CHAPTER 7
LESSON 3

Plate Tectonics

The Theory of Plate Tectonics

Key Concepts

- What is the theory of plate tectonics?
- What are the three types of plate boundaries?
- Why do tectonic plates move?

Before You Read

What do you think? Read the two statements below and decide whether you agree or disagree with them. Place an A in the Before column if you agree with the statement or a D if you disagree. After you've read this lesson, reread the statements to see if you have changed your mind.

Before	Statement	After
	5. Continents drift across a molten mantle.	
	6. Mountain ranges can form when continents collide.	

Study Coach

Make an Outline Use the main heads in this lesson as the main points of your outline. Complete the outline with details found in the lesson. Study the lesson by reviewing your outline.

Read to Learn

The Plate Tectonics Theory

When you blow into a balloon, the balloon expands. Its surface area also increases. As more air is added to the balloon, the balloon gets larger. Similarly, if ocean crust continually forms at mid-ocean ridges and is never destroyed, Earth's surface should be expanding. But measurements of the planet show that Earth is not getting larger. How can this be explained?

Geologists proposed a more complete theory in the late 1960s. It was called plate tectonics theory. The theory of **plate tectonics** states that *Earth's surface is made of rigid slabs of rock, or plates, that move with respect to each other*, or in relation to each other. This new theory suggested that Earth's surface, the lithosphere, is divided into large pieces of rock. These pieces are called plates. Each plate moves slowly over Earth's hot and semiplastic mantle.

Key Concept Check

1. State What is plate tectonics?

The word *tectonic* describes the forces that shape Earth's surface and the rock structures that form as a result. Plate tectonics explains why earthquakes occur and volcanoes erupt. When plates separate on the seafloor, earthquakes result and a mid-ocean ridge forms. When plates come together, one plate can move under the other. This causes earthquakes and creates a chain of volcanoes. When plates slide past each other, earthquakes can result.

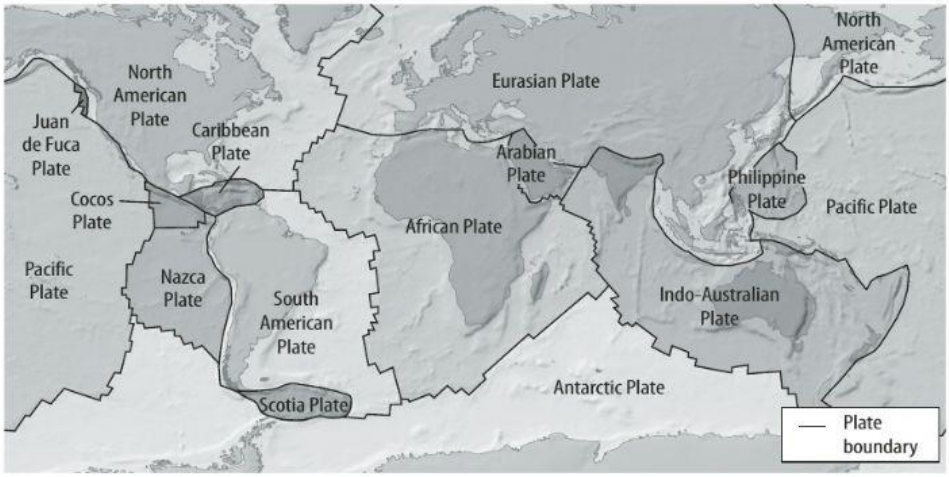
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Earth's Tectonic Plates



Tectonic Plates

Earth's surface is divided into rigid plates that move relative to one another. Look at the map above. It shows Earth's major plates and their boundaries. Notice how some boundaries are in the middle of the oceans. Many of these boundaries are located at mid-ocean ridges. The Pacific Plate is the largest plate. The Juan de Fuca is one of the smallest plates.

