Chapter: Plate Tectonics

1

Evidence for Continental Drift

- If you look at a map of Earth's surface, you can see that the edges of some continents look as though they could fit together like a puzzle.

1

Pangaea

- German meteorologist Alfred Wegener (VEG nur) proposed the hypothesis of continental drift.

- According to the hypothesis of **continental drift**, continents have moved slowly to their current locations.

1

Pangaea

- Wegener suggested that all continents once were connected as one landmass that broke apart about 200 million years ago.
- He called this large landmass **Pangaea** (pan JEE uh), which means "a land."

1

A Controversial Idea

- Wegener's ideas about continental drift were controversial.
- It wasn't until long after Wegener's death in 1930 that his basic hypothesis was accepted.

Click image to view movie.

1

A Controversial Idea

- He was unable to explain exactly how the continents drifted apart.
- He proposed that the continents plowed through the ocean floor, driven by the spin of Earth.

1

A Controversial Idea

- Physicists and geologists of the time pointed out that continental drift would not be necessary to explain many of Wegener's observations.

1

Fossil Clues

- Fossils provided support for continental drift.
- Fossils of the reptile *Mesosaurus* have been found in South America and Africa.

1

Fossil Clues

- This swimming reptile lived in freshwater and on land.
- How could fossils of *Mesosaurus* be found on land areas separated by a large ocean of salt water?
- Wegener hypothesized that this reptile lived on both continents when they were joined.

1

A Widespread Plant

- Another fossil that supports the hypothesis of continental drift is *Glossopteris* (glahs AHP tur us).

- This fossil plant has been found in Africa, Australia, India, South America, and Antarctica.

1

A Widespread Plant

- The presence of *Glossopteris* in so many area also supported Wegener's idea that all of these regions once were connected and had similar climates.

1

Climate Clues

- Fossils of warm-weather plants were found on the island of Spitsbergen in the Arctic Ocean.
- To explain this, Wegener hypothesized that Spitsbergen drifted from tropical regions to the arctic.

1

Climate Clues

- Glacial deposits and rock surfaces scoured and polished by glaciers are found in South America, Africa, India, and Australia.
- This shows that parts of these continents were covered with glaciers in the past.

1

Rock Clues

- Similar rock structures are found on different continents.
- Parts of the Appalachian Mountains of the eastern United States are similar to those found in Greenland and western Europe.
- Rock clues like these support the idea that the continents were connected in the past.

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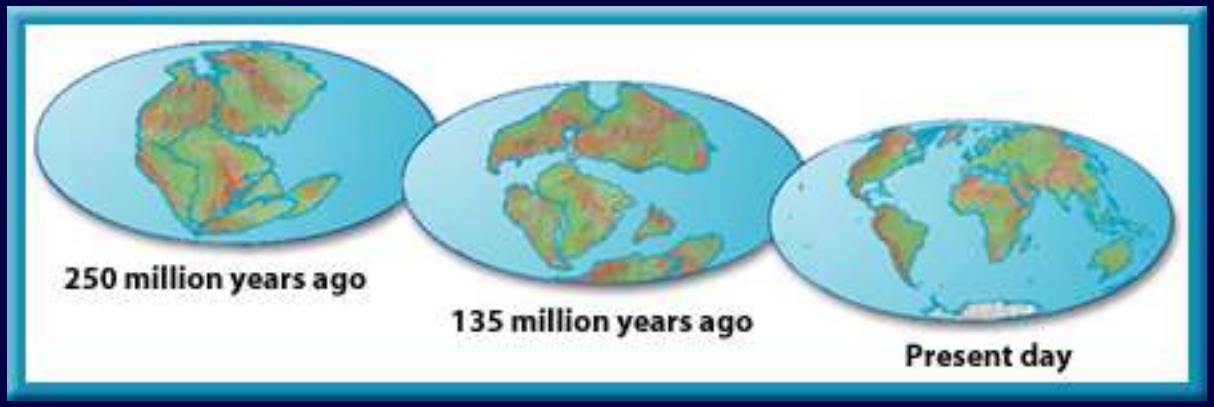
How could continents drift?

- Although Wegener provided evidence to support his hypothesis of continental drift, he couldn't explain how, when, or why these changes took place.



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How could continents drift?

- Because other scientists could not provide explanations either, Wegener's idea of continental drift was initially rejected.
- Rock, fossil, and climate clues were the main types of evidence for continental drift.

1

How could continents drift?

- After Wegener's death, more clues were found, largely because of advances in technology, and new ideas that related to continental drift were developed.

1

Question 1

_____ is the hypothesis that continents have slowly moved to their current locations.

A. Continental drift
B. Mid-ocean shifting
C. Pangaea
D. Seafloor spreading

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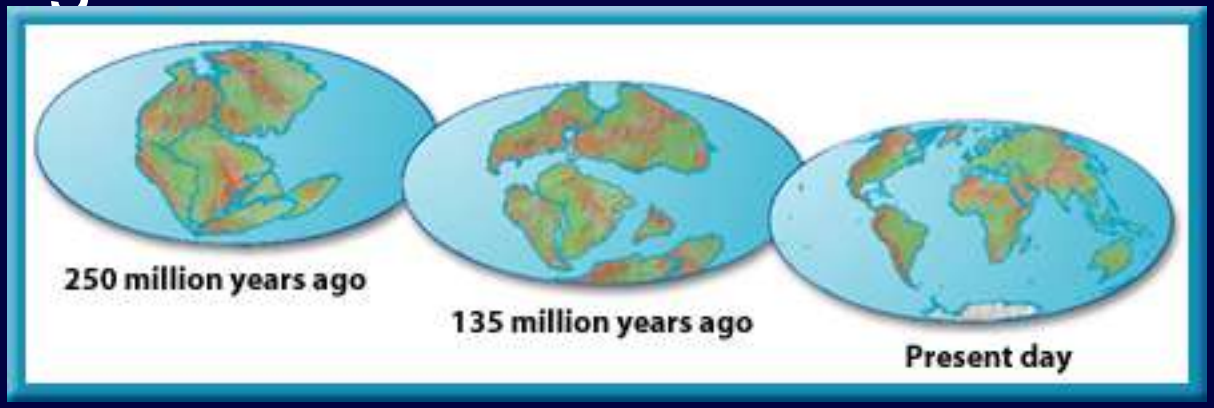
Answer

The answer is A. Continental drift is the theory that the continents have slowly moved. Seafloor spreading is a process that would help explain how the continental drift might occur.



