

What do you think now?

- You first read the statements below at the beginning of the chapter.
1. India has always been north of the equator.
 2. All the continents once formed one supercontinent.
- Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

Wegener used to support his continental drift hypothesis.



Critical Thinking

- 7 **Recognize** The shape and age of the Appalachian Mountains are similar to the Caledonian mountains in northern Europe. What else could be similar?
- 8 **Explain** If continents continue to drift, is it possible that a new supercontinent will form? Which continents might be next to each other 200 million years from now?

EVALUATE

Visual Summary

FOLDABLES Review students' horizontal half-books. Check students' notes under each heading.

Use Vocabulary

- 1 Pangaea is a supercontinent that was made up of all the landmasses on Earth. **DOK 1**
- 2 The continental drift hypothesis suggests that all continents once formed a single landmass and then drifted apart. Fossil evidence showed that organisms living on different continents once lived on the same landmass. Mountain ranges on different continents contain similar rock types. Climate data suggest that parts of present-day continents once had similar climates. **DOK 1**

Understand Key Concepts

- 3 Alfred Wegener first proposed continental drift. **DOK 1**
- 4 **A.** fossils **DOK 1**

Interpret Graphics

- 5 South America has moved west and Africa has moved east since Pangaea began to break apart 250 million years ago. **DOK 2**

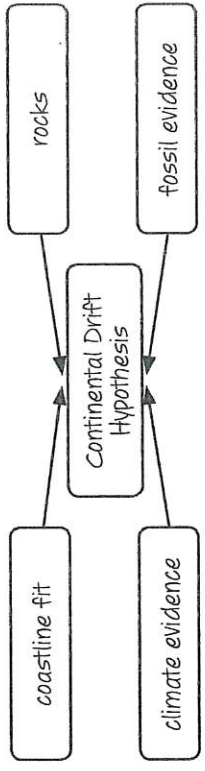
traveled to Antarctica where he discovered the fossilized tooth of a small land mammal. After carefully examining the tooth, he realized that it resembled fossils from ancient land mammals found in Africa and North America. MacPhee believes that these mammals are the ancient relatives of a mammal living today on the African island-nation of Madagascar.

It's Your Turn

How did the fossil remains and their present-day relatives become separated by kilometers of ocean? MacPhee hypothesizes that the mammal migrated across land bridges that once connected parts of Gondwana. Over millions of years, the movement of Earth's tectonic plates broke up this supercontinent. New ocean basins formed between the continents, resulting in the arrangement of landmasses that we see today.

RESEARCH Millions of years ago, the island of Madagascar separated from the continent of Gondwana. In this environment, the animals of Madagascar changed and adapted. Research and report on one animal. Describe some of its unique adaptations.

6



DOK 2

Critical Thinking

- 7 Rock formations and fossils discovered there might also be the same. **DOK 3**
- 8 Yes, a new supercontinent could form. North America will move toward eastern Asia, while South America will move toward Central America. India will be incorporated into Asia, and northern Africa will collide with western Europe. **DOK 4**

What do you think NOW?

Have students review their answers from **What do you think?** at the beginning of the chapter. Have students rewrite disagree statements to make them true. See possible answers on the **Get Ready to Read** page at the beginning of this chapter.

Use your lesson Foldable to review the lesson. Save your Foldable for the project at the end of the chapter.

What do you think NOW?

- You first read the statements below at the beginning of the chapter.
- The seafloor is flat.
 - Volcanic activity occurs only on the seafloor.
- Did you change your mind about whether you agree or disagree with the statements? Rewrite any false statements to make them true.

EVALUATE

Visual Summary

Concepts and terms are easier to remember when they are associated with an image. **Ask: Which Key Concept does each image relate to?**

FOLDABLES Review students' two-tab books. Check students' definitions of cylindrical and conical projections.

Use Vocabulary

- Iron-rich minerals in lava cool, crystallize, and record Earth's magnetic polarity. **DOK 1**
- Student diagrams should resemble the image associated with question 7. **DOK 2.**
- During a process called seafloor spreading, the oceanic crust separates and spreads apart along a mid-ocean ridge. **DOK 1**

Understand Key Concepts

- A. at mid-ocean ridges. **DOK 1**
- New rock is formed when lava erupts along the length of the ridge. When the seafloor spreads, this rock separates and moves in opposite directions, forming lines that are parallel to the ridge. **DOK 1**
- Scientists measure depth to the seafloor using echo-sounding devices. Because sound waves travel at constant speed in water, scientists can measure sound-wave travel time and calculate depth. **DOK 1**

Do not eat anything used in this lab.