Earth's outermost layers are cold and rigid compared to the layers within Earth's interior. *The cold and rigid outermost rock layer is called the* **lithosphere.** The crust and the solid, uppermost mantle form the lithosphere.

The lithosphere varies in thickness. It is thin below mid-ocean ridges. It is thick below continents. Earth's tectonic plates are large pieces of lithosphere. These plates fit together like the pieces of a giant jigsaw puzzle.

Directly below the lithosphere is a very hot part of the mantle. This layer of Earth is called the asthenosphere (as THEE nuh sfihr). Even though it is solid, the asthenosphere behaves like a plastic material because it is so hot.

The asthenosphere flows below Earth's plates and enables the plates to move. The ways in which the lithosphere and asthenosphere interact help explain plate tectonics.

Visual Check

2. Locate Circle the Nazca Plate.

SCIENCE USE V. COMMON USE

plastic

Science Use capable of being molded or changing shape without breaking

Common Use any of numerous organic, synthetic, or processed materials made into objects

Reading Check

3. Identify What are Earth's outermost layers called?

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Plate Boundaries

Imagine placing two books side by side. Imagine that each book is a tectonic plate. The place where the edges of the books meet represents a plate boundary. How many ways can you move the books along a set of boundaries? You can pull the books away from each other. You can push the books together. You can slide the books past each other. Earth's tectonic plates move in much the same way as you can move these books.

Reading Check

4. Describe three ways in which tectonic plates move.

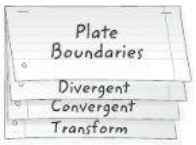
Divergent Plate Boundaries

A **divergent plate boundary** *forms where two tectonic plates separate. Divergent* means "moving apart." Mid-ocean ridges are located along divergent plate boundaries. When the seafloor spreads at a mid-ocean ridge, lava erupts. As the lava cools and hardens, it forms new oceanic crust. As this process continues, the plates move away from each other.

Divergent plate boundaries can also exist in the middle of a continent. At these boundaries, continents pull apart and a rift valley forms. The East African Rift is one example of a continental rift.

FOLDABLES

Make a layered book to organize your notes on the three types of plate boundaries.



Transform Plate Boundaries

The San Andreas Fault in California is a transform plate boundary. *A* **transform plate boundary** *forms where two tectonic plates slide past each other.* As they move past each other, the plates might get stuck and stop moving. Stress builds up where the plates are stuck. When this stress is too great, the rocks break and suddenly move apart. The result is a rapid release of energy in the form of an earthquake.

Convergent Plate Boundaries

A **convergent plate boundary** *forms where two plates collide. The denser plate sinks below the more buoyant plate in a process* called **subduction.** A subduction zone is the area where a denser plate descends into Earth along a convergent plate boundary. The two types of convergent plate boundaries are ocean-to-continent and continent-to-continent.

Key Concept Check

5. Name What are the three types of plate boundaries?

Ocean-to-Continent Boundary When a dense oceanic plate and a less-dense continental plate collide, the oceanic plate subducts, or sinks, under the edge of the continental plate. This creates a deep ocean trench and a line of volcanoes forms on the edge of the continent. This process can also occur when two oceanic plates collide. An older and denser oceanic plate will subduct beneath a younger oceanic plate. A deep ocean trench forms, along with a line of volcanoes.

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Continent-to-Continent Boundary Convergent plate boundaries also form when two continental plates collide. When this happens, neither plate is subducted. The less-dense plate folds and deforms, forming mountains such as the Himalayas in India.

Evidence for Plate Tectonics

When Wegener proposed the continental drift hypothesis, technology was not available to measure how fast the continents moved. Remember that continents move apart or come together at speeds of only a few centimeters per year. This is about the length of a small paper clip.

Today, scientists can measure how fast continents move. A network of satellites orbiting Earth is used to monitor plate motion. By keeping track of the distance between satellites and Earth, it is possible to determine how fast a tectonic plate moves. This network of satellites is called the Global Positioning System (GPS).