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Question 2

Who proposed the hypothesis of continental drift?

A. Esker
B. Gagarin
C. Hess
D. Wegener

1

Answer

The answer is D. Wegener proposed the hypothesis of continental drift. Hess theorized that the seafloor is spreading.

1

Question 3

What is Pangaea?

1

Answer

Pangaea means “all land” and is the name that Wegener used to refer to the one large landmass that he believed existed before it broke apart into continents.

2

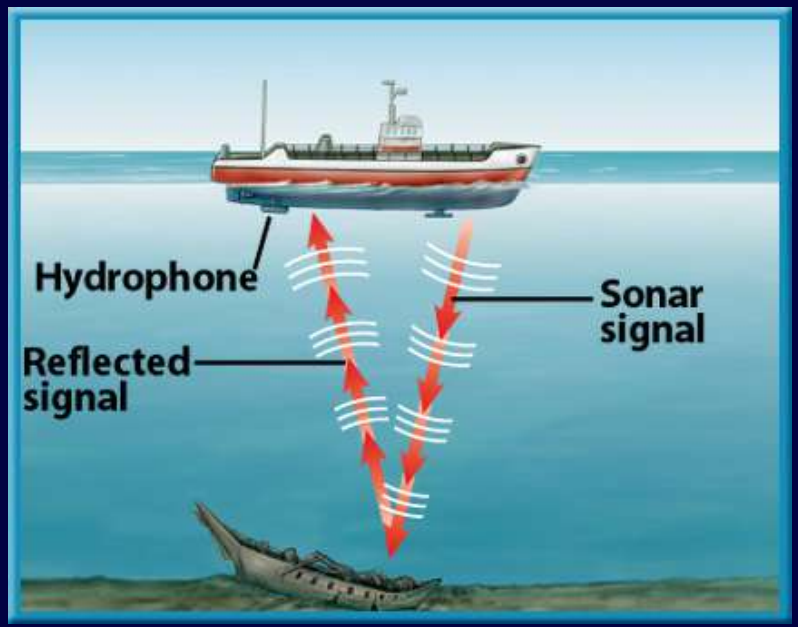
Mapping the Ocean Floor

- If you were to lower a rope from a boat until it reached the seafloor, you could record the depth of the ocean at that particular point.
- This is exactly how it was done until World War I, when the use of sound waves was introduced by German scientists to detect submarines.

2

Mapping the Ocean Floor

- Sound waves echo off the ocean bottom—the longer the sound waves take to return to the ship, the deeper the water is.
- Using sound waves, researchers discovered an underwater system of ridges, or mountains, and valleys like those found on the continents.



2

Mapping the Ocean Floor

- In some of these underwater ridges are rather long rift valleys where volcanic eruptions and earthquakes occur from time to time.
- In the Atlantic, the Pacific, and in other oceans around the world, a system of ridges, called the mid-ocean ridges, is present.

2

The Seafloor Moves

- In the early 1960s, Princeton University scientist Harry Hess suggested an explanation.
- His now-famous theory is known as **seafloor spreading**.

2

The Seafloor Moves

- Hess proposed that hot, less dense material below Earth's crust rises toward the surface at the mid-ocean ridges.
- Then, it flows sideways, carrying the seafloor away from the ridge in both directions.

2

The Seafloor Moves

- As the seafloor spreads apart at a mid-ocean ridge, new seafloor is created.
- The older seafloor moves away from the ridge in opposite directions.

2

Evidence for Spreading

- In 1968, scientists aboard the research ship *Glomar Challenger* began gathering information about the rocks on the seafloor.
- Scientists found that the youngest rocks are located at the mid-ocean ridges.

2

Evidence for Spreading

- The ages of rocks become increasingly older in samples obtained farther from the ridges, adding to the evidence for seafloor spreading.
- As molten material is forced upward along the ridges, it brings heat and chemicals that support exotic life-forms in deep, ocean water.

2

Magnetic Clues

- During a magnetic reversal, the lines of magnetic force run the opposite way.
- Scientists have determined that Earth's magnetic field has reversed itself many times in the past.
- The reversals are recorded in rocks forming along mid-ocean ridges.

2

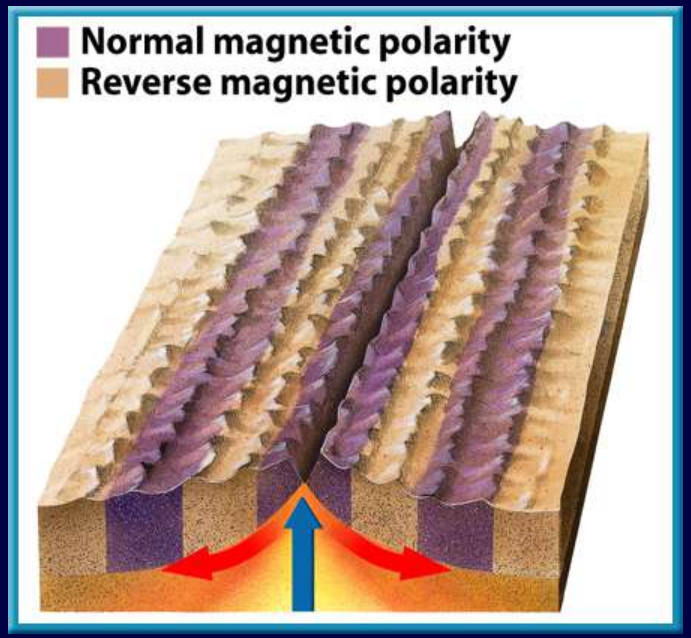
Magnetic Time Scale

- Whenever Earth's magnetic field reverses, newly forming iron minerals will record the magnetic reversal.
- Using a sensing device called a magnetometer (mag nuh TAH muh tur) to detect magnetic fields, scientists found that rocks on the ocean floor show many periods of magnetic reversal.

