Glencoe Science

Chapter Resources

Plate Tectonics

Includes:

Reproducible Student Pages

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✓ Chapter Review

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✓ Laboratory Activities
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✓ Teacher Guide and Answers
Photo Credits
Section Focus Transparency 1: Ron Watts/CORBIS; Section Focus Transparency 2: Museum of Paleontology, University of CA, Berkeley; Section Focus Transparency 3: Jeremy Stafford-Deitsch/ENP
Reproducible Student Pages

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Hands-On Activities
Interpreting Fossil Data

**Procedure**

1. Build a three-layer landmass using clay or modeling dough.
2. Mold the clay into mountain ranges.
3. Place similar “fossils” into the clay at various locations around the landmass.
4. Form five continents from the one landmass. Also, form two smaller landmasses out of different clay with different mountain ranges and fossils.
5. Place the five continents and two smaller landmasses around the room.
6. Have someone who did not make or place the landmasses make a model that shows how they once were positioned.
7. Return the clay to its container so it can be used again.

**Analysis**

What clues were useful in reconstructing the original landmass?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Mini LAB  Modeling Convection Currents

Procedure
1. Pour water into a clear, colorless casserole dish until it is 5 cm from the top.
2. Center the dish on a hot plate and heat it.
   **WARNING:** Wear thermal mitts to protect your hands.
3. Add a few drops of food coloring to the water above the center of the hot plate.
4. Looking from the side of the dish, observe what happens in the water.
5. In the space below, illustrate your observations.

Analysis
1. Determine whether any currents form in the water.

2. Infer what causes the currents to form.
Lab Preview

Directions: Answer these questions before you begin the Lab.

1. Where can you find the data about each peak that you need for this lab?

2. What formula do you use to calculate the rate of movement in this lab?

How did scientists use their knowledge of seafloor spreading and magnetic field reversals to reconstruct Pangaea? Try this lab to see how you can determine where a continent may have been located in the past.

Real-World Question

Can you use clues, such as magnetic field reversals on Earth, to help reconstruct Pangaea?

Materials
- metric ruler
- pencil

Goals
- Interpret data about magnetic field reversals. Use these magnetic clues to reconstruct Pangaea.

Procedure

1. Study the magnetic field graph below. You will be working only with normal polarity readings, which are the peaks above the baseline in the top half of the graph.

2. Place the long edge of a ruler vertically on the graph. Slide the ruler so that it lines up with the center of peak 1 west of the Mid-Atlantic Ridge.

3. Determine and record the distance and age that line up with the center of peak 1 west. Repeat this process for peak 1 east of the ridge.

4. Calculate the average distance and age for this pair of peaks.

5. Repeat steps 2 through 4 for each remaining pair of normal-polarity peaks.

6. Calculate the rate of movement in cm per year for the six pairs of peaks. Use the formula rate = distance/time. Convert kilometers to centimeters. For example, to calculate a rate using normal-polarity peak 5, west of the ridge:

\[
\text{rate} = \frac{125 \text{ km}}{10 \text{ million years}} = \frac{12.5 \text{ km}}{1,000,000 \text{ years}} = \frac{1,250,000 \text{ cm}}{1,000,000 \text{ years}} = 1.25 \text{ cm/year}
\]
Hands-On Activities

Data and Observations

<table>
<thead>
<tr>
<th>Peaks</th>
<th>Peak 1</th>
<th>Peak 2</th>
<th>Peak 3</th>
<th>Peak 4</th>
<th>Peak 5</th>
<th>Peak 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance west normal polarity (km)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance east normal polarity (km)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average distance (km)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average age from scale (millions of years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate of movement (cm/year)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclude and Apply

1. Compare the age of igneous rock found near the mid-ocean ridge with that of igneous rock found farther away from the ridge.

2. If the distance from a point on the coast of Africa to the Mid-Atlantic Ridge is approximately 2,400 km, calculate how long ago that point in Africa was at or near the Mid-Atlantic Ridge.

3. How could you use this method to reconstruct Pangaea?
Plate Tectonics

Use the Internet
Predicting Tectonic Activity

The movement of plates on Earth causes forces that build up energy in rocks. The release of this energy can produce vibrations in Earth that you know as earthquakes. Earthquakes occur every day. Many of them are too small to be felt by humans, but each event tells scientists something more about the planet. Active volcanoes can do the same, and volcanoes often form at plate boundaries.

