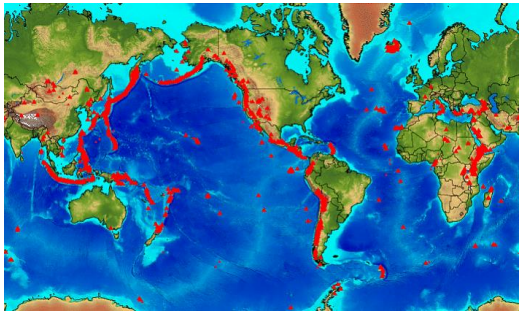
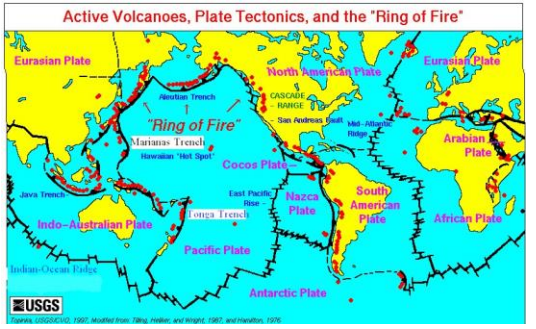
The red triangles mark the location of ?????



Why are they there??

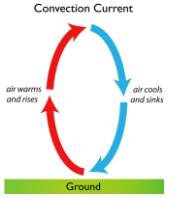
Chapter 17 – Plate Tectonics



Convection Review

1). What causes convection to occur?

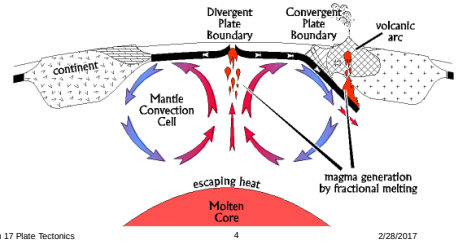
2). Where (in what previous unit) have you seen this same process before?



Causes of Plate Motions

Convection: The transfer of thermal energy by the movement of heated matter

1. Warms, expands, and becomes less dense & rises
2. Cooler, denser material sinks due to gravity
3. Forms a cycle or convection current



Alfred Wegener

1. Alfred Wegener proposed the theory of Continental Drift
2. Continental Drift theory: All continents were originally joined as a single landmass called Pangaea.
   A. Pangaea began to break up 200 million years ago and began drifting apart
   B. The process is still occurring.
3. Wegener's evidence for continental drift went beyond the "puzzle fit" the map-makers had seen and includes:
   A. Rocks
   B. Fossils
   C. Climatic Data

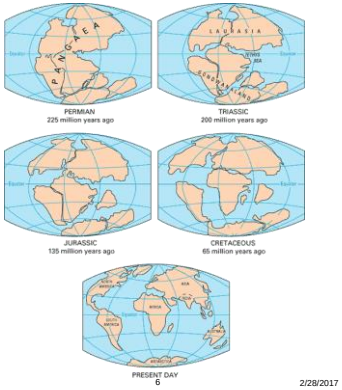
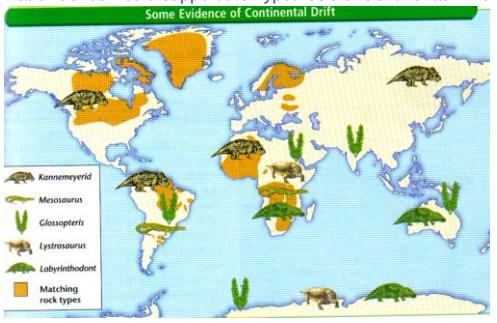


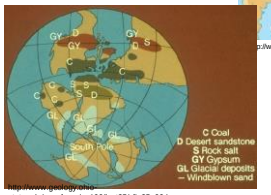
Fig 17-2 p 445 Evidence of Continental Drift

What evidence would support the hypothesis of Continental Drift?



