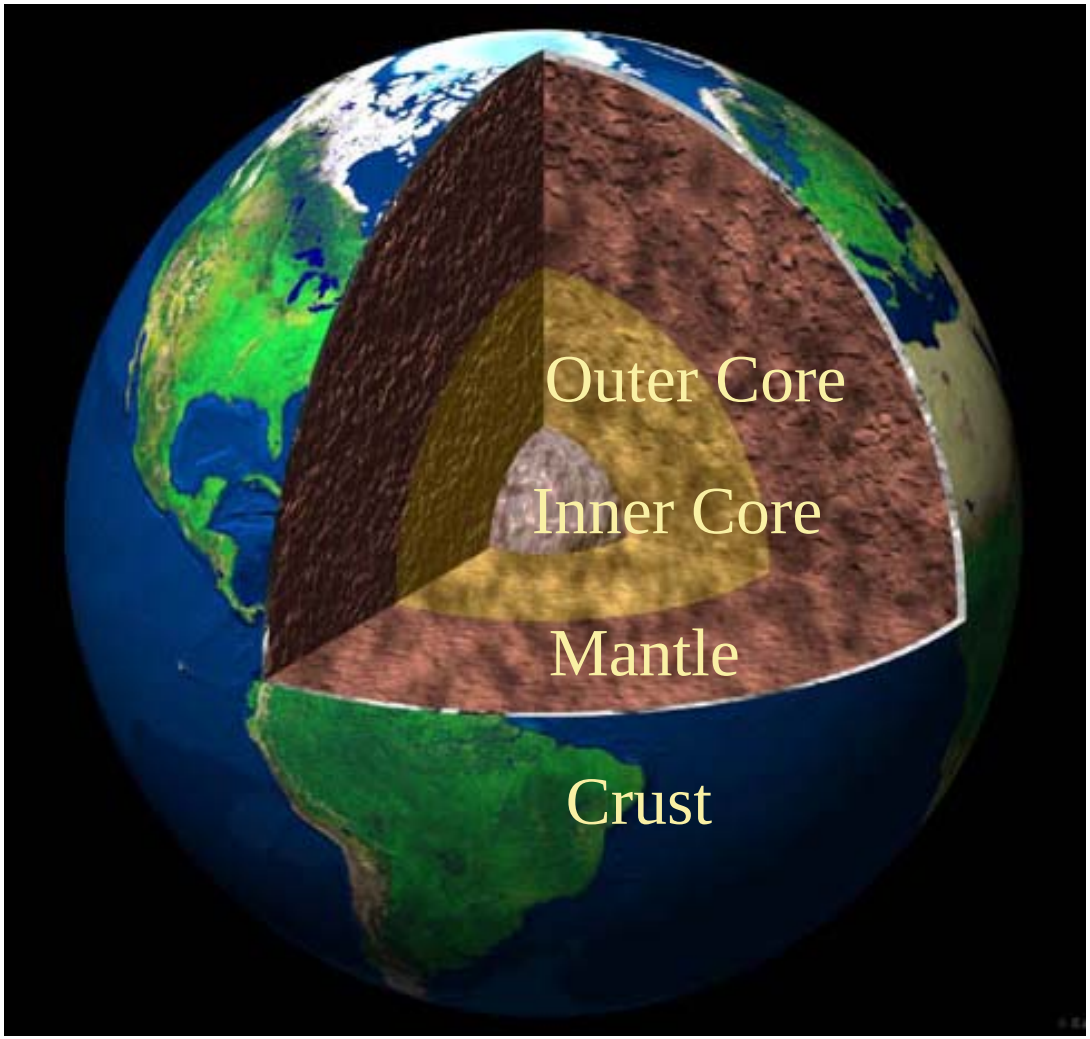


Earth's Differentiation

- We know average density of earth is 5.5 g/cm3, but average density on crust is 2.6 to 3 g/cm3.
- So, something heavy must be inside– heavy metal
- With a hot interior during the formation of the earth differentiation has taken place
  - Heavy materials (e.g. iron and nickel) sank and lighter materials floated on top

Structure

- Temperature increases as you go deeper
- From around 290 K on surface to nearly 5000 K at center.
- But deeper you go more pressure from mass of Earth.



Inner Core

- With high pressures the inner core remains a solid
- Reaches very high temperatures– 5000 K (Close to the temperature at the surface of the Sun)!
- Mostly made of iron (Fe)
- Information about the inner core comes from the study of earthquakes, meteorites and the Earth's magnetic field.
- Might be rotating faster than the rest of the planet.

Outer Core

- The liquid layer of the Earth, high pressure but not enough to solidify
- Mostly Iron
- Made of very hot molten liquid that floats and flows around the solid inner core– heat convection plays major role
- This convection produces complicated circulation pattern of iron (electrical conductor)– creates a magnetic field

Mantle

- Largest layer of the Earth, source of magma and lava
- Distinct from the core
- Temperature increases the deeper you go into the mantle
- Heated from below, parts of the Mantle are hot enough to have an oozing, plastic flow (sort of like silly putty).
- There is a major force of convection heat flow in the Mantle.

