Interactive Notes-"Plate Tectonics"

Materials (per group of 4 students):

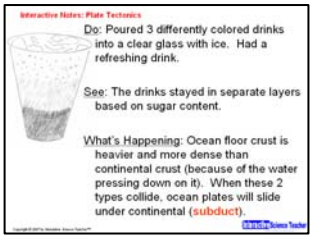
Demo 1	1-hard-boiled egg 1-plastic knife 1-paper plate
Demo 2	1-half of an index card 1-pair scissors 1-black marker
Demo 3	*(nothing new)*
Demo 4	1-large beaker (400mL or 600mL) 2/3 full of water 1-ring stand, ring and wire pad (to set beaker on while it's being heated) 1-candle on stand 1-baggie with potassium permanganate ($KMnO_4$) granules (Item #WW9809104 at sciencekit.com) 1-plastic spoon
…and	4-note sheets (see last page)

Additional Materials for Teacher:

PowerPoint (see last page)
1-lighter for candles
1-globe- to refer to when speaking

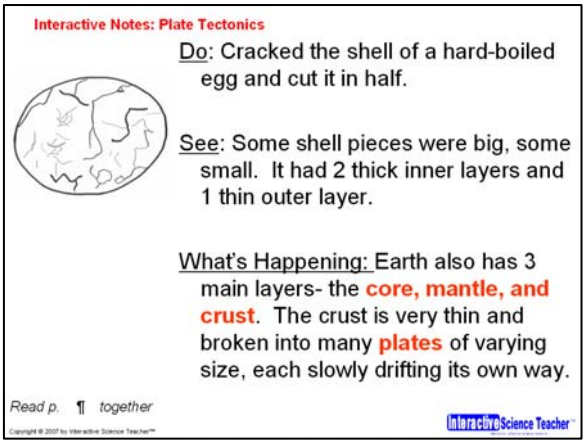
Beforehand:

- With candles being burned today, prepare yourself to use them cautiously. Decide what you'll say to students when you're lighting their candles, and at what point you'll take away their "candle privilege".
- Buy the eggs and hard boil them (boil in water for 10 minutes).
- Instead of putting candles in student boxes at the beginning, you might find it easier (and quicker) to keep them all together, light them, and then have students come and get a lit candle.
- In preparation for demo #1, turn on exhaust fans if you have them (the candles will create smoke when blown out), and remind yourself what to do in case of an emergency with the candles.
- Pour a few $KMnO_4$ granules into plastic bags that can seal shut. In black marker write "potassium permanganate ($KMnO_4$)" on the outside of each.
- Slide 2 compares of how thick earth's crust is with an egg shell. To insert a picture of earth to match that of the egg, do the following: 1. Find a good picture (a good source is http://images.google.com ; type in "earth's interior".) 2. Right-click and "Copy image" when you find one you like. 3. Go to slide two on the PowerPoint and right-click "Paste". 4. Resize it by dragging a corner in. 5. Right-click once more and "send to back", then position it behind the word "Earth".
- There are actually 5 demos that are part of this. The 5th, called "Density Drink" (shown right), has it's own little PowerPoint and set of Teacher Notes. It's separate from the rest because there's not enough time to do all 5 demos, and since the beverage they will make and drink needs to be kept separate from the potassium permanganate.



- Set out all materials *the day before*. Leave yourself time to realize you're missing something, and to practice a new demonstration, research something or even make a change. In the morning read through the slides and notes one last time. Relax and have fun along with your students. Remember- you're only as effective as your plan.
- Insert page and paragraph numbers from relevant pages in your textbook at the bottom of slides 1 and 2 if you choose to have the class read from it together. If your chapter has a figure showing the plates and indicating movement, have them open first to that.
- As with any other demonstration, try these out ahead of time for yourself so you know how they work best and so you know what to expect.
- Print extra copies of the notes pages on paper for yourself, students that are slow writers or can't see well. Click "File" → "Print" → then where it says "Print what:" select "Handouts" → and then "OK".

1.