The theory of plate tectonics explains why earthquakes and volcanoes are more common in some places than in others. Recall that when plates separate, collide, or slide past each other, stress builds. When this stress suddenly releases, earthquakes can result.

Volcanoes can also form along a mid-ocean ridge or continental rifts. They also form where plates collide along a subduction zone. Mountains can form where two continents collide. The map below shows that most earthquakes and volcanoes occur along tectonic plate boundaries.

Reading Check

6. Identify Along what type of convergent plate boundary did the Himalayas form? (Circle the correct answer.)

a. ocean-to-ocean
b. continent-to-continent
c. ocean-to-continent

Key Concept Check

7. Explain How are earthquakes and volcanoes related to the theory of plate tectonics?

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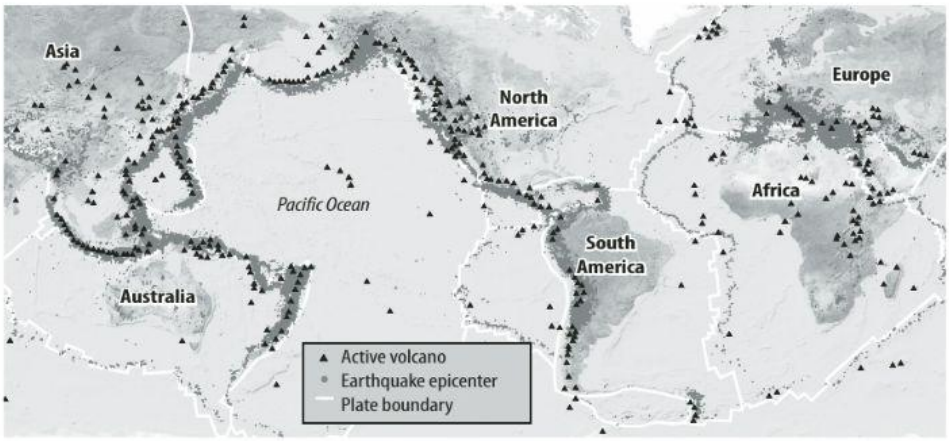
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Visual Check

8. Interpret Do earthquakes and volcanoes occur anywhere away from plate boundaries? If so, where?

_____



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Plate Motion

You learned that the main objection to Wegener's continental drift hypothesis was that he could not explain how or why Earth's continents move. Scientists now understand that continents move because the asthenosphere moves underneath the rigid lithosphere.

Convection Currents

The circulation of material caused by differences in temperature and density is called **convection.** For example, the upstairs floors of homes are often warmer because hot air rises. Hot air is less dense than cold air. As the cold air sinks, the hot air rises.

Reading Check

9. Explain What causes convection?

Convection in the mantle is related to plate tectonic activity. The warmth for convection comes from radioactive elements inside Earth, such as uranium, thorium, and potassium. When materials such as solid rock are heated, they expand and become less dense. Heated mantle material rises and comes in contact with Earth's crust. Thermal energy is transferred from hot mantle material to the colder surface above. As the mantle cools, it becomes denser and sinks, forming a convection current. These currents in the asthenosphere act like a conveyor belt moving the lithosphere above it. Therefore, tectonic plates move in response to the heating and cooling of mantle material.

Key Concept Check

10. Cause and Effect Why do tectonic plates move?

Forces Causing Plate Motion

How can something as large as the Pacific Plate move? Convection currents in the mantle produce enormous forces that can move Earth's massive plates. These forces are basal drag, ridge push, and slab pull. Scientists' opinions differ on which force is strongest.

Basal Drag Convection currents in the mantle produce a force on plates that causes motion called basal drag. Convection currents in the asthenosphere can drag the lithosphere. This is similar to how a conveyor belt moves items at a supermarket.

