

Earthquakes

6–8

Earthquake Science

LESSON PLAN 1

Inside the Earth

Learning about the composition of the earth gives us a better understanding of our changing planet.

Key Terms and Concepts

| | | |
|-------------------|---------------|----------------------|
| asthenosphere | geologist | outer core |
| continental crust | inner core | Pangaea (pan-GEE-ah) |
| deep mantle | lithosphere | plate tectonics |
| earthquakes | oceanic crust | |

Purposes

To help the students discover that the earth is composed of distinct layers

To reinforce the concept of the movement of earth's plates

Objectives

The students will—

- Conduct online research, guided by *Seismic Picture of the Hidden Earth*, to illustrate a model of the earth's interior structure.
- Follow the directions on *Making a Mobile* to make a three-dimensional, scale model of the layers of the earth.
- Use *Earth as an Egg* to demonstrate a model of the earth and its moving plates. (Linking Across the Curriculum)
- Graph the thickness of the earth's layers and answer questions about the graph on the activity sheet *Graphing the Depth*. (Linking Across the Curriculum)
- Use *Facts About Pangaea* and online research to gather facts about plate tectonics, the theory, its history and the evidence.
- Classify and share information with the help of *Mapping the Facts*.
- Research and discuss how the landmasses of the earth might look millions of years in the future and compare the class projections to actual geologic forecasts.
- Use the Internet to work an interactive puzzle of Pangaea and today's continents. (Linking Across the Curriculum)

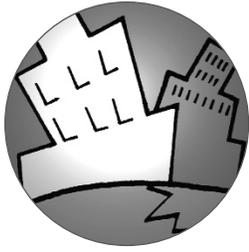
Activities

“Inside the Earth”

“Plates of the World”



Visit the American Red Cross Web site at www.redcross.org/disaster/masters



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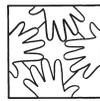
LESSON PLAN 1 Inside the Earth

Materials

- *Seismic Picture of the Hidden Earth*, 1 copy per student
- *Making a Mobile*, 1 copy per team
- Construction paper in multiple colors
- Markers
- Glue
- Scissors
- Needle and strong thread
- *Graphing the Depth*, 1 copy per student (Linking Across the Curriculum)



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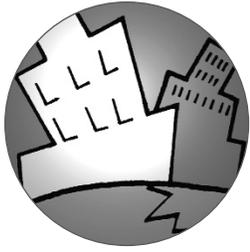
“Inside the Earth”

SET UP 15 minutes CONDUCT 50 minutes

Science: Earth Science; Language Arts: Reading and Research; Fine Arts: Visual Arts

-  Distribute *Seismic Picture of the Hidden Earth*. Have the students research the Internet and other resources to label each of the layers represented. The following Web sites are excellent starting points.
 - Into the Earth from the U.S. Geological Survey at <http://wrgis.wr.usgs.gov/docs/parks/pltec/index.html#into>
 - The Interior of the Earth from the U.S. Geological Survey at <http://pubs.usgs.gov/gip/interior/>
 - Scientific Frontiers: Earth on the Move, from PBS at <http://www.pbs.org/saf/1207/features/Platetech.htm>
2. Based on the drawing and their research, discuss with the class:
 - The relative thickness of each layer. (The mantle is the thickest layer—1,802 miles [2,900 kilometers]. The outer core is next—1,243 miles [2,000 kilometers]. The inner core is 870 miles [1,400 kilometers] thick. The lithosphere is 62 miles [100 kilometers] thick. The crust is the thinnest layer of the earth—25 miles [40 kilometers] deep.)
 - The relative temperature of each layer. (The deeper the layer, the hotter the temperature.)
 - The relative density of each layer. (The deeper the layer, the denser the matter.)
3.  Divide the class into teams, one for each layer of the earth. Using textbooks, media center resources and the Internet, send each team on a scavenger hunt to search for the following information about its assigned layer:
 - The material of which the layer is primarily composed
 - The state of the material, that is, molten, solid or gaseous
 - The depth into the earth at which the layer can be found
 - The predominant temperature
 - What is happening within the layer that affects the earth
 - Who discovered the layer and when it was discovered

Have the students share, compare and discuss their findings on a class chart.



Earthquakes

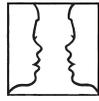
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Inside the Earth



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Wrap-Up

Scientists often build models to illustrate a concept. Divide the class into small groups and distribute the construction materials and *Making a Mobile*.