- Lay the two pieces of foam board over the yogurt, leaving a small opening in the middle. Push the foam boards together and down, so the yogurt oozes up and over each of the foam boards.
- Pull the foam boards apart and add a new row of two spoonsful of berry yogurt down the middle. Lift the boards and place them partly over the new row. Push them together gently. Observe the outer edges of the new yogurt while you are moving the foam boards together.

Key Concept

What happens to the material already on the ocean floor when magma erupts along a mid-ocean ridge?

Interpret Graphics

- The youngest oceanic crust is located closest to the mid-ocean ridge. The oldest oceanic crust is located farthest away from the mid-ocean ridge. **DOK 1**
- Oceanic crust moves away from a mid-ocean ridge during seafloor spreading. The moving crust carries along the overlying continents. **DOK 3**
- The seafloor spreads → the mantle melts and forms magma that rises through cracks in the crust → magma erupts as lava on the seafloor → the lava accumulates in layers and forms a mid-ocean ridge. **DOK 4**

Critical Thinking

- Magnetic stripes in the Pacific Ocean are wider because the seafloor spreads more rapidly there than in the Atlantic Ocean. **DOK 2**
- Seafloor sediment increases in thickness away from the mid-ocean ridge because the oceanic crust is older farther away from the ridge. More sediment will accumulate on the seafloor over time; therefore, the older the crust, the thicker the sediment deposits. **DOK 1**

What do you think NOW?

Have students review their answers from **What do you think?** at the beginning of the chapter. Have students rewrite disagree statements to make them true. See possible answers on the **Get Ready to Read** page at the beginning of this chapter.

Visual Summary

Concepts and terms are easier to remember when we associate them with an image. **Ask:** Which Key Concept does each image relate to?

FOLDABLES Review students' Foldables and make sure the notes show a good understanding of plate boundaries, how plates move along different types of boundaries, and some of the results of plate motions.

Use Vocabulary

- 1 plate tectonics **DOK 1**

Understand Key Concepts

- 2 Earthquakes are associated with all types of convergent plate boundaries. Plates separate along a divergent plate boundary. Earthquakes and volcanic eruptions are common along divergent plate boundaries. Plates collide along a convergent plate boundary. Volcanoes occur where plates of different densities collide along a subduction zone. Mountains form where two plates of the same density collide. Plates slide past each other in opposite directions along a transform plate boundary. Earthquakes occur along transform plate boundaries. **DOK 2**
- 3 Mantle convection occurs due to the transfer of thermal energy in the mantle. Radioactive elements in the core heat the mantle. Hot mantle material rises to the base of the crust and cools, sinking back down into the mantle. This process creates circular currents in the mantle called convection currents. **DOK 1**
- 4 A. convection currents. **DOK 1**

Interpret Graphics

- 5 divergent; convergent **DOK 1**
- 6 cause—convection current; effects—moving plates; results—earthquakes, volcanic eruptions, mountain building **DOK 2**

Critical Thinking


- 7 Earthquakes occur at greater depths along convergent plate boundaries because slabs of rigid rock sink deep into the mantle along a subduction zone. As this cold, old, and rigid rock sinks, stress accumulates with increasing depth. When stress is released along a subduction zone, an earthquake occurs. **DOK 2**

Math Skills

- 8 $5,000 \text{ y} \left(\frac{15 \text{ cm}}{\text{y}} \right) = 75,000 \text{ cm} = 75 \text{ m}$ **DOK 3**

What do you think




Have students review their answers from **What do you think?** at the beginning of the chapter. Have students rewrite disagree statements to make them true. See possible answers on the **Get Ready to Read** page at the beginning of this chapter.

 **Cooperative Learning** Pair students and pair give a short (2–3 min), live-at-the-scene news of the following topics: *divergence*, *convergence*, *motion*, *mantle convection*, *basal drag*, *ridge push*




Intervention Planner

Based on the results of the Lesson Review, use below to address individual needs.