Ridge Push Recall that mid-ocean ridges are higher than the surrounding seafloor. Because mid-ocean ridges are elevated, gravity pulls the surrounding rocks down and away from the ridge. *Rising mantle material at mid-ocean ridges creates the potential for plates to move away from the ridge with a force called* **ridge push.** Ridge push moves the lithosphere in opposite directions away from the mid-ocean ridge.

Reading Check

11. Explain What causes ridge push? (Circle the correct answer.)

a. a plate going into the mantle

b. force on the bottom of a plate

c. movement along a mid-ocean ridge

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Slab Pull You learned that when tectonic plates collide, the denser plate will sink into the mantle along a subduction zone. This sinking plate is called a slab. Because the slab is old and cold, it is denser than the surrounding mantle. Therefore, it sinks. *As a slab sinks, it pulls on the rest of the plate with a force called* **slab pull.** This is similar to pushing a tablecloth over the edge of a table. When enough of the cloth slides over the edge, it will pull the rest of the cloth off the table.

A Theory in Progress

Plate tectonics is often said to be the unifying theory in geology. It explains the connection between continental drift and the formation and destruction of crust along plate boundaries. It also helps explain why earthquakes and volcanoes occur and why mountains form.

The investigation that Wegener began nearly a century ago is still being updated. Several questions remain.

- Why is Earth the only planet in the solar system that has plate tectonic activity? No other planet in our solar system is known to have active tectonic plates.
- Why do some earthquakes and volcanoes occur far from plate boundaries? Perhaps it is because plates are not perfectly rigid. Different thicknesses and weaknesses exist within plates. Also, the mantle is much more active than scientists originally understood.
- What forces actually dominate plate motions? Currently accepted models suggest that convection currents occur in the mantle. However, there is no way to measure or observe them.
- How will scientists answer these questions? One topic of interest is creating 3-D images of seismic wave velocities in a subduction zone. This technology is called anisotropy. It might help scientists better understand the processes that occur within the mantle and along plate boundaries.

Math Skills

The plates along the Mid-Atlantic Ridge spread at an average rate of 2.5 cm/y. How long will it take the plates to spread 1 m? Use proportions to find the answer.

a. Convert the distance to the same unit.

$$1\ \text{m} = 100\ \text{cm}$$

b. Set up a proportion:

$$\frac{2.5\ \text{cm}}{1\ \text{y}} = \frac{100\ \text{cm}}{x\ \text{y}}$$

c. Cross-multiply and solve for x as follows:

$$2.5\ \text{cm} \times x\text{y} = 100\ \text{cm} \times 1\text{y}$$

d. Divide both sides by 2.5 cm.

$$x\ \text{y} = \frac{100\ \text{cm y}}{2.5\ \text{cm}}$$

$$x = 40\ \text{y}$$

12. Use Proportions The Eurasian Plate travels the slowest, at about 0.7 cm/y. How long would it take the plate to travel 3 m?

_____

Reading Check

13. Explain Why does the theory of plate tectonics continue to change?

_____

_____

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After You Read

Mini Glossary

convection: the circulation of material caused by differences in temperature and density

convergent plate boundary: forms where two plates collide

divergent plate boundary: forms where two tectonic plates separate

lithosphere: the cold and rigid outermost rock layer of Earth

plate tectonics: the theory that states that Earth's surface is made of rigid slabs of rocks, or plates, that move with respect to each other

ridge push: when the rising mantle material at mid-ocean ridges creates the potential for plates to move away from the ridge with a force

slab pull: when a slab sinks and pulls on the rest of the plate with a force

subduction: the process by which the denser plate sinks below the more buoyant plate when two plates collide

