

Lab: Dance of the Continents

(modified from Life on an Ocean Planet)



Background: When Alfred Wegener first proposed his radical new theory of continental drift, he knew that it was going to be an uphill battle to get his scientific colleagues to take him seriously. Many scientists face the same challenge when proposing a radical new theory. When first proposed by Wegener, continental drift was severely ridiculed. Nevertheless, steadily accumulating evidence finally prompted scientists to accept it. His theory had immense consequences for geology, geophysics, oceanography, and paleontology.

To support his theory, Wegener had something on his side that many of his predecessors did not have – developing technology. He also had greater access to remote areas, which provided evidence he used to support the theory. Wegener also had better access to published information, allowing him to develop the ideas that would eventually blossom into his continental drift theory.

Born on November 1, 1880, Alfred Wegener earned a PhD in astronomy from the University of Berlin in 1904. However, he also had an interest in

geophysics, meteorology and climatology. During his life, Wegener made several key contributions to meteorology. Wegener pioneered the use of balloons to track air circulation, and wrote a textbook on the subject. The book became a standard reference on meteorology throughout Germany. In 1906, Wegener joined an expedition to Greenland to study polar air circulation. He accepted a post as tutor at the University of Marburg, taking time to visit Greenland again in 1912. While at Marburg, in the autumn of 1911, Wegener was browsing in the university library when he came across a scientific paper that listed fossils of identical plants and animals found on opposite sides of the Atlantic. Intrigued by this information, Wegener began to look for, and to find, more cases of similar organisms separated by great oceans. At the time, science explained such cases by hypothesizing that land bridges had once connected far-flung continents. But, Wegener also noticed the close fit between the coastlines of Africa and South America. Putting the two together, he began to think that the similarities among organisms resulted from the continents having been joined together at one time, not land bridges. To be accepted, such an insight would require large amounts of supporting evidence. Wegener found that large-scale geological features on separated continents often matched very closely when the continents were brought together. For example, the Appalachian mountains of eastern North America matched with the Scottish Highlands. The distinctive rock strata of the Karoo system of South Africa appeared identical to those of the Santa Catarina system in Brazil. Wegener also found that fossils often indicated a climate utterly different from the present climate where they were found. For example, fossils of tropical ferns and cycads are found on the Arctic island of Spitsbergen. All of these facts supported Wegener's theory of continental drift. In 1915, the first edition of *The Origin of Continents and Oceans*, a book outlining Wegener's theory, was published. Later, expanded editions followed. Wegener proposed that about 300 million years ago the continents had formed a single mass, called Pangaea (from the Greek word for all the Earth). Pangaea had split, and its pieces had been moving away from each other ever since. Wegener was not the first to suggest that the continents had once been connected, but he was the first to present extensive evidence for it from several fields.

Reaction to Wegener's theory was almost uniformly hostile. For example, Dr. Rollin T. Chamberlain of the University of Chicago said, "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."

Part of the problem was that Wegener couldn't explain how the continents might move. Wegener thought that the continents moved through the Earth's crust, like icebreakers plowing through ice sheets. He said that centrifugal and tidal forces provided the energy for moving the continents. Opponents noted that plowing through oceanic crust would distort continents beyond recognition, and that centrifugal and tidal forces were far too weak anyway. Another problem was that flaws in Wegener's original data led him to make some incorrect predictions. He suggested that North America and Europe were moving apart at more than 250 cm per year. That's about a hundred times faster than the measured rate.

Some scientists supported Wegener. A South African geologist, Alexander Du Toit, supported continental drift as a plausible explanation for the close similarity of strata and fossils in Africa and South America. Swiss geologist Emile

Argand saw continental collisions as the best explanation for the folded and buckled strata that he observed in the Swiss Alps. Although Wegener's theory found more scattered support after his death, the majority of geologists continued to believe in static continents and land bridges. The revival of the continental drift theory coincided with the increased exploration of the Earth's crust. This was most notable with the exploration of the ocean floor during the early 1950s. By the late 1960s, the plate tectonics theory was well supported and accepted by almost all geologists. Wegener's theory conflicted with plate tectonics on one major point – continents do not plow through the ocean floor. Rather, plate tectonics tell us that both continents and ocean floor form solid plates that float on the asthenosphere. The asthenosphere is the zone in the Earth's mantle located below the lithosphere at between 100 and 200 kilometers. Incidentally, this is why the older term "continental drift" is not quite accurate – all plates drift. Since Wegener's day, scientists have mapped, explored and seen first-hand the great system of oceanic ridges. These ridges are the sites of frequent earthquakes, where molten rock rises from below the crust and hardens into new crust. Dating methods show that the farther away you travel from a ridge, the older the crust is and the older the sediments on top of the crust are. The implication is that the ridges are the sites where plates move apart. Where plates collide, mountain ranges may push up, such as the Himalayas. Or, if one plate sinks below another, deep oceanic trenches and chains of volcanoes form. Earthquakes are frequent along plate boundaries and rift zones. Plotting the location of earthquakes allows seismologists to map plate boundaries and depths. Magnetic data of the crust has also allowed us to map past plate movements more precisely than before. Today, it is even possible to measure the speed of continental plates extremely accurately using satellite technology. Although his explanation for how continents moved wasn't sound, Wegener's basic insights were. Scientists are still researching and expanding the lines of evidence he used to support his theories.

Pre-Lab Questions:

1. What theory was proposed by Alfred Wegener?
2. List three pieces of information that Wegener had that supported his theory.
3. What actions occur at oceanic ridges that we use to collect tectonic information?
4. How does data on magnetic polarity assist us in studying plate movements?

Activity:

- a. You and your partner will be given two maps to examine. Look at the coded areas on the map for fossil and geological evidence found on the landmasses. The fossils give you hints as to how the continents fit together. There are areas that show mountain chains that have the same geology from one continent to another. Pick one map (your partner picks the other) and color the fossil types based on their pattern. Color the continents different colors.
- b. Cut out the continents. NOTE: Do not cut off the continental shelves.
- c. Combine the continents together in the best possible fit to create one large continent. Once you have the best possible fit, glue the pieces to the white piece of paper. When you combine the continents together, some overlap. This is acceptable, especially with Greenland and Europe.
- d. Compare and contrast your map with your partners.

Analysis Questions:

5. What do you feel was the most compelling evidence that the continents were once linked together?
6. Why does it seem that the continents fit together better with today's knowledge than in Wegener's time?
7. Based on the apparent movement of the continents from Pangaea to today, what can you infer about the size of the Atlantic and Pacific Ocean basins at some time in the future?
8. What ocean scanning technology, developed during Wegener's time, could have produced data to support his Theory of Continental Drift?