Section 5

The Theory of Plate Tectonics

Key Terms
- plate
- plate tectonics
- fault
- spreading boundary
- rift valley
- colliding boundary
- sliding boundary

5.1.c. Students know lithospheric plates the size of continents and oceans move at rates of centimeters per year in response to movements in the mantle.

What is the theory of plate tectonics?

What are the three types of plate boundaries?

How Well Do the Continents Fit Together?

1. Using a world map in an atlas, trace the shapes of the continents North America, South America, Africa, and Europe.
2. Carefully cut apart the landmasses.
3. Piece together these landmasses as they may have looked before Pangaea split apart, creating the Atlantic Ocean.
4. Attach your partial reconstruction of Pangaea to a piece of paper.
5. Obtain a map that shows the continental shelf. The continental shelf is the apron of continental crust that extends under water around the edges of the continents. Trace around the shelves of the same continents used in Step 1.
6. Repeat steps 2 through 4 to compare the fit of the continents with and without their continental shelves.

Think It Over
Drawing Conclusions Do your observations support the idea that the continents were once joined together? When did they fit together better: when you cut them out along their coastlines or along their continental shelves? Explain.

Have you ever dropped a hard-boiled egg? If so, the eggshell probably cracked in many places. Earth’s lithosphere, its solid outer shell, is not one unbroken layer. It is more like that cracked eggshell. It’s broken into jagged pieces.

There are cracks in the continents similar to those on the ocean floor. In the 1960s, scientists proposed that these cracks break the lithosphere into separate sections called plates. The plates fit together along cracks in the lithosphere. As shown in Figure 20, the plates carry the continents or parts of the ocean floor, or both. One scientist combined what geologists knew about sea-floor spreading, Earth’s plates, and continental drift into a single theory. Recall that a scientific theory is a well-tested concept that explains a wide range of observations.
How Plates Move

The theory of plate tectonics (tek TAHN ikst) states that pieces of Earth’s lithosphere are in slow, constant motion, driven by convection currents in the mantle. The theory of plate tectonics explains the formation, movement, and subduction of Earth’s plates.

What force is great enough to move Earth’s heavy plates? Geologists think that movement of convection currents in the mantle is the major cause of plate motion. Mantle motion is transferred to the lithosphere at its boundary with the asthenosphere. The plates are carried along in much the same way that ice floats on slow-moving water. During subduction, gravity pulls one edge of a plate down into the mantle. The rest of the plate also moves. This slow movement is similar to what happens in a pot of soup when gravity causes the cooler, denser soup near the surface to sink.

As the plates move, they change Earth’s surface. These changes include earthquakes, volcanoes, mountain ranges, and deep-ocean trenches.

**FIGURE 20**
Plate boundaries divide the lithosphere into large plates. **Interpreting Maps** Which plates include both continents and ocean floor?
Plate Boundaries

The edges of Earth’s plates meet at plate boundaries. Plate boundaries extend deep into the lithosphere. Faults form along these boundaries. Faults are breaks in Earth’s crust where rocks have slipped past each other. There are three kinds of plate boundaries: spreading boundaries, colliding boundaries, and sliding boundaries. A different type of plate movement occurs along each type of boundary.

Scientists have used instruments on satellites to measure plate motion. The plates move about 1 to 24 centimeters per year in response to movements in the mantle. The North American and Eurasian plates are moving apart at a rate of 2.5 centimeters per year. That’s about as fast as your fingernails grow. But these plates have been moving for millions of years.

Spreading Boundaries The place where two plates move apart is called a spreading boundary. Most spreading boundaries occur along the mid-ocean ridges where sea-floor spreading occurs. Spreading boundaries are also called divergent boundaries.

Spreading boundaries also occur on land. When a spreading boundary develops on land, two of Earth’s plates slide apart. A deep valley called a rift valley forms along the spreading boundary. For example, the Great Rift Valley in East Africa marks a deep crack in the African continent.

**FIGURE 21 Plate Tectonics**

Plate movements have built many of the features of Earth’s land surfaces and ocean floors. **Predicting** What will eventually happen if a rift valley continues to pull apart?
Colliding Boundaries The place where two plates come together, or collide, is called a **colliding boundary**. Another term for colliding boundary is convergent boundary. When two plates collide, the density of the plates determines which one comes out on top. There are three types of collision between plates.

In the first type of collision, two plates made up of oceanic crust meet at a trench. The plate that is more dense sinks under the other plate. The reason for this is that oceanic crust becomes cooler and denser during sea-floor spreading.

In the second type of collision, an oceanic plate collides with a continental plate. Subduction occurs as the denser oceanic plate sinks beneath the less dense continental plate.

In the third type of collision, two plates carrying continental crust collide, but subduction does not take place. Neither piece of crust is dense enough to sink very far into the mantle. Instead, the collision squeezes the crust into mighty mountain ranges.

**Sliding Boundaries** A **sliding boundary** is a place where two plates slide past each other, moving in opposite directions. Along sliding boundaries, crust is neither created nor destroyed. Sliding boundaries can also be called transform boundaries.

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**Math Skills**

**Calculating a Rate**

To calculate the rate of plate motion, divide the distance the plate moves by the time it takes to move that distance.

\[
\text{Rate} = \frac{\text{Distance}}{\text{Time}}
\]

For example, a plate takes 2 million years to move 156 km. Calculate its rate of motion.

\[
\frac{156 \text{ km}}{2,000,000 \text{ years}} = 7.8 \text{ cm per year}
\]

**Practice Problem** The Pacific plate is sliding past the North American plate. It has taken 10 million years for the plate to move 600 km. What is the Pacific plate’s rate of motion?

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What features form where two continental plates come together?

**Spreading Boundary** A rift valley forms when two pieces of continental crust pull apart.

**Sliding Boundary** Two plates slide past each other.

**Colliding Boundary** Two continental plates collide, forming a mountain range.
Plate Motions Over Time  The movement of Earth's plates has greatly changed Earth's surface. Geologists have evidence that, before Pangaea existed, other supercontinents formed and split apart over billions of years. Pangaea itself formed when Earth's landmasses drifted together about 260 million years ago. Then, about 225 million years ago, Pangaea began to break apart. Figure 22 shows how major landmasses have moved since the breakup of Pangaea.

**Figure 22**
Continental Drift
Geologists have used computer modeling to trace the movements of the continents since the breakup of Pangaea. **Posing Questions** What questions would you need to answer in order to predict where the continents will be in 50 million years?

Vocabulary Skill  Use Greek Word Origins This chapter is about the theory of plate tectonics. Use what you know about the Greek word origin of *tectonics* to explain the meaning of *plate tectonics*.

Reviewing Key Concepts
1. **a. Defining**  What are plates?
   b. **Summarizing**  What is the theory of plate tectonics?
   c. **Relating Cause and Effect**  What do scientists think causes the movement of Earth's plates?
2. **a. Listing**  What are the three types of plate boundaries?
   b. **Describing**  Describe the type of movement that occurs at each type of plate boundary.
   c. **Predicting**  What is likely to occur at a plate boundary where oceanic crust collides with continental crust?

3. **Calculating a Rate**  There are two islands on opposite sides of a mid-ocean ridge in the Atlantic Ocean. During the last 8 million years, the distance between the islands has increased by 200 kilometers. Calculate the rate at which the two plates are moving apart.