Interactive Science Content Presentation: Currents

Overview:

This session uses a series of demonstrations to illustrate the causes of ocean circulation—both at the surface of the ocean and in the deep ocean. There are three demos: 1) wind: wind moves water at the surface of a small tank; 2) temperature: in a tank of room-temperature water, cold water sinks and warm water rises; and 3) salinity: salty water is denser than fresh water, and in a tornado-tube/bottle set-up, salty water sinks. Together, these demos illustrate thermohaline circulation. For each demonstration, the instructor sets up a question, the students discuss the question with each other and make predictions, and the instructor does the demonstration. Students see with their own eyes whether their predictions were correct. This lesson was designed for use in a lecture setting: demos are done at the front of the classroom/lecture hall, and are accompanied by a PowerPoint presentation. The lesson works equally well in a smaller lab environment.

About the Interactive Science Content Presentations:
These presentations are designed to model how effective strategies in teaching and learning can be used in a variety of educational settings at the college level.

Session Objectives:

- To visually demonstrate what drives deep currents: differences in density due to differences in temperature and salinity.
- To model the making and testing of hypotheses.

Time Frame:
About 25 minutes.

Materials Needed:

- Computer and digital projector
- Chalkboard or whiteboard
- PowerPoint presentation: COSIA_Currents.ppt
- For the wind demo:
    - Overhead projector
    - Overhead transparency with image of world (see pg. 7)
    - Clear plastic bin that can hold water
    - Items that will sink, such as marbles or small pebbles
    - Items that will float, such as bits of plastic confetti
    - Drinking straw
- For the temperature demo:

  - Fish tank or tub with clear glass or plastic sides, minimum size ~1.5 gallons
  - Several sheets of white paper
  - Tape
  - Two Styrofoam cups
  - Two thumbtacks
  - Marbles or small pebbles
  - Two binder clips (optional – see below)
  - Fresh water
  - Ice
  - Small pitcher or large cup for holding ice/ice water
  - Hot pot/kettle
  - Red and blue food coloring
  - Two spoons, stir sticks, or popsicle sticks
- For the salinity demo:
  - Two small plastic bottles and one lid for the bottle – Fiji brand water bottles work well, because the bottle has straight sides.
  - Tornado tube, a plastic tube that screws onto the tops of the water bottles and connects them. Tornado tubes can be found at toy stores and on Amazon.com.
  - Flat piece of plastic – a circle with a diameter of 3-4 inches, cut from the lid of a yogurt or similar food container, works well.
  - A pitcher of fresh water at room temperature
  - Salt water, dyed green, at room temperature. Recommend mixing this in advance.
    - Salt
    - Food coloring – green recommended

Preparation Before Class Begins:

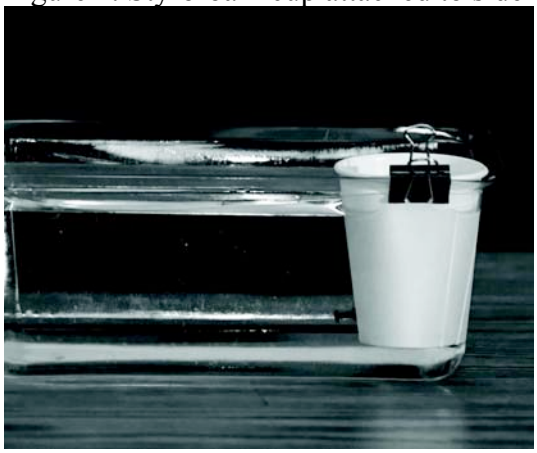
- **Wind Demo:**
  1. Fill the tank with water, about 2/3 full.
  2. Set up the overhead projector so it projects on the screen at the front of the lecture hall.
  3. Put the transparency of the world ocean on the overhead projector, and the tank on top of the transparency, so when you turn on the projector's light bulb, the water in the tank covers the image world ocean.
  4. Have the marbles, floating objects, and straw nearby.

