Plate Tectonics

The Prune Effect - 1800s
The molten Earth cools and contracts
The crust wrinkles and crumples
Mountains form

Problems
What about rift valleys?
What about shape and position of the continents?

The Expanding Earth
20th century - radioactive decay
Land masses are ripped apart
Explains the continents

Problems
What about the mountains?

Continental Drift
An idea before its time
- Alfred Wegener 1915
- Processor to plate tectonics
Pangaea – supercontinent (200 million years ago)
Land fragmented and floated around

Lines of Evidence for Continental Drift
1. Matching Coastlines
2. Matching Geology
3. Glacial Striations
4. Fossil Evidence
   Glossopteris
   Mesosaurus - links South America and Africa during the late Paleozoic and early Mesozoic eras.
5. Apparent Polar Wandering
   - The Earth has a magnetic field. This creates an invisible force field in space. We can detect this field with a compass -- a compass needle aligns with magnetic field lines.
   - We can represent this field by an arrow that points from the north magnetic pole to the south magnetic pole, through the center of the Earth.
   - Geologists discovered that rocks contain tiny magnetic mineral grains, each of which acts like a tiny compass needle and points to the Earth's magnetic poles.
   - When an igneous rock, like basalt, forms, these needles (representing the magnetization of the magnetic grains) align with Earth's field and lock into place.
   - The magnetization of recently-formed lavas points toward the present-day magnetic poles (which is near, but not exactly at the geographic poles).
   - But the magnetization in older rocks does not point toward MNP. Why not? One possible explanation would be that the location of the magnetic pole has changed through
time, an idea known as polar wandering.
- Geologists measured magnetism in rocks of different ages in North America and constructed a polar-wander path (PWP), to show how the pole had moved through time.
- They did the same for rocks in Europe and found that the PWP is different from the PWP for North America. This didn't make sense!
- So, polar wandering does not occur!! The magnetic pole doesn't wander. The pole stays fixed, and continents move. So, we call the trace of the pole relative to the continent and "apparent polar-wander path."
- The occurrence of apparent polar-wander paths means that continental drift does occur.

**Unifying Theory - Plate Tectonics**

**Tectonic cycle**- deals with the movement and interactions of the lithospheric plates. The theory describing the movement of the continents and the mechanism which drives them. It brings together two earlier theories (continental drift and sea-floor spreading). This is the “Unifying” theory of geology and explains many of the landforms we see and processes which form them.

**Ring of fire** – location around plate margins where most earthquakes and volcanoes occur.

**Paleomagnetism** – as iron rich rock cools the iron crystals align themselves with the north pole. Geologists notice the “compass needle” in rocks have reversed many times during the Earth’s history. Mapping these reversals along with geochronology of the ocean crust further solidify the theory of plate tectonics.

**Plate Boundaries / Margins**

**Divergent Plate Boundaries**
1. continental - rift valleys
2. ocean - mid-oceanic ridge / spreading sea floor

**Transform Plate Boundaries**

**Convergent Plate Boundaries**
1. Oceanic - Continental
2. Oceanic – Oceanic
3. Continental - Continental

**Convergent** - when two plates move toward one another, they form either a subduction zone or a continental collision. This depends on the nature of the plates involved. In a subduction zone, the subducting plate, which is normally a plate with oceanic crust, moves beneath the other plate, which can be made of either oceanic or continental crust. During collisions between two continental plates, large mountain ranges, such as the Himalayas are formed.

**Divergent** - linear feature that exists between two tectonic plates that are moving away from each other. These areas can form in the middle of continents but eventually form ocean basins. Divergent boundaries within continents initially produce rifts which produce rift valleys. If the
rafting process stops, a failed rift results. Therefore, most active divergent plate boundaries are between oceanic plates and are often called oceanic rifts.

**Transform fault** - a fault which runs along the boundary of a tectonic plate. The relative motion of such plates is horizontal in either left or dextral right. Typically, some vertical motion may also exist, but the principal vectors in a transform fault are oriented horizontally.

**Hot Spots** – hot spots are locations on the Earth’s crust where large plumes of magma (mantle plumes) have made it to the surface (or are close). Think Yellowstone and Hawaii!

**Forces and Rates**

**Rates** – plate motion varies however most plates are moving approximately 1 – 15 cm per year. This may seem slow however given the vast amount of geologic time, plates have moved great distances

**Forces** –

- Slab pull – the cooler denser crusts at the sub-ducting edge of the plate acts like a large anchor helping pull the plate

- Ridge push – hot thin crust at the spreading centers are higher in elevation than the cool, dense, thicker crust near the subduction margins. The hot thin crust then assists in “pushing” the crust as it glides over the asthenosphere. The reason for the “push” is largely due to the difference in gravitational potential energy from the change in elevation