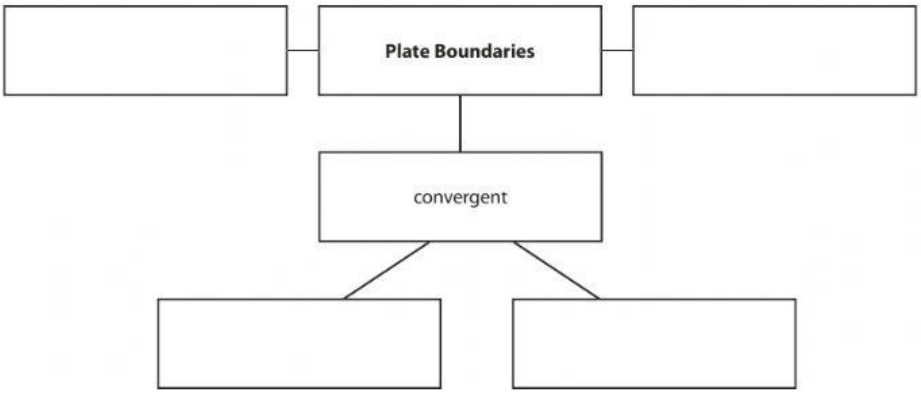
transform plate boundary: forms where two tectonic plates slide past each other

1. Review the terms and their definitions in the Mini Glossary. Choose one term and explain what it means in your own words.

_____

_____

2. Use what you have learned about plate tectonics to complete the concept map.



What do you think NOW?

Reread the statements at the beginning of the lesson. Fill in the After column with an A if you agree with the statement or a D if you disagree. Did you change your mind?

Connect ED

Log on to ConnectED.mcgraw-hill.com and access your textbook to find this lesson's resources.

END OF LESSON

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Content Vocabulary **LESSON 3**

The Theory of Plate Tectonics

Directions: *Each of the sentences below is false. Make the sentence true by replacing the underlined word(s) with a term from the list below. Write your changes on the lines provided.*

convection	**convergent plate boundary**	**divergent plate boundary**	**lithosphere**
plastic	**plate tectonics**	**ridge push**	**slab pull**
subduction	**transform plate boundary**		

_____ **1.** A tectonic material is something that is capable of changing shape without breaking.

_____ **2.** A transform plate boundary is one where two plates collide.

_____ **3.** Two plates separate at a convergent plate boundary.

_____ **4.** Two plates slide by each other at a divergent plate boundary.

_____ **5.** The sinking of a denser plate below a more buoyant plate is called convection.

_____ **6.** Slab pull is a consequence of the rising mantle of ocean ridges.

_____ **7.** Basal drag is the force produced by the sinking of a plate.

_____ **8.** Ridge push is the theory that Earth's surface is made of slowly moving rock plates.

_____ **9.** The rigid outermost rock layer of Earth is the mantle.

_____ **10.** Plate tectonics occurs when material circulates through differences in density.

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Lesson Outline **LESSON 3**

The Theory of Plate Tectonics

A. The Plate Tectonics Theory

1. The theory of _____ states that Earth's surface is divided into large plates of rock. Each plate moves over Earth's _____ and changes position with respect to other plates.

a. When plates _____ on the seafloor, mid-ocean ridges form.

b. When one plate dives under another plate, earthquakes can result and _____ can form.

c. Earthquakes can also result when plates _____ past each other.

2. Of all Earth's tectonic plates, the _____ plate is the largest.

3. The cold, rigid rock layer on the outermost part of Earth is called the _____. It consists of crust and the upper part of the _____.

4. Below the lithosphere is the _____, which is so hot that it flows like _____.

5. _____ of lithosphere move because they rest on the flowing asthenosphere.

B. Plate Boundaries

1. The place where two plates meet is called a(n) _____.

2. When two plates move away from each other, a(n) _____ forms.

a. In the ocean, _____ are located at divergent plate boundaries.

b. If divergent plate boundaries separate parts of a continent, _____ form.

3. When two plates slide by each other, a(n) _____ forms. This type of movement causes _____.

4. When two plates collide, a(n) _____ forms.

a. When plates collide, the plate that is denser slides under the less-dense plate in the process of _____.

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