# Teacher Guide: Building Pangaea

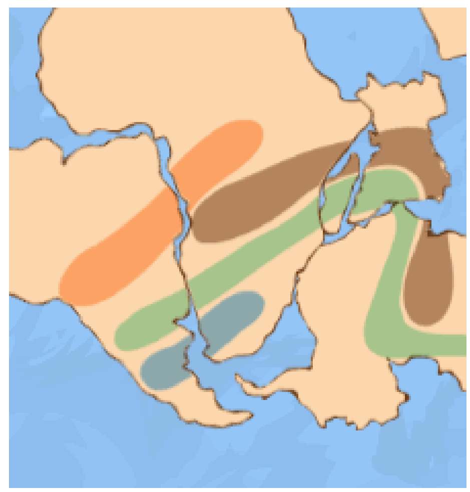
## Learning Objectives
Students will:
- Learn the names of major landmasses.
- Explain the theory of continental drift.
- Fit the landmasses together to form an ancient supercontinent called Pangaea.
- Use several types of evidence (fossils, rocks, glaciers) to revise their model of Pangaea.

## Vocabulary
continental drift, fossil, glacier, ice age, landmass, Pangaea, supercontinent

## Lesson Overview
The *Building Pangaea* Gizmo allows students to explore the fit of the continents that inspired the theories of continental drift and plate tectonics.

The Student Exploration sheet contains three activities:

- Activity A – Students fit the landmasses together to create their version of the supercontinent Pangaea.
- Activity B – Students use evidence from fossils, mountains and rocks to revise and refine their maps.
- Activity C – Glacial evidence is used to further refine the maps of Pangaea.



**Distributions of fossils make sense when the continents are fitted together.**

## Suggested Lesson Sequence

1. **Pre-Gizmo activity: Matching coastlines** (10 – 15 minutes)
   Using a classroom world map, ask students to look closely at the coastlines of Africa and South America. Ask them what they notice, and whether they think that the fit of these continents is just a coincidence or something important.

2. **Prior to using the Gizmo** (10 – 15 minutes)
   *Before* students are at the computers, pass out the Student Exploration sheets and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations. Be sure to demonstrate how to take a screenshot and paste the image into a blank document.

3. **Gizmo activities** (10 – 15 minutes per activity)
   Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo.

Encourage students to paste screenshots of their results into a document so they can compare their work. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (15 – 30 minutes)
As students are working or just after they are done, discuss the following questions:
   - Based on the first map you made (activity A, looking at the fit of coastlines only) do you think there is strong evidence that the continents have moved?
   - Based on the second map (activity B, including fossil and rock evidence) do you think there is strong evidence that the continents have moved?
   - At the time, most scientists did not agree with Wegener's theory. If you were one of those scientists, how would you have explained some of the following things?
     - The fit of the coastlines of Africa and South America.
     - Fossils of animals and plants that are found on opposite sides of large oceans. (After discussing this question, point out that the most popular explanation during Wegener's time was that ancient land bridges used to connect continents across oceans.)
     - Evidence of north-moving glaciers in tropical southern India.

5. **Follow-up activity: What scientists have found** (30 – 60 minutes)
After making their own versions of Pangaea, students may be curious to see how geologists have reconstructed Pangaea. Show an image of Pangaea to your students (see **Web Resources**). Discuss how it is similar to and different from their maps.

   The idea that continents are moving was not accepted until detailed maps of the ocean floor were made. Show your students a map of the ocean floor (see **Web Resources**). Students will see the **Mid-Atlantic Ridge** running down the middle of the Atlantic Ocean, mirroring the coastlines of North America, Europe, Africa and South America. The existence of a worldwide network of mid-ocean ridges inspired the idea of **sea floor spreading**, which led directly to the general theory of **plate tectonics**.