A. Evidence from Rocks: Similar rock types between:

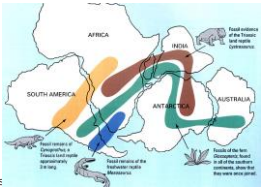
- Appalachian mountains in U.S. & rocks in Greenland
- S. America & Africa



http://www.geology.sdsc-state.edu/~vonfrese/gs100/lect25/xfig25_09.jpg

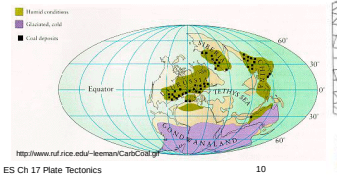
B. Evidence from Fossils: Similar fossils & plants have been found on widely separated continents:

- Continents must have once been joined & had a similar temperate (mid-latitude like us) climate to grow the fern
- Antarctica must have been closer to the equator to have a warm enough climate to grow the fern

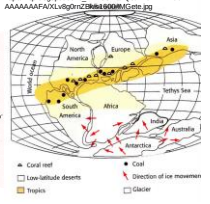


C. Ancient Climatic Evidence

- Coal deposits have been found in Antarctica
  - It forms from dead swamp plants. Swamps only occur in an area that is wet and spongy
  - This indicates that Antarctica was once warmer and wetter, closer to the equator
- Glacial deposits in Africa, India, S. America, and Australia
  - This suggests that these areas were closer to the S. Pole at one time



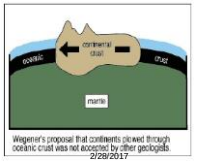
http://www.ruf.rice.edu/~leeman/CarbCoal.gif



Problems with Wegener's Continental Drift Theory

Problems caused it to be rejected in the early 1900's because of these 2 "flaws":

- Wegener couldn't explain what caused the caused the continents to move
- Wegener couldn't explain how the continents could move without shattering
- Ideas about the ocean floor were wrong until the mid-1900s. Scientists thought the seafloor was flat, older then the continents and unchanging-ALL WRONG.

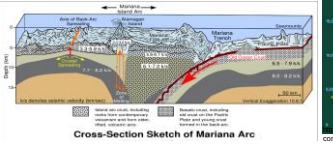


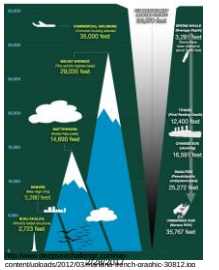
Wegener's proposal that continents plowed through oceanic crust was not accepted by other geologists.

Ocean Floor Topography

A. Ocean ridges contain the longest mountain range on Earth
   - Earthquakes & volcanoes occur along the ridges

http://home.earthlink.net/~dengelhardt/images/zonesmedium.jpeg



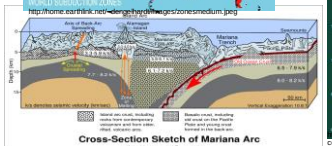


contentuploads/2012/03/Mariana-trench-graphic-30812.jpg

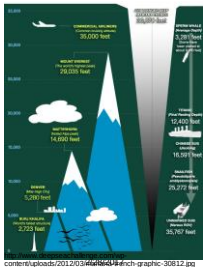
Ocean Floor Topography

B. Deep-sea trenches are narrow & elongated depressions with very steep sides
- Deepest trench: Marianna trench is over 11km deep

http://home.earthlink.net/~dengchunhui/images/zonesmedium.jpeg



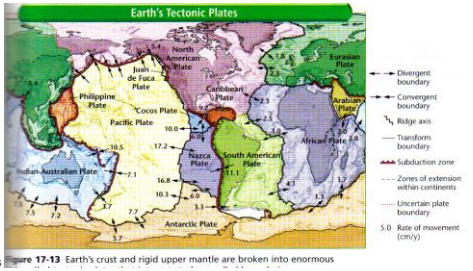
Cross-Section Sketch of Mariana Arc



content/uploads/2012/03/Marianas-Trench-graphic-30812.jpg

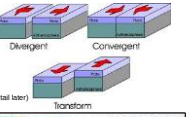
Theory of Plate Tectonics

- The Earth's crust & ridged upper mantle are broken into enormous slabs called plates.
  - Plates move in different directions and at different rates.
- Plate Boundaries = Where tectonic plates interact

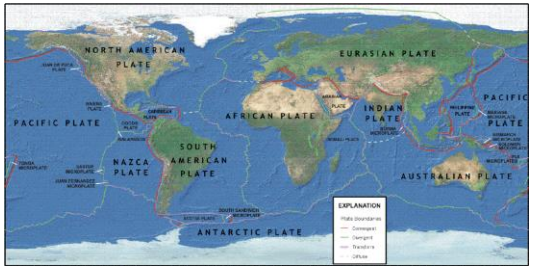


ES **Figure 17-13** Earth's crust and rigid upper mantle are broken into enormous