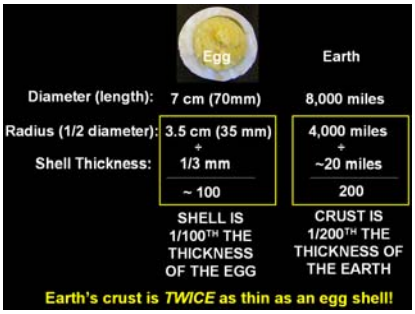
Before student #1 begins, student #4 needs to get their demo set up first. After lighting candles, tell each student #4 to put it on the base of the ring stand and adjust the ring so that it's about an inch above the tip of the flame. Tell students that anyone who plays with the flame will have theirs put out (and be ready to do so!). Then have them set the beaker of water on the wire pad. In 15-20 minutes the convection currents will be going strong.

Ask student #1 to tap their hard-boiled egg on the table, with the paper plate below to control the mess. Ask- "Looking at your eggs, what are some differences in the way cracks formed?" (Some pieces are small, some large. Some are flat, some stick up, and others are pushed in.) Throw in any other comparisons you can- "If this is the earth, I wonder what caused the cracks?" "Do you think the core and mantle of the earth are about as big as the yolk and albumen (white)?"

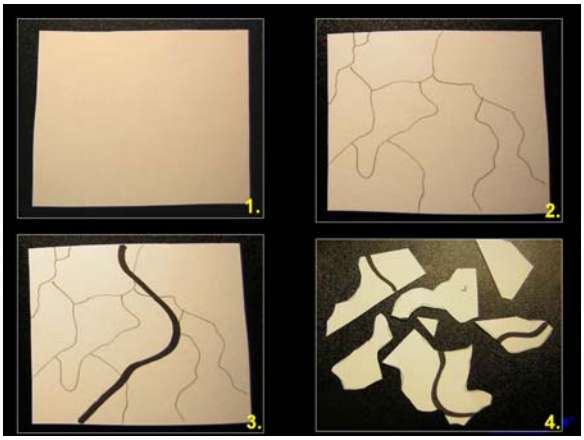
Now have student #1 cut the egg open with the plastic knife to see the inside. See if students know what the 3 layers of the egg represent if compared with earth (the crust, mantle, core). Then add this question that leads into the numerical comparison between the earth and the egg- "See how thin the shell is compared with the egg? Is earth's crust this thin compared with the rest of it?"

Caution: Locate all fire safety equipment and be familiar with their operating procedure BEFORE lighting candles; keep the lighter in your pocket the whole time and blow them out as soon as possible (after demo #4); warn students to keep clothing, hair, hands, and any other flammables away from the flame; comply with the fire codes in your building.

Slide #2 continues on with a numerical comparison between the thickness of the egg shell and the earth's crust. The numbers are a little rounded, but they're not off by much.

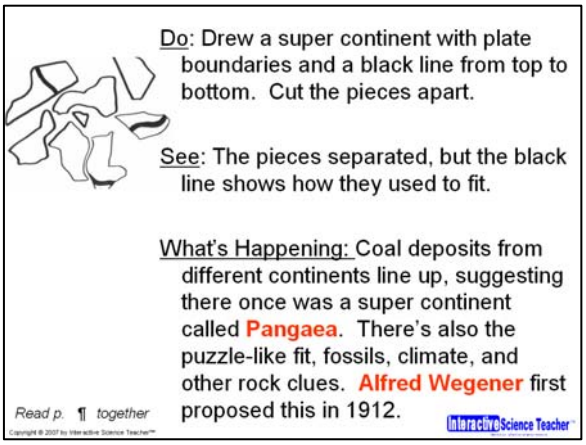


Further reference:
http://earthquake.usgs.gov/research/structure/crust/index.php



Click through this sequence to show student #2 what to do with the note card. First have them draw 4 or 5 lines with pencil to represent plate boundaries, then a black line with marker (this represents a coal deposit). Have them cut the pieces apart along the plate boundaries (pencil lines) and separate their "super-continent" into pieces. As they're working, refer to photo 1 (the card before anything is done to it) as Pangaea- pristine and unbroken, #2 as it with fault lines developing, #3 with a coal seam, and #4 after the pieces have drifted apart.