Crust

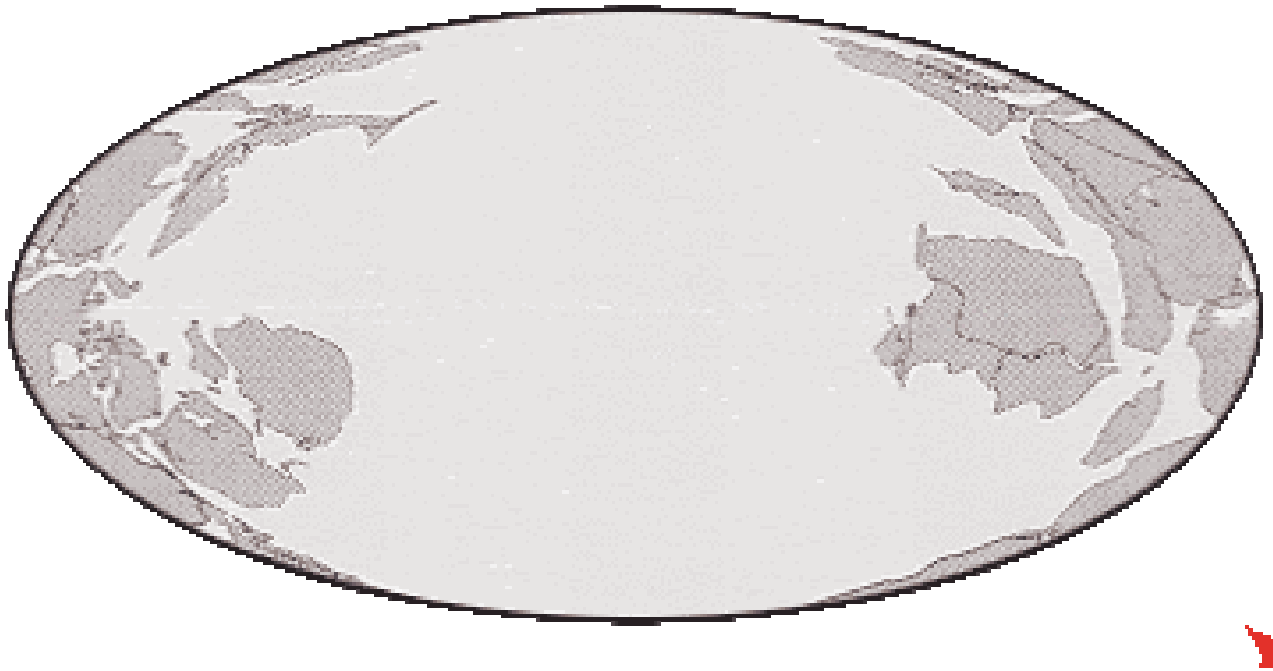
- Outside layer of the Earth (includes oceans) that floats on top of the mantle
- Much thinner and colder than any of the other layers
- Crust is rocky and broken into about 21 different pieces (like the shell of a cracked hard-boiled egg).
- Oxygen and Water are abundant

In Hawaii

Continental Drift

- You might think that parts of S. America might fit with Africa.
- In 1915, the theory arose that in fact the continents started with a single land mass that broke up 200 million years ago. This means speeds of cm/year.
- In the 1950s the underwater ridges confirmed the idea.
- The seafloor between the North America and Europe/Africa was spreading
- It was generally accepted in the 1960s.

