SECTION 2

Earth's Changing Continents

Key Concept Movements of Earth's tectonic plates have affected climate, geographic connections, and the distribution of organisms.

What You Will Learn

- Earth's continents have moved around Earth's surface throughout Earth's history and have only recently arrived at their current locations.
- Rocks and fossils provide evidence of continental drift. They also provide evidence of the changes in life and climate that have occurred during Earth's history.

Why It Matters

Understanding the history of climate change and life on Earth will help you better understand today's Earth.

Vocabulary

- plate tectonics
- continental drift

READING STRATEGY

Graphic Organizer In your **Science Journal,** make a Spider Map that organizes the types and details of plate boundaries.

The surface of Earth on which we live is constantly moving. Sometimes, we feel this movement as earthquakes. But did you know that Earth's surface has changed so much during Earth's long history that the continents have changed locations?

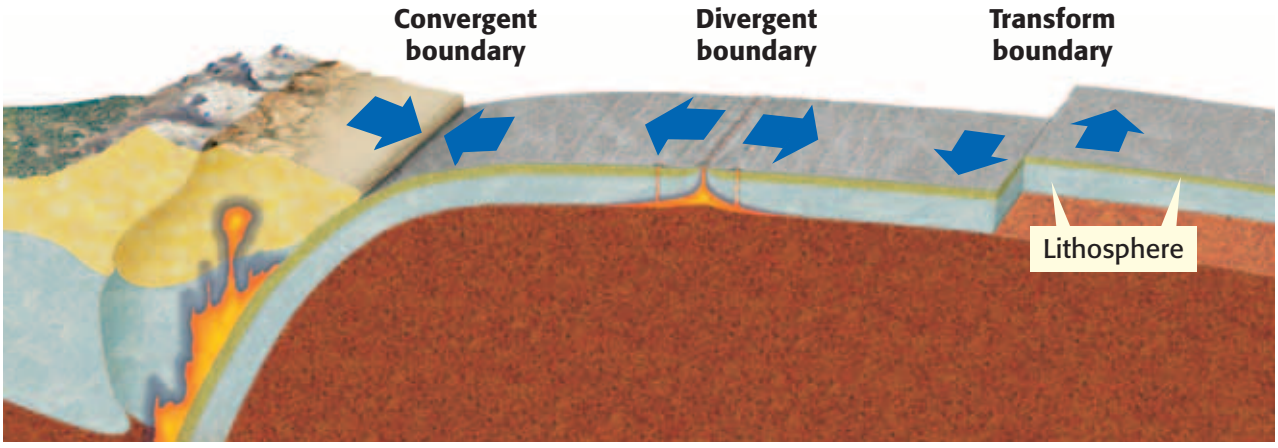
Plate Tectonics

The thin, cool "skin" of Earth is called the *lithosphere*. This layer is broken into several smaller blocks called *tectonic plates*. These plates rest on a thick layer of solid rock called the *mantle*. Earth's mantle is solid, but it moves very slowly. As the mantle moves, it drags on the bottom of the cold tectonic plates lying on top of it. As a result, the tectonic plates move. Earth's surface currently has about 12 large plates and many small ones. Some of the large plates are labeled in **Figure 1.** Most plates move as fast as your fingernails grow—between 2 cm and 5 cm per year. Over geologic time scales, this movement can cause large cumulative effects—plate movements may total thousands of miles. The theory that explains how Earth's tectonic plates move and change shape is called **plate tectonics.**

Standards Check **What is plate tectonics?** 7.4.a, 7.4.f

Figure 1 **Earth's Tectonic Plates**

Figure 2 Tectonic Plate Boundaries



Where Tectonic Plates Meet

Tectonic plates may contain oceanic lithosphere, continental lithosphere, or both types of lithosphere. As tectonic plates move, they collide, separate, and grind past each other. Places where two or more tectonic plates meet are called *plate boundaries*. There are three main types of plate boundaries. The type of plate boundary that forms is a result of how the plates move relative to each other.