Think about where earthquakes and volcanoes have occurred in the past. Make a hypothesis about whether the locations of earthquake epicenters and active volcanoes can be used to predict tectonically active areas.

Real-World Question
Can you predict tectonically active areas by plotting locations of earthquake epicenters and volcanic eruptions?

Goals
■ Research the locations of earthquakes and volcanic eruptions around the world.
■ Plot earthquake epicenters and the locations of volcanic eruptions obtained from mssscience.com site.
■ Predict locations that are tectonically active based on a plot of the locations of earthquake epicenters and active volcanoes.

Data Sources
Visit mssscience.com/internet_lab for more information about earthquake and volcano sites and data from other students.

Make a Plan
1. Study the data table shown below. Use it to record your data.
2. Collect data for earthquake epicenters and volcanic eruptions for at least the past two weeks. Your data should include the longitude and latitude for each location. For help, refer to the data sources given above.

<table>
<thead>
<tr>
<th>Earthquake Epicenter/Volcanic Eruption</th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Hands-On Activities
Hands-On Activities

**Communicating Your Data**

Find this lab using the link below. Post your data in the table provided. **Compare** your data with those of other students. Combine your data with those of other students, and **plot** these combined data on map to recognize the relationship between plate boundaries, volcanic eruptions, and earthquake epicenters.

Visit [msscience.com/internet_lab](http://msscience.com/internet_lab)

---

**Follow Your Plan**

1. Make sure your teacher approves your plan before you start.
2. **Plot** the locations of earthquake epicenters and volcanic eruptions on a map of the world. Use an overlay of tissue paper or plastic.
3. After you have collected the necessary data, predict where the tectonically active areas on Earth are.

**Analyze Your Data**

1. What areas on Earth do you predict to be the locations of tectonic activity?
2. How close did your prediction come to the actual location of tectonically active areas?

**Conclude and Apply**

1. How could you make your predictions closer to the locations of actual tectonic activity?
3. What types of plate boundaries were close to your locations of earthquake epicenters? Volcanic eruptions?
4. **Explain** which types of plate boundaries produce volcanic eruptions. Be specific.

(continued)
Palaeography refers to a drawing or painting. Therefore, palaeographic could be translated as “Old Earth Picture.” Scientists often use fossil evidence to help them develop a picture of how Earth was long ago. By examining and dating rock formations and fossils of various plants and animals, scientists are able to formulate hypotheses about what Earth’s surface might have looked like during a particular period in history. For example, similar rock formations and certain types of plant and animal fossils of a particular age could indicate whether two, now separate, land areas might have been connected during that period. Further analysis of the samples and data could also provide clues to the climate of that area or whether it was dry land or covered by an ocean. To classify events in the geologic past, scientists have divided the millions of years of Earth’s history into segments, called eras.

In this activity, you will examine evidence from the fossil record relative to a current map of an imaginary continent and develop a map of what the continent and the surrounding area might have looked like during the Mesozoic Era (248 million to 65 million years ago).

**Strategy**

You will determine how fossil evidence can be used to infer information about a continent during the geologic past.

You will interpret fossil evidence to draw a map showing how a continent appeared during the Mesozoic Era.

**Materials**

- colored pencils or markers

**Procedure**

1. Figure 1 shows a map of a present-day imaginary continent. Locations A through I are places where fossils have been found in rocks dating to the Mesozoic Era. Study the map and look at the fossils key below the map.

2. From the locations of the different fossils, infer where the land areas were at the time the fossil organisms lived. Keep in mind that the way the modern continent looks may have no relationship to where the land/ocean boundaries were during the Mesozoic Era.

3. Use one color of pencil or marker to color in the land areas on the map in Figure 1. Fill in the block labeled Land with the same color. Use a different color of pencil or marker to color in the ocean areas on the map in Figure 1. Fill in the block labeled Ocean with this color.

4. In the space provided under Data and Observations, draw a map showing land and water areas during the Mesozoic Era. Use the color boundaries you added to Figure 1 as your guideline. Based on these boundaries, add all of the symbols from the map key in Figure 1 to your map.