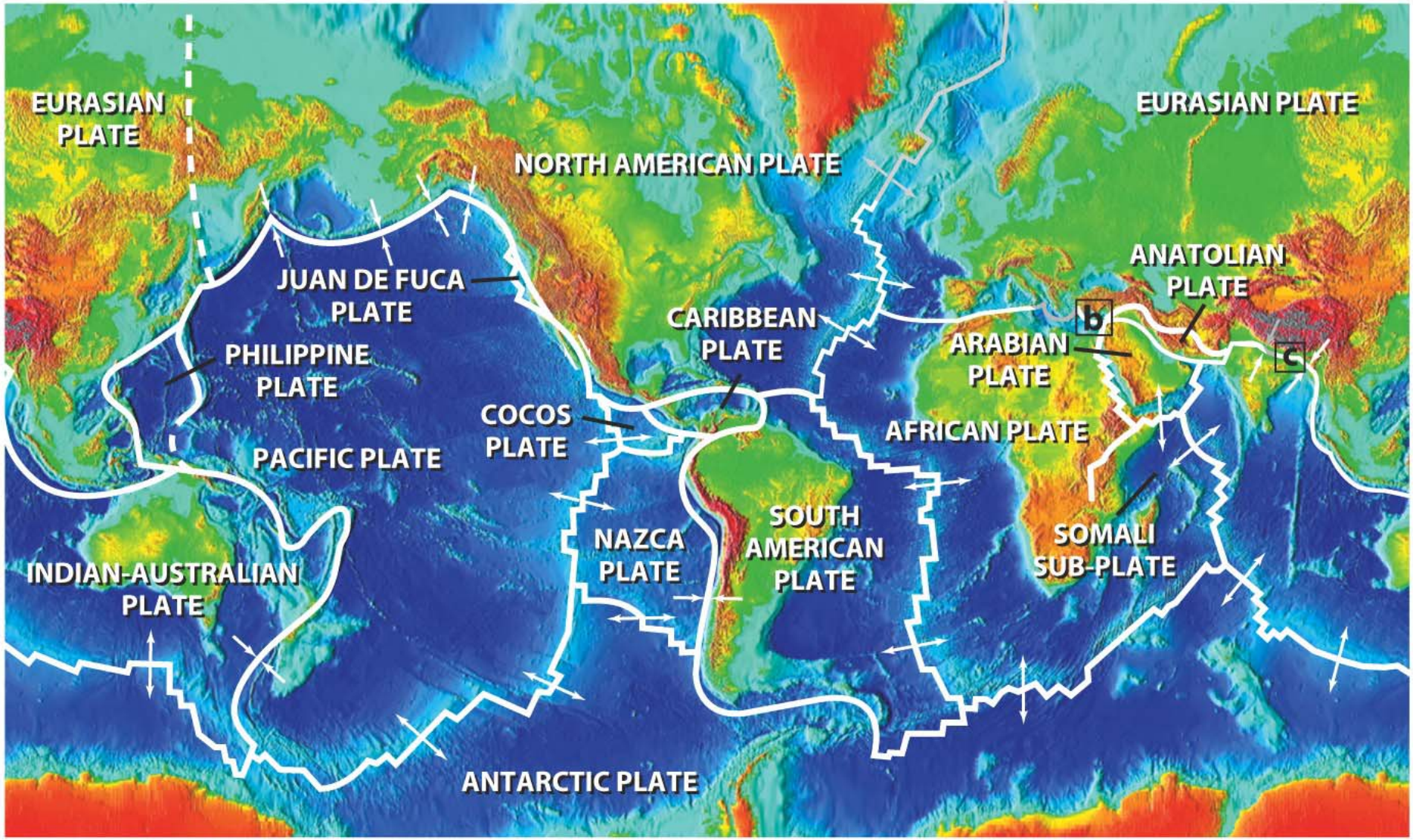
Moving Earth



Million of years ago

http://www.ucmp.berkeley.edu/geology/anim1.html

Plate Tectonics



a

Examples


Saudi
Arabia
