

5. What was the other theory at the time that explained how mountain ranges formed?

6. Give three examples of the hostile reaction by the scientific community to Wegener's early proposal of continental drift:
 - a.

 - b.

 - c.

7. Why do you think other scientists reacted so harshly?

8. What was the one major weakness in Wegener's theory of continental drift?

ALFRED WEGENER (1880-1930)

adapted from www.pangaea.org/wegener.htm

Alfred Wegener was a German climatologist and geophysicist who, in 1915, published an expanded version of his 1912 book "The Origin of Continents and Oceans". This work was one of the first to suggest continental drift and plate tectonics. He suggested that a supercontinent he called Pangaea had existed in the past, broke up starting 200 million years ago, and that the pieces "drifted" to their present positions. He cited the fit of South America and Africa, ancient climate similarities, fossil evidence (such as the fern *Glossopteris* and *Mesosaurus*), and similarity of rock structures. The American F. B. Taylor had published a rather speculative paper suggesting continental drift in 1910 which, however, had attracted relatively little attention, as had previous such suggestions by Humbolt and Fisher. The book was translated to English in 1924, when it aroused hostile criticism. The proposal remained controversial until the 1960s. *Eric Weisstein: 11 Mar 1996*

The Meteorologist Who Started a Revolution (adapted)

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"Utter, damned rot!" said the president of the prestigious American Philosophical Society. "If we are to believe [this] hypothesis, we must forget everything we have learned in the last 70 years and start all over again," said another American scientist. "Anyone who valued his reputation for scientific sanity would never dare support such a theory", said a British geologist. Thus did most in the scientific community ridicule the concept that would revolutionize the earth sciences and revile the man who dared to propose it, German meteorological pioneer and polar explorer Alfred Wegener. Science historians compare his story with the tribulations of Galileo.

A Geographic Jigsaw Puzzle

"Doesn't the east coast of South America fit exactly against the west coast of Africa, as if they had once been joined?" wrote Wegener to his future wife in December 1910. "This is an idea I'll have to pursue."

The following fall Wegener came across scientific papers promoting the prevailing theory that Africa and South America had once been connected by a continent-size land bridge that had since sunk into the sea. They cited as evidence fossils of identical animals that had lived in both areas simultaneously hundreds of millions of years ago. Wegener was fascinated and searched out other papers about such continental coincidences. As he read, his earlier conjecture that the continents had once been joined became a conviction he would champion for the rest of his life.

Just a few months later, on January 6, 1912, Wegener startled a meeting of the Geological Association in Frankfurt with his radical theory. Dismissing the concept of sunken land bridges, he proposed instead a grand vision of drifting continents and widening seas to explain the evolution of Earth's geography. Four nights later he made a similar presentation to the Society for the Advancement of Natural Science in Marberg, Germany. When he returned to Marberg, Wegener resumed work on continental drift, marshaling all the scientific evidence he could find to support his theory. Using a pioneering interdisciplinary approach, Wegener wrote one of the most influential and controversial books in the history of science: *The Origin of Continents and Oceans*, published in 1915. Because of the First World War, Wegener's book went unnoticed outside Germany. In 1922, however, a third (revised) edition was translated into English, French, Russian, Spanish, and Swedish, pushing Wegener's theory of continental drift to the forefront of debate in the earth sciences.

The Origin of Continents and Oceans

Wegener began by demolishing the theory that large land bridges had once connected the continents and had since sunk into the sea as part of a general cooling and contraction of the Earth. He pointed out that the continents are made of a different, less dense rock (granite) than the volcanic basalt that makes up the deep-sea floor in which Wegener proposed that the continents floated somewhat like icebergs in water. Wegener reasoned that if continent-size land bridges had existed and somehow been forced to the ocean bottom, they would have re-appeared — "bobbed-up" again — when the force was released.

Wegener also offered a more plausible explanation for mountain ranges. The prevailing theory at that time stated that as the Earth cooled and contracted, mountains formed on the Earth's crust just as wrinkles form on the skin of a drying apple. If this were so, however, they should be spread evenly over the Earth; instead mountain ranges occur in narrow bands, usually at the edge of a continent. Wegener said they formed when the edge of a drifting continent crumpled and folded--as when India hit Asia and formed the Himalayas.