5. Color all the areas around and between the labeled areas on your map as either land or ocean. Fill in the blocks labeled Land and Ocean with the colors you used.
Hands-On Activities

Laboratory Activity 1 (continued)

Figure 1

Fossils found in Mesozoic rocks

A (shark teeth)  F (teeth/bones of small mammals)
B (petrified wood)  G (dinosaur bones)
C (sea stars)  H (corals)
D (leaf and fern imprints)  I (dinosaur footprints)
E (seashell fragments)
X, Y (Areas to be identified after completing your map)
Data and Observations

Mesozoic Map

Questions and Conclusions

1. According to your map, was location Y land or water during the Mesozoic Era? Explain how you decided.

2. According to your map, was location X land or water during the Mesozoic Era? Explain how you decided.

3. Compare your map with those of other students. Why do you think that not everyone agreed on whether location X was land or water? How could you find out which interpretation was correct?
Laboratory Activity 1 (continued)

4. Corals grow only in warm, shallow oceans near the coastlines of continents that are relatively near the equator. Would knowing this fact make you revise your map? Why or why not?

________________________________________________________________________

________________________________________________________________________

5. Suppose the modern continent shown in Figure 1 was located in an area that is extremely cold. Using the evidence you have, plus the information in Question 4, what could you infer about the continent?

________________________________________________________________________

________________________________________________________________________

Strategy Check

_____ Can you determine how fossil evidence can be used to infer information about a continent during the geologic past?

_____ Can you interpret fossil evidence to draw a map showing how a continent appeared during the Mesozoic Era?
How do continental plates move?

One of the models that helps explain how tectonic plates move is the convection model. In this hypothesis, the molten magma of the mantle boils like water in a pot. The pattern of the moving water forms a circular wave or current as hot water rises to the top and cooler surface water is forced to the side of the pot and back down to be heated again. Inside the Earth it is believed there are many convection cells, or regions in the mantle, that boil like this. The different cells have their own currents and constantly move independently of one another. The crust of the Earth has a much lighter mass and density than the magma. As a result, the plates of crust are moved by convection currents and broken up on the boiling surface of the mantle.

Strategy
You will model convection currents and the movement of tectonic plates.
You will predict what will happen to tectonic plates at the margins of convection cells.

Materials
- hot plate
- scissors
- tongs
- water
- medium to large-mouthed pot
- sheets of plastic foam wrap for padding packages (not made from corn or organic materials)

Procedure
1. The hot plates should be turned on high. Carefully fill the pot 2/3 full of water and place it on the hot plate. It will take a while for the water to boil.
2. Obtain a piece of flat plastic foam wrap. Use scissors to cut several shapes that represent tectonic plates. If you are working in a group you may mark your tectonic plates with a pencil or pen if you wish so that you can recognize it when the water boils.
3. Carefully place your pieces of foam on the surface of the water. If the water has any steam or tiny bubbles at the bottom of the pan, ask your teacher to place the foam in the pot for you.
4. As the water heats, watch the action of the bubbles as they rise from the bottom of the pot. Observe everything you can about what happens to them when they rise under a piece of foam. Record your observation in the table provided.
5. Once the water begins to boil, watch your pieces of foam. How do they move? In what direction do they go? Do they stay in one place in the pot or do they move? Do they crash into other pieces of foam?

Record the answers to these observations in the data table. Be sure to observe the boiling pot for a while. It may first seem there is no pattern to the action in the pot, but careful observation will reveal certain movements in the boiling water.
6. When the experiment is over, your teacher will turn off the hot plates and remove the foam with tongs for cooling. DO NOT remove the pieces yourself. They will cool quickly. When they are cooled, find your pieces and return to your lab station or seat.

7. In your data table write down any observed changes in your foam. Does it still have water in it? Have any of the corners been melted or damaged? Write down any other observations in your table.

### Data and Observations

<table>
<thead>
<tr>
<th>Action of bubbles</th>
<th>1.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Movement of foam pieces in boiling water</th>
<th>2.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Condition of foam after experiment</th>
<th>3.</th>
</tr>
</thead>
</table>

### Questions and Conclusions

1. How did you describe what happened to the bubbles as they gathered under the foam? What happened at the sides of the foam? 

   
   
   
   
   


2. What type of natural feature is similar to the action of the bubbles? Explain your answer.

____________________________________________________________________________________

3. Describe the movement of the plastic pieces when the water started to boil. Could you see a pattern?

____________________________________________________________________________________

4. How does this experiment model the moving tectonic plates?

____________________________________________________________________________________

5. How is this experiment different from the real world in terms of tectonic plates? (Hint: What were your foam pieces like after the experiment?)

