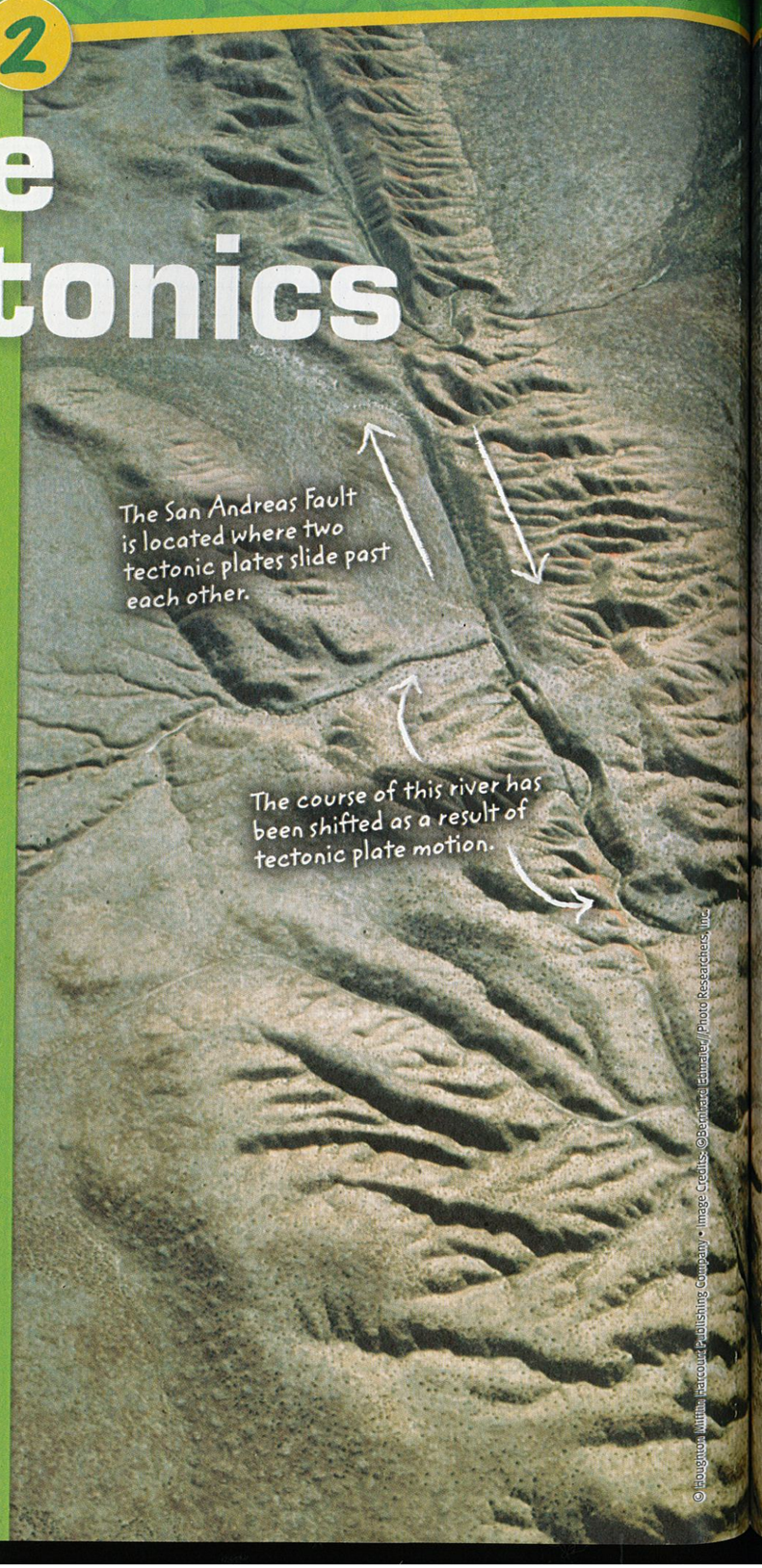
Lesson 2

Plate Tectonics

ESSENTIAL QUESTION

What is plate tectonics?

By the end of this lesson, you should be able to explain the theory of plate tectonics, to describe how tectonic plates move, and to identify geologic events that occur because of tectonic plate movement.



