Historical Plate Tectonics

Name:
Date:

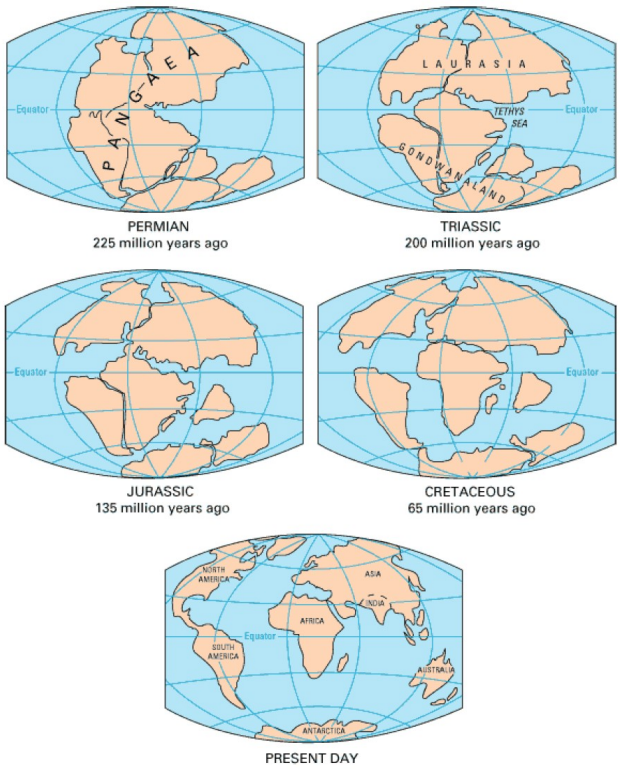
In geologic terms, a *plate* is a large, rigid slab of solid rock. The word *tectonics* comes from the Greek root "to build." Putting these two words together, we get the term *plate tectonics*, which refers to how the Earth's surface is built of plates. The *theory of plate tectonics* states that the Earth's outermost layer is fragmented into a dozen or more large and small plates that are moving relative to one another as they ride atop hotter, more mobile material.

1. Why was plate tectonics given its name?

2. Summarize the theory of plate tectonics.

Before the advent of plate tectonics, however, some people already believed that the present-day continents were the fragmented pieces of preexisting larger landmasses ("supercontinents"). The diagrams below show the break-up of the supercontinent *Pangaea* (meaning "all lands" in Greek), which figured prominently in the *theory of continental drift* – the forerunner to the theory of plate tectonics.

3. Why was the supercontinent given its name?



According to the continental drift theory, the supercontinent Pangaea began to break up about 225-200 million years ago, eventually

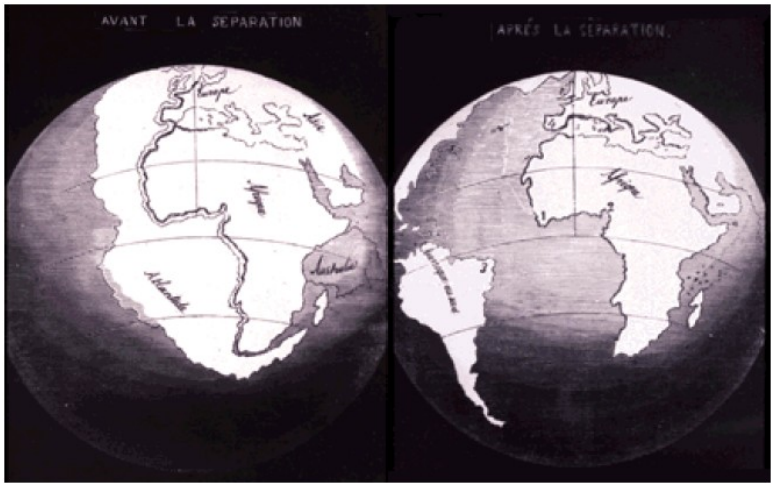
fragmenting into the continents as we know them today.

Plate tectonics is a relatively new scientific concept, introduced some 30 years ago, but it has revolutionized our understanding of the dynamic planet upon which we live. The theory has unified the study of the Earth by drawing together many branches of the earth sciences, from paleontology (the study of fossils) to seismology (the study of earthquakes). It has provided explanations to questions that scientists had speculated upon for centuries -- such as why earthquakes and volcanic eruptions occur in very specific areas around the world, and how and why great mountain ranges like the Alps and Himalayas formed.

The belief that continents have not always been fixed in their present positions was suspected long before the 20th century; this notion was first suggested as early as 1596 by the Dutch map maker Abraham Ortelius in his work *Thesaurus Geographicus*. Ortelius suggested that the Americas were "torn away from Europe and Africa ... by earthquakes and floods" and went on to say: "The vestiges of the rupture reveal themselves, if someone brings forward a map of the world and considers carefully the coasts of the three [continents]." Ortelius' idea surfaced again in the 19th century. However, it was not until 1912 that the idea of moving continents was seriously considered as a full-blown scientific theory -- called Continental Drift -- introduced in two articles published by a 32-year-old German meteorologist named Alfred Lothar Wegener. He contended that, around 200 million years ago, the supercontinent Pangaea began to split apart. Alexander Du Toit, Professor of Geology at Johannesburg University and one of Wegener's staunchest supporters, proposed that Pangaea first broke into two large continental landmasses, Laurasia in the northern hemisphere and Gondwanaland in the southern hemisphere. Laurasia and Gondwanaland then continued to break apart into the various smaller continents that exist today.

