Lesson 3

The Theory of Plate Tectonics

Reading Guide

Key Concepts

ESSENTIAL QUESTIONS

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

Vocabulary

plate tectonics p. 511
lithosphere p. 512
divergent plate boundary p. 513
transform plate boundary p. 513
convergent plate boundary p. 513
subduction p. 513
convection p. 516
ridge push p. 517
slab pull p. 517

Multilingual eGlossary

Inquiry How did these islands form?

The photograph shows a chain of active volcanoes. These volcanoes make up the Aleutian Islands of Alaska. Just south of these volcanic islands is a 6 km deep ocean trench. Why did these volcanic mountains form in a line? Can you predict where volcanoes are? Are they related to plate tectonics?

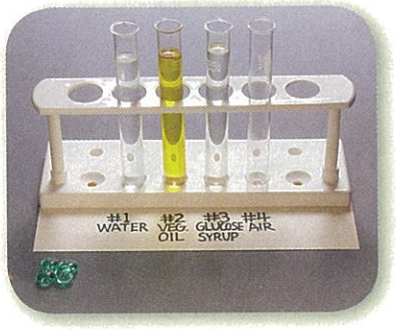
inquiry Launch Lab

15 minutes

Can you determine density by observing buoyancy?

Density is the measure of an object's mass relative to its volume. Buoyancy is the upward force a liquid places on objects that are immersed in it. If you immerse objects with equal densities into liquids that have different densities, the buoyant forces will be different. An object will sink or float depending on the density of the liquid compared to the object. Earth's layers differ in density. These layers float or sink depending on density and buoyant force.

1. Read and complete a lab safety form.
2. Obtain four **test tubes.** Place them in a **test-tube rack.** Add **water** to one test tube until it is ¾ full.
3. Repeat with the other test tubes using **vegetable oil** and **glucose syrup.** One test tube should remain empty.
4. Drop **beads** of equal density into each test tube. Observe what the object does when immersed in each liquid. Record your observations in your Science Journal.



Think About This

1. How did you determine which liquid has the highest density?
2. Key Concept What happens when layers of rock with different densities collide?

The Plate Tectonics Theory

When you blow into a balloon, the balloon expands and its surface area also increases. Similarly, if oceanic crust continues to form at mid-ocean ridges and is never destroyed, Earth's surface area should increase. However, this is not the case. The older crust must be destroyed somewhere—but where?

By the late 1960s a more complete theory, called plate tectonics, was proposed. 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.* This new theory suggested that Earth's surface is divided into large plates of rigid rock. Each plate moves over Earth's hot and semi-plastic mantle.

Key Concept Check What is plate tectonics?

Geologists use the word *tectonic* to describe the forces that shape Earth's surface and the rock structures that form as a result. Plate tectonics provides an explanation for the occurrence of earthquakes and volcanic eruptions. When plates separate on the seafloor, earthquakes result and a mid-ocean ridge forms. When plates come together, one plate can dive under the other, causing earthquakes and creating a chain of volcanoes. When plates slide past each other, earthquakes can result.