2

Magnetic Time Scale

- The magnetic alignment in the rocks reverses back and forth over time in strips parallel to the mid-ocean ridges.



- A strong magnetic reading is recorded when the polarity of a rock is the same as the polarity of Earth's magnetic field today.

2

Magnetic Time Scale

- This discovery provided strong support that seafloor spreading was indeed occurring.
- This helped explain how the crust could move—something that the continental drift hypothesis could not do.

2

Question 1

What is seafloor spreading?

2

Answer

Seafloor spreading is the process in which hot, less dense material below Earth's crust rises toward the surface at the mid-ocean ridges. This material flows sideways and carries the seafloor away from the ridge in both directions.

2

Question 2

What method of mapping the ocean floor was developed by scientists in the 1940s and 1950s?

Answer

In the 1940s and 1950s, scientists began to use sound waves echoing off the ocean bottom to map large areas of the ocean floor in detail.

2

Question 3

What was the significance of the discovery that the magnetic alignment in rocks on the ocean floor reverses back and forth in strips parallel to mid-ocean ridges?

2

Answer

The magnetic reversals showed that new rock was being formed at the mid-ocean ridges, and helped explain how the crust could move.

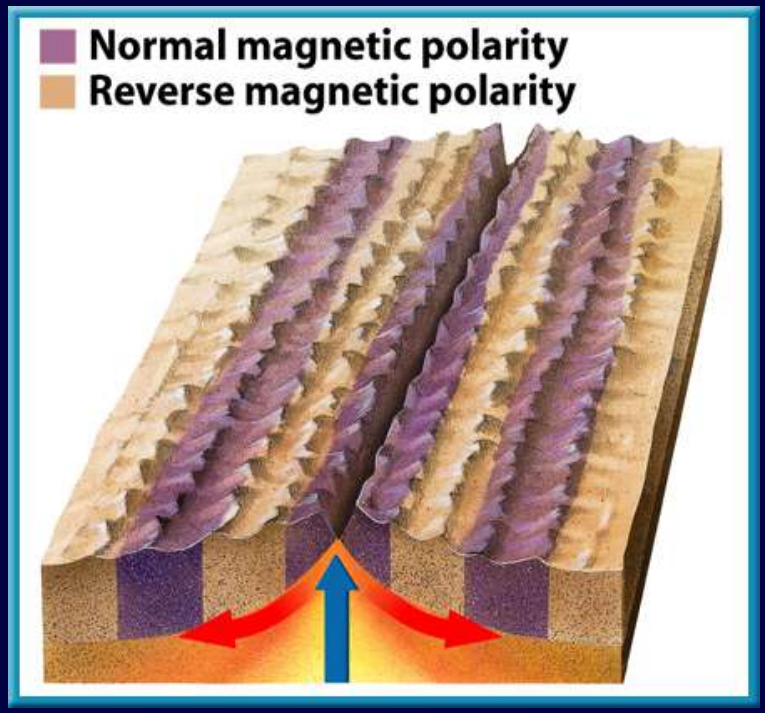


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Plate Tectonics

- The idea of seafloor spreading showed that more than just continents were moving, as Wegener had thought.
- It was now clear to scientists that sections of the seafloor and continents move in relation to one another.

3

Plate Movements

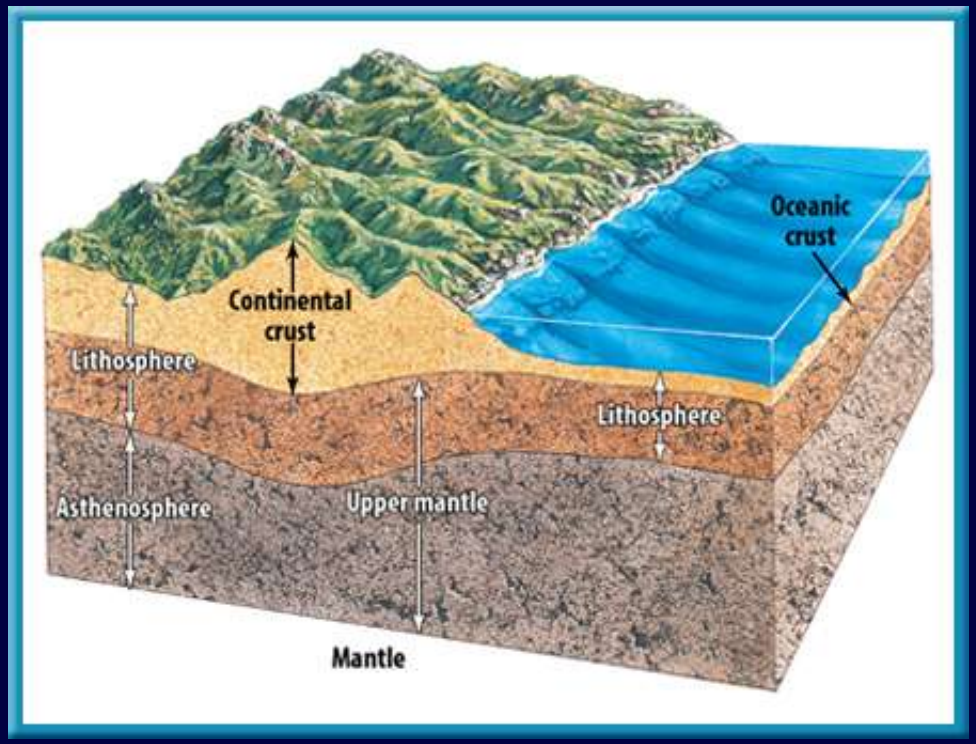
- According to the theory of **plate tectonics**, Earth's crust and part of the upper mantle are broke into sections.
- These sections, called **plates**, move on a plasticlike layer of the mar e.

