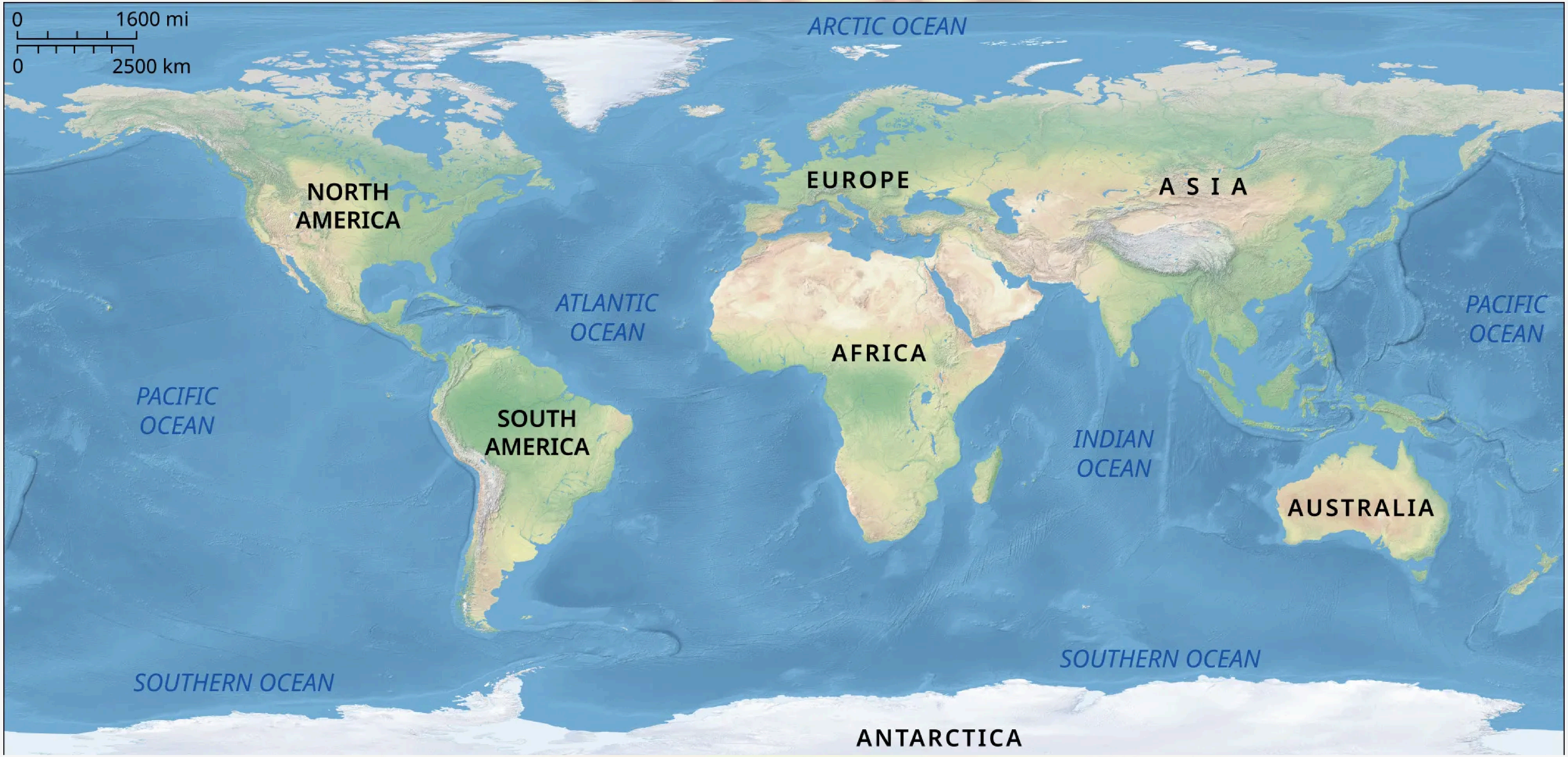
Continental Drift Theory, Plate Tectonics, Seafloor Spreading Theory