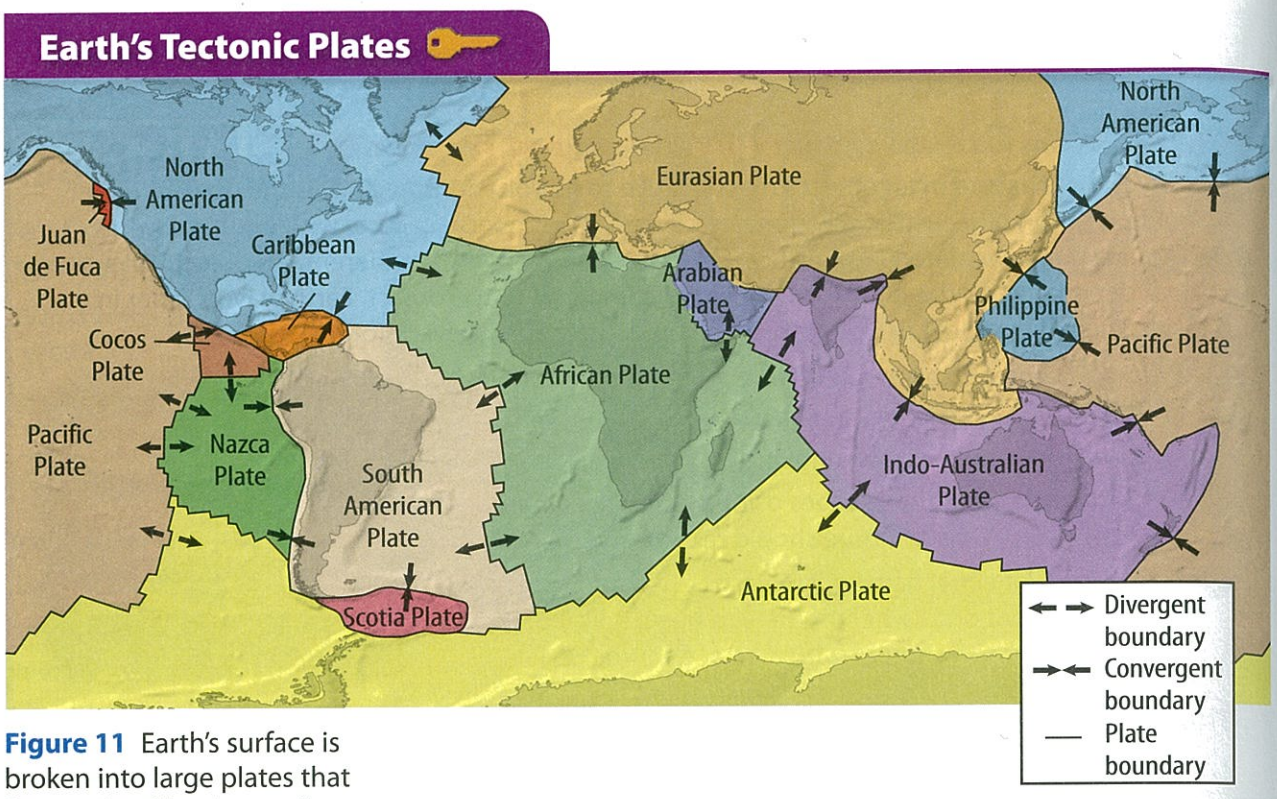


Figure 11 Earth's surface is broken into large plates that fit together like pieces of a giant jigsaw puzzle. The arrows show the general direction of movement of each plate.

Tectonic Plates

You read on the previous page that the theory of plate tectonics states that Earth's surface is divided into rigid plates that move relative to one another. These plates are "floating" on top of a hot and semi-plastic mantle. The map in **Figure 11** illustrates Earth's major plates and the boundaries that define them. The Pacific Plate is the largest plate. The Juan de Fuca Plate is one of the smallest plates. It is between the North American and Pacific Plates. Notice the boundaries that run through the oceans. Many of these boundaries mark the positions of the mid-ocean ridges.

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.** It is made up of the crust and the solid, uppermost mantle. The lithosphere is thin below mid-ocean ridges and thick below continents. Earth's tectonic plates are large pieces of lithosphere. These lithospheric plates fit together like the pieces of a giant jigsaw puzzle.

The layer of Earth below the lithosphere is called the asthenosphere (as THEN uh sfihr). This layer is so hot that it behaves like a **plastic** material. This enables Earth's plates to move because the hotter, plastic mantle material beneath them can flow. The interactions between lithosphere and asthenosphere help to explain plate tectonics.

Reading Check What are Earth's outermost layers called?

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

Plate Boundaries

Place two books side by side and imagine each book represents a tectonic plate. A plate boundary exists where the books meet. How many different ways can you move the books with respect to each other? You can pull the books apart, you can push the books together, and you can slide the books past one another. Earth's tectonic plates move in much the same way.

Divergent Plate Boundaries

Mid-ocean ridges are located along divergent plate boundaries. A **divergent plate boundary** *forms where two plates separate.* When the seafloor spreads at a mid-ocean ridge, lava erupts, cools, and forms new oceanic crust. Divergent plate boundaries can also exist in the middle of a continent. They pull continents apart and form rift valleys. The East African Rift is an example of a continental rift.

Transform Plate Boundaries

The famous San Andreas Fault in California is an example of a transform plate boundary. A **transform plate boundary** *forms where two plates slide past each other.* As they move past each other, the plates can get stuck and stop moving. Stress builds up where the plates are "stuck." Eventually, the stress is too great and the rocks break, suddenly moving apart. This results in a rapid release of energy as earthquakes.

Convergent Plate Boundaries

Convergent plate boundaries *form where two plates collide. The denser plate sinks below the more buoyant plate in a process called* **subduction.** The area where a denser plate descends into Earth along a convergent plate boundary is called a **subduction** zone.