3

Composition of Earth's Plates

- Plates are made of the crust and a part of the upper mantle.

- These two parts combined are the **lithosphere** (LIH thuh sfihr).



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Composition of Earth's Plates

- The plasticlike layer below the lithosphere is called the **asthenosphere** (as THEN uh sfihr)
- The rigid plates of the lithosphere float and move around on the asthenosphere.

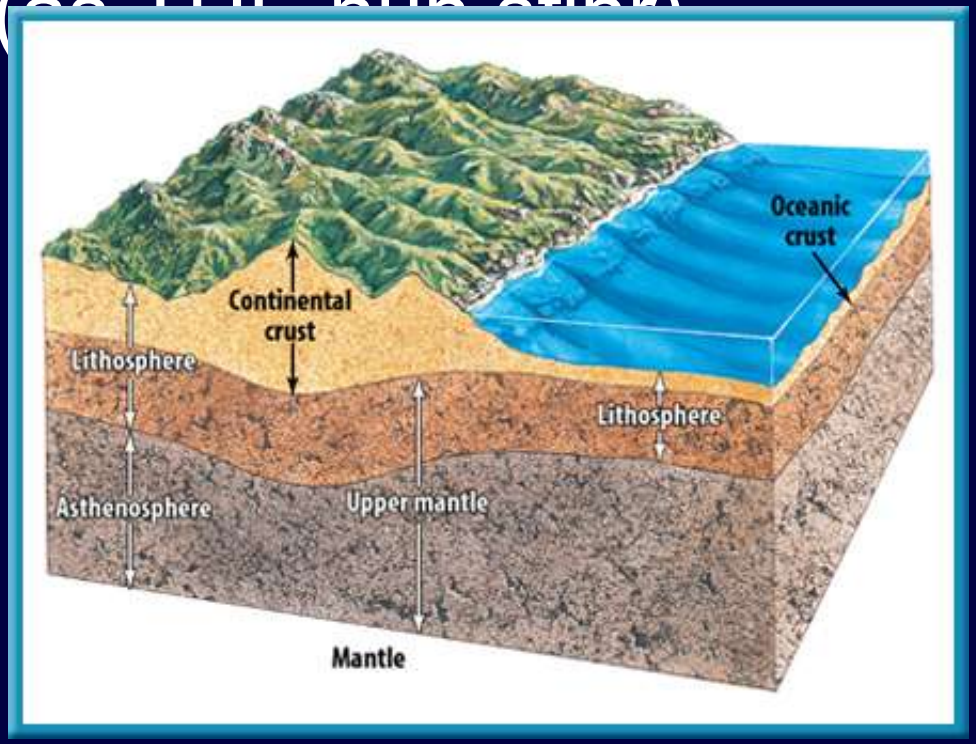

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Plate Boundaries

- When plates move, they can interact in several ways.
- They can move toward each other and converge, or collide.
- They also can pull apart or slide alongside one another. When the plates interact, the result of their movement is seen at the plate boundaries.

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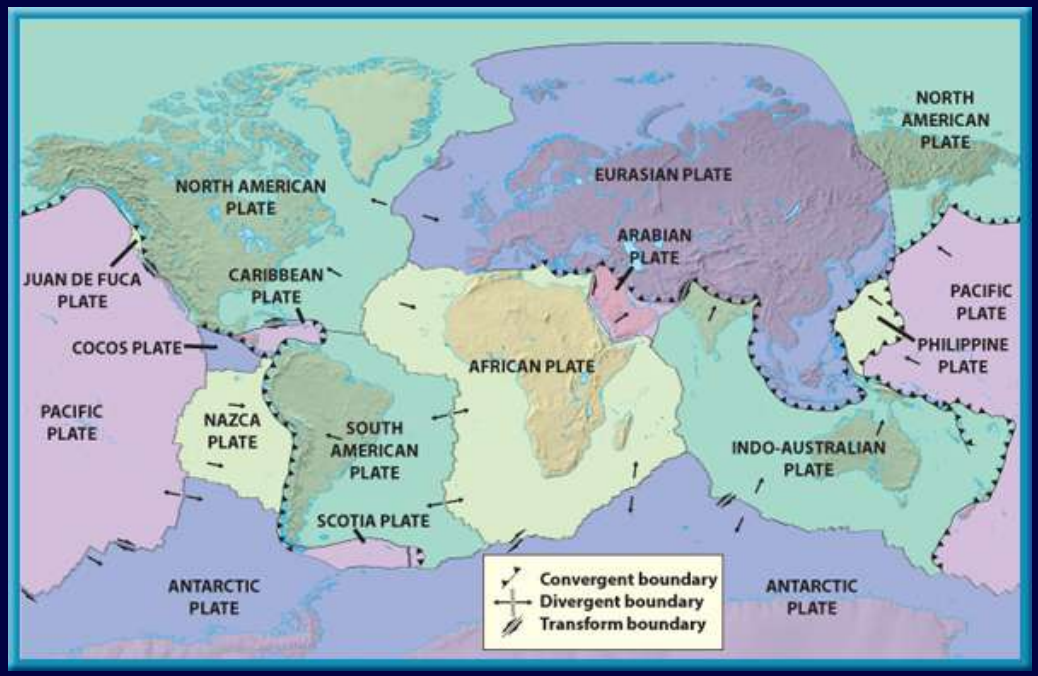
Plate Boundaries

- Movement along any plate boundary means that changes must happen at other boundaries.
- What is happening to the Atlantic Ocean floor between the North American and African Plates?