NDA CDS COACHING CENTRE

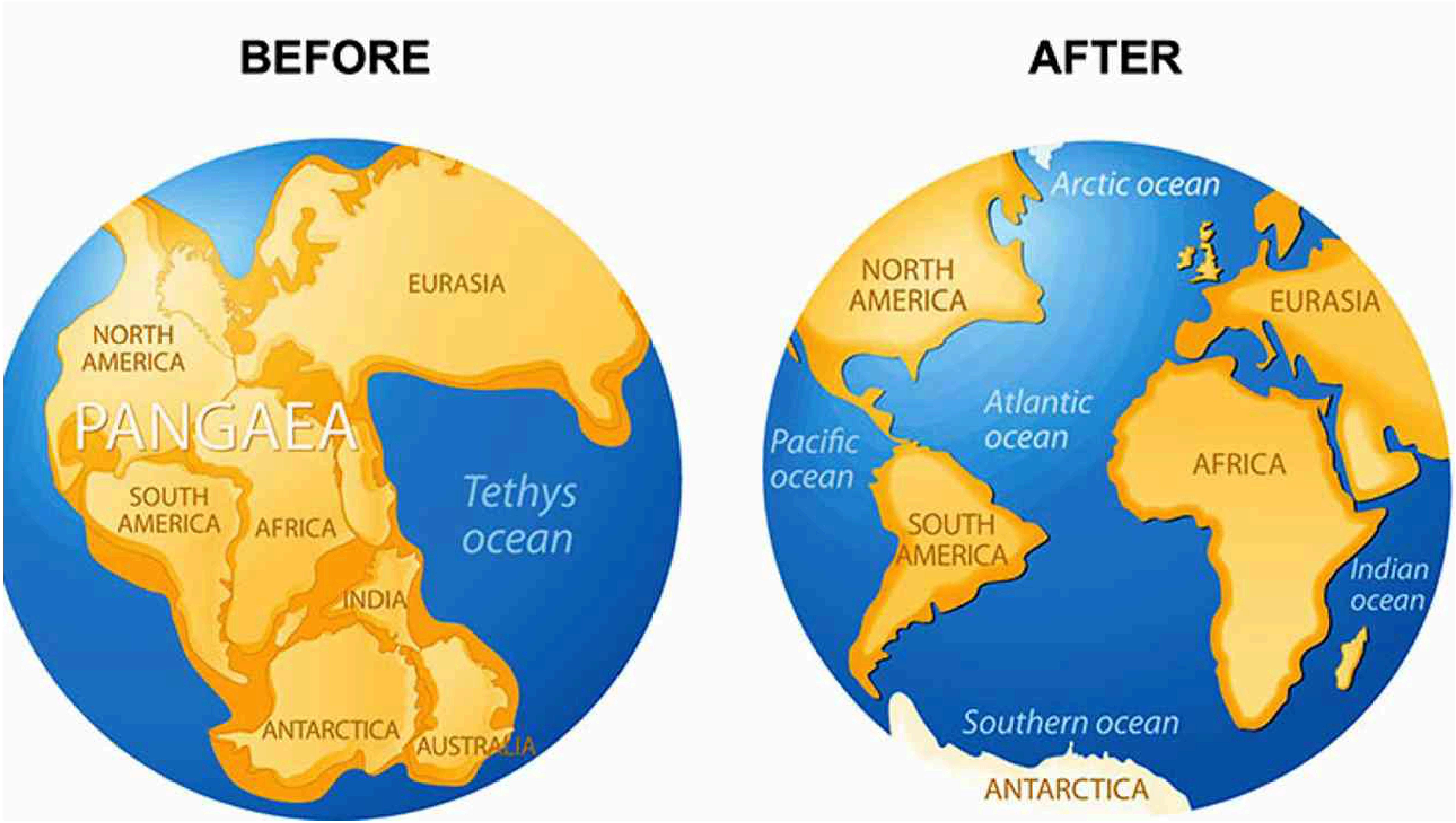
The Continental Drift Theory is a geological hypothesis that suggests the continents were once part of a single, massive landmass called Pangaea (all-earth), which gradually broke apart and drifted to their current positions over geological time. Proposed by German meteorologist and geophysicist Alfred Wegener in 1912, the theory marked a significant departure from earlier notions that continents were static.


0 1600 mi
0 2500 km
ARCTIC OCEAN
NORTH AMERICA
EUROPE
ASIA
ATLANTIC OCEAN
PACIFIC OCEAN
AFRICA
PACIFIC OCEAN
SOUTH AMERICA
INDIAN OCEAN
AUSTRALIA
SOUTHERN OCEAN
SOUTHERN OCEAN
ANTARCTICA