Assign the students to make a three-dimensional model of the earth by stringing together consecutively smaller concentric rings, one for each major layer, to hang from the ceiling like a mobile. Have them label each layer and add interesting facts about each.



Linking Across the Curriculum

Science: Earth Science; Mathematics: Modeling

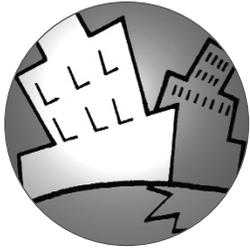
Each group of 4 to 5 students will require these materials:

- Hard-boiled egg
- Plastic knife
- Small bowl of water
- Paper towel
- *Earth as an Egg*

Distribute the materials to small groups of students. Following the steps on *Earth as an Egg*, the groups will explore the hard-boiled egg as a model of the earth's layers and answer the questions. Work with students to create a class list of geological facts that can be gleaned from the demonstration.

Answers to *Earth as an Egg*

- What parts of the earth's structure are represented by the shell, the white, and the yolk?
The shell represents the lithosphere, or the crust and uppermost mantle—earth's plates. The white represents all the remaining mantle, and the yolk represents the core of the earth.
- What about the egg's membrane?
The membrane corresponds to the asthenosphere, the partially molten part of the mantle that becomes pliable or "plastic," stretching, folding, compressing and flowing. Earth's plates float on the denser asthenosphere.
- Do the plates slide smoothly when pushed alongside each other? If not, where do they catch?
The plates, represented by pieces of shell, will slide smoothly on the liquid dropped on the membrane of the egg, which represents the asthenosphere. If moving laterally, they will catch when they slide against a rough spot. With continued pressure along the rough surface, the edges will eventually crumble and the plates will lurch until they can slide smoothly or are caught by another rough edge.
- What happens if you push two plates together—head-to-head?
Given enough pressure, one plate may dive under the other, so that one pushes up and the other down, or they will break against each other.



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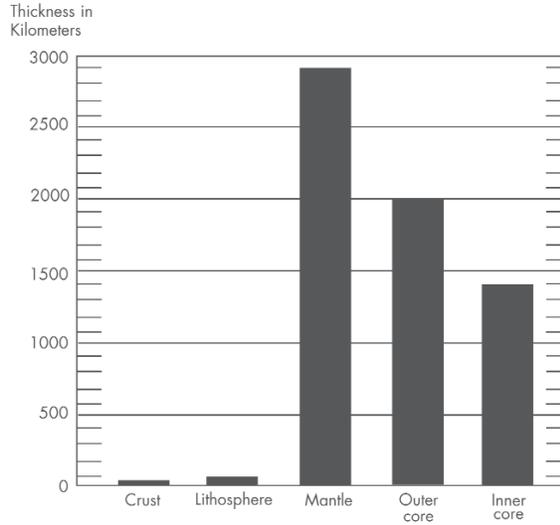
LESSON PLAN 1

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Challenge: The moving shells (plates) help to demonstrate some basic points about plate tectonics and earthquakes. Plates float on the asthenosphere as long as there's no obstruction; but, where they meet, they will push against each other, building pressure until something gives way. Either one plate moves over another, bumps into another or they catch and bump moving alongside each other. Earthquakes occur at these pressure points.

Mathematics: Charts and Graphs; Language Arts: Reading
Distribute *Graphing the Depth*. Have the students graph the thickness of the earth's layers and answer the questions about the graph.

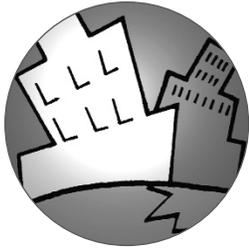
Answers to *Graphing the Depth*



1. Mantle
2. Crust
3. 6,440 kilometers (4,002 miles)



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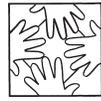
Inside the Earth

Materials

- Globe
- *Facts About Pangaea* and *Mapping the Facts*, 1 copy per student (or have the students do their own Internet research)
- Chalkboard and chalk or chart paper and markers



Visit the American Red Cross Web site at www.redcross.org/disaster/masters



"Plates of the World"

SET UP 15 minutes **CONDUCT** 45 minutes, plus time for online research

Science: Earth Science; Mathematics: Classification; Social Studies: Geography; Language Arts: Reading and Research

1. Have the students use a globe to locate the continents. If the continents were puzzle pieces, which continents would fit together easily? Does the map suggest that some time in earth's history there could have been only one large continent? Explain. (Possible answers: South America and Africa look as though they could fit together; and northeastern Asia and northwestern North America seem as if they're almost touching.)
2. Distribute *Facts About Pangaea* and *Mapping the Facts*. Provide time for the students to read the information take notes, and categorize the facts.