Plate Boundaries: 3 Main Types



1. Divergent
2. Convergent
3. Transform (we will focus on these in much more detail later)

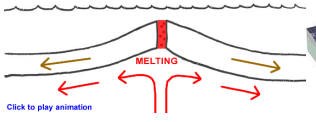


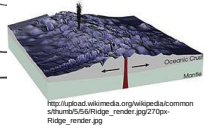
Divergent Boundaries

Divergent Boundaries: Plates move apart

- There are 2 subtypes of divergent boundaries, depending on their location:

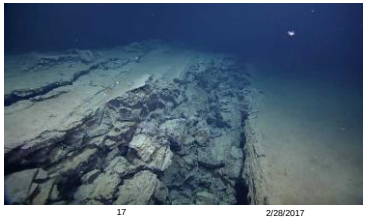
A. Mid-Ocean Ridge forms if the divergent boundary is underwater
- Mid-Ocean Ridge is a long mountain chain with volcanoes
- Causes the ocean basin to widen.





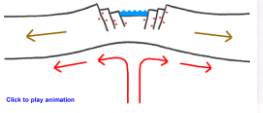
http://upload.wikimedia.org/wikipedia/commons/thumb/5/56/Ridge_render.jpg/270px-Ridge_render.jpg

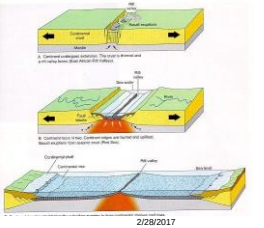
http://geology.com/nsta/divergent-plate-boundaries.shtml -Link to animation

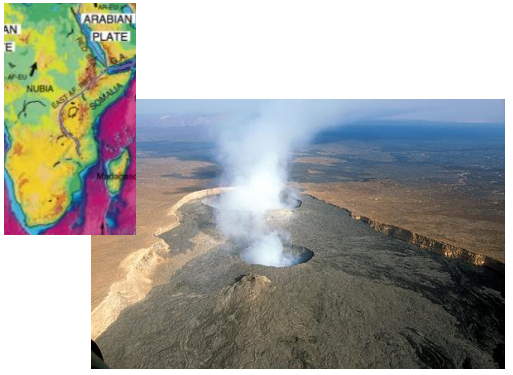


2nd Type of Divergent Boundary – Rift Valley

B. Rift Valley forms if the divergent boundary is on land
- As the continent is torn farther and farther apart, the rift valley gets deeper and deeper.
- It may eventually fill with water and become an ocean
- Example Rift Valley Locations: Iceland & East Africa

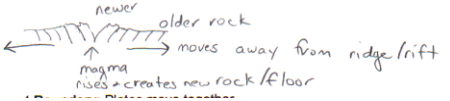






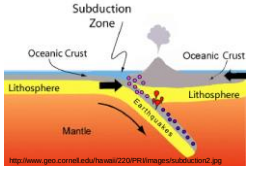
Divergent/widen Boundaries – Additional General Info

- BOTH types of divergent boundaries add(create) new crust
- Divergent boundaries widen ocean basins and lengthen/widen earth's surface
  - The Atlantic Ocean is widening an average of 2-3cm / year.
- Volcanoes and earthquakes are common along both rift valleys and mid-ocean ridges
  - Explains why young rock is in the middle of the ocean and older rock near the continents.



Convergent Boundaries

2. **Convergent Boundaries:** Plates collide & move towards each other.
   A. **Subduction** *MAY* occur: One plate descends below the other
      - Destroys & recycles crust material
      - Due to differences in density
      - May create deep-sea trenches, volcanoes & volcanic islands – depending on where the boundary is located



http://www.geo.cornell.edu/hawaii/220/PRI/images/subduction2.jpg

Fig 17-15 p457 Convergent Diagrams

- What type of crust MUST be present for subduction to occur?