Key Concepts

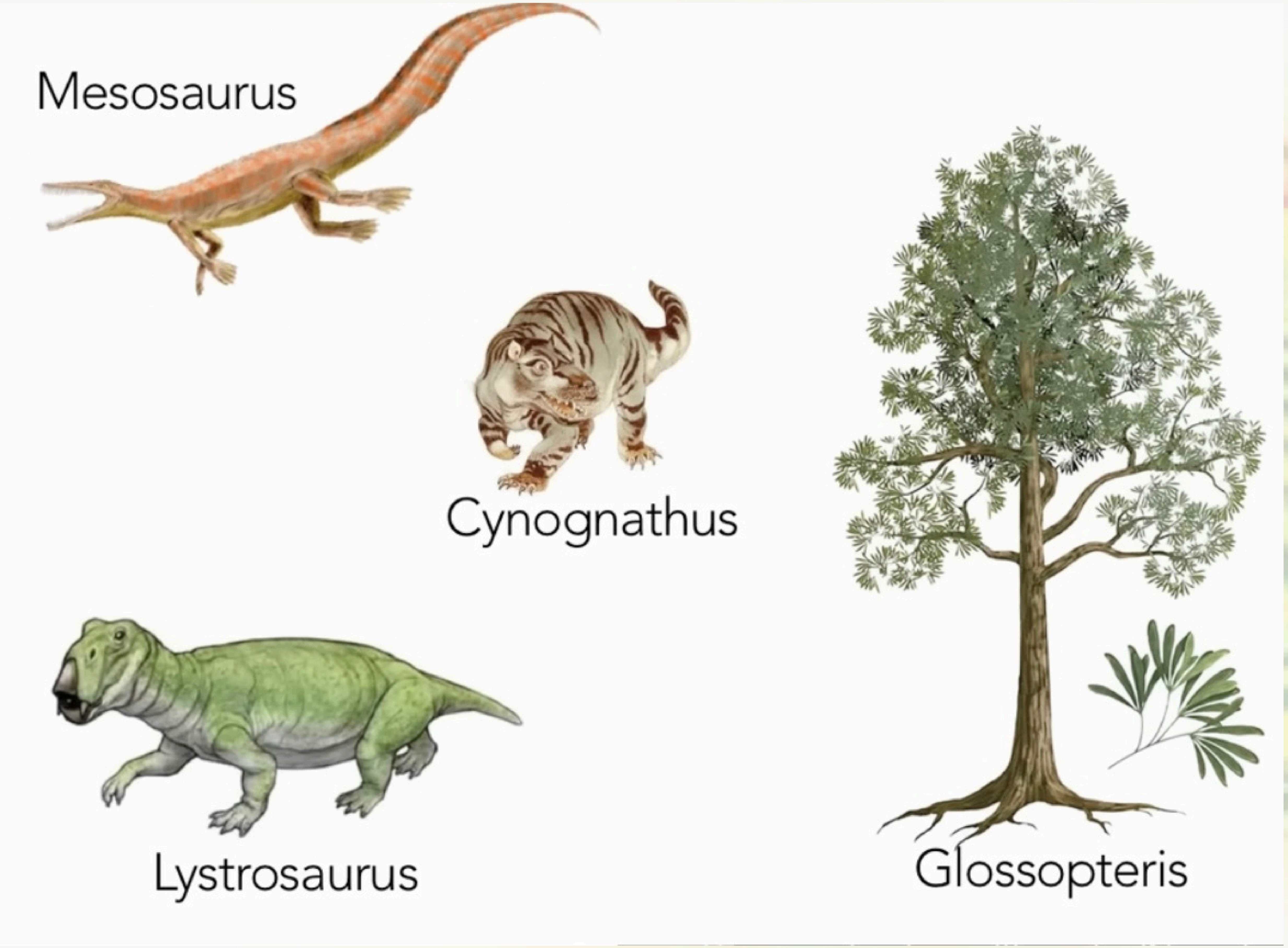
1. **Pangaea:** According to Wegener, around 300 million years ago, all the continents were joined together in a supercontinent he named Pangaea, which began to break apart about 200 million years ago.
2. **Drifting Continents:** Wegener proposed that the continents slowly drifted across the Earth's surface to their present locations, a process he believed was driven by forces like Earth's rotation and tidal forces.


Eurasia
North America
Africa
South America
India
Australia
Antarctica


BEFORE
AFTER
EURASIA
NORTH AMERICA
PANGAEA
SOUTH AMERICA
AFRICA
Tethys ocean
INDIA
ANTARCTICA
AUSTRALIA
Arctic ocean
NORTH AMERICA
EURASIA
Atlantic ocean
Pacific ocean
AFRICA
SOUTH AMERICA
Indian ocean
Southern ocean
ANTARCTICA

Evidence of Theory

1. Fit of the Continents: The coastlines of continents such as South America and Africa appear to fit together like pieces of a jigsaw puzzle, suggesting they were once joined.
2. Fossil Evidence: Identical fossils of plants and animals, such as the Mesosaurus (a freshwater reptile), have been found on continents now separated by oceans, indicating these lands were once connected.
3. Geological Similarities: Similar rock formations, mountain ranges, and geological structures are found on continents that are now far apart. For instance, the Appalachian Mountains in North America are geologically similar to the Caledonian Mountains in Scotland and Scandinavia.
4. Paleoclimatic Evidence: Evidence of past climates, such as glacial deposits found in now-tropical regions of Africa and India, suggests these continents were once located in colder regions near the poles.