Convergent Boundaries

Plates move toward each other at a *convergent boundary*, as shown in **Figure 2.** If both plate edges are continental lithosphere, the rocks are forced together until they crumple to make great mountain belts. But if one plate is thin, dense oceanic lithosphere, it may sink downward into the mantle. As the plate sinks, surrounding rock may melt. Some of this molten rock rises to the surface and makes a line of volcanoes.

Divergent Boundaries

Plates move apart at a *divergent boundary*, as shown in **Figure 2.** This process forms a rift—a giant crack in the lithosphere. Volcanic eruptions fill the crack with lava that cools to form new oceanic lithosphere. If a rift tears apart a continent and then widens for millions of years, a new sea forms. The sea may gradually grow into a new ocean.

Transform Boundaries

Two plates slide horizontally past each other along a *transform boundary*, as shown in **Figure 2.** The movement of the plates can cause earthquakes in the area of a transform boundary. One of the world's most well known transform boundaries is the San Andreas fault, which cuts right across California.

plate tectonics (PLAYT tek TAHN iks) the theory that explains how large pieces of Earth's outermost layer, called *tectonic plates,* move and change shape

7.4.a Students know Earth processes today are similar to those that occurred in the past and slow geologic processes have large cumulative effects over long periods of time.
7.4.e Students know fossils provide evidence of how life and environmental conditions have changed.
7.4.f Students know how movements of Earth's continental and oceanic plates through time, with associated changes in climate and geographic connections, have affected the past and present distribution of organisms.

Continental Drift

As the tectonic plates move, they carry the continents along as passengers. **Continental drift** is the term that is used to describe how continents have moved around Earth's surface throughout Earth's history. As a continent moves across Earth's surface, it carries rocks and fossils with it. Sometimes, the rocks and fossils provide evidence of how the continent has moved.

Geologic Evidence of Continental Drift

Rocks in India show scratches and scars that formed when glaciers ground over their surfaces. So, at one time, India must have been covered by ice. Such a thick layer of ice could not form at sea level in the tropical zone where India is today. Southern Africa and Brazil also have ice-scratched rocks of the same age. This evidence suggests that at one time, the rocks were joined and were located in a colder climate. Scientists now know that India, South America, and Africa were part of a single landmass that was located near the South Pole about 280 million years ago.

MATH PRACTICE

Tectonic Motion

Tectonic plates move slowly but may be in motion for millions of years. If a plate moves 4 cm per year, how many kilometers would it move in 1 million years? Record your work in your **Science Journal.**

continental drift (KAHN tuh NENT'l DRIFT) the hypothesis that a single large landmass broke up into smaller landmasses to form the continents, which then drifted to their present locations; the movement of continents

Fossil Evidence of Continental Drift

A fossil of a little reptile called *Mesosaurus* is shown in **Figure 3.** Mesosaurs ate fishes in rivers and lakes about 270 million years ago. Today, *Mesosaurus* fossils are found in South America and southwestern Africa. These areas are separated by 3,000 miles of ocean. Mesosaurs could not have swum across this ocean. And there is no evidence of land bridges between these continents. Thus, mesosaurs must have lived at a time when the two continents were joined. This fossil evidence supports continental drift.

Figure 3 *Fossils of* Mesosaurus*, such as the one shown on the left, were found in both South America and southwestern Africa.*

History of Continental Drift

By putting together all of the evidence, scientists can draw maps that show how Earth's geography has changed over time. For example, all of Earth's continents made up a supercontinent called *Pangaea* (pan JEE uh) about 245 million years ago. At the same time, Earth also had a single superocean. Pangaea split into several new plates beginning about 200 million years ago. As the plates drifted apart, those new continents separated, and new oceans formed between them. The breakup of Pangaea is shown in **Figure 4.**

These huge changes moved rocks and fossils all over Earth. The rocks and fossils give scientists evidence of the plate movements. In addition, plate movements changed Earth's climate and affected *evolution*, or how populations of species have changed over time.

Changes in Climate

As continents moved, they changed the way land and sea were placed on Earth's surface. If continents moved toward the equator, they received more energy from the sun and developed warmer climates. Continental drift caused ocean currents and winds to flow differently. These changes affected heat flow. As a result, temperature and precipitation patterns around the planet changed.