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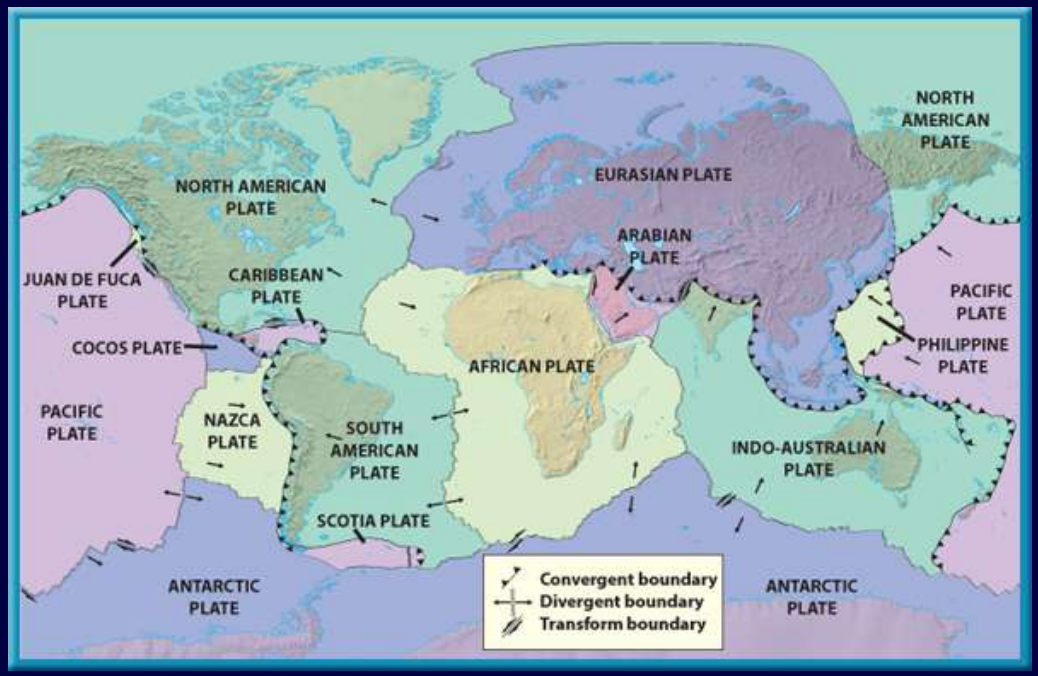
Plates Moving Apart

- The boundary between two plates that are moving apart is called a divergent boundary.
- In the Atlantic Ocean, the North American Plate is moving away from the Eurasian and the African Plates.



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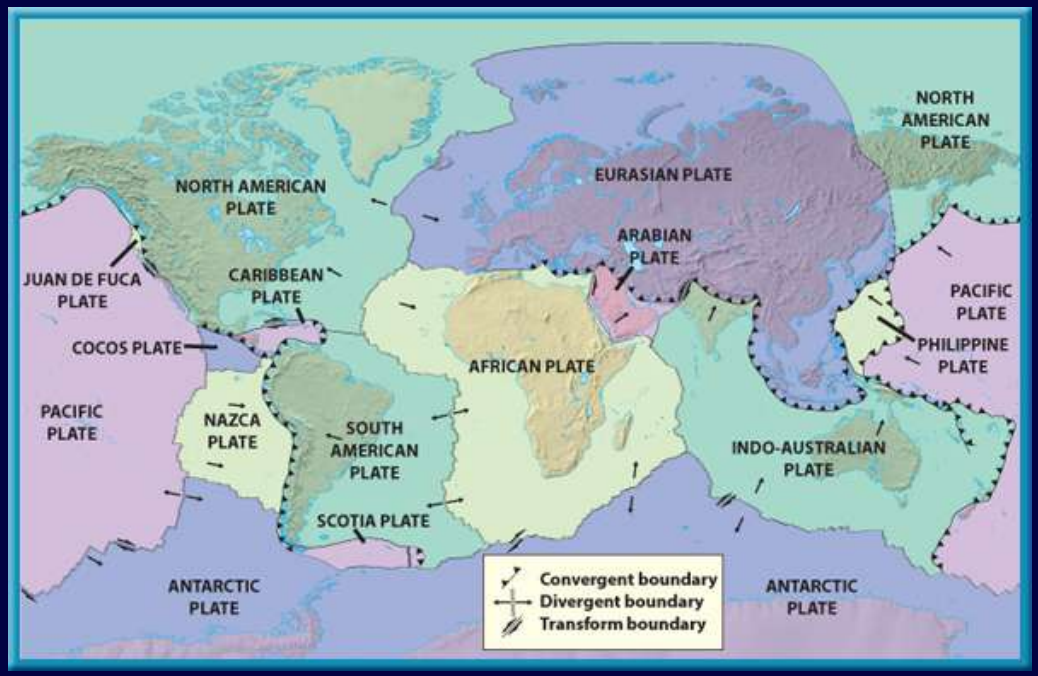
Plates Moving Apart

- That divergent boundary is called the Mid-Atlantic Ridge.



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Plates Moving Together

- As new crust is added in one place, it disappears below the surface at another.
- The disappearance of crust can occur when seafloor cools, becomes denser, and sinks.
- This occurs where two plates move together at a convergent boundary.

3

Plates Moving Together

- When an oceanic plate converges with a less dense continental plate, the denser oceanic plate sinks under the continental plate.
- The area where an oceanic plate subducts, or goes down, into the mantle is called a subduction zone.

3

Plates Moving Together

- Some volcanoes form above subduction zones.
- This type of convergent boundary creates a deep-sea trench where one plate bends and sinks beneath the other.

3

Plates Moving Together

- High temperatures cause rock to melt around the subducting slab as it goes under the other plate.
- The newly formed magma is forced upward along these plate boundaries, forming volcanoes.

3

Where Plates Collide

- A subduction zone also can form where two oceanic plates converge.
- In this case, the colder, older, denser oceanic plate bends and sinks down into the mantle.
- Usually, no subduction occurs when two continental plates collide.

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Where Plates Collide

- Because both of these plates are less dense than the material in the asthenosphere, the two plates collide and crumple up, forming mountain ranges.
- Earthquakes are common at these convergent boundaries.

