

Target audience: undergraduate freshmen in Introduction to Earth Sciences or Introduction to Oceanography type of course

Goal: Understand plate tectonics, and more specifically seafloor spreading (continental drift, tectonic activity, paleomagnetism)

Invitation: has anyone ever noticed how the continents fit together? (*assume yes*). Why do you think they aren't together anymore?

- ask for evidence of explanation
- solicit dissenting opinions by asking if anyone has a different explanation
- if plate tectonics hasn't been brought up yet, ask if anyone has heard of it and if anyone can explain the two words (*plate* and *tectonics*)

Introduce basic concepts of plate tectonics. Discussion mixed with explanation. Try to be guide on side, leading students to discuss the processes of density and how it is the underlying cause for plate tectonics

- plate tectonics is term for processes that reshape the face of the planet (i.e. Crust)
- earth made of different layers. What causes those layers? What is the top most layer? (*lithosphere, crust*) Are there different parts to the crust? what are the different parts? (*ocean, land*)
- the earth is made of different layers separated by density. So is the crust. which do you think is more dense- oceanic or continental crust? why? Lead students through thought exercise on why water covers oceanic crust. (*oceanic crust is more dense than continental crust. more dense = sinks into underlying asthenosphere more = lower-lying than continental crust = water covers it*)
- crust isn't one big chunk. Broken into smaller pieces that float around on the asthenosphere. Each of the pieces is a plate. plates usually really big (thousands of kilometers wide) and about 100 km thick. They are all moving, and not necessarily in the same directions.
- What do you think happens as these pieces float around on the lithosphere? (*Bump into one another, go under/over one another, slide past one another*).
- Introduce types of plate boundaries: convergent, divergent, transform
- As plates diverge, what do you think might happen? Is there a big gap left where they diverge? What might fill the gap? (*get students to describe magma from underneath rising up*)
- Introduce convection cells as part of mantle circulation (assume they have covered this in physics or other course). This is how new earth is created- at divergent zones that move plates apart.
- When divergent boundary in ocean, special term- seafloor spreading. Seafloor is spreading apart slowly, and new magma is rising up to fill the hole that's left. Very slow process.
- Can anyone guess how we know this is what's happening?
- We know this is occurring because of paleomagnetism... assume students already know earth switches magnetism directions from time to time.

Exploration: Exercise to understand seafloor spreading and how paleomagnetism offers proof

- In groups of 2, push to tables or desks until only a small crack between them.
- Have each student put blank piece of paper in crack, and practice slowly pulling paper towards them at same rate.
- This is example of plates diverging. As paper pulled apart, new paper comes up to replace old paper. "extends" the plate's size. The new paper is like magma coming up through the crack in crustal plates. What happens when the magma hits the cold seawater? What forms?
- Now we will demonstrate a change in magnetic direction. One of students uses colored marker to color paper at the crack while each student continues to pull paper towards one another. Students then told to switch polarity, so 2nd student then begins coloring paper at the crack.
- Tell them to switch again. This signifies a polarity switch back to the original magnetic direction. Continue until a few switches have occurred and paper is striped different amounts of colors, with mirror images of other side of crack.

Post-exploration discussion:

- Why rock wouldn't change polarity with the earth's switch?
- Which rock is oldest? Youngest?
- Can anyone describe how this is evidence of plate tectonics?
- If there were continents on plates next to your paper, what would be happening to them? (*continental drift*).
- if crust being created at seafloor spreading centers, why isn't earth's surface getting "bigger"? discuss mass balance. Get students to the idea that there must be a place that the earth's crust is going into the mantle. Discussion of convection.

Application:

- have students discuss in small groups or pairs what might be happening at other types of boundaries. This will require thoughts about density differences, convection cells, and rock formation.
- Share ideas as a class, using discussion techniques and appropriate questions to guide class towards "correct" answers. Be sure earthquakes, volcanoes, subduction zones, and trenches are brought up and discussed.

Assessment:

- Explain that the ocean floor is about 200 million years old, but the earth is 4.6 billion years old. Essay question about why the ocean floor is so much younger.