2.



As students write these notes, remind them of the first time they looked at South America and Africa on a globe or map and noticed that they appeared to be a near-perfect match for each other.

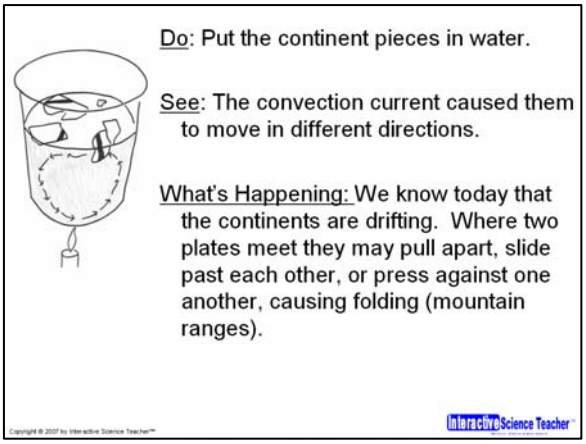
The black marker represents coal seams on earth that run along the coast of continents that are separated now by an ocean. The composition of these coal samples are identical even though they're on difference continent, which suggests that it they used to be together in one, continuous seam that was broken apart.

The "fossil evidence" in the notes refers to the remains of plant and animal species on different continents (some of which, like Antarctica, are now completely un-inhabitable to them now) that no other reasonable theory can account for. Something like Pangaea would give the animal and plant species the ability roam anywhere across a continuous landmass that hadn't yet split and drifted apart.

You can also use this occasion to remind everyone that scientists are as human as anyone else, as is evidenced by the bias and arrogance of geologists in the day of Wegener who couldn't (or wouldn't) listen to reasonable ideas being proposed because they were 1.) new and 2.) different. Even as recently as a few decades ago, the idea of land bridges between the continents was still bought into by some as a way to explain away all the evidence.

Once the theory of continental drift is accepted, everything falls into place, fits together, and makes sense. It explains everything from earthquakes to why climate has changed so much on the continents. There were once glaciers on continents presently on the equator, and tropical plants in the Antarctic.

3.

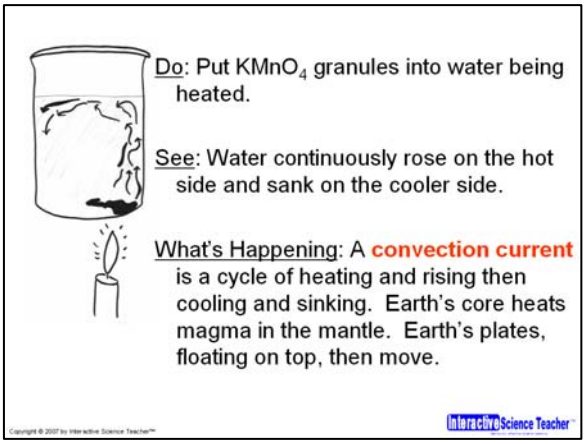


Ask student #3 to drop 2 of the smallest pieces of index card into the center of the beaker. Watch as they either drift off in the same direction, or drift in different directions. Walk around the room and notice out loud that everyone's did something different.

A great trick question that draws even more attention to the pieces floating around is "what's causing the pieces to drift off?" (it's partly the water, but mostly the heat from the candle is causing the water to slowly stir, as they're about to see in the next demo.)

Don't let them put all the note card pieces in, just have them just drop 2 small pieces into the center of the beaker. Any more and they'll all bunch up and nothing will move.

4.



Have student #4 fish the index card pieces out of beaker with a pencil while trying not to disturb the water too much. (This is so they won't have to get them later and come in direct contact with the potassium permanganate.)

Before putting in the $KMnO_4$ have them look into the water and try to detect any movement. It looks like there isn't any. Advance the slide to show the picture of the spoon with a few granules in it- that's all the potassium permanganate they need. Instruct them to drop the granules on the "hot" side of the beaker and watch the beautiful streams of purple show how the water is actually moving. Ask if anyone knows the name of this movement (convection).