If you prefer, the students can use the Internet to research facts about Pangaea and plate tectonics.



Wrap-Up

Draw a diagram on the chalkboard similar to the one on *Mapping the Facts* to set up a mind map for students.

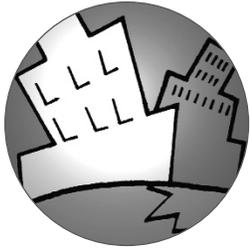


As a whole group, have the students classify information from their reading into the mind map, expanding each section of the map with specific facts.

In 1912, scientist and meteorologist Alfred Wegener theorized about the huge landmass that was once Pangaea, 250 million years in the past. Today, scientists have used this theory about the past to project the future. Divide the class into small groups and challenge them to take the information they have learned concerning the movement of plates and forecast how the landmasses will appear in 100 million years, or in 250 million years. Have the students describe the changes the earth could expect and the impact on the face of the earth we know.



Afterward, have the students use the sequence on The Dance of the Continents at http://www.nytimes.com/packages/html/science/20070109_PALEO_GRAPHIC to see what scientists are predicting about the future and compare their ideas.

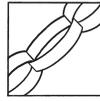


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Inside the Earth



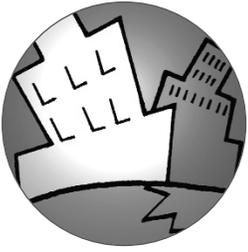
Linking Across the Curriculum

Science: Earth Science and Technology; **Social Studies:** Geography

Cornell University has an excellent interactive map that clearly depicts how today's landmasses were once part of one large landmass, Pangaea. Direct the students to the Continental Puzzle at http://atlas.geo.cornell.edu/education/student/continental_puzzle.html to see how well they can "puzzle Pangaea."



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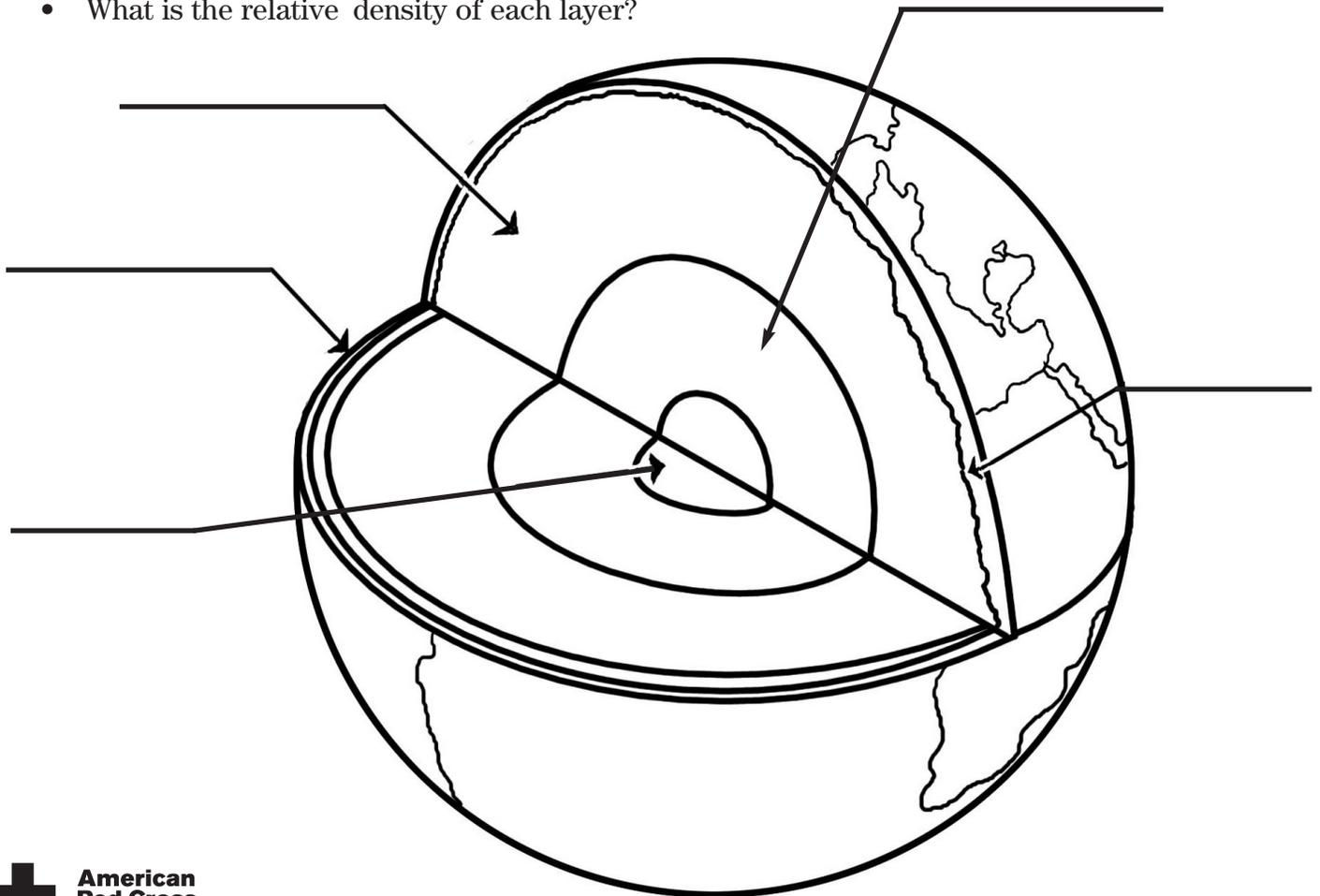
Seismic Picture of the Hidden Earth

