Development of a Theory
Chapter 29: Continental Drift & Plate Tectonics

As the continents drift apart, Bob tries one last time to save his faithful dog Rex.

How are Mountains & Continents Formed?
- Prior to the early 1900’s we had no clue!
- It was thought that mountains were pushed up from below somehow
- So how would you go about trying to come up with an explanation (a theory)?
  - Make a hypothesis
  - Collect evidence
  - Review the evidence to see if it fits the hypothesis
  - Revise the hypothesis and formulate a theory

Alfred Wegener
- Born Nov 1, 1880 in Germany
- Earned PhD in astronomy in 1904, Univ. of Berlin
- However, he was most interested in meteorology and geophysics
- 1914 drafted into German army, but was wounded early on and released
- While convalescing in the hospital, he began to write and put together some ideas he had been thinking about for some time about the continents
- Published in 1915 the 1st edition of his treatise “The Origin of the Continents and Oceans”

What was the Evidence?
- Jigsaw Fit of Continents
- Structural Fit of Continents
- Patterns of Ancient Continental Glaciations and other Paleoclimate Indicators
- Patterns of Fossil Occurrence
- Changing magnetic field directions in ancient rocks

Jigsaw fit of the Continents
- geographical evidence
- the shapes of the continents align closely at their coasts, and even better at their continental shelves

geographical evidence
Structural Fit of Continents

Not only do the shapes match, the type of rock matches too...and you don't get identical rock types by accident.

Patterns of Ancient Glaciation

paleoclimatic evidence

- glacial deposits
- rocks scratched by stones trapped in moving ice
- How many continental glaciers would you expect to find in India? Africa? South America?

Other Paleoclimate Indicators

Patterns of Fossil Occurrence

- Glossopteris
- Lystrosaurus

Glossopteris
Lystrosaurus

Evidence of the Taconic and Alleghanian orogenies has been found in Africa, Antarctica, and India.
Earth’s Magnetic Field

Igneous rocks that contain iron record the orientation of Earth’s magnetic field. Magnetic minerals lock-in in the direction of earth’s magnetic field when they solidify. Field reversals do happen. Ancient igneous rocks, even those that have about the same age, have magnetic fields that point in different directions.

Apparent Polar Wander

Where have the magnetic poles been in the past?

- What kind of polar wandering curves would we see if the continents were moving?
- What would the curves be like if the continents were once together but have now drifted apart?
- How could we get information on where the magnetic poles were in the past?

If the continents were together, then they do give a single location for the magnetic pole!

While looking back, I suppose it’s been going on for quite some time... but I only noticed we were drifting apart during the last 50 million years...
failure of continental drift theory
- observations:
  - the continents drift
  - continental rock is less dense than ocean-floor rock
- theory: the continents slide *through* the oceanic rock as a raft moves through water
- fact: the ocean floors are **much too rigid** for the continents to be shoved through or over them by any force imaginable

How was Wegener’s Theory received?
- Rollin T. Chamberlin (U of Chicago, 1928)
  “Wegener’s hypothesis in general is of the footloose type, in that it takes considerable liberty with our globe, and is less bound by restrictions or tied down by awkward, ugly facts than most of its rival theories. Its appeal seems to lie in the fact that it plays a game in which there are few restrictive rules and no sharply drawn code of conduct.”

Bailey Willis (Stanford Univ., 1928)
“When we consider the manner in which the theory is presented, we find that the author offers no direct proof of its verity; that the indirect proofs assembled from geology, paleontology, and geophysics prove nothing in regard to drift…; that the fields of related sciences have been searched for arguments that would lend color to the adopted theory, whereas facts and principles opposed to it have been ignored. Thus the book leaves the impression that it has been written by an advocate rather than by an impartial investigator.”

Harold Jeffreys (Cambridge U., 1924)
“It is an impossible hypothesis! How can a small force not only produce indefinitely great movement, but overcome a force many times greater acting in the opposite direction at the same time?”

So, What Turned the Tide?
- The discovery, after WWII, of things that were hidden beneath the oceans during Wegener’s lifetime (he died in 1930).
  - The weight of evidence became too great to ignore
- The proposal of a mechanism (convection) for moving the continents.
  - Even though convection had been proposed in Wegener’s time, it was now looked at with renewed interest
- This led to the development of the “Theory of Plate Tectonics”

What was the New Evidence?
- Topography of Seafloor
  - Mid-ocean ridge
  - Trenches
  - Seamounts and Guyots
- Magnetic Reversals on Seafloor
- Thickness of Sediment on Seafloor
- Age of Basalts and Sediment on Seafloor
- Patterns in Earthquakes and Volcanoes
  - Associations between them and seafloor features
  - Benioff Zones
Topography of Seafloor

Seamounts and Guyots

Magnetic Reversals

Trenches
the answer: plate tectonics

Continental Drift 1912

Sea floor Spreading 1960-62

Plate Tectonics 1967

plate tectonics is a new model which reconciles and unifies continental drift and sea floor spreading

Benioff Zones – Subduction

- Named for U.S. geophysicist Hugo Benioff
- He observed a pattern of earthquake focal depths near trenches, which he concluded confirmed the idea of recycling of the oceanic crust and its convection.
- What was this pattern?
How Do You Move a Continent?

Come back next time and find out!