Gulf of
Aqaba
Sinai
Peninsula
Egypt
Gulf of
Suez
Red Sea

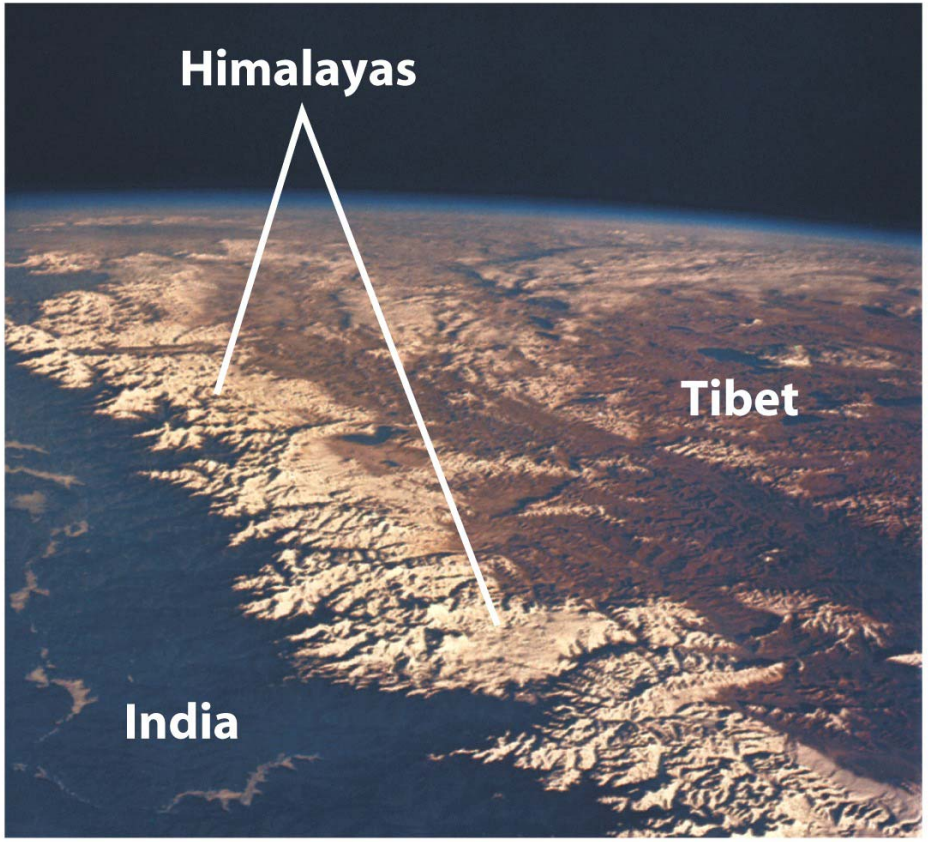
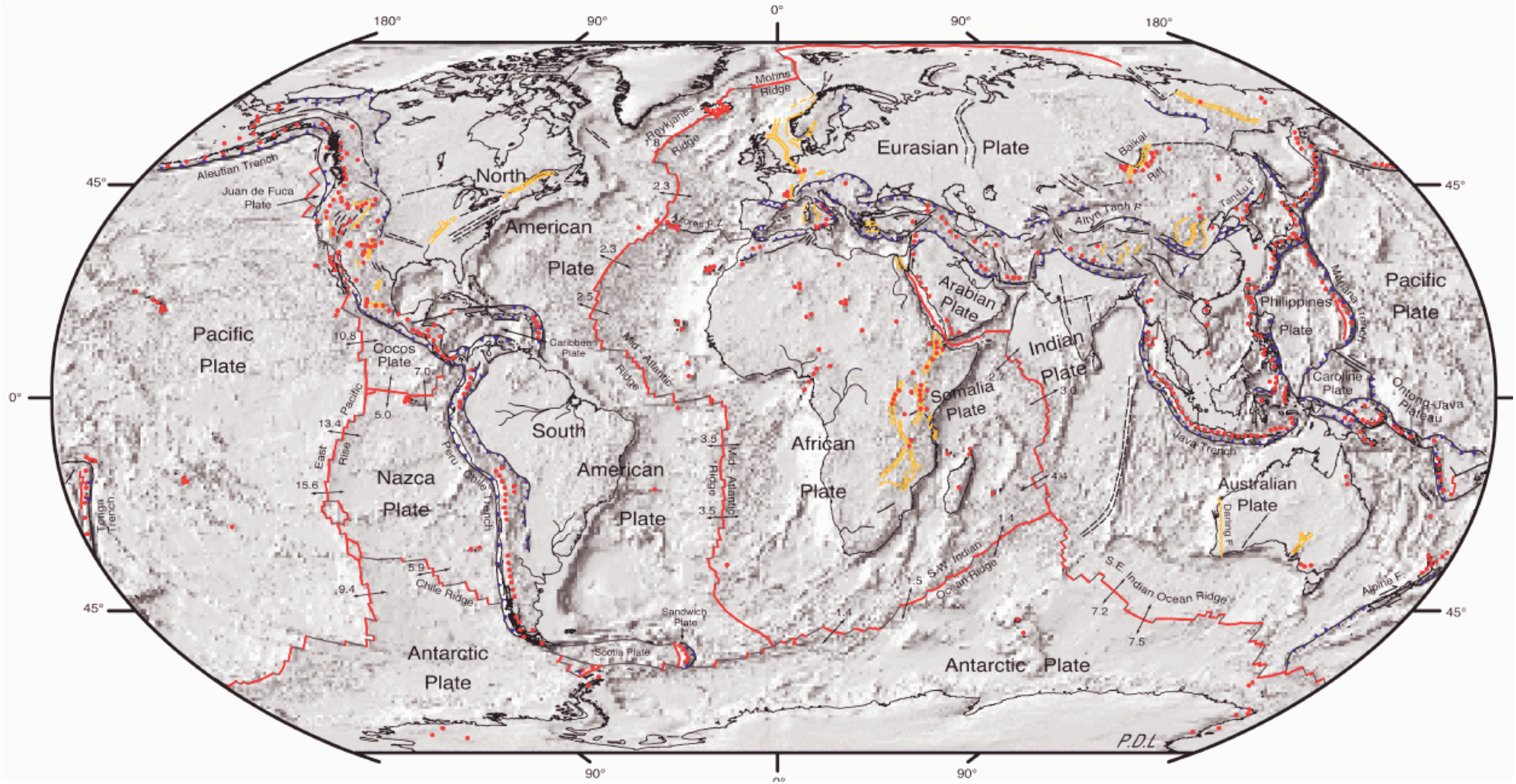
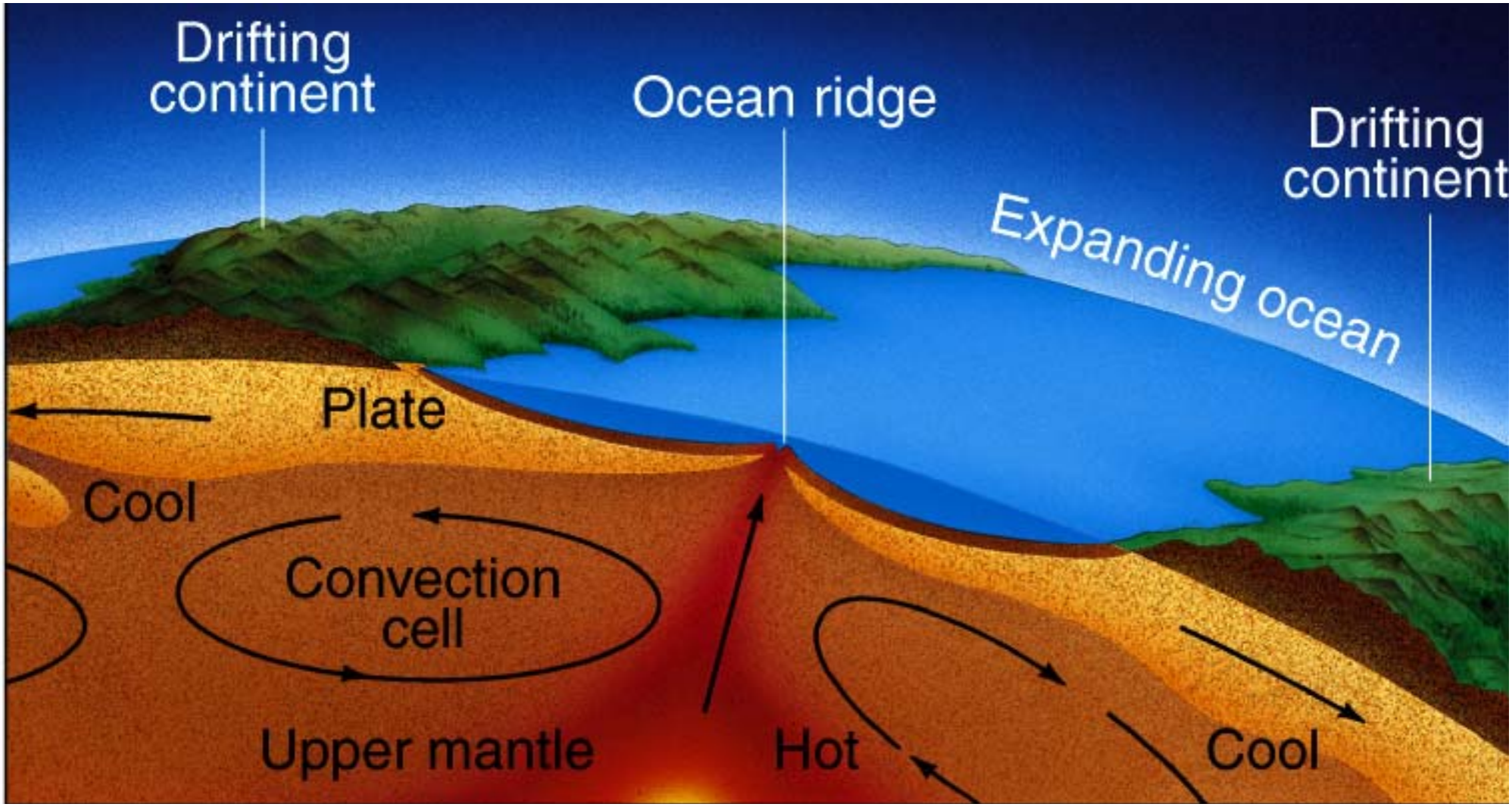