Mesosaurus
Cynognathus
Lystrosaurus
Glossopteris

Evidence?

- The Apparent Fit of the Continents
- Fossil Correlation
- Rock and Mountain Correlation
- Paleoclimate Data

Coal has been found in cold regions and glacial evidence has been found in warm regions.

Challenges and Initial Rejection

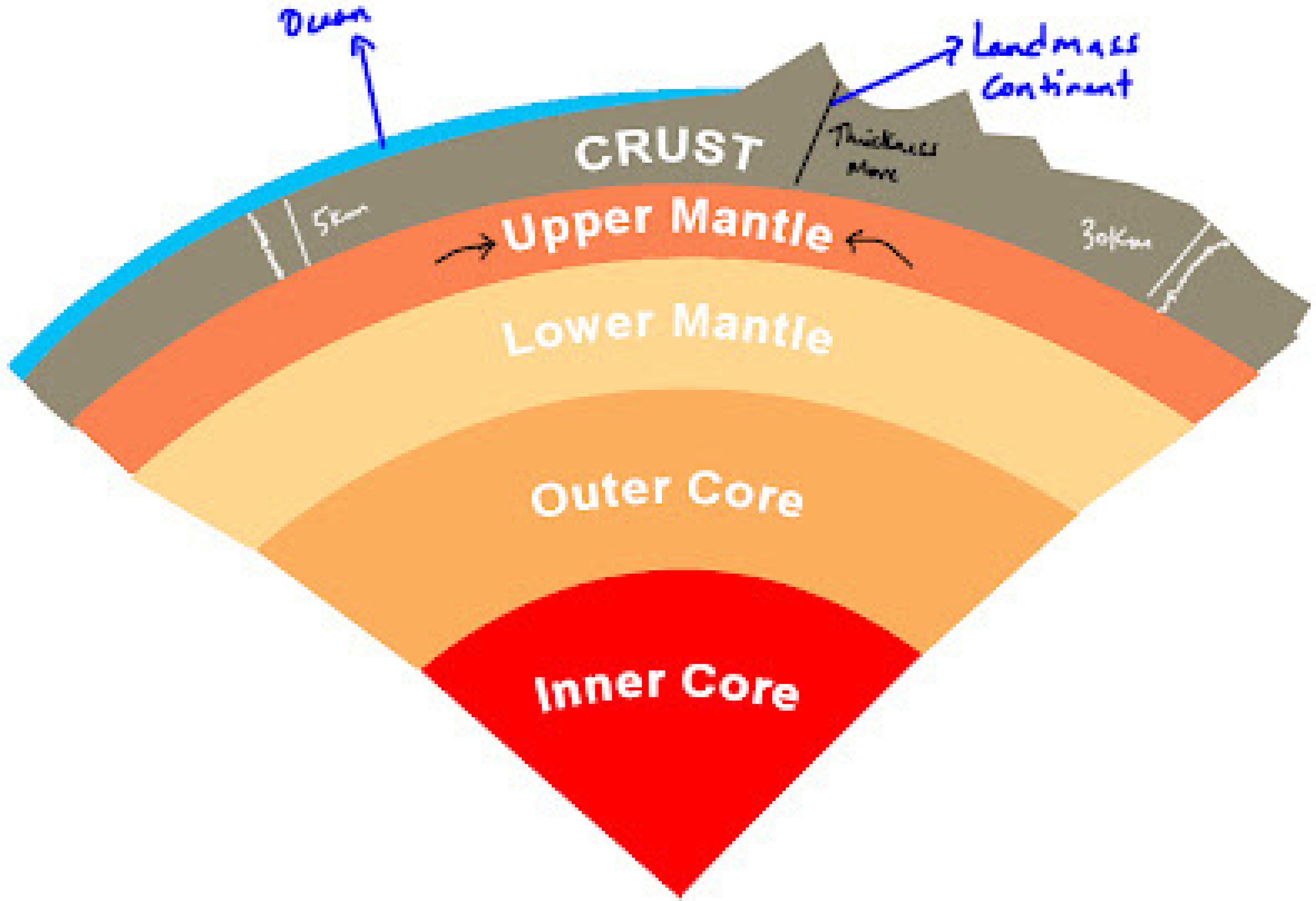
- Lack of Mechanism: Wegener's inability to provide a convincing mechanism for the movement of continents led to skepticism. He suggested that the forces generated by Earth's rotation and tidal forces were responsible, but these explanations were not sufficient to explain the vast movements of the continents.
- Opposition from Established Geologists: The scientific community was initially resistant to Wegener's ideas, favoring the prevailing theories of fixed continents and land bridges.