- **Temperature Demo:**
  1. Place the tank on a table at the front of the classroom. Tape pieces of white paper to the outside of the back of the tank; this will make the movement of the colored water easier for the students to see. Fill the tank about half-full with room-temperature water (good to do this using a pitcher).
  2. Place the marbles in the Styrofoam cups (the cups will be nearly full) and put the cups in the water. You'll have to adjust the number of marbles and the amount of water in the tank so that the cups sit on the bottom of the tank, and

the water from the tanks does not flood into the cups. Alternatively, you can attach each cup to the side of the tank using a binder clip. See Figure 1.

3. Take the scups out of the water for a minute, and pierce the side of each cup with a thumbtack. Put the hole at the same height on each cup, about midway up the side of the cup. Colored water will eventually flow out of the holes – you want students to be able to see the water move up or down in the water column. Once you've pierced the cup with the thumbtack, wiggle the tack around a bit to make the hole larger. Leave the tack in the cup.
4. Fill the electric kettle with water, ready to plug in/turn on.
5. Fill the small pitcher/large cup with ice, and add a little water.
6. Have the food coloring and spoons/stir sticks nearby.

Figure 1. Styrofoam cup attached to side of tank using a binder clip.



- **Salinity Demo:**
  NOTE**:** During the demo, you will need to attach the tornado tube to one bottle that is full of water, then take another (full) bottle, cover the opening with a piece of plastic, invert it over the tornado tube, remove the plastic, and screw the top bottle onto the tube. This can be kind of stressful if you've never done it before, so we recommend trying it out (without food coloring!) a few times before class.
  1. Mix the salty green water: in one bottle, add about 3 tablespoons of salt, 6 drops (or more) of green food coloring, and water. Put the lid on and shake vigorously. Return and shake it every few minutes, until the salt is dissolved.
  2. Fill the other bottle with fresh water. Have a pitcher of fresh water nearby, which you can use to top up the fresh bottle during the demo.
  3. Have the tornado tube and piece of plastic nearby.

Presentation Details:
NOTE: Just before you begin the presentation, plug in/turn on the electric kettle for the Temperature Demo.

1. PowerPoint Presentation. Start with the PowerPoint presentation. The Notes section embedded in the PowerPoint has extensive comments about what to point out when

viewing each slide, and instructions on when to switch to the demos. At slide 3, switch to the Wind Demo.

2. Wind Demo. Tell the students you're going to do a demo to see how wind affects the movement of water.

1. Turn on the overhead projector (you may have to cover up the digital projector so you can see the image of the ocean).
2. Tell the students you're adding two types of objects to the ocean: things that float at the surface, and things that sink to the bottom. Add these objects to the tank of water.
3. Ask the students to make predictions about what will happen to the two types of objects when wind blows, with the help of a straw, across the surface of the water. Students should turn to their neighbor, discuss their predictions/hypotheses, and then share their predictions with the class.
4. Ask for a student volunteer to be the wind. Give them the straw, and instruct them to blow wind across the surface of the tank. They will have to angle the straw carefully so the wind goes along the surface, not down into the water.
5. Once the wind is blowing, ask students if their predictions were correct. Have a discussion with the class, using the following questions:
    a. What happened to the objects at the surface?
    b. When the objects reached the side of the container—the continents—what happened? Why?
    c. What happened to the objects at the bottom of the ocean? Why?
    d. Do objects below the surface move throughout the ocean? What do you think makes them move?

3. PowerPoint Presentation. Return to the PowerPoint Presentation, using the Notes to guide your discussion of the slides. At slide 5, switch to the Temperature Demo.