For example, Antarctica was not frozen 40 million years ago. But as the other continents moved, Antarctica was left surrounded by the cold water near the South Pole. As cold water currents moved around Antarctica, the polar icecap formed. Antarctica slowly became the icy land we see today.

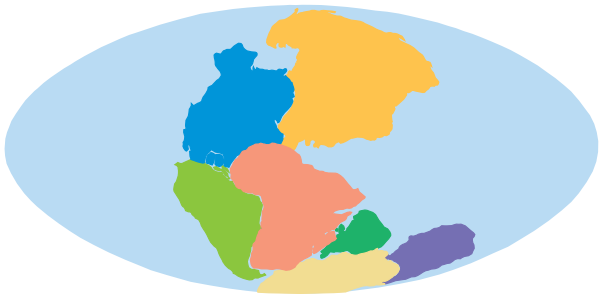
Changes in Life

When Pangaea split apart, the organisms living on each continent were separated. As their environments changed, the organisms that lived in those environments also changed. And as new oceans formed, changes also occurred in sea life. This explains why different organisms live on different continents. It also explains why fossils of the same organisms are found on different continents.

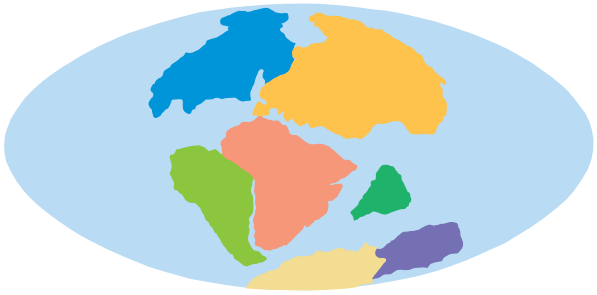
Standards Check **How have tectonic plate motions affected the distribution of organisms?** 7.4.f

Figure 4 The Breakup of Pangaea

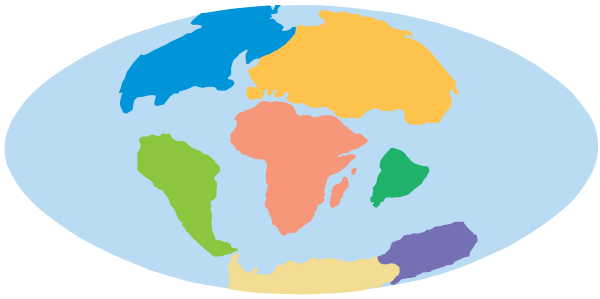
About 245 million years ago The continents were one giant landmass called Pangaea.



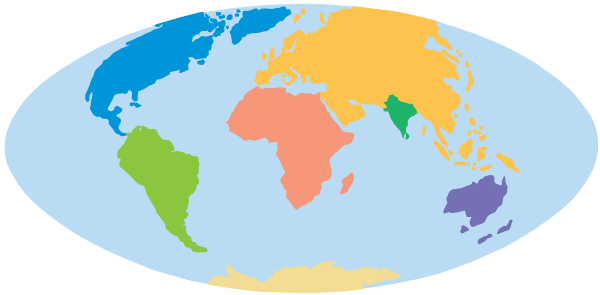
About 135 million years ago As Pangaea broke apart, the North Atlantic and Indian Oceans began to form.



About 65 million years ago The continents continued to drift apart toward their modern locations.



Today The continents continue to move at a rate of about 2 cm to 5 cm per year.



Case Study: The Panama Land Bridge

North and South America drifted close together about 3 million years ago. At that time, a narrow strip of land joined North and South America for the first time, as shown in **Figure 5.** This strip of land was called the Panama Land Bridge.

Changes in Life

Animals could now walk across the Panama Land Bridge. As they migrated, they competed with one another. Many animals became extinct, but successful ones flourished. Opossums and armadillos invaded North America, whereas camels and cats invaded South America. At the same time, creatures in the sea were separated by the new land bridge. Some populations of clams, corals, whales, and sea urchins evolved into separate species on the Pacific and Caribbean coasts of Panama.