____________________________________________________________________________________

____________________________________________________________________________________

6. Predict what would happen if the convection currents of the molten magma changed direction or stopped altogether?

____________________________________________________________________________________

____________________________________________________________________________________

Strategy Check

_____ Can you model convection currents and the movement of tectonic plates?

_____ Can you predict what will happen to tectonic plates at the margins of convection cells?
Directions: Use this page to label your Foldable at the beginning of the chapter.

Know

Like to know

Learned
Meeting Individual Needs
Overview

Plate Tectonics

Directions: Study the following diagram. Then label each part with the letter of the correct description below.

A. A mid-ocean ridge forms whenever diverging plates continue to separate, creating a new ocean basin. As the rising magma cools, it forms new ocean crust.

B. When an oceanic plate converges with a less dense continental plate, the denser oceanic plate sinks under the continental plate.

C. When two oceanic plates converge, the denser plate is forced beneath the other plate and volcanic islands form above the sinking plate.

Directions: Circle the words in parentheses that best complete the sentences below.

4. (Fossils, Human bones), rocks, and climate provided Wegener with support for his continental drift theory.

5. The fact that the (youngest, oldest) rocks are located at the mid-ocean ridges is evidence for seafloor spreading.

6. The transfer of (solar, heat) energy inside Earth moves plates.
Alfred Wegener was one of the first people to suggest that all of the
1. ________________ were joined together in the past. He called the one large
continent 2. ________________. Evidence exists to support his hypothesis.
For example, similar fossils have been found in South America and
3. ________________. Also, fossils of warm weather plants have been found in
the 4. ________________. Similar 5. ________________ structures exist in
the Appalachian Mountains and in Greenland and western Europe. But until clues on
the ocean floor led to Harry Hess’s theory of 6. ________________, scientists
could not think of how the continents might move.

Directions: Study the following diagram of the seafloor. Then match the letters to the statements below.

7. Molten rock flows onto the seafloor and hardens as it cools.
8. Hot, molten rock is forced upward toward the seafloor at a mid-ocean ridge.
9. New seafloor moves away from the ridge, cools, becomes denser, and sinks.
10. Molten rock pushes sideways in both directions as it rises, moving the
mantle with it.
Directions: In the blank at the left, write the letter of the term that best completes the sentence.

1. Earth’s crust and upper mantle are broken into sections called ______
   a. lava.  
   b. plates.

2. The collision of one continental plate with another may produce ______
   a. oceans.  
   b. mountains.

3. New ocean crust is formed at a ______
   a. rift valley.  
   b. mid-ocean ridge.

4. A rift valley can form where two continental plates are ______
   a. moving apart.  
   b. colliding.

5. Where Earth’s plates move, they may slide alongside one another, pull apart, or ______
   a. collide.  
   b. divide.

Directions: Complete the concept map using the terms in the list below.

- mid-ocean ridges
- volcanic islands
- deep-sea trenches
- volcanic mountains
- Plate boundaries
- transform
- divergent
- convergent
- rift valleys
- include
- form
- cause
- include
- include

6. ______
7. ______
8. ______
9. ______
10. ______
11. ______
Directions: Use the following terms to complete the puzzle below. The letters in the darker, vertical box complete question 9.

1. The hypothesis that continents move slowly is called continental ______.
2. All continents once might have been connected in a large landmass called ______.
3. The cycle of heating, rising, cooling, and sinking is a ______ current.
4. Just below Earth’s crust is the ______.
5. The crust and part of the upper mantle are known as the ______.
6. Continental plates move on the plasticlike layer of Earth’s surface called the ______.
7. Hot magma forced upward at mid-ocean ridges produces seafloor ______.
8. Sections of Earth’s crust and part of the upper mantle are called ______.
9. The theory that Earth’s crust and upper mantle are in sections that move is called plate ___________________.

Pangaea
mantle
convection
plates
spreading
drift
lithosphere
asthenosphere
**Sinopsis: Tectónica de las placas**

**Instrucciones:** Estudia el siguiente diagrama. Luego rotula cada parte con la letra de la descripción correcta.

A. Una dorsal mediooceánica se forma cuando las placas divergentes continúan separándose, creando una cuenca oceánica. A medida que se eleva y se enfría, el magma forma nueva corteza oceánica.

