Plate Tectonics

Plate Tectonics is a unifying theory that states that the Earth is composed of lithospheric crustal plates that move slowly, change size, and interact with one another.

This theory was amalgamated from a variety of studies that began in the early 20th century and culminated in the 1960s.

Earliest History Related to Plate Tectonics
About 1600: The first world maps were made. Antarctica and Australia were missing some details.

Sir Francis Bacon (~1620): noted similarity of the shape of the continents on the southern Atlantic Ocean.

Francois Placet (1666): suggested that prior to the "Great Flood" the land was undivided by oceans and that the Atlantic formed when Atlantis sank.

Antonio Snider (1858): developed a theory that when the Earth cooled from a molten mass, continents formed on only one side. This caused instability causing the Americas to be pulled away from the rest of the continents.

Early Players:
Inge Lehmann (1888-1993): discovered P Wave Shadow Zones

Richard Oldham (1858-1936): discovered the S Wave Shadow Zone, including the fact that the outer core is liquid

Eduard Suess (1831-1914): published internal structure of the Earth, utilizing some of Oldham's data, suggested that all of the continents were joined as a supercontinent Gondwanaland.

Andrija Mohorovicic (1857-1936): discovered the seismic discontinuity between the crust and the mantle, known as the Moho.

Beno Gutenberg (1889-1960): found the CMB to be at 2900 km

The Great Synthesizer: Alfred Wegener (1880-1930)
Book: *The Origin of Continents and Oceans* (1915)

Found six major pieces of evidence the continents move, hence his theory is known as Continental Drift. (Figures)
1) The shape of the continents: they fit together
2) Paleontological Evidence: found matching fossils on several continents
    a) Glossopteris: found in rocks of the same age on South America, South Africa, Australia, India and Antarctica
    b) Lystrosaurus: found in rocks of the same age on Africa, India, also some in Asia and Antarctica
    c) Mesosaurus: found in rocks of the same age on South America, South Africa
    d) Cynognathus: found in rocks of the same age on South America, South Africa

3) Glacial Evidence: the glaciers appear to originate from the modern-day oceans (which is impossible)
4) Structure and Rock Type: geologic features end on one continent and reappear on the other (South America and Africa)
5) Paleoclimate Zones: like today, the old Earth had climate zones.
6) Polar Wandering: ancient poles were in different positions than the present poles.

This can only be explained by:
1) Continents remained still and the poles moved
2) Poles were still and the continents moved
(Reality: they both move)

Wegener’s theory was not accepted. Why?

By his death, Continental Drift had gone into obscurity.

Arthur Holmes (1890-1965): proposed that mantle convection may be the cause for Continental Drift.

Then, in the early 1960s, the theory of Seafloor Spreading came about from Robert Dietz (1914-1995) and Harry Hess (1906-1969).

Sea Floor Spreading: the crust is being driven apart by convection currents at mid-ocean ridges (what would later be called Divergent boundaries, where crust is created).

This theory would supported by Paleomagnetic Studies, most notable the Polar Reversal studies of Morley (the first), and later Vine and Matthews.

Iron minerals in the rock preserve information about the magnetic field at the time the rock was formed.

J. Tuzo Wilson (1908-1993): the Earth’s surface is composed of plates. Also identified the Transform Faults associated with the mid-ocean ridges (Divergent Boundaries).
>*A new class of faults and their bearing on continental drift*

The Lamont guys (Sykes, Oliver and Isacks) published papers on the process of subduction, or how crust is destroyed.

Supporting Evidence From the Ocean Floor

Sonar Mapping Indicated Many Features on the Ocean Floor:

1) Mid-Ocean Ridge: can be seen all around the Earth, similar to seems on a baseball.
 >the existence of the ridge
 >high heat flow
 >shallow focus earthquakes
 >basalt eruptions
2) Oceanic Trenches
 >the existence of the trench
 >Low heat flow
 >large negative gravity anomalies
 >Benioff Zones of earthquakes
 >nearby andesitic volcanism
3) Age of the Seafloor: magnetic stripes, as seen above with Vine, Matthews and Morley
4) Volcanic Islands, Seamounts and Guyots

5) Fracture Zones

Plates and Plate Motion

Plate: large mobile slab of lithosphere.

The plates can be made of…

continental crust:	oceanic crust:
a) Composition	a) Composition
b) Thickness	b) Thickness
c) Density	c) Density
d) Character	d) Character

The lithosphere "floats" on the asthenosphere, the gooey layer underneath. At the boundary of each slab of lithosphere, some sort of interaction occurs:
1) Convergence: where the plates move together
2) Divergence: where they are moving apart
3) Transform: where they are moving horizontally past each other.

Review of Geophysical/Compositional Diagram

Diverging Plate Boundaries
>creation of crust occurs here

Where?: Mid-ocean ridges, and East Africa (Figures)

Transform Boundaries
>are really part of Divergent in many ways.
>no creation or destruction, just movement
Not to be confused with Transform Faults, which offset Divergent Boundaries (and hence the connection between the two types of boundaries).

Special Case of Transform Boundary

Convergent Boundaries
>these boundaries can be conservative (no creation or destruction), or destructive, where there is a subduction zone.

1) Ocean-ocean Convergence

2) Ocean-Continent Convergence

3) Continent-continent Convergence

Other Special Features:

Hot Spots, such as the Hawaiian Islands

Aulocogen, and Continental Rifting

The Motion of Plate Boundaries

Plates get larger or smaller.

Examples:

Larger

Smaller

Plate Tectonics help explain:

1) Location of volcanism

2) Earthquake distribution

3) Mountain distribution

What causes plate motions?

Ridge-push vs. Slab Pull