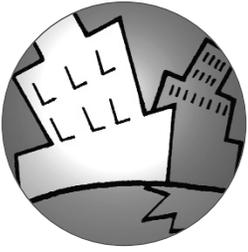
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Name _____

Directions: Learning about the makeup of the earth helps us understand our changing planet. Research and label each of the layers of the earth shown in the drawing. Then, answer the questions. To start, visit Into the Earth by the U.S. Geological Survey at <http://wrgis.wr.usgs.gov/docs/parks/pltec/index.html#into>.

- What is the relative thickness of each layer?
- What is the relative temperature of each layer?
- What is the relative density of each layer?





Making a Mobile

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Name _____

Directions: Scientists often create models in order to clarify information. Follow the steps below and use the diagram on the next page to make a mobile of the earth's inner structure.

Materials:

- Construction paper in multiple colors
- Scissors and glue
- Markers
- Needle and strong thread

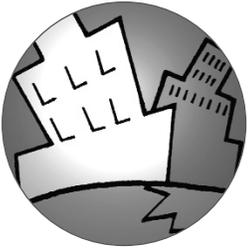
Step 1: Use the scale diagram on the next page to cut rings of construction paper in different colors to represent the layers of the earth.

Step 2: Use markers to color the upper crust of the lithosphere.

Step 3: On each layer or on flags glued to the layers, write the name of the layer and other interesting facts about its composition, temperature and state.