B. Cuando una placa oceánica converge con una placa continental menos densa, la placa oceánica más densa se hunde debajo de la placa continental.

C. Cuando dos placas oceánicas convergen, la placa más densa es forzada a moverse debajo de la otra placa y se forman islas volcánicas sobre la placa que se está hundiendo.

**Instrucciones:** Haz un círculo alrededor de las palabras que mejor completan las siguientes oraciones.

4. Las principales pruebas que Wegener usó para apoyar su teoría de la deriva continental fueron (las rocas, los lenguajes), (los huesos humanos, los fósiles) y (el clima, antiguos cuentos populares).

5. El hecho de que las rocas (más recientes, más antiguas) están ubicadas en las dorsales mediooceánicas es una prueba de la expansión del suelo marino.

6. La transferencia de energía (solar, térmica) dentro de la Tierra mueve las placas.
Alfred Wegener fue una de las primeras personas que sugirió que todos los
1. ________________ estuvieron unidos en el pasado. Él llamó a este gran continente único 2. ________________. Existen pruebas que apoyan su hipótesis. Por ejemplo, se han encontrado fósiles similares en Sudamérica y en
3. ________________. Además, se han encontrado fósiles de climas cálidos en
4. ________________. Existen estructuras de 5. ________________ que son similares en las montañas Apalaches y en Groenlandia y el oeste de Europa. Pero no fue sino hasta que pistas encontradas en el suelo marino llevaron a la teoría de Harry Hess de la 6. ________________, que los científicos pudieron pensar sobre cómo podrían moverse los continentes.

Instrucciones: Estudia el siguiente diagrama del suelo marino. Aparea luego las letras con las afirmaciones de abajo.

7. La roca fundida fluye sobre el suelo marino y se endurece al enfriarse.
8. La roca caliente y fundida es forzada hacia arriba hacia el suelo marino en las dorsales mediooceánicas.
9. El nuevo suelo marino se aleja de la dorsal, se enfria, se hace más denso y se hunde.
10. La roca fundida fluye hacia los lados en ambas direcciones, dividiendo la corteza.
Sección 3 • Teoría de la tectónica de placas

Instrucciones: Escribe en el espacio a la izquierda, la letra del término que completa mejor cada oración.

1. La corteza y el manto superior de la Tierra están quebrados en secciones llamadas ______
   a. lava.                          b. placas.

2. La colisión de una placa continental con otra puede producir ______
   a. océanos.                      b. montañas.

3. Se forma corteza oceánica nueva en un(a) ______
   a. valle de dislocación.         b. dorsal mediooceánica.

4. Un valle de dislocación se puede formar cuando dos placas continentales están ______
   a. separándose.                  b. chocando.

5. En los sitios en donde las placas de la Tierra se mueven, éstas pueden deslizarse una al lado de la otra, separarse o ______
   a. chocar.                       b. dividirse.

Instrucciones: Completa el mapa conceptual con los siguientes términos.

- dorsales mediooceánicas
- valles de dislocación
- islas volcánicas
- fosas oceánicas
- montañas volcánicas
- terremotos fuertes

Límites entre placas incluyen placas convergentes forman y placas transformantes causan

placas convergentes

placas divergentes

6. y 7. y 8.

9. 10. 11.
Instrucciones: Usa los siguientes términos para completar el crucigrama. Las letras en la caja vertical oscura contestan la pregunta 9.

Pangaea
convección
manto
placas
expansión
deriva
litosfera
astenosfera

1. Todos los continentes estuvieron conectados una vez formando una gran masa de tierra llamada _______.
2. Ciclo de calentamiento, elevación, enfriamiento y hundimiento se llama corriente de _______.
3. La corteza y la parte superior del manto se conocen como _______.
4. Las placas continentales se mueven sobre una capa viscosa bajo la superficie de Tierra llamada _______.
5. El magma caliente que sube en las dorsales mediooceánicas produce ______ del suelo marino.
6. La hipótesis de que los continentes se mueven lentamente se llama ______ continental.
7. Las secciones de la corteza y el manto superior de la Tierra se llaman _______.
8. Justo debajo de la corteza terrestre está ubicada la _______.
9. La teoría de que la corteza y el manto superior de la Tierra están divididos en secciones que se mueven se llama ________________ de placas.
**Directions:** Match the descriptions in Column I with the terms in Column II. Write the letter of the correct term in the blank at the left.