Lesson Labs

Quick Labs
- Tectonic Ice Cubes
- Mantle Convection
- Reconstructing Land Masses

Exploration Lab
- Seafloor Spreading

Engage Your Brain

1 Identify Check T or F to show whether you think each statement is true or false.

T	F	
☐	☐	Earth's surface is all one piece.
☐	☐	Scientists think the continents once formed a single landmass.
☐	☐	The sea floor is smooth and level.
☐	☐	All tectonic plates are the same.

2 Predict Imagine that ice cubes are floating in a large bowl of punch. If there are enough cubes, they will cover the surface of the punch and bump into one another. Parts of the cubes will be below the surface of the punch and will displace the punch. Will some cubes displace more punch than others? Explain your answer.

Active Reading

3 Apply Many scientific words, such as *divergent*, also have everyday meanings or are related to words with everyday meanings. Use context clues to write your own definition for each underlined word.

Example sentence
They argued about the issue because their opinions about it were <u>divergent</u>.

divergent:

Example sentence

The two rivers <u>converged</u> near the town.

convergent:

Vocabulary Terms

- **Pangaea**
- **sea-floor spreading**
- **plate tectonics**
- **tectonic plates**
- **convergent boundary**
- **divergent boundary**
- **transform boundary**
- **convection**

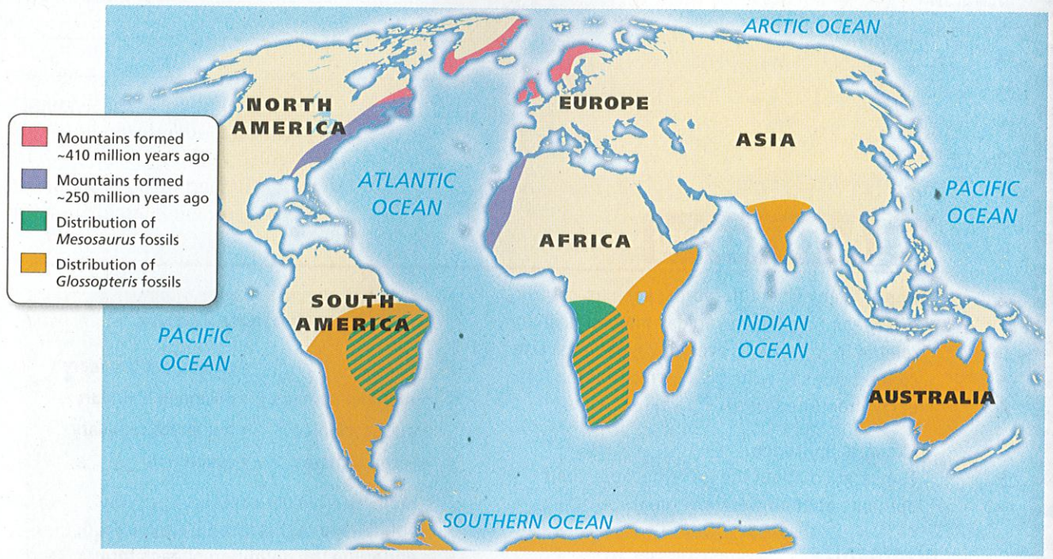
4 Identify This list contains key terms you'll learn in this lesson. As you read, underline the definition of each term.

Puzzling Evidence

What evidence suggests that continents move?

Have you ever looked at a map and noticed that the continents look like they could fit together like puzzle pieces? In the late 1800s, Alfred Wegener proposed his hypothesis of continental drift. He proposed that the continents once formed a single landmass, broke up, and drifted. This idea is supported by several lines of evidence. For example, fossils of the same species are found on continents on different sides of the Atlantic Ocean. These species could not have crossed the ocean. The hypothesis is also supported by the locations of mountain ranges and rock formations and by evidence of the same ancient climatic conditions on several continents.

Geologic evidence supports the hypothesis of continental drift.



Visualize It! **5 Summarize** Using the map and its key, complete the table to describe evidence that indicates each continent pair was once joined.

	Fossil evidence	Mountain evidence
South America and Africa		
North America and Europe		

What is Pangaea?

Active Reading **6 Identify** As you read, underline the description of how North America formed from Pangaea.

