Density Differences: Water

Objectives:

Students will observe that water has different densities, and that this density is affected by both the salinity and temperature of the water. They will understand that these density differences drive global and local patterns of water movement in currents.

Concept:

Temperature- and salinity-dependent gradients of density drive the movement of water. As warm, less salty water rises, cool, saltier water moves in to fill the space left behind. This creates currents in the ocean, which can transport marine debris, organisms, and people across the ocean.

Materials:

- Science notebooks
- Pencils
- Thermometers (1 per group)
- Clear plastic bins or large beakers (1 per group)
- Food coloring (blue, red, and green)
- Reusable cups or small beakers
- Paper or foam cup
- Thumbtack/pushpin
- Hot water (access to faucet or electric kettle)
- Room temperature water
- Ice cubes
- Salt
- Teaspoon
- Stirring stick (1 per group)
- Salinity meter (optional)
- Ground black pepper
- 2 eggs
- Handout: Salinity Layers Lab Instructions
- Handout: Warm & Cold Water Layers Lab Instructions

Preparation:

Prepare materials for the density layers experiments by making sure you have access to hot water and room temperature water. Store the ice cubes in a cold place. Arrange the other materials for groups to use (thermometers, cups or beakers, salt, food coloring, and clear bins/large beakers) on a lab table. Make copies of the handouts "Salinity Layers Lab Instructions" and "Warm and Cold Water Layers Lab Instructions" for each group.

Prepare the egg demonstration at the front of the class. Stir ¼ cup salt into 1 cup room temperature water. Let sit for a few minutes. Meanwhile, fill a different glass or beaker with freshwater.

Introduction:

Begin by introducing the beakers to the class. Do not tell them that one is saltwater and one is freshwater.

Have students hold the eggs to attest that they are approximately the same weight.

Carefully place an egg in the beaker of freshwater *(it should sink because the freshwater is less dense than the egg)* and carefully place an egg in the beaker of saltwater *(it should float because the saltwater is more dense than the egg.)*

Observe as a class what happens to the eggs when placed in the different beakers of water.

Density Differences: Water *Continued*

Ask students to respond in their science notebooks to the following questions:

- Compare the way the two eggs behave in the water. Describe the differences.
- Why do you think the eggs float differently?
- Based on what happened with the eggs, which beaker contains denser water?
- Why do you think this water is more dense? What could affect the density of water?

Procedures & Activities:

Discuss the observations of the egg model with the class, but don't reveal the characteristics of the water yet.

Explain that temperature and salinity affect the density, or weight per certain volume, of the water. Things that are less dense float, while things that are more dense sink.

Ask students to predict which is more dense: cold or hot water.

Break students into groups of 3-5. Pass out the "Salinity Layers Lab Instructions" to each group and explain where they can find the materials.

Instruct students to conduct the first experiment, which will focus on salinity. Which is denser salty water or freshwater? Have students write a hypothesis in their science notebooks about what will happen when salty water and fresh water are poured into the same tub.

If you have a salinity meter, instruct students to test the salinity of the salty water and fresh water. *(The tap water should have a salinity of about 0 parts per thousand, whereas the salty water should have a higher salinity. When the salty water is poured into the tub, it should sink below the fresh water.)*

Discuss the results of this experiment. When freshwater from rivers meets the saltwater of the ocean, what will happen to the freshwater? What if the freshwater is very cold because it is from a glacial river and the saltwater is warm?

Introduce the second experiment by asking students, which is more dense: warm water or cold water? If they have completed the "Density Differences: Air" lesson, students should be able to figure this out pretty quickly.

Ask students to make a hypothesis in their science notebooks about what will happen when cold water and hot water are put in the same tub with the room temperature water.

Pass the "Warm & Cold Water Layers Lab Insructions" out to each group and insruct them to conduct the experiment.

Ask students to write the results of the experiment in their science notebooks. *(If the experiment is done correctly, the cold, blue water will sink below the room temperature water. The hot, red water should form a layer on top of the room temperature water.)*

Discuss the results of this experiment. Ask students to think about what will happen when cold or salty water sinks in the ocean. What will fill in the empty space? *(Warmer or fresher water will fill in the space, and as the water moves, a current is formed.)*

Gather students around a table to demonstrate a current model to the whole class.