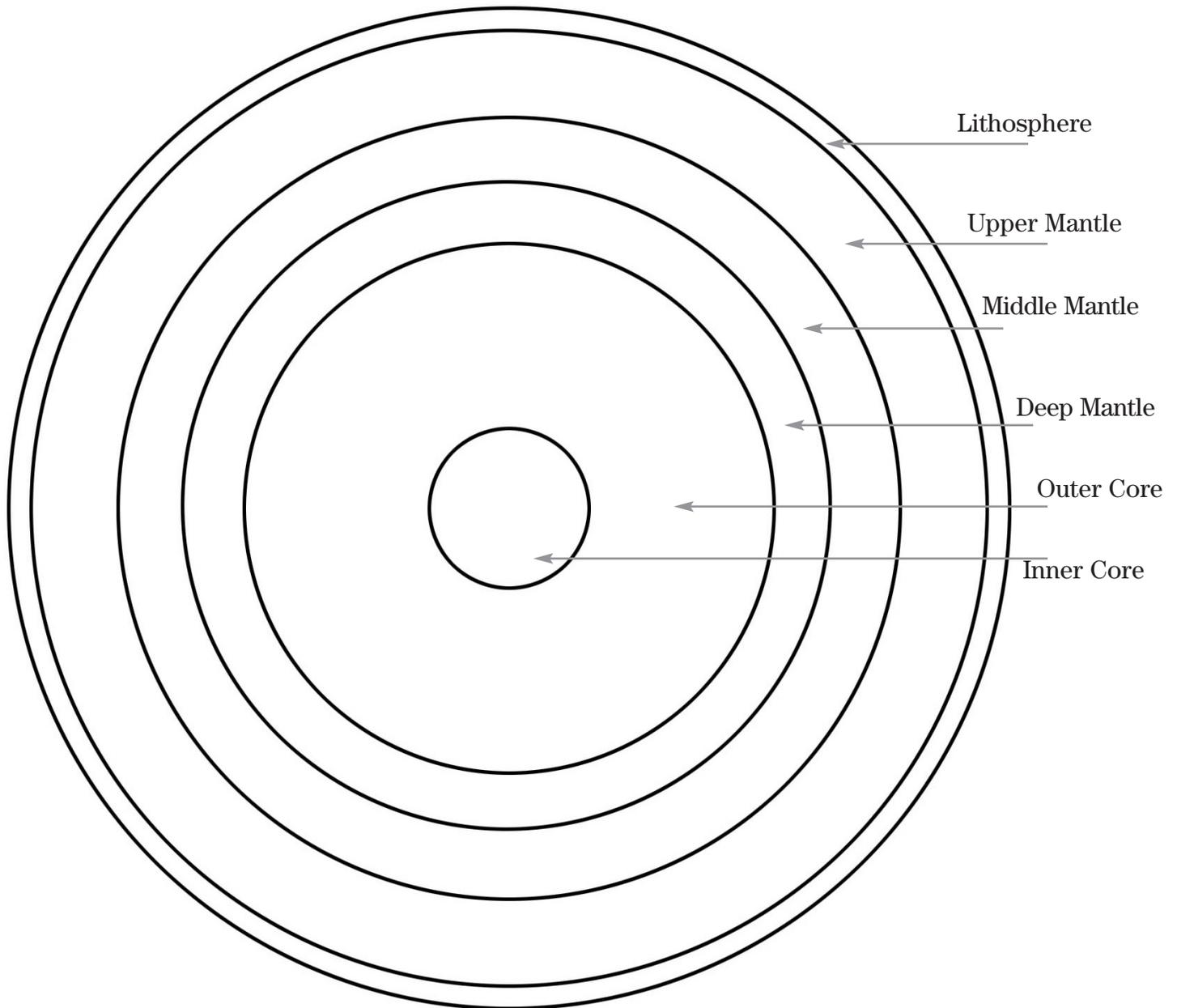
Step 4: Use a needle and strong thread to attach the layers, allowing for a little space between each so that the layers will hang loosely as a mobile.

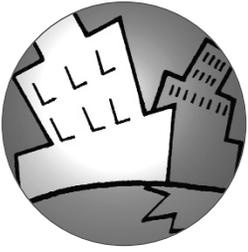




Making a Mobile

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Earth as an Egg

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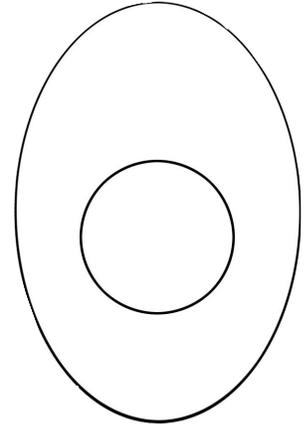
Directions: Can you use an egg to illustrate a cross section of the inside of the earth and explain the movement of the earth's plates? Follow the steps below to make and describe your model.

Materials:

- Hard-boiled egg
- Plastic knife
- Small bowl of water
- Paper towel

Procedure:

1. Use the knife to cut the egg in half. Examine the layers. What parts of the earth's structure are represented by the shell, the white and the yolk?

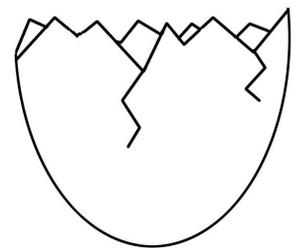


2. What does the thin membrane under the shell represent?

3. Lightly tap one half of the egg on a hard surface. The shell will break into fragments that represent earth's tectonic plates. Carefully lift two of the larger fragments and drop some water underneath them. Now, you can slide those fragments, or plates, more easily.

Describe your observations as you answer the following questions:

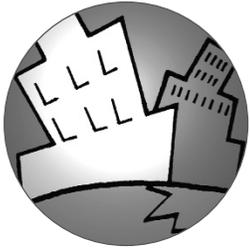
- Do the plates slide smoothly when pushed alongside each other, but in opposite directions? If not, where do they catch?



- What happens if you push the two plates together—head-to-head?

Challenge: Describe how the fragments of the egg shell illustrate some basic points about plate tectonics and earthquakes.