Using evidence from many scientific fields, scientists can construct a picture of continental change throughout time. Scientists think that about 245 million years ago, the continents were joined in a single large landmass they call **Pangaea** (pan•JEE•uh). As the continents collided to form Pangaea, mountains formed. A single, large ocean called Panthalassa surrounded Pangaea.

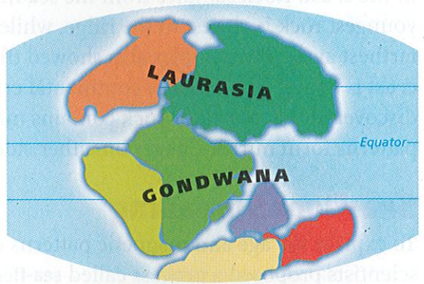
About 200 million years ago, a large rift formed and Pangaea began to break into two continents—*Laurasia* and *Gondwana*. Then, Laurasia began to drift northward and rotate slowly, and a new rift formed. This rift separated Laurasia into the continents of North America and Eurasia. The rift eventually formed the North Atlantic Ocean. At the same time, Gondwana also broke into two continents. One continent contained land that is now the continents of South America and Africa. The other continent contained land that is now Antarctica, Australia, and India.

About 150 million years ago, a rift between Africa and South America opened to form the South Atlantic Ocean. India, Australia, and Antarctica also began to separate from each other. As India broke away from Australia and Antarctica, it started moving northward, toward Eurasia.

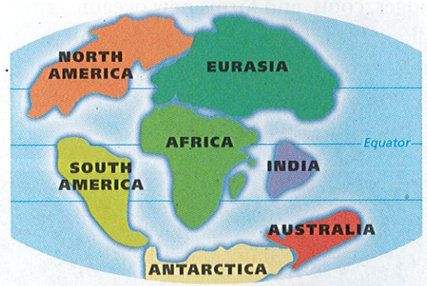
As India and the other continents moved into their present positions, new oceans formed while others disappeared. In some cases, continents collided with other continents. About 50 million years ago, India collided with Eurasia, and the Himalaya Mountains began to form. Mountain ranges form as a result of these collisions, because a collision welds new crust onto the continents and uplifts some of the land.

The Breakup of Pangaea

245 million years ago



200 million years ago



65 million years ago

3 million years ago

What discoveries support the idea of continental drift?

Wegener's ideas of continental drift were pushed aside for many years because scientists could not determine how continents moved. Then, in the mid-1900s, scientists began mapping the sea floor. They expected the floor to be smooth and level. Instead, they found huge under-water mountain ranges called *mid-ocean ridges.* The discovery of mid-ocean ridges eventually led to the theory of plate tectonics, which built on some of Wegener's ideas.

7 Summarize Why would many scientists not accept the hypothesis of continental drift?

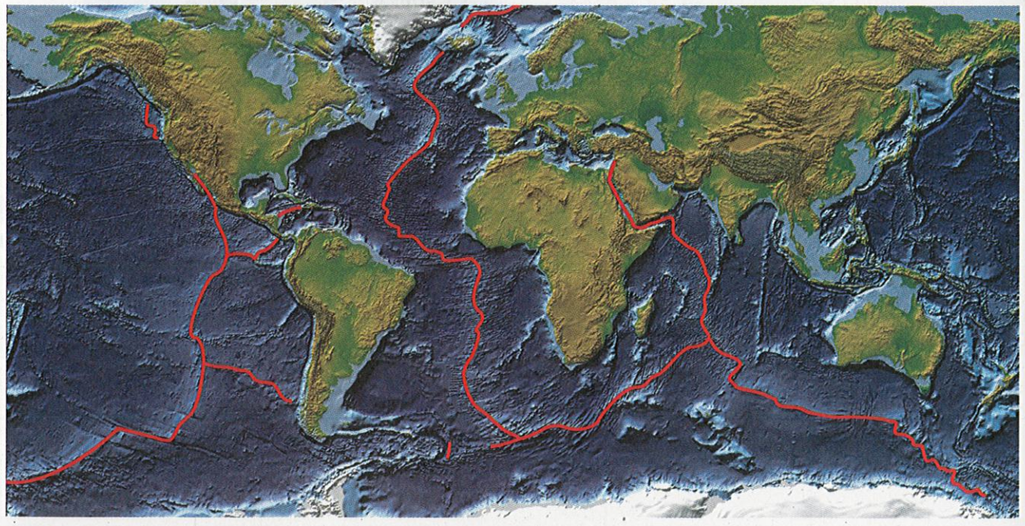
Age and Magnetic Properties of the Sea Floor