3

Where Plates Slide Past Each Other

- The third type of plate boundary is called a transform boundary.
- Transform boundaries occur where two plates slide past one another.
- They move in opposite directions or in the same direction at different rates.

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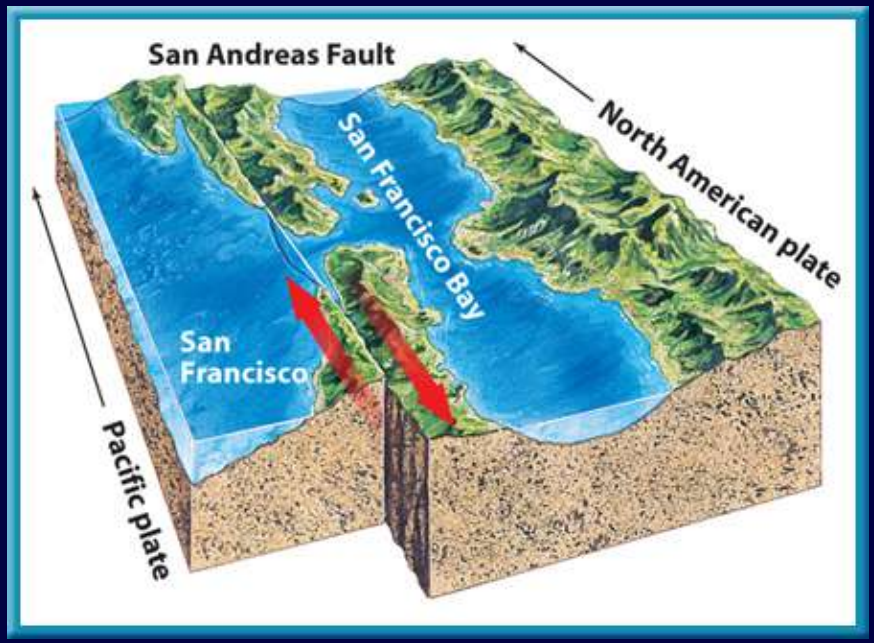
Where Plates Slide Past Each Other

- When one plate slips past another suddenly, earthquakes occur.
- The San Andreas Fault is part of a transform plate boundary. It has been the site of many earthquakes.



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Causes of Plate Tectonics—Convection Inside Earth

- The cycle of heating, rising, cooling, and sinking is called a **convection current**.
- A version of this same process, occurring in the mantle, is thought to be the force behind plate tectonics.
- Scientists suggest that differences in density cause hot, plasticlike rock to be forced upward toward the surface.

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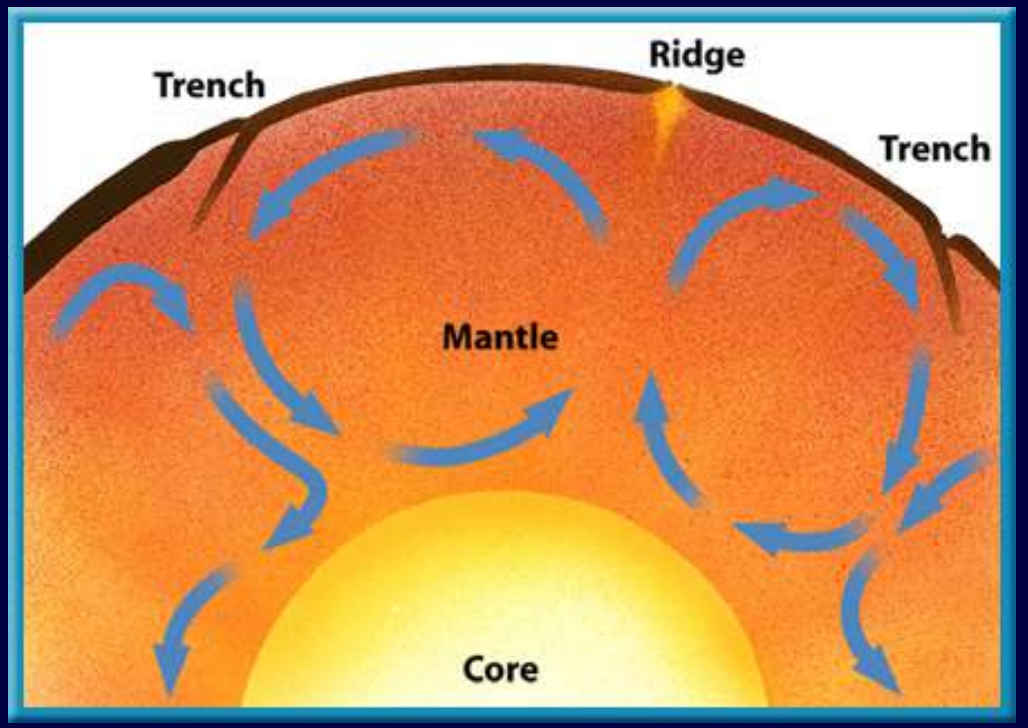
Moving Mantle Material

- In one hypothesis, convection currents occur throughout the mantle.



- Such convection currents (see arrows) are the driving force of plate tectonics.

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Features Caused by Plate Tectonics

- As plates move, they interact.
- The interaction of plates produces forces that build mountains, create ocean basins, and cause volcanoes.

3

Features Caused by Plate Tectonics

- When rocks in Earth's crust break and move, energy is released in the form of seismic waves.
- Humans feel this release as earthquakes.