**Scientific Background**
Almost every field of science has experienced a revolution in thinking, and in geology that revolution was plate tectonics. The theory of plate tectonics states that Earth's crust is divided into many slowly moving plates. New crust is constantly formed in mid-ocean ridges, and old crust is devoured in deep-sea trenches. Continents are carried along on the plates like luggage on a conveyer belt. Mountains and volcanoes are formed at the boundaries of colliding plates, and earthquakes occur when plates move suddenly past one another. In fact, almost every major landscape feature on Earth originated from the motions and interactions of plates.

The precursor to plate tectonics was Alfred Wegener's continental drift theory, published in 1915. Wegener assembled many kinds of evidence to support his contention that the continents were once joined in a supercontinent called Pangaea. Four types of evidence are illustrated on the *Building Pangaea* Gizmo.

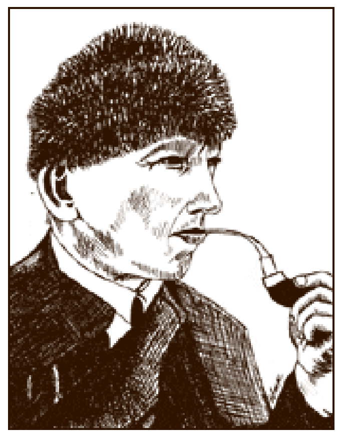
- The coastlines of South America, North America, and Africa fit together. Other landmasses can be joined together as well.

- Many fossil species can be found on continents separated by large oceans. If the continents are joined together, the ranges of these fossil species line up. Four of these species are illustrated in the Gizmo:
    - *Lystrosaurus*, a plant eating reptile more closely related to mammals than dinosaurs.
    - *Cynognathus*, a predatory reptile also related to early mammals.
    - *Mesosaurus*, an aquatic reptile somewhat similar to modern crocodiles.
    - *Glossoptera*, an ancient tree that once dominated Southern Hemisphere forests.
- Distinctive rock layers and mountain ranges also match up when continents are joined together. The Appalachians of North America and the Anti-Atlas range in Morocco are mountains that formed as continents collided 450 million years ago.
- Glacial evidence only makes sense when continents are joined together. For example, India is located just north of the Equator. But glacial scratches on Indian rocks indicate that continental glaciers had once traveled across India, moving north! This only makes sense if India used to be situated fairly close to the South Pole.

## Historical Connection

Like many visionary scientists, Alfred Wegener was ahead of his time. Wegener had many scientific interests. After receiving a degree in astronomy from the University of Berlin, Wegener became interested in meteorology and pioneered the use of weather balloons to study the upper atmosphere. He was also an avid arctic explorer who led several expeditions across the Greenland Ice Cap.

Wegener was certainly not the only one to notice that South America and Africa seemed to fit together. But he was the first to gather extensive geological evidence to back up this idea. Although it was hotly debated, Wegener's theory was ultimately rejected by most of the established geologists of the time, especially in North America. (See **Web resources** for a detailed account of the continental drift debate.)



**Alfred Wegener**
(Hailey King, courtesy of NASA)

Meanwhile, Wegener struggled to find a mechanism that could move giant landmasses over Earth's surface. At first Wegener imagined the continents plowing through the ocean crust and proposed that tidal forces and Earth's rotation caused this motion. After the discovery of the Mid-Atlantic Ridge in 1925, he supported the proposal that convection currents in Earth's mantle carried the continents. This idea was revived in the 1950s and eventually became the core of the theory of plate tectonics. But this was too late for Wegener—in 1930 he died in Greenland.

## Selected Web Resources

Image of Pangaea: http://www.ucmp.berkeley.edu/tectonics/pangaeabig.gif
World Ocean Floor map: http://www.columbia.edu/cu/news/06/08/images/HeezenTharp_900.jpg
Paleomap project (maps of Earth's surface over time): http://www.scotese.com/
Drift and plate tectonics: http://pubs.usgs.gov/gip/dynamic/dynamic.html#anchor19565394
*Plate Tectonics* Gizmo: http://www.explorelearning.com/gizmo/id?446