**Column I**

_____ 1. reptile fossil found in South America and Africa  
_____ 2. fossil plant found in Africa, Australia, India, South America, and Antarctica  
_____ 3. clues that support continental drift  
_____ 4. mountains similar to those in Greenland and western Europe  
_____ 5. Wegener’s name for one large landmass  
_____ 6. slow movement of continents  
_____ 7. evidence that Africa was once cold

**Column II**

- a. Pangaea  
- b. Appalachians  
- c. continental drift  
- d. glacial deposits  
- e. Glossopteris  
- f. Mesosaurus  
- g. fossil, climate, and rock

**Directions:** Answer the following questions on the lines provided.

8. How did the discovery of *Glossopteris* support Wegener’s continental drift hypothesis?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

9. Why was Wegener’s hypothesis of continental drift not widely accepted at the time it was proposed? What do scientists now think might be a possible cause of continental drift?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Seafloor Spreading

Directions: Find the mistakes in the statements below. Rewrite each statement correctly on the lines provided.

1. During the 1940s and 1950s, scientists began using radar on moving ships to map large areas of the ocean floor in detail.

2. The youngest rocks are found far from the mid-ocean ridges.

3. The scientist Henry Hess invented echo-sounding devices for mapping the ocean floor.

4. As the seafloor spreads apart, hot saltwater moves upward and flows from the cracks.

5. As the new seafloor moves away from the ridge and becomes hotter, it moves upward and forms still higher ridges.

6. The research ship Glomar Challenger was equipped with a drilling rig that records magnetic data.

7. Rocks on the seafloor are much older than many continental rocks.

8. When plates collide, the denser plate will ride over the less-dense plate.

9. Earth’s magnetic field has always run from the north pole to the south pole.

10. The magnetic alignment in rocks on the ocean floor always runs from the north pole to the south pole.
**Theory of Plate Tectonics**

**Directions:** Use the following words to fill in the blanks below.

- asthenosphere
- lithosphere
- plate tectonics
- convection
- plates

1. The theory of ___________________ states that Earth’s crust and upper mantle are broken into sections.
2. These sections, called ___________________, are composed of the crust and a part of the upper mantle.
3. The crust and upper mantle together are called the ____________________.
4. Beneath this layer is the plasticlike ____________________.
5. Scientists suggest that differences in density cause hot, plasticlike rock to be forced upward toward the surface, cool, and sink. This cycle is called a ____________________ current.

**Directions:** Four diagrams are shown in the table below. Label and describe each diagram in the space provided in order to complete the table.

<table>
<thead>
<tr>
<th>Diagram</th>
<th>Type of boundary and motion at boundary</th>
<th>Diagram</th>
<th>Type of boundary and motion at boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.</td>
<td></td>
<td>8.</td>
<td></td>
</tr>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Type of boundary and motion at boundary" /></td>
<td><img src="image3.png" alt="Diagram" /></td>
<td><img src="image4.png" alt="Type of boundary and motion at boundary" /></td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td>9.</td>
<td></td>
</tr>
<tr>
<td><img src="image5.png" alt="Diagram" /></td>
<td><img src="image6.png" alt="Type of boundary and motion at boundary" /></td>
<td><img src="image7.png" alt="Diagram" /></td>
<td><img src="image8.png" alt="Type of boundary and motion at boundary" /></td>
</tr>
</tbody>
</table>
You know from your textbook how seafloor spreading changes the ocean floor. You know that magma rises at the mid-ocean ridge and flows away from the ridge. In general, this activity is hidden beneath the ocean's water. But there is a place where seafloor spreading can be seen on land.

1. What is the name of the landmass through which the mid-ocean ridge in the Atlantic Ocean passes?

2. How do the land structures of Iceland help confirm seafloor spreading?

3. Why do you think geologists might find Iceland a useful place to conduct research on seafloor spreading?
Axial Volcano—Evidence for Seafloor Spreading

What happens when a volcano erupts under water? Ocean scientists got the opportunity to find out in January 1988 when Axial erupted. Axial is an underwater volcano, or seamount, located about 480 km west of Oregon’s coast. It looms the largest of all the underwater structures on the Juan de Fuca ridge.