This slide opens with a picture of a spoon with some $KMnO_4$ granules in it so that students can see about how much they need to put in. Too many, and the water will quickly turn purple and they won't see the current very well.

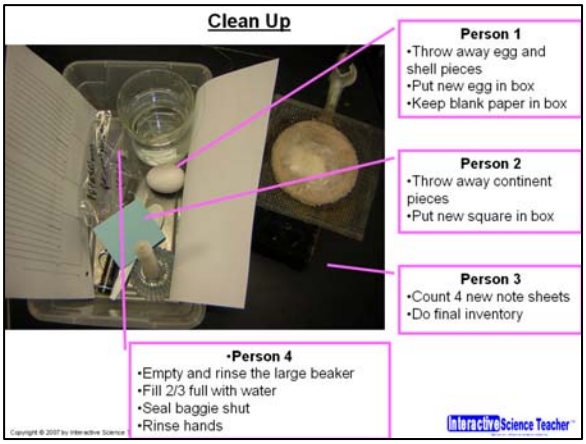
From the time the candles are lit, it takes about 10 minutes for the convection currents to begin to work (that's why this demo was started first). The slow movement of the water is also helpful in relating how slow the magma is stirring inside earth, and thus how slowly the plates are drifting (the average plate moves about 2.5 centimeters a year, which is how fast your fingernails grow). Some scientists believe it takes millions of years for magma inside the earth to make one complete cycle!

If you can't, or would rather not, use candles, then hot plates will work too. But candles heat quicker and are more portable.

If you don't have $KMnO_4$ or it's just too risky for you, another way to show the currents is to add 5 mL of liquid hand soap or shampoo that has either *glycol stearate, glycol distearate or glycerol stearate* in it. It's what gives them their pearly, metallic look, and it will form little "strings" when added to water, allowing you to see the convection currents. This method doesn't show the currents as effectively, though, and is harder to clean up later with all the suds. If you'd rather do the shampoo version, substitute in that drawing.

Blow out candles as soon as you can.

Caution: Potassium Permanganate is slightly toxic and reactive. Familiarize yourself with the MSDS sheet . This demo was set up so that students would never come in direct contact with it. All bags should be sealed up to when the $KMnO_4$ is spooned, and then resealed immediately after. Potassium permanganate is also a strong oxidizing agent, so it should remain a safe distance from the candle flame, as should anything else flammable.



Use this slide to direct students how to clean up and reset everything for the next class. You'll need at least 5 minutes to reset everything for the next class.

Refills to have in various places around your room:

- Index card halves
- hard-boiled eggs
- note sheets
- extra paper plates

Remind student #4 to wash/rinse hands, to remove any residual potassium permanganate.

This is a clean-up that you'll want to make rounds during, to make sure all boxes were reset properly.

If you choose not to use this slide, you can right-click the slide and select "Hide Slide".

To help you with clean up, have your last science class take everything out of the boxes and put them in like piles in the back of your room.

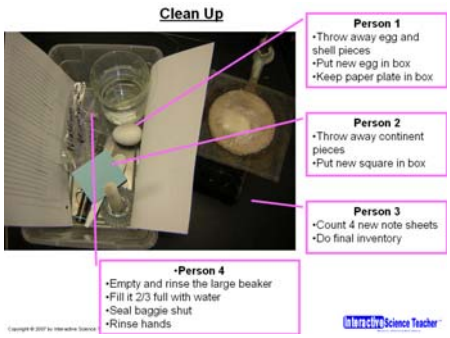
Come back and visit InteractiveScienceTeacher.com to upgrade this lesson with:

PowerPoint- lead your students through the lesson click-by-click

Do: Put the continent pieces in water.

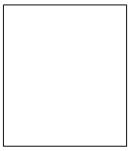
See: The convection current caused them to move in different directions.

What's Happening: We know today that the continents are drifting. Where two plates meet they may pull apart, slide past each other, or press against one another, causing folding (mountain ranges).



Student Handout

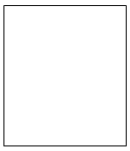
Topic: _____ Date: ___/___/___



Do: _____

See: _____

What's happening: _____



Do: _____

See: _____

What's happening: _____