Himalayas
Tibet
India

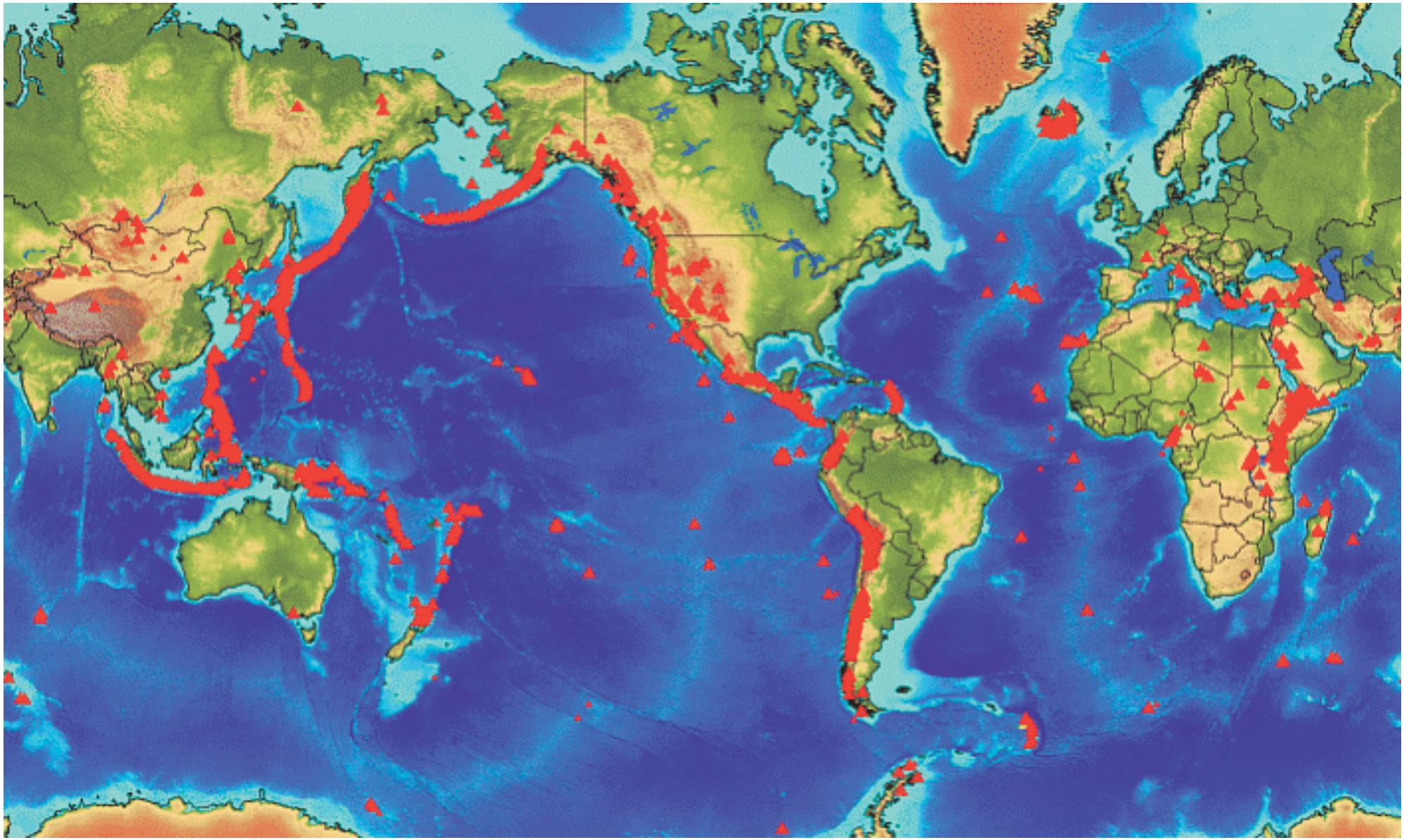
Plate Tectonics



http://epod.usra.edu/archive/epodviewer.php3?oid=39392

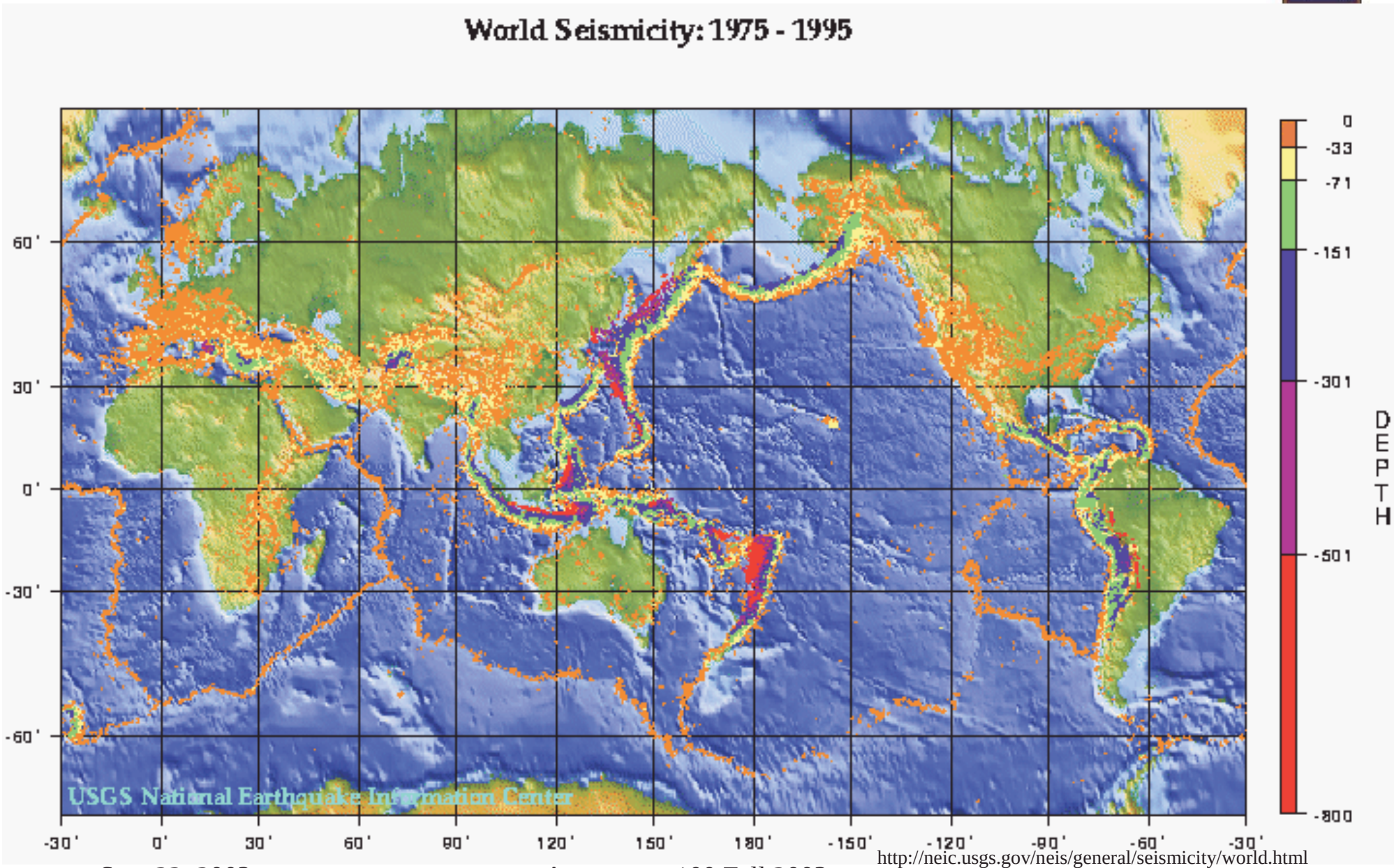

Drifting continent
Ocean ridge
Drifting continent
Expanding ocean
Plate