Use Vocabulary (1)

-  Science Use v. Common Use, plastic
-  Quick Vocabulary, p. 3–4
Content Vocabulary, p. 45
-  Vocabulary eFlashcards
Vocabulary eGames
Vocabulary Puzzlemaker




Understand Key Concepts (2–4)

-  Key Concept Checks
-  Key Concept Builder, p. 55–58
-  Personal Tutor: Conduction, Convection
Online Quiz




Interpret Graphics (5–6)

-  Visual Literacy, Plate Interactions
-  Animation: Plates Collide

Critical Thinking (7)

-  Guiding Questions, Plate Boundaries
-  Enrichment, p. 59
Challenge, p. 60
-  Virtual Lab: Where do most earthquakes and volcanoes occur?

Math Skills (8)

-  Math Skills: Use Proportions
-  Math Skills, p. 53
-  Math Practice



Pangaea

- 5 Mid-ocean ridges are associated with
- convergent plate boundaries.
 - divergent plate boundaries.
 - hot spots.
 - transform plate boundaries.

- 6 What happens to Earth's magnetic field over time?
- It changes polarity.
 - It continually strengthens.
 - It stays the same.
 - It weakens and eventually disappears.
- 9 Which of Earth's outermost layers includes the crust and the upper mantle?
- asthenosphere
 - lithosphere
 - mantle
 - outer core

Writing in Science

- 4 Infer Warm peanut butter is easier to spread than cold peanut butter. How does knowing this help you understand why the mantle is able to deform in a plastic manner?
- 11 Predict If continents continue to move in the same direction over the next 200 million years, how might the appearance of landmasses change? Write a paragraph to explain the possible positions of landmasses in the future. Based on your understanding of the plate tectonic theory, is it possible that new supercontinents will form in the future?

Use Proportions

- 12 Mountains on a convergent plate boundary may grow at a rate of 3 mm/yr. How long would it take a mountain to grow to a height of 3,000 m? (1 m = 1,000 mm)
- 13 The North American Plate and the Pacific Plate have been sliding horizontally past each other along the San Andreas fault zone for about 10 million years. The plates move at an average rate of about 5 cm/yr. a. How far have the plates traveled, assuming a constant rate, during this time? b. How far has the plate traveled in kilometers? (1 km = 100,000 cm)

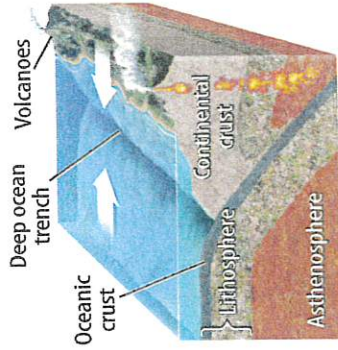
Understand Key Concepts

- continental drift 1
- produced at the mid-ocean ridge. 3
- GPS (global positioning system) 2
- South America 1
- divergent plate boundaries. 3
- continent-to-continent convergent boundaries. 6
- divergent boundary 6
- It changes polarity. 4
- lithosphere 7

Critical Thinking

- 10 If we know the age of the oldest oceanic crust in the Atlantic Ocean and the relative rate of seafloor spreading, we can determine when North America first began to separate from Europe. 4


- 11 With sonar technology, scientists were able to map the seafloor and discovered the mid-ocean ridge system. Differences in the magnetic polarity and the age of rocks exposed on the seafloor led to the discovery of seafloor spreading. Satellites helped to prove that plates move. An examination of Earth's layers and seismic data helped to explain convection currents in the mantle, which proved the theory. 5
- 12 Africa must have at one time been located closer to the South Pole, because it had a colder climate that supported glaciation. Africa has since drifted to its present location, farther from the South Pole. 1



As a slab of rock subducts into the mantle, parts of it melt to form magma. The magma rises and fuels volcanoes that erupt onto the crust. 6



- 14 Warmer materials are more pliable and deform more easily than colder materials. 

Writing in Science

- 15 Possible response: If continents continue to move, some landmasses will get larger and others will become smaller. Yes, it is possible that some or all of Earth's continents might join to form one or more supercontinents. 



REVIEW

THE BIG IDEA

- 16 The theory of plate tectonics states that Earth's crust and rigid upper mantle are broken into slabs called plates. Plates move slowly over Earth's surface as the result of convection in the partly melted asthenosphere. Continental drift is a hypothesis that suggests that Earth's continents move over time. Seafloor spreading is a theory that states that new ocean crust forms along mid-ocean ridges and moves away from the ridge over time. Evidence to support plate tectonics includes echo-sounding and magnetic studies of the seafloor, the locations of earthquake epicenters and volcanoes, satellite imaging, and seismic studies. 
- 17 Two plates of equal density collide. Neither is subducted. Instead, the edges of both plates are folded and crumpled to produce towering mountain ranges. 