Graphing the Depth

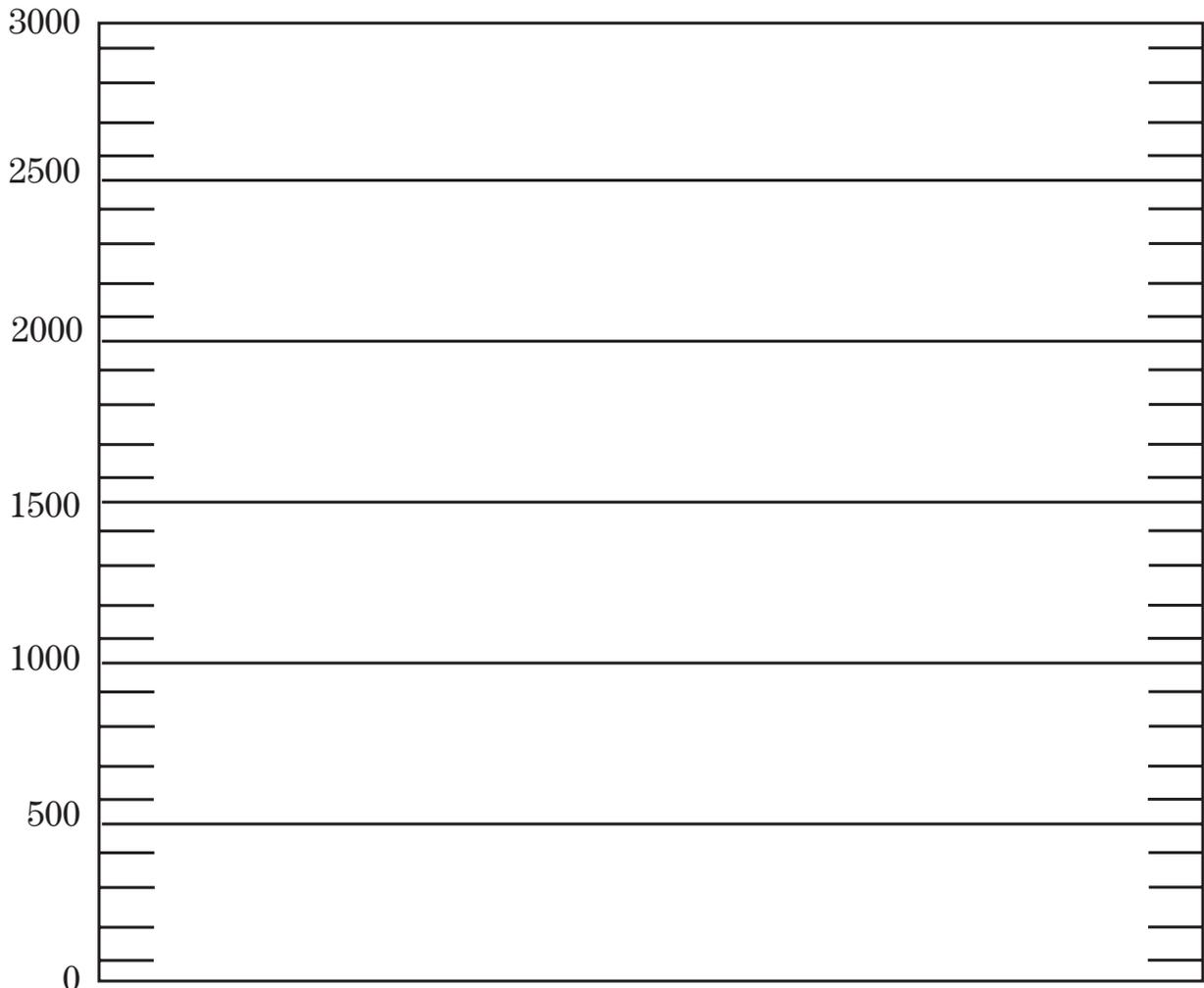
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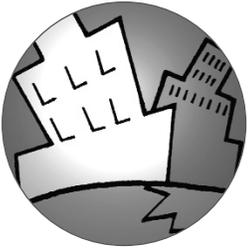
Name _____

Directions: Research to put the layers of the earth in the correct order and to match each layer with the correct thickness. Then complete the bar graph.

| Earth layer (x-axis) | Layer thickness (y-axis) | |
|----------------------|--------------------------|------------|
| Mantle | 2,900 km | (1,802 mi) |
| Outer core | 40 km | (25 mi) |
| Crust | 1,400 km | (870 mi) |
| Inner core | 100 km | (62 mi) |
| Lithosphere | 2,000 km | (1,243 mi) |

Kilometers





Graphing the Depth

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Now, answer the following questions:

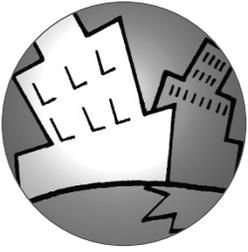
1. Which layer of the earth is the thickest?