Quakes Along the Seafloor

Underwater listening instruments called hydrophones, which are used by the Navy to hear submarines, first picked up rumblings from Axial on January 25. Scientists recorded nearly 7,000 earthquakes during the first four days alone. Scientists hypothesized that these quakes resulted from hot magma moving and cracking rock, uncapping the top of Axial. The earthquakes followed a line in the seafloor where the Juan de Fuca oceanic plate is moving eastward, away from the Pacific oceanic plate. East of the shoreline, the Juan de Fuca plate is being pushed under the North American continental plate.

Creating New Seafloor

The scientists discovered that when Axial erupted, boiling-hot water shot up out of the volcano, followed by a great amount of super-hot lava. Much of this lava filled part of the gap between the Pacific Ocean plate and the Juan de Fuca plate, creating new seafloor. Having lost so much magma, Axial caved in somewhat—by about 3.2 m in the center.

Megaplumes

Around the same time, another group of scientists was on a 52 m research ship, the Wecoma, on the ocean’s surface about a mile above. They fought stormy conditions to gather data such as water temperature, water current flow, and samples of chemicals from the eruption. In 1986 scientists had learned that underwater volcanoes can cause underwater “hurricanes,” called megaplumes, which shoot hot water loaded with minerals and life-forms some 305 m up from the bottom. Only seven megaplumes in the world had been observed previously.

Hydrothermal Vents

At Axial’s summit sits a rectangular caldera (roughly 20 km² in area) between two rift zones. In the dark caldera, hydrothermal vents furnish heat and “food” such as hydrogen sulfide—poisonous to most creatures—to communities of bacteria and tube worms comfortable in temperatures hotter than the boiling point of water.

Axial provides scientists with a model for the rest of Earth’s 64,000 km or so of mid-ocean ridges. Various groups of scientists are conducting long-term studies of Axial and other areas along the Juan de Fuca ridge, focusing on various aspects of seafloor exploration.

1. Describe how seafloor spreading occurs along the Juan de Fuca ridge.

2. Using a physical map of Oregon, identify the geographical feature where the Juan de Fuca plate is pushing under the North American plate. 

3. Do you think that the rocks near Axial are younger or older than the rocks in Oregon? Explain.
The word tectonics comes from the same Greek base word as “architect.” Both words refer to building. An architect designs structures. Tectonics is a process by which Earth’s structures are built and changed.

1. Cut the map along the boundaries. Move the pieces to show how the plates will move in the next million years, according to the types of boundaries. Tape the pieces in place.

2. In which place(s) did you have to crumple your paper to account for the various plate movements?

3. Compare your new map with those of your classmates. Discuss similarities and account for any differences.

4. Research another area in the world where plates meet. Share your findings with the class.
Plate Tectonics

Section 1  Continental Drift

A. The continental drift hypothesis—continents have moved slowly to their current locations.
   1. All continents were once connected as one large landmass now called ________________.
   2. The land mass broke apart, and the ________________ drifted to their present positions.
   3. Evidence for continental drift
      a. ________________ fit of the continents
      b. Similar ________________ have been found on different continents.
      c. Remains of warm-weather plants in ________________ areas and glacial deposits in
         ________________ areas suggest that continents have moved.
      d. Similar ________________ structures are found on different continents.

B. At first, continental drift was not accepted because no one could explain ________________ or
   ________________ continents had moved.

Section 2  Seafloor Spreading

A. Using ________________ waves, scientists discovered a system of underwater mountain ranges
   called the mid-ocean ridges in many oceans.

B. In the 1960s, Harry Hess suggested the theory of ___________________________ to explain
   the ridges.
   1. Hot, less dense material below Earth’s ________________ rises upward to the surface at the
      mid-ocean ridges.
   2. Then, it flows sideways, carrying the ________________ away from the ridge.
   3. As the seafloor spreads apart, ________________ moves up and flows from the cracks, cools,
      and forms new seafloor.

C. Evidence for seafloor spreading
   1. ________________ rocks are located at mid-ocean ridges.
   2. Reversals of Earth’s ________________ field are recorded by rocks in strips parallel to ridges.
Section 3  Theory of Plate Tectonics

A. Plate movements
   1. Earth's __________________ and upper mantle are broken into sections.
   2. The sections, called ________________, move on a plasticlike layer of the mantle.
   3. The plates and upper mantle form the ____________________.
   4. The plasticlike layer below the lithosphere is called the ____________________.