4. Who first thought that the land masses of Earth could move?

5. Who put forth the actual theory of Continental Drift?



In 1858, geographer Antonio Snider-Pellegrini made these two maps showing his version of how the American and African continents may once have fit together, then later separated. Left: The formerly joined continents before (avant) their separation. Right: The continents after

(aprés) the separation. (Reproductions of the original maps courtesy of University of California, Berkeley.)

6. What made Wegner curious enough to come up with his theory?

Wegener's theory was based in part on what appeared to him to be the remarkable fit of the South American and African continents, first noted by Abraham Ortelius three centuries earlier. Wegener was also intrigued by the occurrences of unusual geologic structures and of plant and animal fossils found on the matching coastlines of South America and Africa, which are now widely separated by the Atlantic Ocean. He reasoned that it was physically impossible for most of these organisms to have swum or have been transported across the vast oceans. To him, the presence of identical fossil species along the coastal parts of Africa and South America was the most compelling evidence that the two continents were once joined.

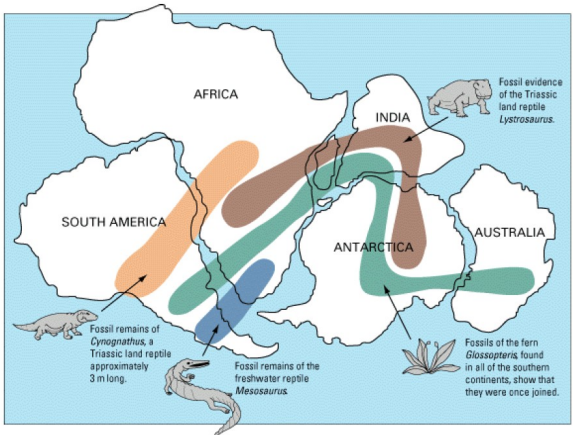
7. What evidence confirmed that Wegener was on the right track?

In Wegener's mind, the drifting of continents after the break-up of Pangaea explained not only the matching fossil occurrences but also the evidence of dramatic climate changes on some continents. For example, the discovery of fossils of tropical plants (in the form of coal deposits) in Antarctica led to the conclusion that this frozen land previously must have been situated closer to the equator, in a more temperate climate where lush, swampy vegetation could grow. Other mismatches of geology and climate included distinctive fossil ferns (Glossopteris) discovered in now-polar regions, and the occurrence of glacial deposits in present-day arid Africa, such as the Vaal River valley of South Africa.

8. Were Wegener's ideas welcomed?

The theory of continental drift would become the spark that ignited a new way of viewing the Earth. But at the time Wegener introduced his theory, the scientific community firmly believed the continents and oceans to be permanent features on the Earth's surface. Not surprisingly, his proposal was not well received, even though it seemed to agree with the scientific information available at the time. A fatal weakness in Wegener's theory was that it could not satisfactorily answer the most fundamental question raised by his critics: What kind of forces could be strong enough to move such large masses of solid rock over such great distances? Wegener suggested that the continents simply plowed through the ocean floor, but Harold Jeffreys, a noted English geophysicist, argued correctly that it was physically impossible for a large mass of solid rock to plow through the ocean floor without breaking up.

9. What was Wegener's fatal flaw?



As noted by Snider-Pellegrini and Wegener, the locations of certain fossil plants and animals on present-day, widely separated continents would form definite patterns, if the continents are rejoined.

10. Did Wegener give up? What proof does the author have to make his claim?

Undaunted by rejection, Wegener devoted the rest of his life to doggedly pursuing additional evidence to defend his theory. He froze to death in 1930 during an expedition crossing the Greenland ice cap, but the controversy he spawned raged on. However, after his death, new evidence from ocean floor exploration and other studies rekindled interest in Wegener's theory, ultimately leading to the development of the theory of plate tectonics.

Plate tectonics has proven to be as important to the earth sciences as the discovery of the structure of the atom was to physics and chemistry and the theory of evolution was to the life sciences. Even though the theory of plate tectonics is now widely accepted by the scientific community, aspects of the theory are still being debated today. Ironically, one of the chief outstanding questions is the one Wegener failed to resolve: What is the nature of the forces propelling the plates? Scientists also debate how plate tectonics may have operated (if at all) earlier in the Earth's history and whether similar processes operate, or have ever operated, on other planets in our solar system.

11. Was Wegener's fatal flaw corrected in Plate Tectonics?

12. Is Earth the only planet with plate tectonics?