Standards Check **How did the formation of the Panama Land Bridge affect the distribution of organisms in the Americas? 7.4.f**

Changes in Climate

The land bridge forced warm, tropical water that had once flowed between the continents to flow around the Gulf of Mexico and north past Florida. The new flow of water formed the Gulf Stream—a strong ocean current. The Gulf Stream changed the climate of western Europe by transporting warm water across the Atlantic Ocean. This water heats the air and makes climates milder.

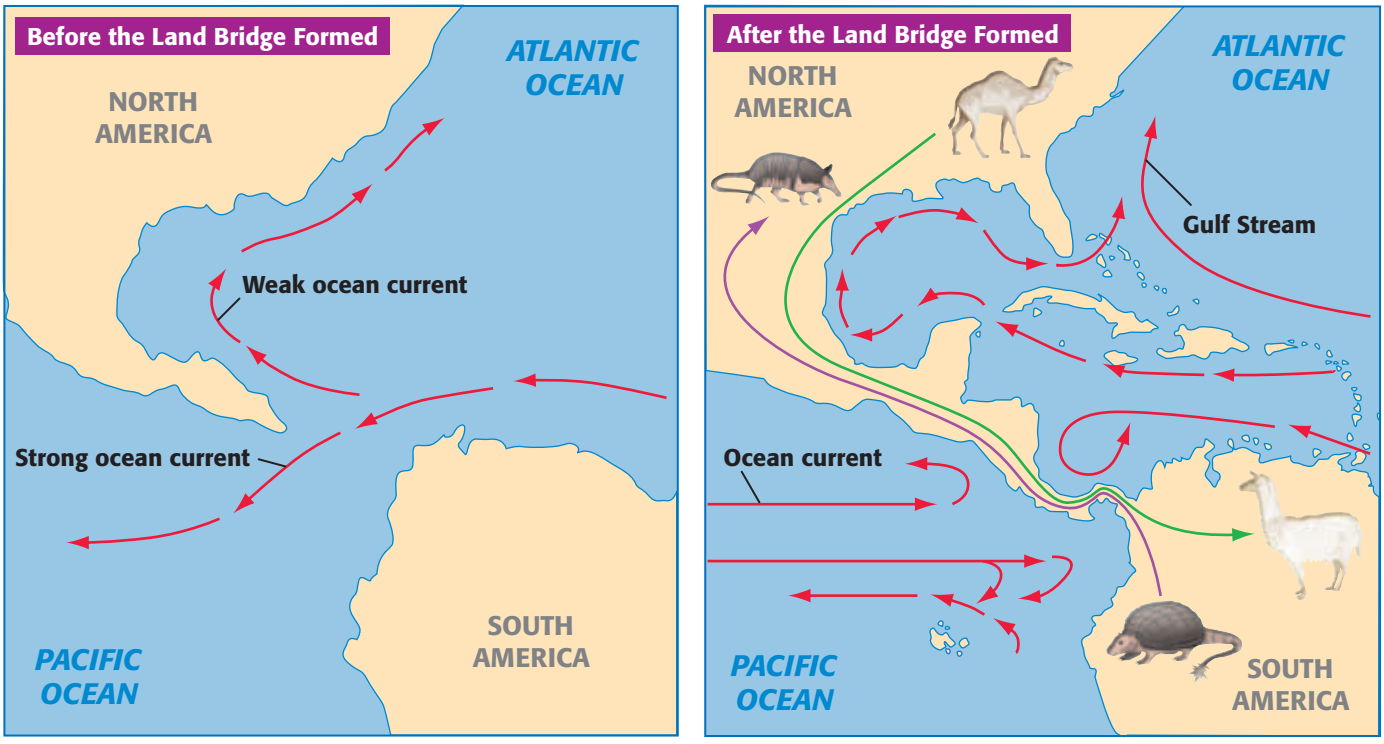


Figure 5 *After North and South America were joined by the Panama Land Bridge, animals migrated across the bridge and ocean currents changed dramatically.*