B. Plate boundaries
   1. Plates moving ______________—divergent boundaries
   2. Plates moving ________________—convergent boundaries
      a. Denser plates sink under less ______________ plates.
      b. Newly formed hot ______________ forced upward forms volcanic mountains.
   3. Plates collide
      a. Plates crumple up to form ______________ ranges.
      b. ____________________ are common.
   4. Plates slide past—called ________________ boundaries; sudden movement can
      cause earthquakes

C. Convection inside Earth—the cycle of heating, rising, cooling, and sinking of material inside
   Earth is thought to be the ______________ behind plate tectonics.

D. Features caused by plate tectonics
   1. Faults and ______________ valleys
   2. Mountains and __________________
   3. Strike-slip faults—cause of __________________

E. Testing for plate tectonics—scientists can measure ________________ as little as 1 cm per year.
Assessment
Part A. Vocabulary Review

Directions: Write the term that matches each description below in the spaces provided. Then unscramble the letters in the boxes to reveal the mystery phrase.

1. plasticlike layer of Earth’s surface below the lithosphere
2. cycle of heating, rising, cooling, and sinking
3. theory that states that Earth’s crust and upper mantle are broken into sections, which move around on a special layer of the mantle
4. area where an oceanic plate goes down into the mantle
5. plate boundary that occurs when two plates slide past one another
6. place where two plates move together
7. rigid layer of Earth’s surface made up of the crust and a part of the upper mantle
8. sensing device that detects magnetic fields, helping to confirm seafloor spreading
9. one large landmass hypothesized to have broken apart about 200 million years ago into continents
10. hypothesis that the continents have moved slowly to their current locations
11. boundary between two plates that are moving apart
12. sections of Earth’s crust and upper mantle
13. largest layer of Earth’s surface, composed mostly of silicon, oxygen, magnesium, and iron
14. outermost layer of Earth’s surface
15. where rocks on opposite sides of a fault move in opposite directions or in the same direction at different rates

Mystery phrase: ________________________________
Part B. Concept Review

Directions: Study the following diagram. Then label the parts of Earth’s surface.

1. __________
2. __________
3. __________
4. __________
5. __________

Directions: Answer the following questions using complete sentences.

6. Compare and contrast divergent, convergent, and transform plate boundaries.

7. Describe how convection currents might be the cause of plate tectonics.

8. Why are new ideas often rejected, and what is needed before new ideas should be accepted?
Transparency Activities
If you were interested in the fossils of an animal that liked warm weather, would you think of digging in Antarctica? Archaeologists have found many interesting fossils there, including parts of a hadrosaur, a dinosaur previously found only in the Americas.

1. Antarctica has a very inhospitable climate. Why might fossils of warm-weather animals be found there?
2. What are some reasons that the climate of Antarctica might change in the future?
Until recently, the bottom of the sea was impossible to see. New technology has improved the view, and today we have a better idea of what is going on there. This photo shows one feature of the ocean floor—a deep-sea vent.

1. What is occurring in the photograph?
2. What features on land are similar to this deep-sea vent?
3. Judging from the photo, what do you think conditions around this vent are like?
Valley of Ten Thousand Smokes

One of the most massive volcanic eruptions ever investigated occurred in a valley in southern Alaska in 1912. The eruption covered over forty square miles with ash as deep as 210 meters and left thousands of vents (called fumaroles) in the valley spewing steam and gas.

1. How did this valley get its name, the Valley of Ten Thousand Smokes?
2. Why don’t you see any smoke in the photograph?
3. Name some other places where there are volcanoes.
### Teaching Transparency Activity (continued)

1. What makes up the lithosphere?

   

2. What is a convergent boundary?

   

3. What type of boundary is on the western coast of South America?

   

4. Which plate is covering most of two continents? What two continents?

   

5. What kind of boundary forms the Mid-Atlantic Ridge?

   

6. What two plates form the boundary on the western coast of Canada?
Directions: Carefully review the diagram and answer the following questions.

1. Which is the oldest rock layer in the picture?
   A W  C Y
   B X  D Z

2. The arrows indicate the directions the two plates are moving.
   What is this type of boundary called?
   F convergent boundary  H transform boundary
   G divergent boundary  J moving boundary

3. Which of the following is the danger most likely posed by the rock formation shown in the diagram?
   A flooding
   B earthquake
   C tornado
   D forest fire