Cool
Convection cell
Upper mantle
Hot
Cool

Volcanoes



http://www.volcano.si.edu/world/location.cfm

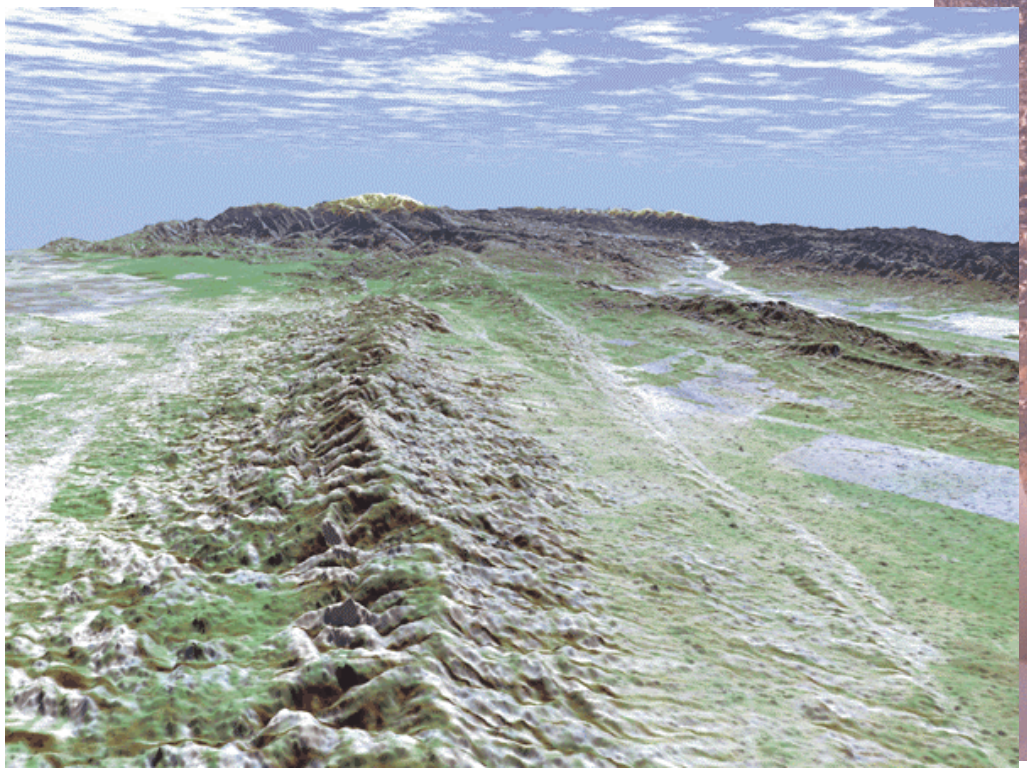
Earthquake Activity



http://neic.usgs.gov/neis/general/seismicity/world.html

Whose Fault is it anyway?