NDA CDS COACHING CENTRE

Impact of Continental Drift Theory

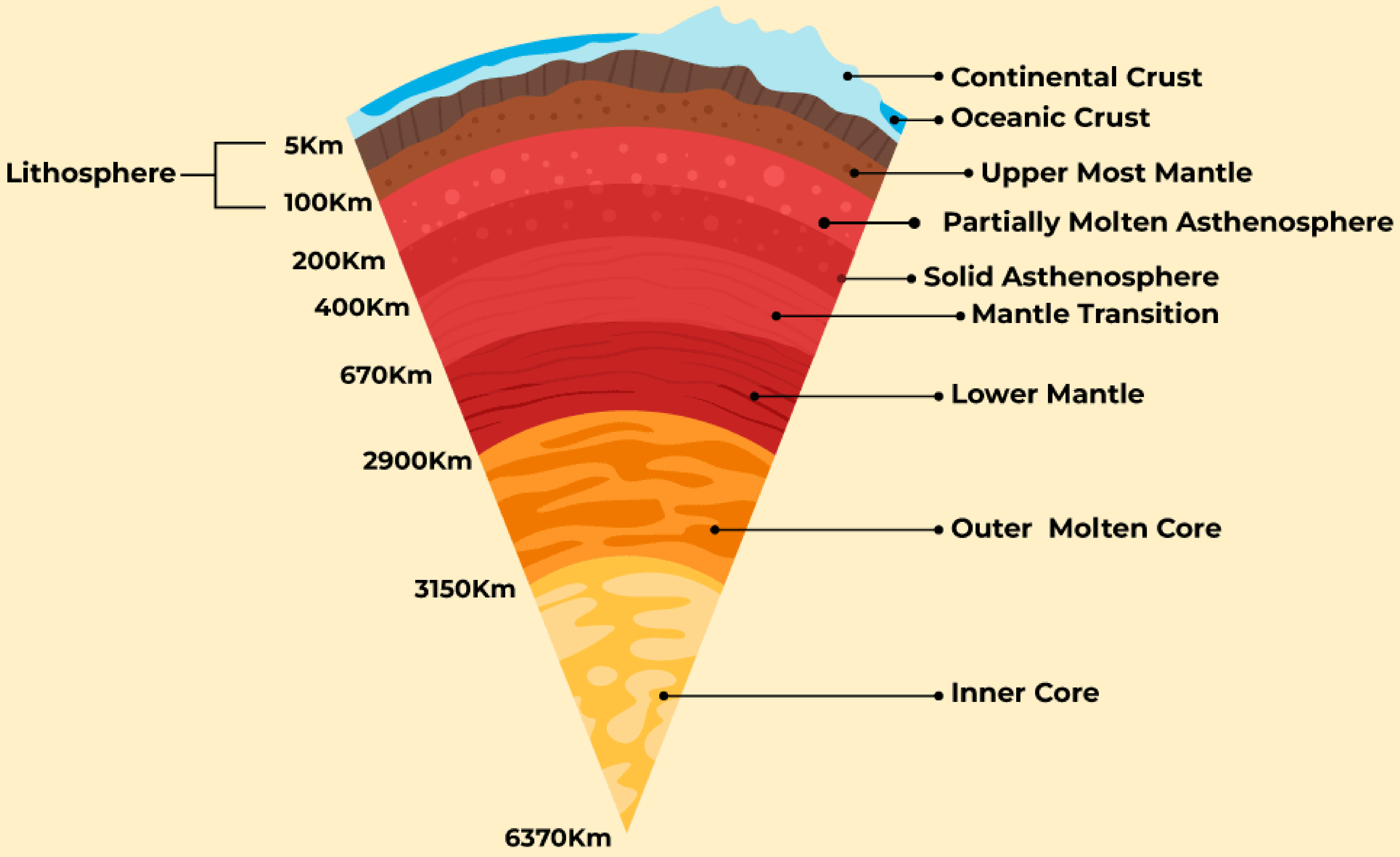
- Foundation of Plate Tectonics: The Continental Drift Theory is considered a precursor to the more comprehensive Plate Tectonics Theory, which describes the Earth's lithosphere as divided into tectonic plates that move and interact at their boundaries.
- Understanding Geological Processes: It has improved our understanding of various geological processes, including mountain building, earthquakes, and volcanic activity.
- Evolution and Distribution of Life: The theory has also influenced the study of the historical distribution of species and the evolution of life on Earth, providing explanations for the current distribution of flora and fauna.

- **Plate Tectonics Theory:**
- The Tectonic Plates Theory, also known as Plate Tectonics, explains the structure and movement of the Earth's lithosphere, which is divided into several large and small plates that float on the semi-fluid asthenosphere beneath. Here are the key points of the theory:
- Key Points of Tectonic Plates Theory
- **Earth's Structure:**
- **Lithosphere:** The rigid outer layer of the Earth, about 100 km thick, comprising the crust and the uppermost part of the mantle.
- **Asthenosphere:** The semi-fluid layer beneath the lithosphere, allowing the plates to move.