Density Differences: Water *Continued*

Set up a bin filled with 3 inches of room temperature water where everyone can see it.

Pour 3 inches of hot water into a paper or foam cup. Add 2 drops of red food coloring and stir well. Place a weight such as a marble or rock in the cup. Carefully poke a thumbtack into the cup near the bottom of the cup's side. Keep the thumbtack in the cup and carefully place it into the water at one end of the bin.

Carefully place ice cubes at the other end of the bin.

When everyone in the class is ready to watch what happens, carefully remove the thumbtack from the cup to let the hot water slowly flow out. Add a few drops of blue food coloring around the ice cubes.

Observe what happens to the water cooling near the ice cubes and the warm water flowing out of the cup. (*The cold blue water from the ice cubes should sink, while the hot red water should rise/stay on the surace and move towards the ice cubes to fill in the void let by the sinking cold water. When it reaches the ice cubes, the red hot water will cool and eventually sink.)* You've formed a current!

Sprinkle a few pieces of black pepper onto the current to see how plankton or marine debris can be transported in the ocean by currents.

Wrap-Up:

Ask students to respond to the following questions in their science notebooks:

- How does temperature affect the density of water?
- How does salinity affect the density of water?
- How do differences in temperature and salinity affect ocean currents?
- Choose on of the following things and describe a way it might be affected by ocean currents created by differences in the density of water:
    - o Marine debris
    - o Plankton
    - o Fishing boat
    - o Sea Otter
    - o Kayaker
    - o Sea bird

Extensions & Lesson Connections:

This activity is meant to follow the "Density Differences: Air" lesson and pairs well with the "Currents & Coriolis" and "Predicting the Path of Marine Debris" lessons.

Evaluation:

Review the observations, hypotheses, and experiment results in the science journals for understanding of the basic concepts of density-based movement of water how this concept can be applied to understanding of currents. Assess student responses to the prompts for comprehension and application of the material.

Salinity Layers Lab Instructions

1. Which is denser: salty water or freshwater? Write a hypothesis about what will happen when salty water and fresh water are poured into the same tub.

2. Fill your bin about ¼ full with room temperature tap water.

   If you have a salinity meter, measure and record the salinity of the room temperature tap-water in your science notebook.

3. Have one person from your group fill a cup or beaker with room temperature tap-water.

4. Stir 2 teaspoons of salt and 2 drops of green food coloring into the cup of tap-water.

   If you have a salinity meter, measure and record the salinity of this water in your science notebook.

5. Carefully pour this salt water along the edge of the bin into the bin.

6. Record the results of your experiment in your science notebook.
   Answer the following questions:

   - What happened when you added the saltwater?
   - Did the saltwater form a layer?
     If so, is the layer below or above the freshwater?
   - Which is more dense, saltwater or freshwater?

7. After discussing the results with the rest of your class, empty the bins in the sink and rinse well.

Warm and Cold Water Layers Lab Instructions

1. Which is denser: warm water or cold water? In your science notebook, write a hypothesis about what will happen when cold water and hot water are poured into the same tub with room temperature water.

2. Have one person in your group fill a bin or large beaker about a quarter of the way full with room temperature water to bring to your table.

3. Use a thermometer to measure and record in your science notebook the temperature of this water.

4. Have one person in your group fill a cup with room temperature water and add five ice cubes and 2 drops of blue food coloring.

5. Bring this cup to your table and record the temperature of the cold water in your science notebook.

6. Then, have one person carefully fill a cup with hot water (from a faucet or electric kettle) and add 2 drops of red food coloring.

7. Use the thermometer to measure and record the temperature of the hot water.

8. Have one person in your group slowly pour the cold water into the tub, pouring along the edge of the plastic tub so it flows more gently into the tub of water.

9. Next, have a different person slowly pour the hot water into the tub, pouring along the plastic edge.

10. Draw the results of the experiment in your science notebook and answer the following questions:

    - What happened to the hot water?
      Did it mix, sink, or form a layer on top?
    - What happened to the cold water?
      Did it mix, sink, or form a layer on top?
    - Which is more dense: hot water or cold water?

11. After discussing the results with the rest of your class, empty the bins in the sink and rinse well.