More than 100 years ago, geologist Alfred Wegener made an interesting connection. Wegener realized that the coastlines of America and Africa fit together like a jigsaw puzzle. Also, similar fossils are found on both continents. He proposed that the continents had once been joined. They had later drifted apart. He did not know how this continental drift happened. New technology was required to discover the underwater ridges and trenches that make continental drift possible.

Most scientific discoveries combine observation and inspiration. In the 1950s, Marie Tharp and Bruce Heezen led a team of geologists. They made the first scientific map of the ocean floor. They sailed around the ocean. They made many measurements of water depths. They found a vast mountain range running along the middle of the Atlantic Ocean. They named it the Mid-Atlantic Ridge. At first they thought that this ridge was unique to the Atlantic Ocean. Later they found that ridges are in most oceans. These scientists discovered that mid-ocean ridges existed. They still did not know how they formed.

Later studies by other scientists provided clues to how mid-ocean ridges form. Geologists measured the magnetic properties of the ocean floor near the ridges. They found a pattern of “stripes.” Rocks record the magnetic orientation of Earth at the time they are formed. Earth’s magnetic field flips orientation every few million years. Therefore, the stripes alternate. Importantly, the stripes are the same on both sides of the ridge. This suggests that rock moves away from the ridge in both directions. Geologists found the age of rocks at different distances from the ridge. Their data showed that younger rock is closer to the ridge. Older rocks are found farther from the ridge. The last piece of evidence is from pictures of ridges. The ridges show lava flows like those seen on volcanoes on land. These observations led scientists to propose that seafloor spreading is part of continental drift. This is also known as plate tectonics. The theory of plate tectonics explains how Earth looked in the distant past. It explains many modern features. Plate tectonics allows us to predict how Earth might look in the distant future.

We now know that the seafloor itself moves. It carries the continents with it. The entire crust of Earth is divided into about 15 plates. These plates move on top of a semisolid mantle. The movements are powered by convection currents. New crust forms at the mid-
ocean ridges. It moves away from the ridges in both directions. The plates are moving away from each other. Therefore, these areas are called divergent plate boundaries. Between 2 cm and 20 cm of new crust are formed at each mid-ocean ridge. A fissure in Earth’s crust allows magma to erupt; it then cools into new crust. Eruptions and small earthquakes are common along the 65,000 km of mid-ocean ridges encircling Earth. The formation of new crust increases the distance between continents. It makes some oceans bigger.

5 New crust is being added continually at mid-ocean ridges. Doesn’t that mean that Earth is always getting bigger? If addition of new crust were the only process at work, the answer would be yes. Some scientists do think Earth is actually getting bigger. However, most scientists think Earth stays pretty much the same size. To keep Earth at the same size, crust must be destroyed at about the same rate as it is created. In fact, old crust is destroyed at convergent boundaries. Old crust goes back into the mantle through the process of subduction. How does this work? Continents are carried along the moving plates. Some plates collide and break apart. These movements cause earthquakes and volcanic activity.

6 Here is where ocean trenches become important. Ocean trenches are also called submarine valleys. They are the deepest parts of the ocean. Scientists must use special submarines to explore the trenches. The water pressure is very high at these extreme depths. The pressure can be equal to a car sitting on top of one square centimeter. The Marianas Trench in the western Pacific Ocean reaches depths up to 11 km. Mount Everest is the tallest mountain on Earth. Mount Everest could fit into the trench with 2 km to spare! These trenches form where two tectonic plates come together. This is usually a continental plate and an oceanic plate. The oceanic plate is denser. It gets pushed under the continental plate. The oceanic plate goes back into the mantle and melts. This process often creates earthquakes or hot spots that cause volcanoes. A perfect example of this is an area known as the Pacific Ring of Fire. This large area forms a horseshoe shape around the Pacific Ocean. It runs along the eastern coasts of Indonesia and Japan, north to Russia. Then it extends to the west coast of North America, all the way to South America. It has the largest number of active volcanoes and destructive earthquakes on the planet. Most of this activity is due to subduction of the seafloor under tectonic plates at the continents’ edges.

7 The basics of the theory have been worked out over the last century. Research is still discovering new aspects. Two large earthquakes were recorded in the Indian Ocean in 2012. These earthquakes suggest that the Australian and Indian plates are separating. The actual separation will probably take several million years. Large earthquakes, however, might become more common. Geologists have studied earthquake waves passing through the crust near the California coast. Data show that a chunk of an ocean plate is still stuck to the bottom of the continental plate. Subduction may therefore not always be smooth. Research also shows that Earth may not be the only planet with plate tectonics. A large canyon system on Mars seems to have fault lines. Fault lines often mark plate boundaries. Several long lines of volcanoes suggest that a tectonic plate moved slowly over a hot spot.
1. Which of the following pieces of evidence does not explain how mid-ocean ridges are formed?

A. The rocks closer to the ridge are younger than those farther away.
B. Mid-ocean ridges are found on the bottom of most oceans.
C. The magnetic orientation of rocks is symmetrical on either side of mid-ocean ridges.
D. Pictures of ridges show evidence of lava flows.

2. Which of the following correctly defines a divergent boundary?

A. A small part of Earth’s mantle
B. A location of high volcanic activity
C. A location where tectonic plates move apart
D. A section of crust that moves as a unit
3. Which of the following is LEAST NECESSARY for plate tectonics?

A. A solid core inside the planet.
B. A semisolid mantle.
C. Convection currents in the mantle.
D. A crust divided into plates.

4. Which of the following statements regarding a convergent plate boundary between continental crust and oceanic crust is not true?

A. Earthquakes are common at the boundary.
B. Mountains are formed.
C. Hot spots that may create volcanoes are formed.
D. Oceanic crust changes into continents.
5  Subduction of ocean crust happens—
   A  at a mid-oceanic ridge.
   B  far from tectonic plate boundaries.
   C  inside volcanoes of the Ring of Fire.
   D  in deep ocean trenches.

6  What evidence suggests that the Australian and Indian plates are separating?
   A  The formation of a new oceanic ridge
   B  Recent large magnitude earthquakes
   C  The way earthquake waves travel through the area
   D  The presence of a string of volcanoes