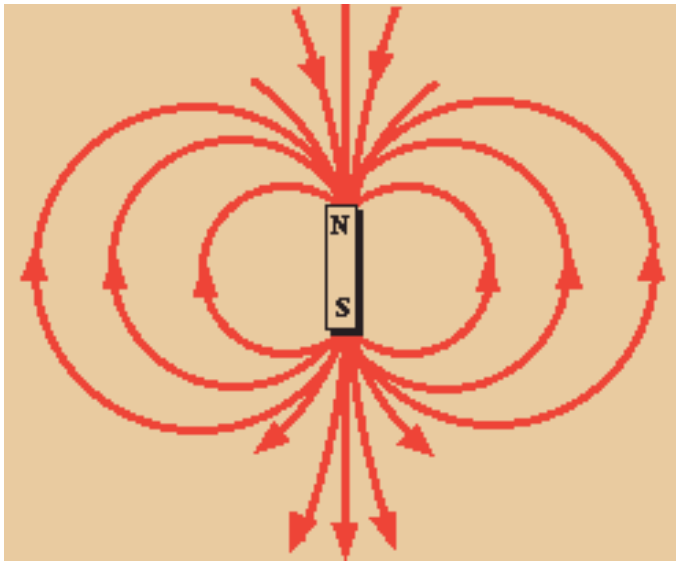
http://epod.usra.edu/archive/images/pia02786.gif



http://sepwww.stanford.edu/public/oldsep/joe/fault_images/FT02.3.gif

Earth's Magnetic Field

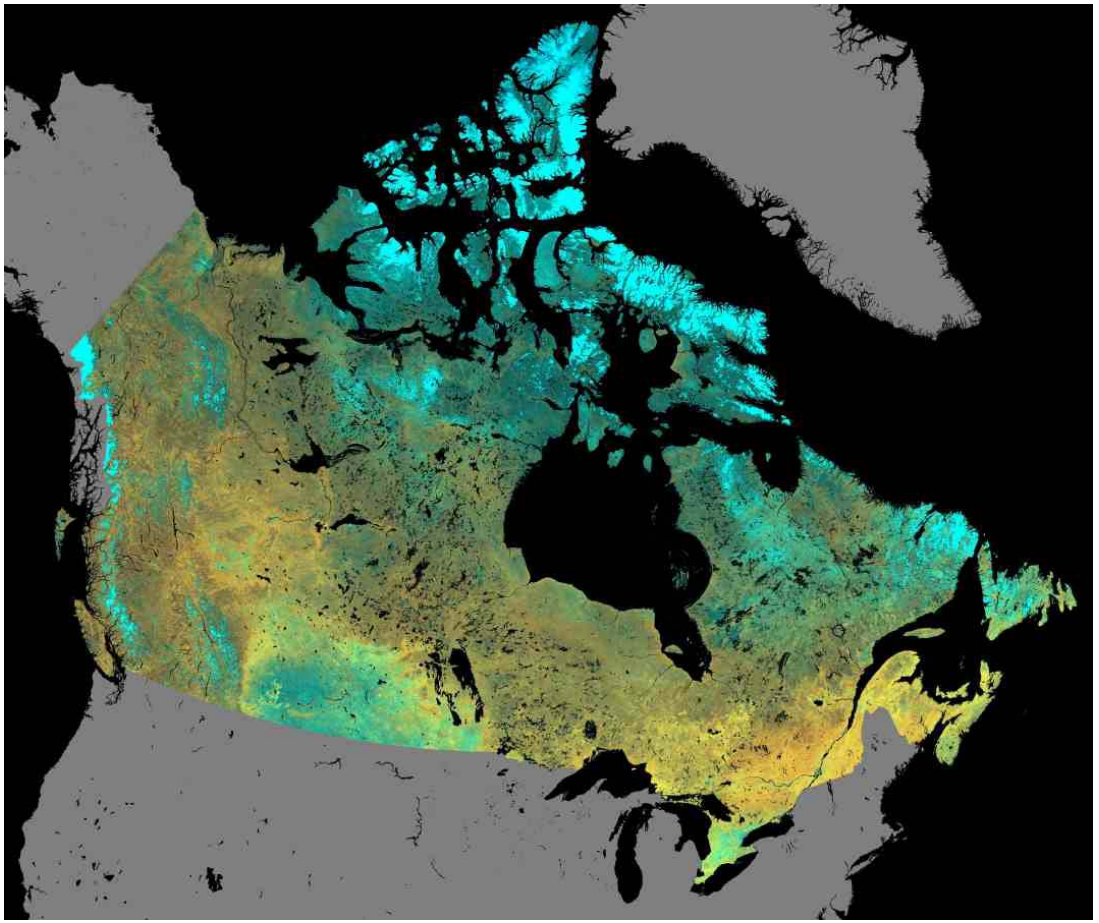
- As you know from using a compass, the Earth has a magnetic field.
- We believe that the convection of the molten iron outer core and the Earth's rotation, creates an electrical current. An electric current produces a magnetic field.
- The "North" of the Earth is slightly offset.
- It irregularly flips direction– last time was 600,000 years ago.
- It protects the Earth from energetic particles– Van Allen Belt



http://liftoff.msfc.nasa.gov/academy/space/mag_field.html

Magnetic North

- Magnetic North can move as much as 40 meters a day.