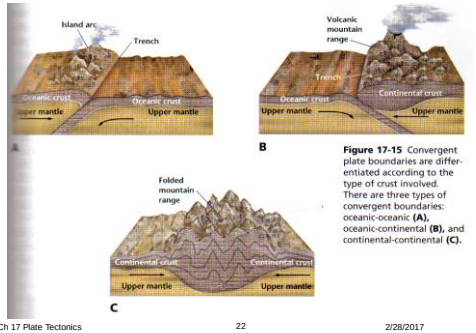
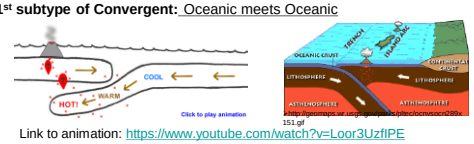


Figure 17-15 Convergent plate boundaries are differentiated according to the type of crust involved. There are three types of convergent boundaries: oceanic-oceanic **(A)**, oceanic-continental **(B)**, and continental-continental **(C)**.

1st Subtype Convergent -Oceanic meets Oceanic

3 subtypes of Convergent Boundaries

1. **1st subtype of Convergent:** Oceanic meets Oceanic



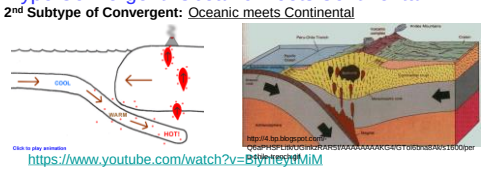
http://geomaps.wr.usgs.gov/sparks/plate/tectonics/oceanic/289x151.gif

Link to animation: https://www.youtube.com/watch?v=Loor3UzfIPE

A. Subduction occurs
   - The cooler & denser oceanic plate descends below the less dense oceanic plate
   - Forms deep-sea trenches, island arcs, volcanoes & deep focus earthquakes
   - Example locations: Mariana Trench & Islands, Aleutian Islands near Alaska, and Japan & Phillipines

2nd Type Convergent -Oceanic meets Continental

2. **2nd Subtype of Convergent:** Oceanic meets Continental



http://4.bp.blogspot.com/QcaPHSFLbWUCmkzRARSYAAAAAAAAKG4/GTo6ohs3Ak1600/per-Bible-trench.gif

https://www.youtube.com/watch?v=BlymeytMiM

A. Subduction occurs.
   - Dense ocean plate descends below the less dense continental plate
     - Ocean plates more dense because they are made of basalt
     - Continental plates are less dense since they are made of granite

B. Forms deep-sea trenches along the edge of continents

C. Mountain ranges, volcanoes, deep focus earthquakes may occur along the continental edge above the subduction zone

D. Example locations: Peru-Chile trench & Andes Mountains along western edge of South America

Diagram: Convergent Oceanic-Continental

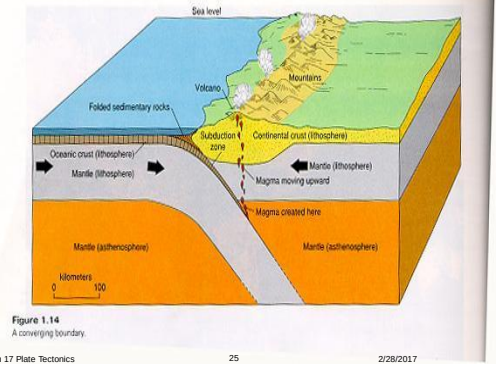
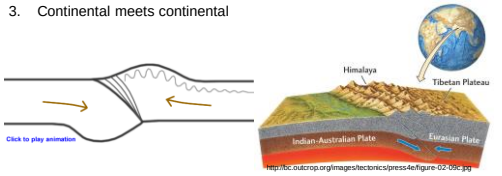


Figure 1.14
A converging boundary.

3rd Subtype Convergent: Continental meets Continental

3. Continental meets continental



http://bc.outcrop.org/images/tectonics/press4e/figure-02-09c.jpg

https://www.youtube.com/watch?v=HuSHOQ6gv5Y

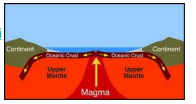
A. Subduction does NOT occur
   - Both continental plates are too buoyant due to low density
   - Therefore, there is NO melting & NO volcanoes
B. HIGH mountain ranges, extremely folded
C. Earthquakes present
D. Example location: Himalayas

Seafloor Spreading Theory

1. **Seafloor Spreading Theory**: SUMMARY: New ocean crust is formed at ocean ridges & is destroyed at deep-sea trenches
   A. Proposed by Harry Hess