2. Which layer of the earth is the thinnest?

3. What is the total thickness of all the earth's layers?

Adapted from *Earthquakes: A Teacher's Package for K-6*, developed by the National Science Teachers Association with the support of the Federal Emergency Management Agency; revised April 1999.





Facts About Pangaea

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Name _____

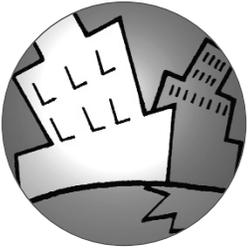
In 1912, a German scientist named Alfred Wegener had the idea that the continents once formed a single huge landmass, which he called Pangaea. This word means “all earth.” He suggested that Pangaea broke into pieces. We call these pieces **plates**. The theory Wegener suggested to explain the drifting plates is called the **theory of plate tectonics** and is sometimes referred to as **continental drift**.

By 1929, Alfred Wegener’s ideas were all but dismissed. But, Arthur Holmes elaborated on one of Wegener’s hypotheses: thermal convection and the earth’s mantle. Thermal convection states that, as a substance is heated, its density decreases and it rises. Once it cools, its density increases and it falls. This continuing process causes a current. Within the magma in the upper level of the mantle, this powerful current can cause plates to break and continents to move in opposite directions, floating on the convection currents.

More than 30 years later, in the early 1960s, other scientists began looking into Holmes’s ideas to provide further illustration of Wegener’s theory of plate tectonics. Harry Hess and Robert Dietz believed that the Mid-Atlantic Ridge marked one place where Pangaea began to break apart. Their theories are that—

- Along the Mid-Atlantic Ridge, the ocean floor was ripped in two and continuously pulled apart lengthwise as the newly created, drifting plates floated apart.
- The rip formed a weak area in the crust.
- New magma rose and erupted through the weak crust along the spreading ridge and formed new oceanic crust.
- The new oceanic crust continuously spread away from the ridges as the new plates continued to separate.
- This process, called **seafloor spreading**, began many millions of years ago and continues to this day. Along the Mid-Atlantic Ridge, the erupting lava and drifting plates produced a huge basin that eventually filled with water to become the Atlantic Ocean.

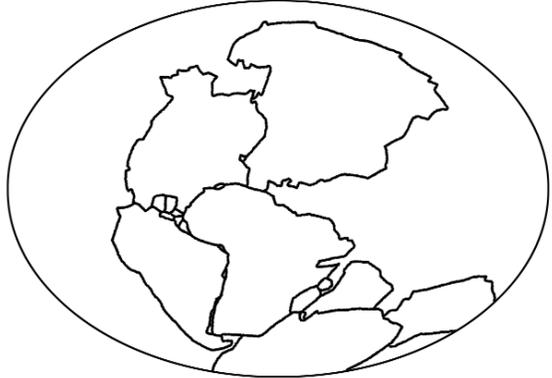




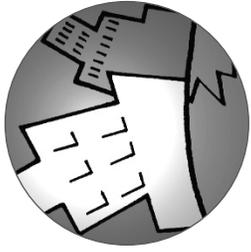
Facts About Pangaea

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Evidence for the Plate Tectonics Theory:

1. Here is the supercontinent of Pangaea, as it began to break up about 225 million years ago. Look at the image as if it were a puzzle that you could take apart to form today's continents. Use a world map to decide which piece you think represents which continent. This suggests that the continents were, in fact, once joined into one huge landmass, torn away from each other by the force of the convection currents in the mantle of the earth.
- 
2. A second piece of evidence supporting the idea of drifting continents is the close match between fossils of *Glossopteris* (a genus of plants) and fossils of *Mesosaurus* (a genus of reptiles) found on the eastern tip of Africa and those found on the corresponding part of South America.
 3. The geological structures of the rocks in southwest Africa and southeast Brazil are identical in their makeup and age. If Pangaea existed, these rocks would have been part of one landmass. Rock formations of similar makeup and age are found in Europe's Caledonian Mountains and in the Appalachian Mountains in the southeast United States.
 4. The San Andreas Fault in California forms a section of the boundary between the North American Plate on the east and the Pacific Plate on the west. The western edge of California below San Francisco is actually on the Pacific Plate and has been moving northward with respect to the rest of the continent. Geologists have found sections of specific rock formations on opposite sides of the fault separated by hundreds of kilometers. Streams that cross the fault have been offset by earthquakes, and even fences and buildings are pulling apart, creating additional evidence of the Pacific Plate's movement.