http://antwrp.gsfc.nasa.gov/apod/ap991019.html

Aurora from Space

When the Van Allen belts overload with charged particles, they leak through at the poles and cascade down in the Earth's upper atmosphere– sort of like a neon sign

Earth's Atmosphere

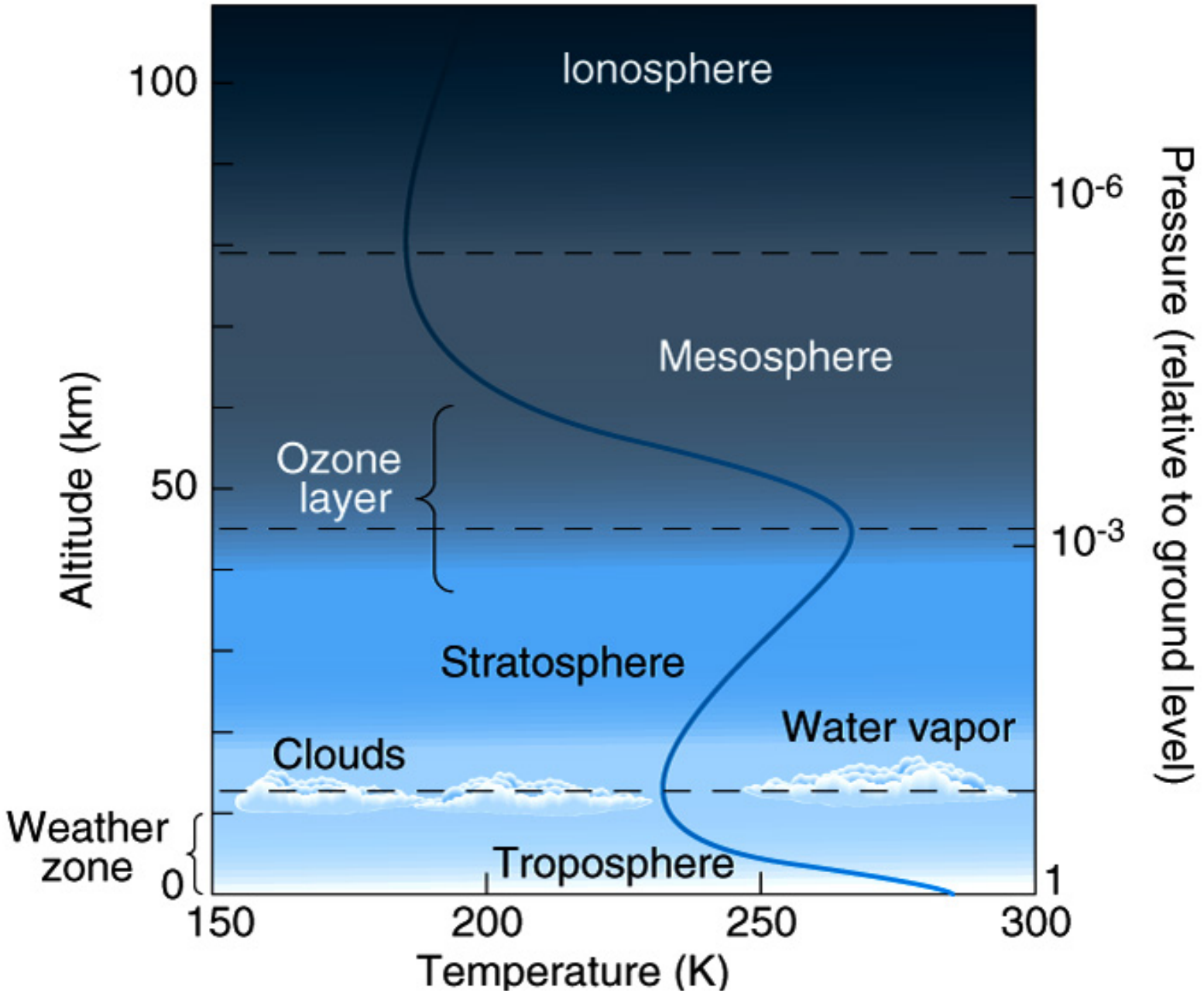
- Atmosphere is essential to live, made from Nitrogen and Oxygen– rare in other planets atmosphere
- However, this is the Earth's 3rd atmosphere
  - First was hydrogen and helium
  - Second was from volcanoes– carbon dioxide and some nitrogen (more like Venus)
  - Water helped dissolve the CO_2, and we arrived at the atmosphere we have today (thanks to plants)

Temperature with Altitude

Does it…

1. Increase
2. Decrease
3. Stay about the same

Layers of the Atmosphere



Ozone Layer

- Ozone is O_3– three oxygen atoms bound together: created by sunlight
- Absorbs solar ultraviolet light
- Ozone layer (40 km thick so maybe region) has an increase in temperature
- If at the same density as near the surface only a few mm thick
- Human-made chemicals deplete the ozone layer– This is bad!