   B. Theory provided answers to the 2 flaws of Wegener's Continental Drift hypothesis
      - Seafloor spreading caused the landmasses to move
      - Landmasses didn't shatter because they weren't plowing through the ocean crust. Rather, the ocean floor & continents **moved together**

http://www.biogeo.info/Animaciones/SeafloorMagnet.swf
Link to animation of seafloor spreading



Seafloor Spreading Theory

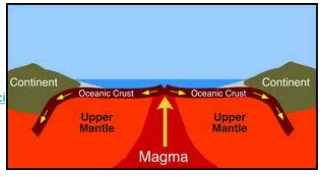
C. Magma is hotter & less dense at the mid-ocean ridge, so it fills the gap in the ridge

D. Magma in the gap cools, forming new ocean floor

E. More & more magma rises & hardens, forcing the previous rock to move away from the ridge

F. Therefore, younger rock is near the ridge & age increases farther from the ridge

http://www.biogeo.info/Animaciones/SeafloorMagnet.swf
Link to animation of seafloor spreading

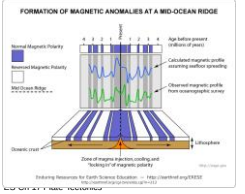


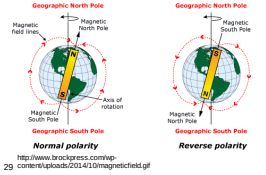
Paleomagnetism

A. The magnetic record of rocks containing iron

B. Basalt contains iron minerals which get "stuck" pointing towards Earth's magnetic pole as it cools & hardens

C. The iron minerals show a pattern of magnetic reversals which indicate a change in Earth's magnetic field



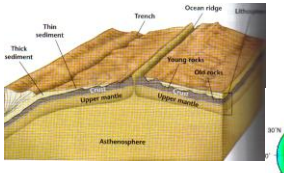


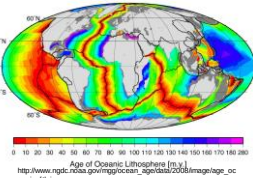
http://www.brockpress.com/wp-content/uploads/2014/10/magneticfield.gif

Ocean Rocks and Sediments

A. Rocks near the ridges are the youngest, age increases with distance from the ridge

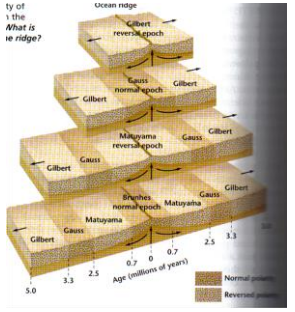
B. Oceanic rocks are much younger than continental rocks



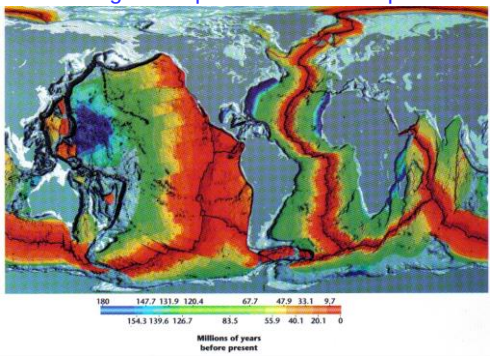


http://www.ngdc.noaa.gov/mgg/ocean_ages/data/2008/image/age_oceanic_lith.jpg

Fig 17-10 p 452 Magnetic Field Reversals

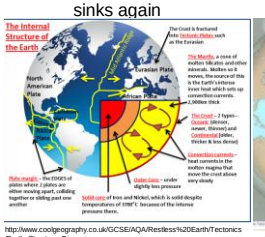


TT #48 & Fig 17-11 p453: Isochron Map of Floor

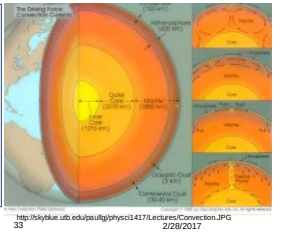


Mantle Convection Currents in the Asthenosphere

1. Convection in the aesthenosphere is thought to cause the plate movements
   - Asthenosphere is soft & pliable layer of the mantle that flows and allows the plates to move
   - Hot mantle material is less dense & rises, as it cools it sinks again