Scientists learned that the mid-ocean ridges form along cracks in the crust. Rock samples from the sea floor revealed that the youngest rock is closest to the ridge, while the oldest rock is farthest away. The samples also showed that even the oldest ocean crust is young compared to continental crust. Scientists also discovered that sea-floor rock contains magnetic patterns. These patterns form mirror images on either side of a mid-ocean ridge.

Sea-Floor Spreading

To explain the age and magnetic patterns of sea-floor rocks, scientists proposed a process called **sea-floor spreading**. In this process, molten rock from inside Earth rises through the cracks in the ridges, cools, and forms new oceanic crust. The old crust breaks along the mid-point of the ridge and the two pieces of crust move away in opposite directions from each other. In this way, the sea floor slowly spreads apart. As the sea floor moves, so do the continents on the same piece of crust.

This map shows where mid-ocean ridges are located.



Ocean Trenches

If the sea floor has been spreading for millions of years, why is Earth not getting larger? Scientists discovered the answer when they found huge trenches, like deep canyons, in the sea floor. At these sites, dense oceanic crust is sinking into the asthenosphere as shown in the diagram below. Older crust is being destroyed at the same rate new crust is forming. Thus, Earth remains the same size.

With this new information about the sea floor, sea-floor spreading, and ocean trenches, scientists could begin to understand how continents were able to move.

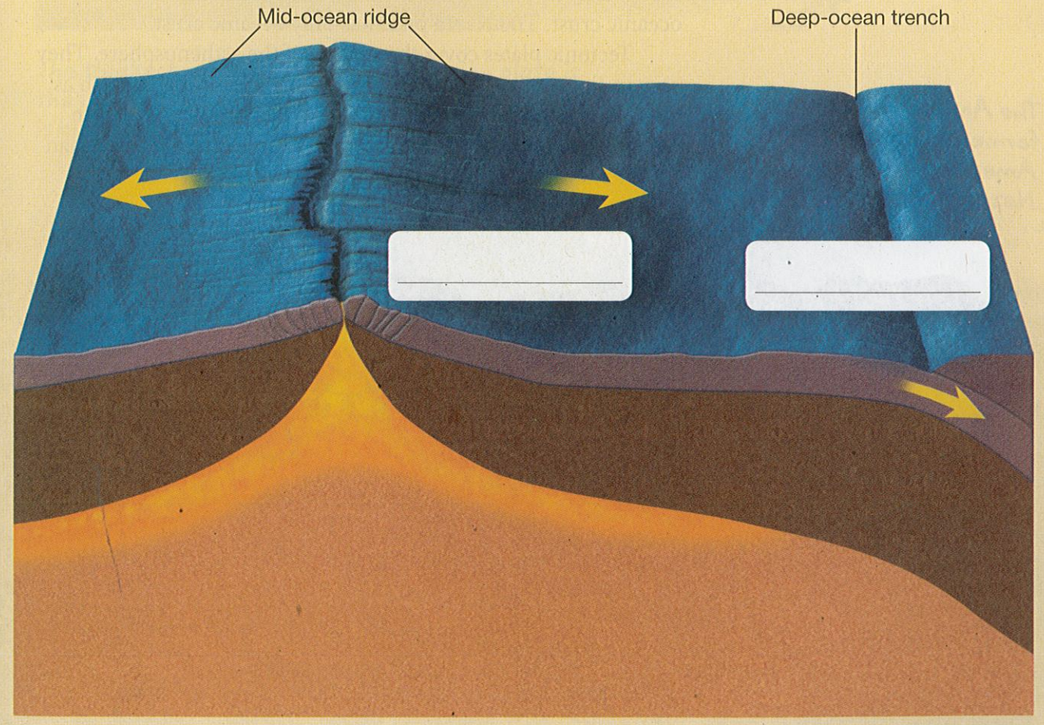
Active Reading

8 Identify Why is Earth not getting larger if the sea floor is spreading?

Visualize It!

