Plate Tectonics

Chapter 2
**Scientific Method**

1. **Observation (fact)**
   - This is a *repeatable* measurement or experiment

2. **Hypothesis**
   - One or more possible explanations to link observations

3. **Testing**
   - Further experiment or observation to test hypothesis
   - Non-testable hypotheses also rejected

4. **Theory**
   - A grand or unifying hypothesis that has survived tests
   - Relativity, Evolution, Plate tectonics
1. Observation: Early Evidence (Wegener)

- The geometric fit of the continents.
- The similarity in rock age groups between adjoining regions.
- The similarity in Paleozoic fossils between adjoining areas.
- The distribution of Paleozoic glaciation in S. America, S. Africa, Australia, and India.
The geometric fit of the continents.
Similarity of Paleozoic Fossils in adjoining regions.
Early Objections

- Mantle is solid (Transmits S-waves).
- How can continents move and remain intact?
- What is the driving force?
Compelling New Evidence: Magnetic Anomalies

- Magnetic minerals such as magnetite ($\text{Fe}_3\text{O}_4$) record Earth’s field.
- They also perturb the field by a small amount.
- Perturbations are called magnetic anomalies.
- Anomalies can be mapped using magnetometers dragged behind aircraft or ships.
Magnetic stripes on ocean floor
Magnetic Anomalies

- Anomalies were first solid evidence of sea-floor spreading.
- Here was a credible hypothesis that demanded testing.
2. The Hypothesis:

- The continents have moved (drifted) over geologic time so that North and South America have separated from Europe and Africa.
3. Test the Hypothesis

- The hypothesis makes several predictions that allow it to be tested by further observation.
  - Rocks in adjoining parts of Africa and South America should be similar in age and type.
  - Rocks on Atlantic floor should get younger toward the mid-ocean ridge.
  - New bathymetric measurements define the continental crust boundary. Do South America and Africa still fit together?
  - If crust is being created at mid-ocean ridges, it should also be consumed. Where is the crust consumed?
  - There needs to be a driving force.
3. Test the Hypothesis

- Rocks in adjoining parts of Africa and South America were age-dated using new radio-isotopic methods: they matched perfectly.

- Rocks were dredged from the sea floor: they showed ages symmetrically increasing away from the ridge. There were no old (>250MY) rocks.

- The fit of continents was revised using the edge of the continental slope rather than the coastline: the match was nearly perfect.
3. Test the Hypothesis

Rocks were dredged from the sea floor: They showed ages symmetrically increasing away from the ridge.

There were no old rocks (>250MY).
Rock terranes match in age and type.
Fit of continental shelf boundaries is nearly perfect
Test the Hypothesis

- Seismic evidence suggested that crust was being subducted (returned to the mantle) at **convergent boundaries** to balance crust production at the ridges.
- Hess proposed a plausible mechanism for the driving force that moved continents: **thermal convection** in the solid mantle.
4. Theory of Plate Tectonics

• There appear to be 13 major plates that cover the globe.
• The plates can contain oceanic, or continental crust or both.
• New oceanic crust is created at the mid-ocean ridge (divergent boundary).
• Old oceanic crust is consumed (subducted) at convergent plate boundaries.
There appear to be 13 major plates that cover the globe.
Theory of Plate Tectonics

- Continental crust resists subduction.
- Continent-continent convergent boundaries form major mountains.
- Ocean-ocean and ocean-continent convergent boundaries form subduction zones marked by deep ocean trenches and Benioff Zones (deep earthquake zones extending to 670km).
Passive and Active Continental Margins