Ocean
Landmass
Continent
CRUST
Thickness more
5Km
30Km
Upper Mantle
Lower Mantle
Outer Core
Inner Core

Earth's Interior

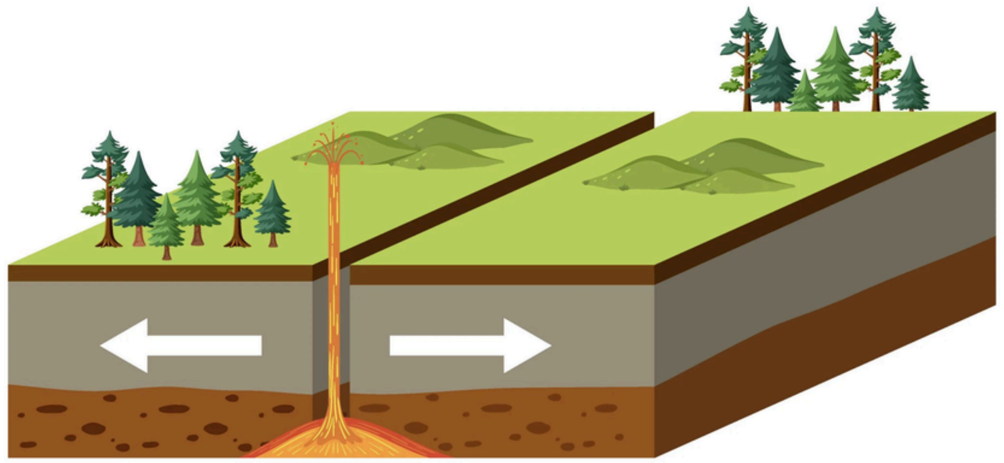


1. **Tectonic Plates:**
   - The lithosphere is divided into several tectonic plates, including major ones like the Pacific Plate, North American Plate, Eurasian Plate, and African Plate, as well as many smaller plates.
2. **Plate Movement:**
   - Tectonic plates are constantly moving, albeit very slowly, at rates of a few centimeters per year. This movement is driven by forces such as mantle convection, slab pull, and ridge push.

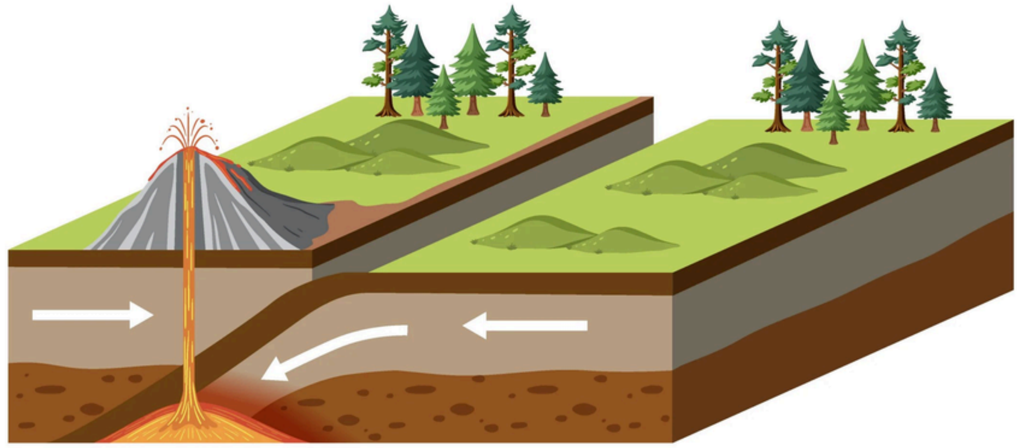
Types of Plate Boundaries:

1. **Divergent Boundaries:** Plates move apart from each other. Magma rises from below the Earth's surface to create new crust, as seen at mid-ocean ridges (e.g., the Mid-Atlantic Ridge).
2. **Convergent Boundaries:** Plates move towards each other. One plate is forced under another in a process called subduction, leading to mountain building, earthquakes, and volcanic activity (e.g., the Andes Mountains, the Himalayas).
3. **Transform Boundaries:** Plates slide past each other horizontally, causing earthquakes (e.g., the San Andreas Fault in California).