9 Provide Label the youngest rock and the oldest rock on this diagram of sea-floor spreading.

Sea-floor spreading takes place at mid-ocean ridges.



A Giant Jigsaw

What is the theory of plate tectonics?

Think Outside the Book

10 Apply Imagine that the theory of plate tectonics has just been proposed. Design a magazine ad for the theory.

As scientists' understanding of continental drift, mid-ocean ridges, and sea-floor spreading grew, scientists formed a theory to explain these processes and features. **Plate tectonics** describes large-scale movements of Earth's lithosphere, which is made up of the crust and the rigid, upper part of the mantle. Plate tectonics explains how and why features in Earth's crust form and continents move.

What is a tectonic plate?

Active Reading

11 Identify As you read, underline the definition of *tectonic plates*.

The lithosphere is divided into pieces called **tectonic plates.** These plates move around on top of the asthenosphere. The plates are moving in different directions and at different speeds. Each tectonic plate fits together with the plates that surround it. The continents are located on tectonic plates and move around with them. The major tectonic plates include the Pacific, North American, Nazca, South American, African, Australian, Eurasian, Indian, and Antarctic plates. Not all tectonic plates are the same. The South American plate has an entire continent on it and has oceanic crust. The Nazca plate has only oceanic crust.

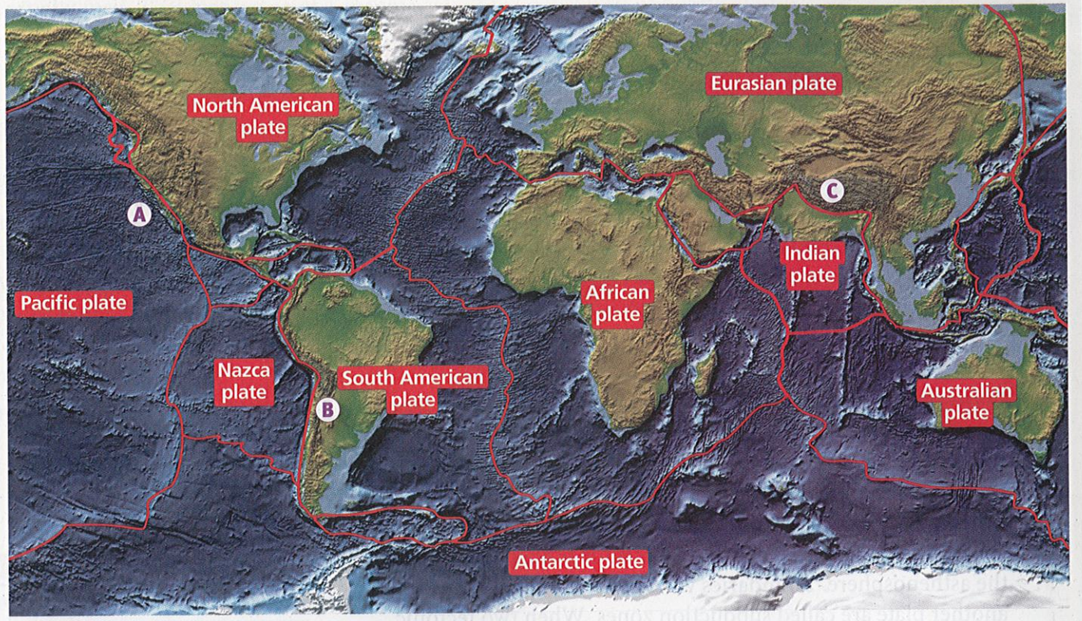
Tectonic plates cover the surface of the asthenosphere. They vary in size, shape, and thickness. Thick tectonic plates, such as those with continents, displace more asthenosphere than thin oceanic plates do. But, oceanic plates are much more dense than continental plates are.

The Andes Mountains formed where the South American plate and Nazca plate meet.

Visualize It!

12 Locate Which letter marks where the Andes Mountains are located on the map of tectonic plates, A, B, or C? _____

The tectonic plates fit together like the pieces of a jigsaw puzzle.



The thickest part of the South American plate is the continental crust. The thinnest part of this plate is in the Atlantic Ocean.