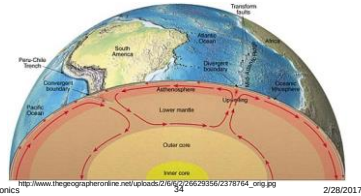
http://www.coolgeography.co.uk/GCSE/AQA/Restless%20Earth/Tectonics



http://skyblue.utb.edu/paulg/physci1417/Lectures/Convection.JPG

Convection Relationship to Type of Boundary

2. **Rising** part of the current occurs at divergent boundaries
   A. Causes upward & lateral forces that split the lithosphere
   B. As plates separate, rising magma cools & forms new ocean crust
3. **Sinking** part of the current occurs at convergent boundaries, pulling plate material down
   A. Sometimes forms deep-sea trenches



http://www.thegeographeronline.net/uploads/2/6/6/2/26629356/2378764_orig.jpg

Diagram of Convection & Plate Boundaries

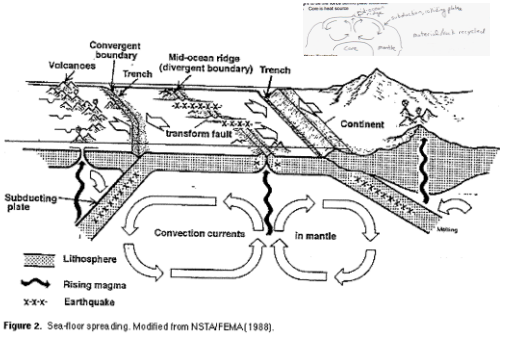


Figure 2. Sea-floor spreading. Modified from NSTA/FEMA (1988).

Bellringer #1:Review of Section 17.1 & Video

1. What theory suggests that South America and Africa were once part of a larger continent that broke and moved apart?
2. Who was the German scientist who proposed the most famous version of this theory?
3. List 3 lines of evidence he used to support his theory.

Bellringer #2

1. **Thinking Critically:** Oil deposits approximately 200 million years old have been discovered in Brazil. Where might geologists find oil deposits of a similar age? **Explain.**

Bellringer #3

What type of plate boundary is it IF???

1. Plates are pulling apart

1. Boundary where you will see mountains
2. Boundary that creates mid ocean ridges
3. Mid-Atlantic Ridge
4. Where we see lots of quakes and volcanic activity

Bellringer #4 Evidence & Features at Boundaries

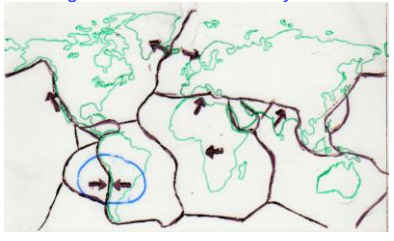
Are the following features typical for an oceanic to oceanic convergent boundary?

A = Usually present B = Not usually present

1. Volcanoes
2. Ocean ridge
3. Folded mountains
4. Subduction
5. Rift valley

6. What evidence suggests that Africa & India were once closer to the South Pole?

Bell Ringer # 5 Plate Boundary Review

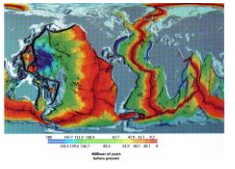


Look at the circled boundary:

1. What type of boundary is it?
2. What are 3 landforms or movements that are likely to be present?
3. Explain a convection current.

Bellringer #6

1. Magnetic minerals in undisturbed rocks on the ocean floor will:
   A. Indicate where magnetic pole was at the time of formation
   B. Align with "north" as we know it to be now, no matter what
   C. Change in their direction of alignment slowly over time
2. How do glacial deposits in Africa, India, Australia, and South America support the idea of continental drift?
3. **THINKING CRITICALLY:** Why are the magnetic bands in the eastern Pacific Ocean so far apart compared to the magnetic bands along the Mid-Atlantic Ridge?



Bellringer #7

1. If sea floor spreading centers create new crust constantly, does that mean the earth is getting bigger? Explain.

2. Describe the age of rocks at a mid-ocean ridge.

Bellringer #8

1. How will lithospheric plates that are directly above a **rising** current move?
   - Together or apart?
2. How will a plate above a **sinking** current move?
   - Together or apart?
3. Use ONE word to describe the
   A. Lithosphere:
   B. Aesthenosphere
4. Which contains the plates? Lithosphere or Aesthenosphere?
5. Which has convection currents? Litho or Aesthenosphere?
6. Which has oceanic crust? Lithosphere or Aesthenosphere?
7. Which is hotter? Lithosphere or Aesthenosphere?