Math Skills

Use Proportions





- 18 $3,000 \text{ m} = 3,000,000 \text{ mm}$; $3,000,000 \text{ mm} (1 \text{ y} / 3 \text{ mm}) = 1,000,000 \text{ y}$ 
- 19 a. $10,000,000 \text{ y} (5 \text{ cm} / \text{y}) = 50,000,000 \text{ cm}$
 b. $50,000,000 \text{ cm} (1 \text{ km} / 100,000) = 500 \text{ km}$ 

Intervention Planner

Based on the results of the Chapter Review, use the table below to address individual needs.

Lesson	Questions	Intervention Options
Understand Key Concepts		
1	1, 4	 Key Concepts pp. 16–19, 30  Content Practice 14, 30, 31, 40
2	2–3, 8	 Key Concepts  Animations: Continental Drift; Visualizing Seafloor Spreading
3	5–6, 7, 9	 Interactive Plate Tectonics  Personal Tutor: Convection





Critical Thinking

1	12	 Enrichment
3	10–11, 13–14	 Challenge  Virtual Lab: Earthquake and Volcanoes  WebQuest: Fossils


Writing in Science

3	15	 Language Arts  Enrichment  WebQuest: Fossils
---	----	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Review the Big Idea

3	16–17	 Content Practice 14, 30, 31  Enrichment  Challenge  Online Tutor
---	-------	--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

Math Skills

3	18–19	 Math Skills  Math Practice: Proportions  Math Practice: Proportions
---	-------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

- 10 **C—Correct.** A, B, D—When the seafloor spreads, the mantle beneath can melt to form magma. Magma is buoyant and rises to Earth's surface through cracks in the crust along a mid-ocean ridge. When magma reaches Earth's surface it is called lava. When lava cools and crystallizes on the seafloor, it becomes basalt. **DOK 1**

Constructed Response

- 11 Location answers will vary. Possible answers:

Plate Boundary	Location
Convergent	Andes (ocean to continent); Himalayas (continent to continent)
Divergent	Mid-Atlantic Ridge
Transform	San Andreas Fault (California)

DOK 3

- 12 Diagrams will vary but should illustrate one of the three types of plate boundaries. Possible labels include lithosphere, asthenosphere, continental crust, mountains, deep ocean trenches, mid-ocean ridges, and volcanoes. Arrows should accurately reflect the direction of plate movement at the boundary. **DOK 3**
- 13 Answers will vary but can include the following: The continents are now far apart and in different climates. Climatic evidence, such as the location of similar glacial grooves across several continents, suggests that continents were once connected. Also, rock formations and mountains on different continents, such as the Appalachians and the Caledonian Mountains, have similar ages and origins. **DOK 3**
- 14 Answers will vary but will most likely include at least two of the following: Continental drift is not easily observable because tectonic plates move slowly. When Wegener proposed the continental drift hypothesis, he was unable to identify a force that could move continents. Scientists have since understood how continents could move through the solid rock of the continents and the seafloor. **DOK 3**
- 15 Answers will vary. Possible response: Scientists discovered magnetic stripes on either side of the mid-ocean ridge. Each pair had similar composition, magnetic character, and age. The stripes represent that new oceanic crust formed along a mid-ocean ridge and spread out there. Scientists also drilled holes in the seafloor to measure temperature beneath the surface. Measurements confirmed that more heat is released from Earth's interior near a mid-ocean ridge than from the abyssal plain. Scientists determined the age of sediments on the seafloor. Test results showed that sediment closest to the mid-ocean ridge is younger than sediment further away from the ridge. Lastly, sediment layers increase in thickness away from the mid-ocean ridge, confirming that the seafloor is created from the mid-ocean ridge. **DOK 3**
- 16 Answers will vary. Possible response: The theory of plate tectonics states that why Earth's surface area does not increase. When tectonic plates of different densities collide, one will subduct beneath the other. Therefore, the crust that is created along a mid-ocean ridge is eventually recycled back into Earth's mantle along a subduction zone. **DOK 3**