4. Temperature Demo.

1. Ask students what they think drives the currents. Some may say the density of the water, the temperature of the water, or the salinity of the water. Right now, we're going to look at how temperature affects the movement of water.
2. Tell the students you have a tank full of room-temperature water. You're going to add some hot water, dyed red, and cold water, dyed blue, and see how these colored waters move throughout the ocean.
3. Ask students to predict how hot water will move throughout the ocean. Accept their responses, don't tell them if they're right or wrong. Ask them to predict how cold water will move throughout the ocean.
4. Put 4 drops of red food coloring in one of the cups, add hot water from the kettle, and stir with a spoon or stir stick. Tell the students what you're doing as you do this.
5. Put 4 drops of blue food coloring in the other cup, add ice water from the small pitcher/cup, and stir. Tell the students what you're doing as you do this.

6. Tell the students you're going to remove the thumbtacks that are plugging little holes in the cups. Have them repeat their predictions for what will happen to the 2 colored waters. Don't remove the pins yet.
7. Ask for a student volunteer to come up to the class and describe to the class what they see when you remove the pins. This is especially useful if you're in a large lecture hall and the students at the back might have trouble seeing what's going on. The student might want to crouch down and get right in front of the tank, so they can see what is going on.
8. Remove the thumbtack from the cold/blue cup, and have the student report to the class about what they see. Ask students if what happened was consistent with their prediction. (Cold water sinks below room temperature water, because it is more dense.)
9. Remove the thumbtack from the hot/red cup, and have the student volunteer report to the class about what they see. Ask students if what happened was consistent with their prediction. (Hot water rises/floats above room temperature water, because it is less dense.)
10. Observe the tank for a few minutes. Have the student volunteer tell the class what they're seeing. Telling the students that you'll check in with the tank before the end of class to see what has happened. Return to the PowerPoint presentation.

5. PowerPoint Presentation. Return to the PowerPoint Presentation. At slide 15, switch to the Salinity Demo.

6. Salinity Demo.

1. Ask students how they think salinity would affect water. Is salty water denser than fresh water, or less dense than fresh water?
2. Show students the set-up with the water bottles and the tornado tube. Explain that the green water is salty—you added 3 tablespoons of salt to the bottle, along with green food coloring, before class.
3. Tell students you're going to take the bottle with fresh water and invert it over the bottle with salt water. Then you're going to turn the bottles on their side. What do they predict will happen to the water? Have students share their predictions.
4. Top off the bottle of fresh water, so water comes to the very top of the bottle. Put the piece of plastic over the top of the bottle of fresh water. Turn it upside down, put it on top of the tornado tube, and quickly and carefully slide the piece of plastic out. Screw the top bottle on the tornado tube. NOTE: You want to put the clear, fresh water bottle on top, NOT the green water. If you spill, you don't want green water everywhere.
5. Turn the bottles on their side. Prop up a piece of white paper behind the bottles, so students can see what is happening to the waters. Ask for a student volunteer to describe what is happening to the class. (The salty green water sinks below the fresh water, in both bottles on either side of the tornado tube.)
6. Ask students whether their prediction was correct. Ask students why the green, salty water sinks below the fresh water. Return to the PowerPoint presentation.

Suggested Reading:
For more information on surface and deep circulation, visit the following websites:

Surface Currents:
http://oceanservice.noaa.gov/education/kits/currents/05currents1.html