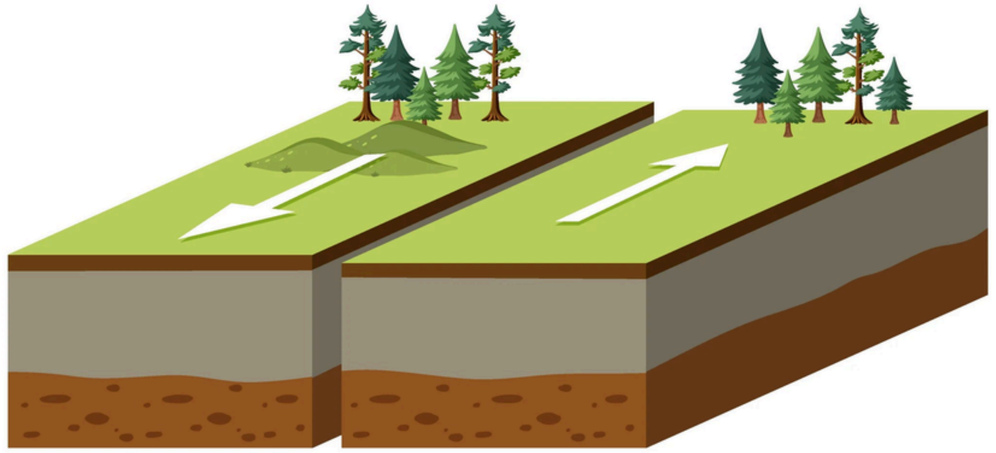
PLATE BOUNDARIES



DIVERGENT
PLATE BOUNDARY



CONVERGENT
PLATE BOUNDARY



TRANSFORM
PLATE BOUNDARY

Sea-floor spreading is a geological process that explains the formation and expansion of oceanic crust. This concept is a key component of the broader theory of Plate Tectonics. Here are the essential points:

Key Points of Sea-Floor Spreading

1. **Mid-Ocean Ridges:**
   - Mid-ocean ridges are underwater mountain ranges where new oceanic crust is formed. Examples include the Mid-Atlantic Ridge and the East Pacific Rise.
2. **Creation of New Crust:**
   - Magma from the Earth's mantle rises to the surface at mid-ocean ridges. When it reaches the surface, it cools and solidifies to form new oceanic crust.

3. Divergent Boundaries:

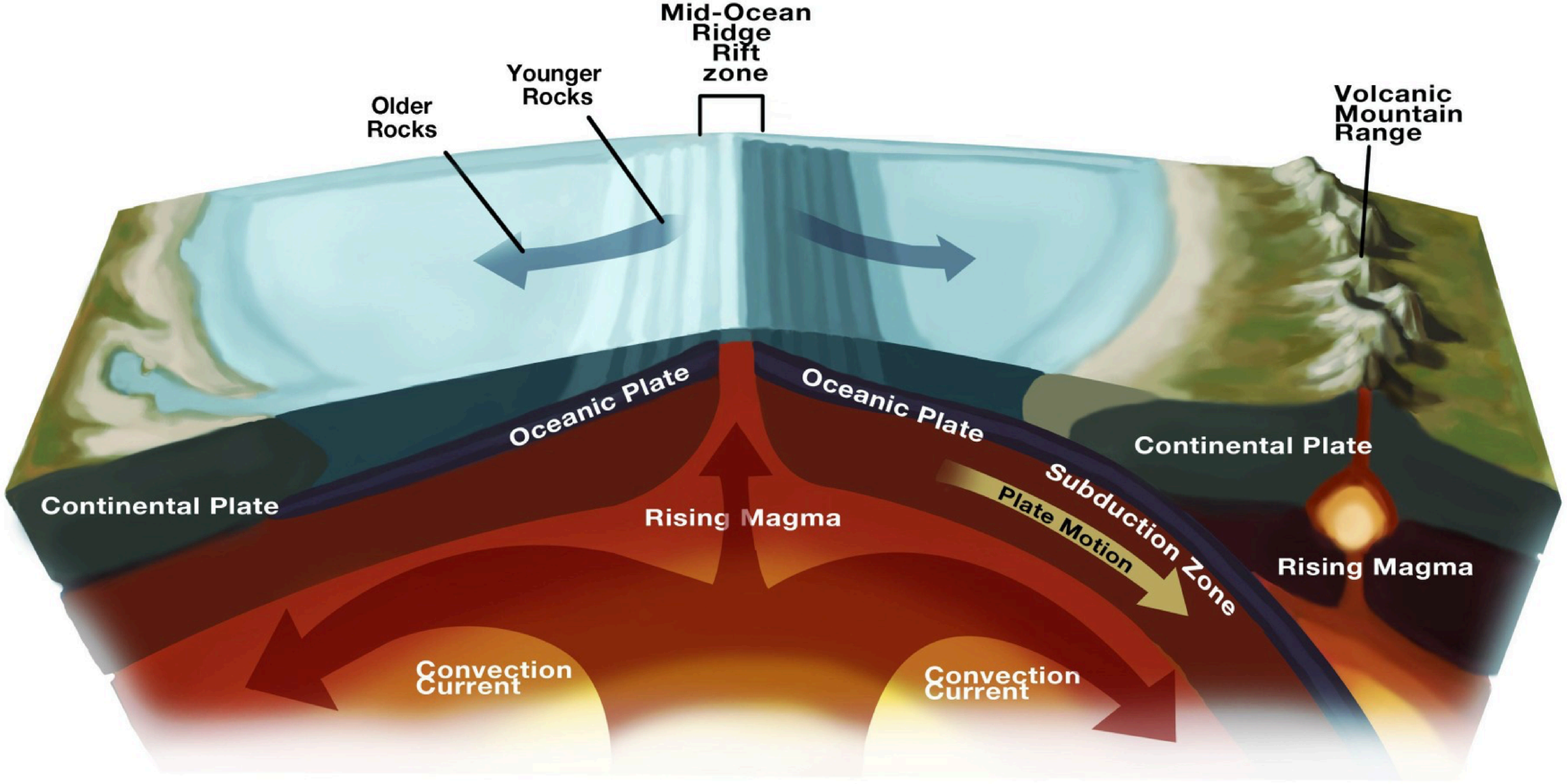
- Mid-ocean ridges are located at divergent plate boundaries where two tectonic plates are moving away from each other. As the plates separate, magma fills the gap, creating new crust.