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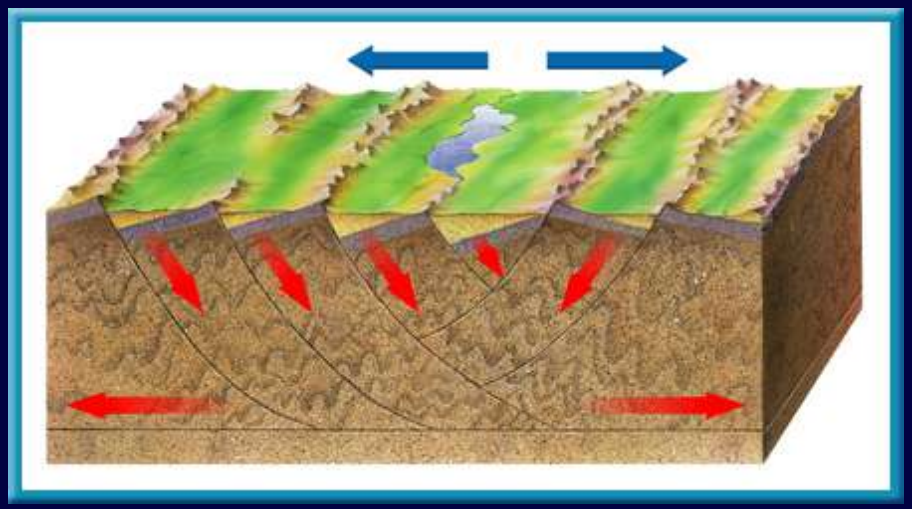
Normal Faults and Rift Valleys

- When rocks break and move along surfaces, a fault forms.
- Faults interrupt rock layers by moving them out of place.

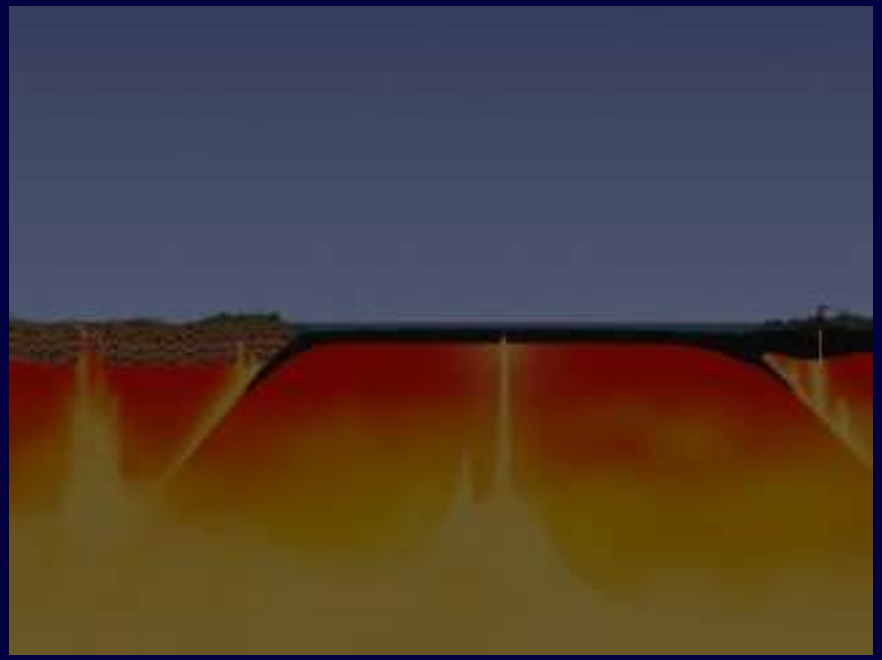


- Entire mountain ranges can form in the process, called fault-block mountains

3

Normal Faults and Rift Valleys

- Rift valleys and mid-ocean ridges can form where Earth's crust separates.
- Examples of rift valleys are the Great Rift Valley in Africa, and the valleys that occur in the middle of mid-ocean ridges.



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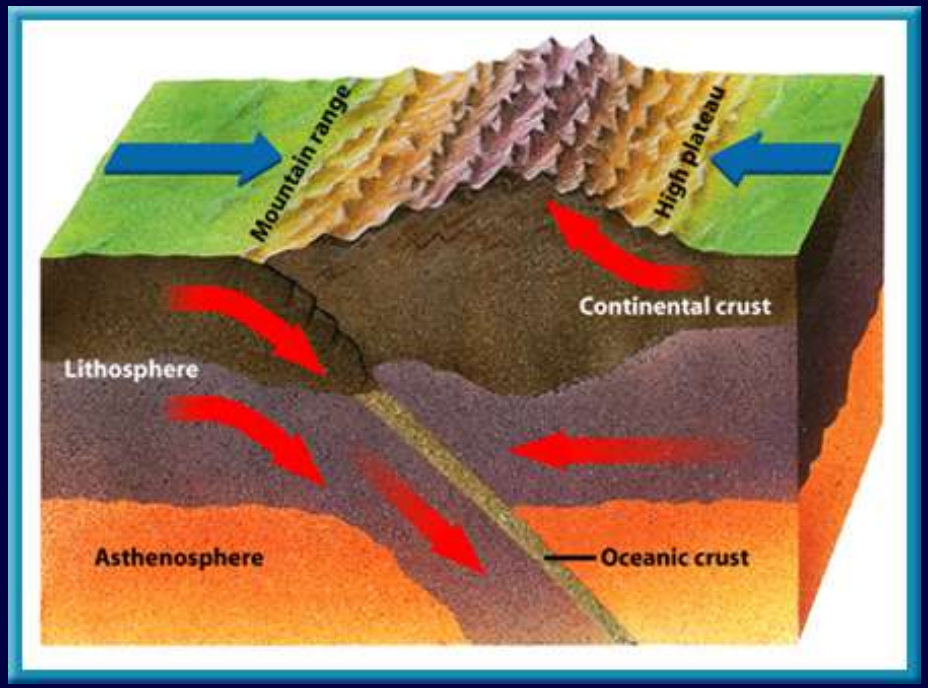
Mountains and Volcanoes

- As continental plates collide, the forces that are generated cause massive folding and faulting of rock layers into mountain ranges such as the Himalaya.



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Mountains and Volcanoes

- The type of faulting produced is generally reverse faulting.
- When two oceanic plates converge, the denser plate is forced beneath the other plate.
- Curved chains of volcanic islands called island arcs form above the sinking plate.

3

Mountains and Volcanoes

- If an oceanic plate converges with a continental plate, the denser oceanic plate slides under the continental plate.
- Folding and faulting at the continental plate margin can thicken the continental crust to produce mountain ranges.

