Long before satellites and airplanes captured a view of our planet's surface, explorers were our only set of eyes. Through their travels they gave mapmakers information about oceans, new continents, and their coastlines. This is how our first reliable maps of Earth were made. Early explorers also noticed how the continental shorelines on both sides of the Atlantic Ocean appeared as if they fit together. They looked as if they were broken apart from a continental jigsaw puzzle. If you were to look at a world map, you may have noticed that the western coast of Africa appears to fit perfectly with the eastern coast of South America. Alfred Wegener also noticed this feature about our coastlines.

Wegener was a German scientist who proposed the continental drift hypothesis in 1912. His hypothesis stated that our continents were once part of a single supercontinent. Wegener also stated that this supercontinent started breaking into smaller continents over 250 million years ago during the Mesozoic Era. It took millions of years for our continents to drift to their present locations. Wegener also accounted for their formation of mountain ranges. He suggested that as the continents moved, crust became crumpled in some areas. These areas became mountain ranges, like the Andes in South America.

Wegener's continental drift hypothesis was cutting edge for its time. He had three types of evidence to support his hypothesis. Wegener looked at fossils found in Africa and South America. He believed that if continents were joined, then fossils of the same plants and animals should be on both continents. He gave the example of the Mesosaurus, which is a small, extinct land reptile. Fossils of this reptile have been found in South America and in western Africa. Scientists have dated the Mesosaurus fossils as part of the Paleozoic Era, over 270 million years ago. The two continents had to be joined for the fossils to exist in both places. Wegener also did not find evidence of land bridges that connected South America and Africa across the Atlantic Ocean.

Wegener also studied rock formations. He found that rocks along the coastal regions of these separated continents matched closely in type and age. He proposed that mountain chains which began on one continent appeared to continue onto other continents across the ocean. For example, the Appalachian Mountains, located along the eastern coast of North America, appear to be similar in age and structure to the mountain ranges found in Greenland and Scotland. Wegener believed that if you put our continents together, the mountain ranges similar in age would fit together to form a continuous chain.

The last type of evidence used by Wegener was changes in climatic patterns. He pointed out that geologists found evidence of glaciers in southern Africa and South America. Today these continents are too warm to support glaciers. Scientists have also found fossils of plants that would normally grow in tropical or subtropical areas, in areas that have colder climates. Continents that were once joined together would have been located in areas that resulted in climates different from today.

Although Wegener presented his evidence to support his continental drift hypothesis, his scientific peers dismissed his work. They believed his evidence for how the continents moved was weak. Wegener believed the continents moved by plowing through the rock on the ocean floor. Geologists disproved Wegener's idea through geologic evidence. Alfred Wegener continued to search for the mechanism that moved the continents until he died in 1930. It would be years before his mechanism was found. In fact, it wasn't until 1947 when scientists started mapping the ocean floor.

A group of scientists wanted to map the Mid-Atlantic Ridge. This ridge is part of the system of mid-ocean ridges or undersea mountain ranges. These mid-ocean ridges have steep, narrow valleys that are located through the center of the ridges. Scientists noticed two amazing observations about the Mid-Atlantic Ridge. They noticed that thinner sediment is found on the sea floor closer to the ridge than the sediment on the floor as you move away from the ridge. Based on this observation, sediment farther away from the ridge is older than sediment near the ridge. Scientists also learned that oceanic rocks are young compared to rocks on land. In fact, they found that oceanic rocks are younger than 175 million years old. The oldest land rocks are 3.8 million years old. When the scientists used radiometric dating, they found that rocks close to the mid-ocean ridge are younger than rocks farther away from the ridge.

After the first scientists studied the ocean floor, other scientists started studying sea-floor spreading. During the late 1950's, geologist Harry Hess proposed that the valley at the center of the mid-ocean ridge was a rift. This rift is a crack where magma from inside the Earth rises through to fill the crack. Once the magma rises, it cools and solidifies. Once this occurs, new rock is formed and replaces the ocean floor or lithosphere that has moved away from the ridge. Geologist Robert Dietz later called this process sea-floor spreading. Hess also suggested that the continents may be moving the same way the oceanic floor was moving. He proposed that sea-floor spreading was Wegener's missing mechanism.

Paleomagnetism became another theory suggested by scientists during the mid-1960's to explain sea-floor spreading.
Paleomagnetism refers to the magnetic properties that rocks acquire during their formation and that become permanent after they harden. Scientists found that as magma cools and solidifies, the rock that is formed contains minerals rich in iron. These minerals align with the Earth's magnetic field. This is similar to how compass needles align with the Earth's geomagnetic north and south poles. Once the rock hardens, its magnetic orientation is permanent. As scientists have studied the magnetism of rocks, they have discovered information about Earth's magnetic fields. They have discovered rocks with magnetic orientations different from Earth's current magnetic field. This meant that our planet's magnetic field has not always pointed north. When these rocks with different polarities are dated, all rocks with the same polarity are from the same time period. Simply put, all rocks that point north or have normal polarity were part of the same time periods. Rocks that have reversed polarity or pointed south also belonged to the same time periods. By placing these rocks in order according to time periods, scientists discovered a pattern. They realized the rocks alternated normal and reversed polarity or the direction in which their magnetic fields pointed. Based on their discovery, scientists developed the geomagnetic reversal time scale.

Geologists have used this scale to try to solve the mystery of the mid-ocean ridge. When studying rocks on both sides of the ridge, scientists found an alternating pattern. The striped magnetic pattern on the rocks on one side of the ridge was the mirror image of the pattern on the other side of the ridge. They also had alternating stripes of normal and reversed polarity which matches the geomagnetic reversal time scale. So, what does this mean? As the sea-floor is constantly being rebuilt, it records the changes in Earth's magnetic field. It also means that the scale can be used to date sea-floor rocks once the magnetic patterns have been matched. This meant that the ages of sea-floor rock was symmetrical. Just as the scientists in 1947 discovered, young rocks were in the ridge's center and as you moved farther from the ridge on either side, the rocks became older. Newer rocks formed in the center of the ridge. Sea-floor spreading moves this rock away from the center making room for new rock. Hess' sea-floor spreading hypothesis was proven by the symmetrical patterns of magnetism and the ages in the rocks.

Finally, after thirty years, Wegener's hypothesis was accepted. Scientists had found the mechanism or way for the continents to move. After further study, scientists found the same magnetic reversal patterns in rocks on land, which also matched the geomagnetic reversal time scale. These rocks on land were also similar in age to the rocks on the sea-floor. Now scientists had proof of Earth's changes in crust over time.

1. Sequence the steps for sea-floor spreading.

2. Scientists rejected Wegener's continental drift theory based on his ______.
   - Explanation of Earth's climatic changes
   - Explanation of how the continents moved
   - Explanation for similarities between mountain chains
   - Explanation for occurrence of similar fossils on different continents

3. How did Robert Dietz and Harry Hess extend Wegener's continental drift theory?

4. What fossil evidence did Wegener use to conclude that South America and Africa were joined in the past?

5. How do scientists assign ages to sea-floor rocks?

6. Complete the following sentence: After matching magnetic patterns of rocks on each side of the mid-ocean ridge, scientists found that ____________________________.