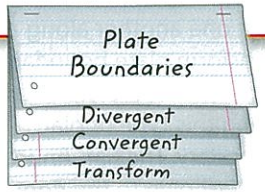
When an oceanic plate and a continental plate collide, the denser oceanic plate subducts under the edge of the continent. This creates a deep ocean trench. A line of volcanoes forms above the subducting plate on the edge of the continent. This process can also occur when two oceanic plates collide. The older and denser oceanic plate will subduct beneath the younger oceanic plate. This creates a deep ocean trench and a line of volcanoes called an island arc.

When two continental plates collide, neither plate is subducted, and mountains such as the Himalayas in southern Asia form from uplifted rock. **Table 1** on the next page summarizes the interactions of Earth's tectonic plates.

Key Concept Check What are the three types of plate boundaries?

FOLDABLES®

Make a layered book using two sheets of notebook paper. Use it to organize information about the different types of plate boundaries and the features that form there.



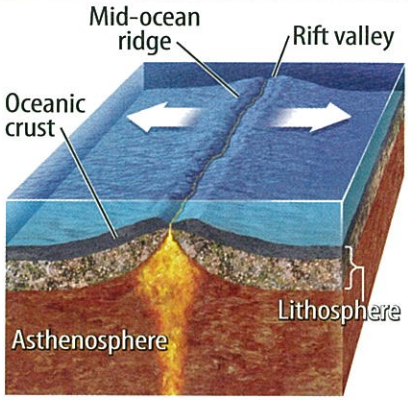
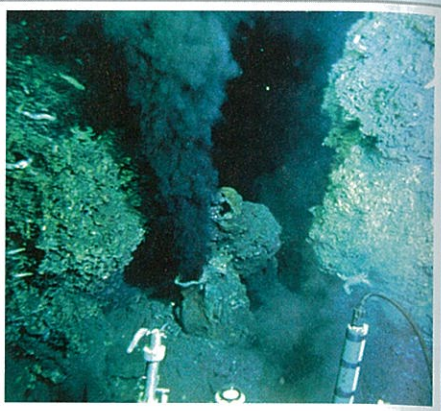
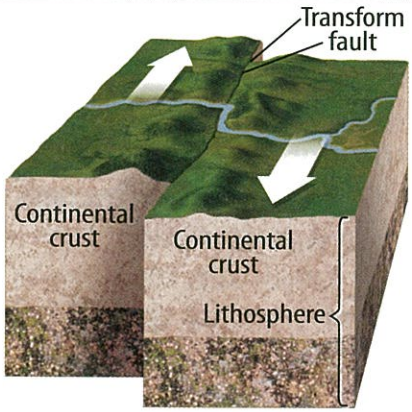
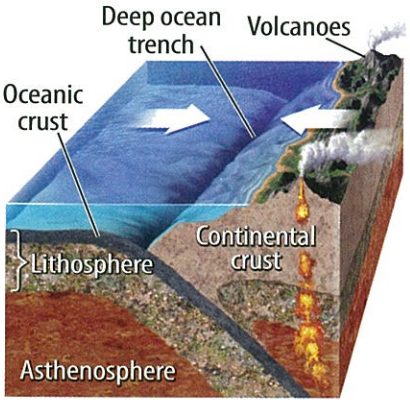
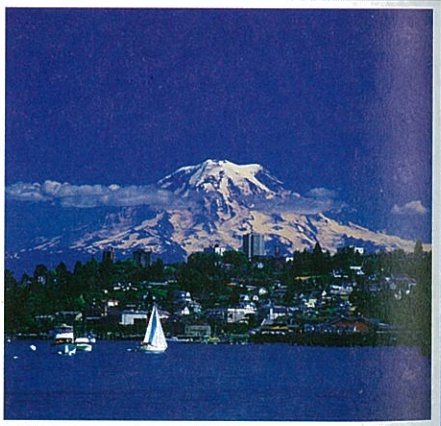
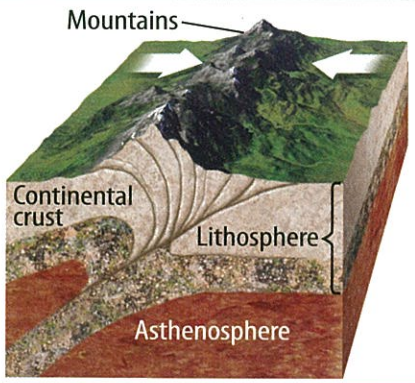
WORD ORIGIN

subduction
from Latin *subductus,* means "to lead under, removal"

Table 1 The direction of motion of Earth's plates creates a variety of features at the boundaries between the plates.