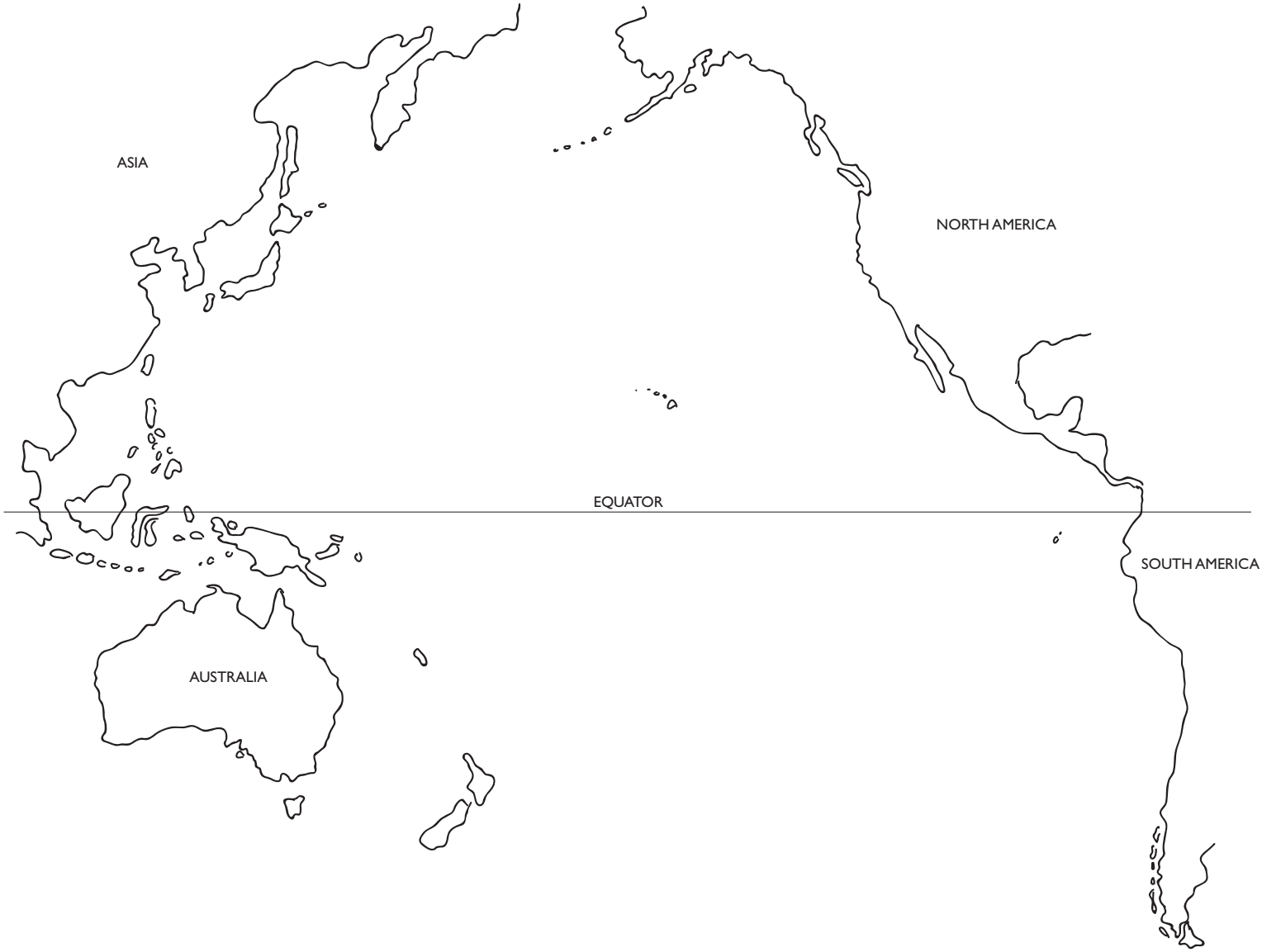
NASA Ocean Odyssey: Surface Currents:
http://www.youtube.com/watch?v=YCorkyBe66o&feature=relmfu

The Global Conveyer Belt:
http://oceanservice.noaa.gov/education/kits/currents/06conveyor.html

NASA Ocean Odyssey: Density Current:
http://www.youtube.com/watch?v=FuOX23yXhZ8&feature=related

Ocean Conveyor Belt visualization:
https://pmm.nasa.gov/education/sites/default/files/videos/thermohaline_conveyor_30fps.mp4

You Tube Video describing factors affecting ocean circulation:
https://www.youtube.com/watch?v=p4pWafuvdrY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