4. Movement of Oceanic Crust:

- As new crust forms at the ridges, it pushes the older crust away from the ridge, causing the ocean floor to spread. This movement is akin to a conveyor belt.

5. Magnetic Stripes:

- The ocean floor exhibits symmetrical patterns of magnetic stripes on either side of mid-ocean ridges. These stripes are formed by the alignment of magnetic minerals in the basaltic rock with the Earth's magnetic field as the rock cools.
- Periodic reversals of the Earth's magnetic field are recorded in these rocks, providing a time-stamped record of sea-floor spreading.
- **Age of Oceanic Crust:**
- The age of the oceanic crust increases with distance from the mid-ocean ridges. The youngest rocks are found at the ridges, while the oldest rocks are found further away.
- **Subduction Zones:**
- As new oceanic crust is created at mid-ocean ridges, older crust is destroyed at subduction zones, where it sinks back into the mantle. This recycling process balances the creation of new crust.


Mid-Ocean Ridge Rift zone
Younger Rocks
Older Rocks
Volcanic Mountain Range
Oceanic Plate
Oceanic Plate
Continental Plate
Continental Plate
Rising Magma
Subduction Zone
Plate Motion
Rising Magma
Convection Current
Convection Current

Evidence for Sea-Floor Spreading:

- **Magnetic Anomalies:** Symmetrical magnetic patterns on the ocean floor.
- **Age Dating:** Radiometric dating of oceanic rocks shows increasing age with distance from ridges.
- **Sediment Thickness:** The thickness of sediment layers increases with distance from mid-ocean ridges, consistent with older crust being further from the ridge.

Importance of Sea-Floor Spreading

- **Supports Plate Tectonics**: Sea-floor spreading provides a mechanism for the movement of tectonic plates, supporting the theory of Plate Tectonics.
- **Explains Ocean Basin Formation:** It explains the creation and expansion of ocean basins.
- **Geological Activity:** Helps understand the distribution of earthquakes and volcanic activity along mid-ocean ridges and subduction zones.

Here are the key figures associated with the development of Plate Tectonics Theory:

1. Alfred Wegener
2. Arthur Holmes
3. Harry Hess
4. Marie Tharp
5. Bruce Heezen
6. Fred Vine
7. Drummond Matthews
8. Lawrence Morley
9. John Tuzo Wilson
10. Dan McKenzie
11. Robert Parker
12. W. Jason Morgan

- **Folded Mountains:** Formed by the compression of tectonic plates at convergent plate boundaries, resulting in the folding and uplift of sedimentary rock layers. Examples include the Appalachians, Alps, and Himalayas.
- **Unfolded Mountains:** Formed by the uplift of fault blocks along fault lines in the Earth's crust, resulting in steep cliffs and rugged terrain. Examples include the Sierra Nevada Mountains and Basin and Range Province.

Both types of mountains provide valuable insights into the dynamic processes that shape the Earth's crust and contribute to the diverse geological landscapes found around the world.

- **Shield Volcanoes: Broad, dome-shaped volcanoes with gentle slopes, characterized by effusive eruptions.**
- **Stratovolcanoes: Steep-sided, conical volcanoes with explosive eruptions, composed of layers of lava and volcanic ash.**
- **Cinder Cone Volcanoes: Small, steep-sided volcanoes formed from ejected volcanic materials, resulting in short-lived explosive eruptions.**