Concepts in Motion Animation

Table 1 Interactions of Earth's Tectonic Plates

Plate Boundary	Relative Motion	Example
Divergent plate boundary When two plates separate and create new oceanic crust, a divergent plate boundary forms. This process occurs where the seafloor spreads along a mid-ocean ridge, as shown to the right. This process can also occur in the middle of continents and is referred to as a continental rifting.		
Transform plate boundary Two plates slide horizontally past one another along a transform plate boundary. Earthquakes are common along this type of plate boundary. The San Andreas Fault, shown to the right, is part of the transform plate boundary that extends along the coast of California.		
Convergent plate boundary (ocean-to-continent) When an oceanic and a continental plate collide, they form a convergent plate boundary. The denser plate will subduct. A volcanic mountain, such as Mount Rainier in the Cascade Mountains, forms along the edge of the continent. This process can also occur where two oceanic plates collide, and the denser plate is subducted.		
Convergent plate boundary (continent-to-continent) Convergent plate boundaries can also occur where two continental plates collide. Because both plates are equally dense, neither plate will subduct. Both plates uplift and deform. This creates huge mountains like the Himalayas, shown to the right.		

Evidence for Plate Tectonics

When Wegener proposed the continental drift hypothesis, the technology used to measure how fast the continents move today wasn't yet available. Recall that continents move apart or come together at speeds of a few centimeters per year. This is about the length of a small paperclip.

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

The theory of plate tectonics also provides an explanation for why earthquakes and volcanoes occur in certain places. Because plates are rigid, tectonic activity occurs where plates meet. When plates separate, collide, or slide past each other along a plate boundary, stress builds. A rapid release of energy can result in earthquakes. Volcanoes form where plates separate along a mid-ocean ridge or a continental rift or collide along a subduction zone. Mountains can form where two continents collide. **Figure 12** illustrates the relationship between plate boundaries and the occurrence of earthquakes and volcanoes. Refer back to the lesson opener photo. Find these islands on the map. Are they located near a plate boundary?

Key Concept Check How are earthquakes and volcanoes related to the theory of plate tectonics?

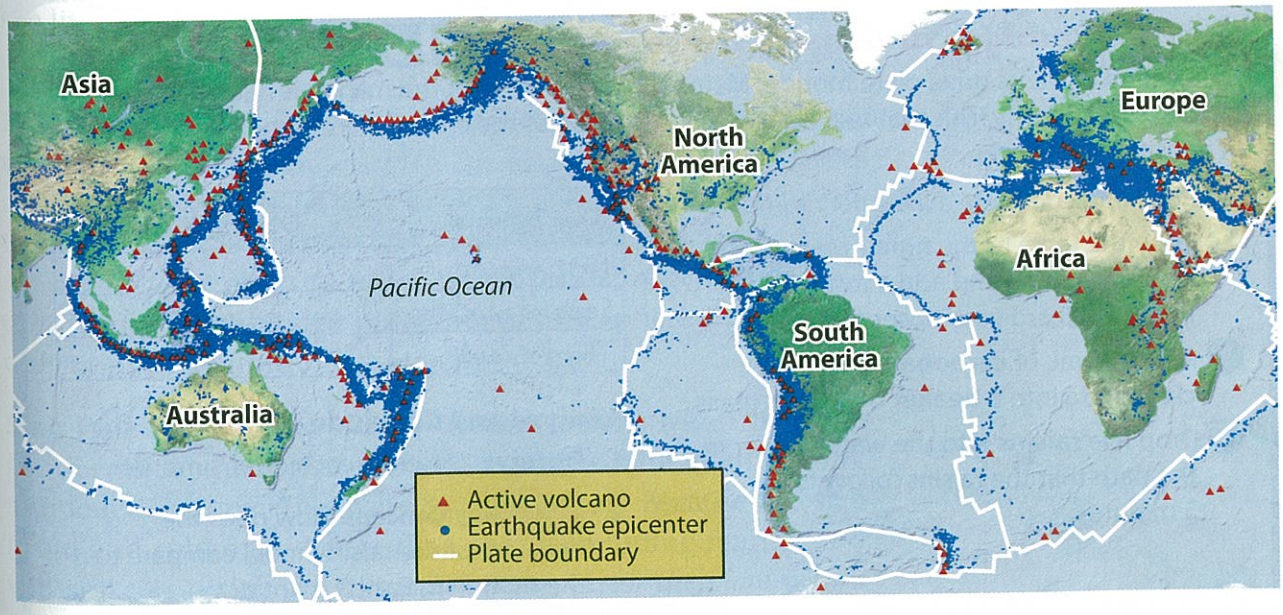


Figure 12 Notice that most earthquakes and volcanoes occur near plate boundaries.

Visual Check Do earthquakes and volcanoes occur anywhere away from plate boundaries?