3

Strike-Slip Faults

- In a strike-slip fault, rocks on opposite sides of the fault move in opposite directions, or in the same direction at different rates.
- When plates move suddenly, vibrations are generated inside Earth that are felt as an earthquake.

3

Testing for Plate Tectonics

- Until recently, the only tests scientists could use to check for plate movement were indirect.
- They could study the magnetic characteristics of rocks on the seafloor.
- They could study volcanoes and earthquakes.

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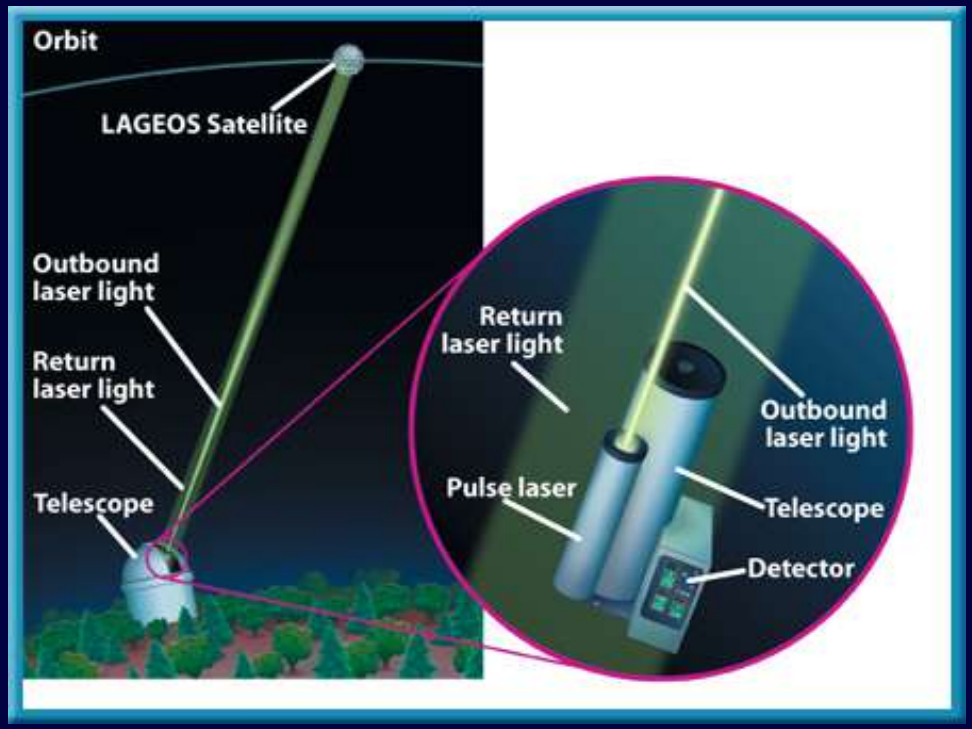
Testing for Plate Tectonics

- One new method uses lasers and a satellite.
- Now, scientists can measure exact movements of Earth's plates of as little as 1 cm per year.



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Current Data

- Satellite Laser Ranging System data show that Hawaii is moving toward Japan at a rate of about 8.3 cm per year.
- Using such methods, scientists have observed that the plates move at rates ranging from about 1 cm to 12 cm per year.

3

Question 1

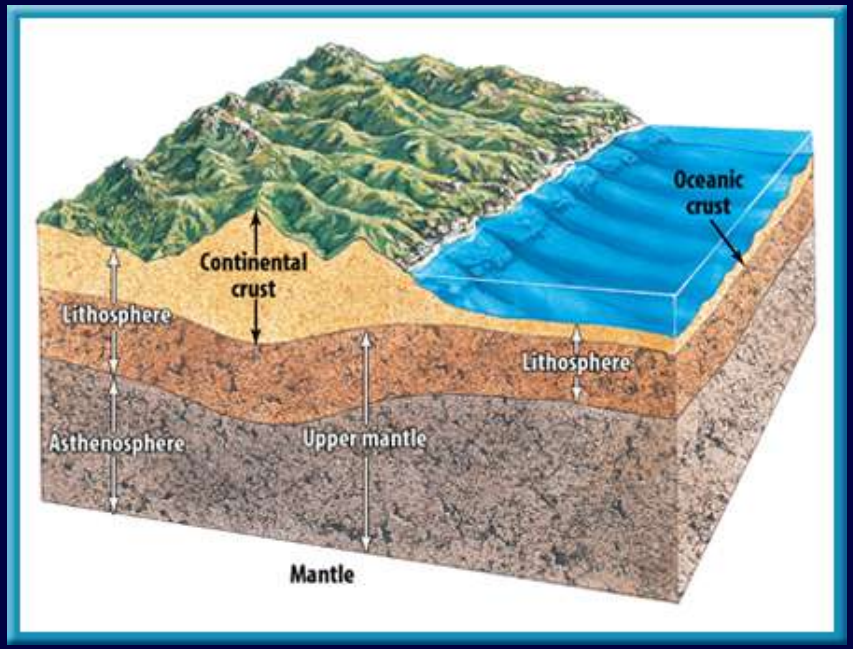
Which of the following is made up of Earth's crust and part of the upper mantle?

A. asthenosphere
B. continental crust
C. lithosphere
D. plastisphere

3

Answer

The answer is C. The asthenosphere is the plasticlike layer below the lithosphere.



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Question 2

_____ is the theory that Earth's crust and part of the upper mantle are broken into sections.

A. Continental drift
B. Pangaea effect
C. Plate tectonics
D. Seafloor spreading

3

Answer

The answer is C. The sections are called plates and are thought to move on a plasticlike layer of Earth's mantle.

3

Question 3

The boundary between two plates that are moving apart is a _____ boundary.

A. convergent
B. creeping
C. divergent
D. tectonic

3

Answer

The answer is C. An example of a divergent boundary is the Mid-Atlantic Ridge, where the seafloor is spreading.

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