He also noted that when you fit Africa and South America together, mountain ranges (and coal deposits) run uninterrupted across both continents, writing: "*It is just as if we were to refit the torn pieces of a newspaper by matching their edges and then check whether the lines of print ran smoothly across. If they do, there is nothing left but to conclude that the pieces were in fact joined in this way*".

By his third edition (1922), Wegener was citing geological evidence that some 300 million years ago all the continents had been joined in a supercontinent stretching from pole to pole. He called it Pangaea (all lands), and said it began to break up about 200 million years ago, when the continents started moving to their current positions.

Fossils and geologic evidence show that most of the continents used to have startlingly different climates than they do today. Wegener thought continental drift was the key to these climatic puzzles, so he and Vladimir Koppen plotted ancient deserts, jungles, and ice sheets on paleogeographic maps based on Wegener's theory. Suddenly the pieces of the puzzles fell into place, producing simple, plausible pictures of past climates. Evidence of the Permo-Carboniferous ice-age era that peaked some 280 million years ago, for example, was scattered over almost half the Earth, including the hottest deserts. On Wegener's map, however, it clustered neatly around the South Pole--because Africa, Antarctica, Australia, and India had once comprised a Southern Hemisphere supercontinent (Gondwanaland). Wegener considered such paleoclimatic validation one of the strongest proofs of his theory. Conversely, continental drift has since become the organizing principle of paleoclimatology and other paleosciences.

Perhaps the best summary of Wegener's revolutionary theory was provided by countryman Hans Cloos: "It placed an easily comprehensible, tremendously exciting structure of ideas upon a solid foundation. It released the continents from the Earth's core and transformed them into icebergs of gneiss [granite] on a sea of basalt. It let them float and drift, break apart and converge. Where they broke away, cracks, rifts, trenches remain; where they collided, ranges of folded mountains appear."

The Wrath of Science

Except for a few converts, the international geological community's reaction to Wegener's theory was militantly hostile. Wegener's cogent and comprehensive work, however, was impossible to ignore and ignited a firestorm of rage and rancor. Moreover, most of the blistering attacks were aimed at Wegener himself, an outsider who seemed to be attacking the very foundations of geology. Because of this abuse, Wegener could not get a professorship at any German university. Fortunately, the University of Graz in Austria was more tolerant of controversy, and in 1924 it appointed him professor of meteorology and geophysics. In 1926 Wegener was invited to an international symposium in New York called to discuss his theory. Though he found some supporters, many speakers were sarcastic to the point of insult.

Scientifically, Wegener's major problem was finding a force or forces that could make the continents "plow around in the mantle," as one critic put it. Wegener tentatively suggested two candidates: centrifugal force caused by the rotation of the Earth, and tidal-type waves in the Earth itself generated by the gravitational pull of the sun and moon. Wegener himself realized later that these forces would not be sufficient, however.

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Vindication of a Visionary

Despite general rejection, Wegener's compelling concept continued to attract a few advocates over the next several decades. Then, beginning in the mid-1950s, a series of confirming discoveries in paleomagnetism and oceanography finally convinced most scientists that continents do indeed move. Moreover, as Wegener had predicted, the movement is part of a grand scale process that causes mountain-building, earthquakes, volcanic eruptions, sea-level fluctuations, and apparent polar wandering as it rearranges Earth's geography. Geologists call the process "plate tectonics," after the large moving plates that form the planet's outer shell. These plates carry both continents and sea floor, but unlike the sea floor, the less-dense, buoyant continents resist subduction into the mantle. Thus, despite significant differences in detail, Alfred Wegener was right in most of his major concepts. Plate tectonics also confirms the accuracy of many of his paleogeographic reconstructions.

During the last few decades, Alfred Wegener has finally gotten the recognition he deserves. Unfortunately, as with most visionaries, it must be posthumous praise.