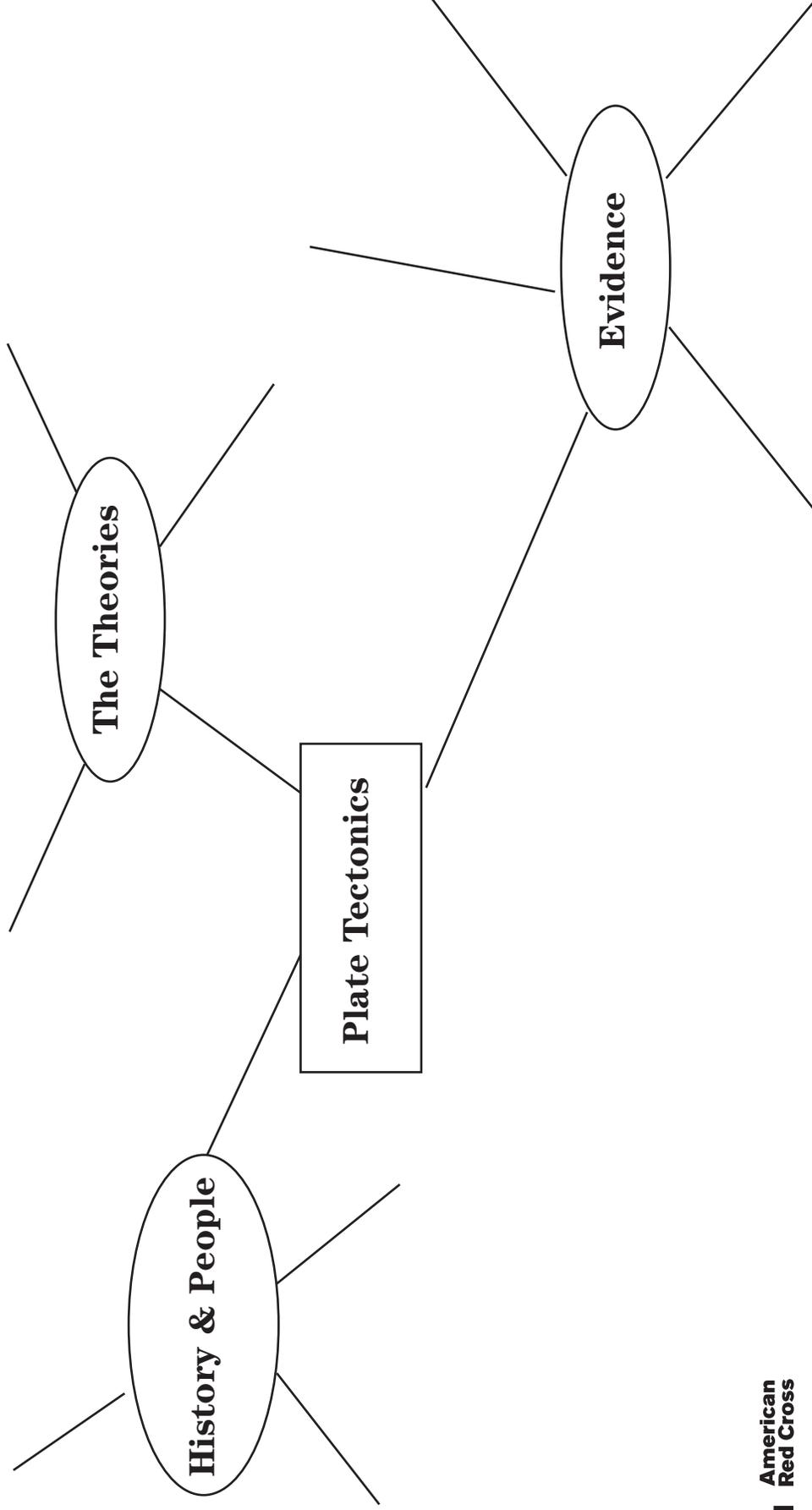


Mapping the Facts

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Name _____

Directions: Since 1912, when Alfred Wegener first introduced the concept of plate tectonics, many scientists have added to and found evidence of the theory. Use the mind map below to help organize and share the information you discover as you research.



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