NAME: DATE:

Exploring Convection Currents Lab Activity

Introduction

Nearly all of the earth's energy comes from the sun. Some of this radiant energy is reflected by water droplets and dust particles in the atmosphere and bounced back into space or scattered throughout the atmosphere; some is absorbed by clouds or ozone. The remaining energy that is not absorbed or scattered by the atmosphere reaches the earth's surface. This energy is absorbed by the earth and radiated as heat. The heating of the earth's surface by the sun's radiant energy directly influences the heating of the air above it. Different surfaces absorb varying amounts of incoming solar energy. We can observe the land surface warm up and cool off faster than bodies of water. This unequal heating and cooling is a cause of wind currents, cloud formation, and even severe storms in some locations. While the process of differential heating plays a key role in atmospheric heating, its origins are not always readily apparent.

The most significant reason for the observed phenomenon of differential heating is a physical property of substances called **heat capacity**. Recall, heat capacity is defined as the amount of energy (in calories) required to raise the temperature of one gram of a substance by 1 degree Celsius. Heat capacity is a measurable physical property of all substances. As heat energy is added to two substances, the substance with the lower heat capacity will increase in temperature fast than the other substance.

The transfer of heat through the movement of heated fluid material is called convection. When fluids, like air or water, are heated unequally, **convection currents** form. The difference in heat capacity between land materials and water is what causes the unequal heating of the adjacent air and the formation of convection currents along coastlines. This same convection process can be viewed when heating a pot of water on a stove. As the water at the bottom of the pot (nearest the heat source) begins to heat up, it expands and becomes less dense than the cooler water above it. The cooler, denser water now sinks and forces the warm water to the surface. A convection current soon forms as this cycle of rising warm water and sinking cold water takes place. Convection currents are an integral part of many earth processes, effecting atmospheric circulation, currents in lakes and oceans, and even the movement of lithospheric plates in the earth's crust.

Objective

To construct several models to demonstrate the principle of convection, and to use your observations to explore the role convection plays in the development of atmospheric circulation and ocean currents.

Materials Needed per Lab Group	Shared Materials
1 Clear Plastic Box	Food Coloring
1 Beaker, 50 ml	Salt
1 Wood Block	Water (hot and cold)
2 Pipettes	Ice Cubes
6 Styrofoam Cups	Graduated Cylinder, 100 ml
8 Plastic Lids (spacers)	Colored Pencils
1 Plastic Spoon	Periodic Table
Student Study and Analysis Sheets	

Procedure – Part 1

Setup A

1. Fit two plastic lids on each of 4 Styrofoam cups. Set the clear plastic box onto the four Styrofoam cups as shown in figure 2. Carefully fill the box with cold tap water to within 3-4 cm from the top. Let the water calm before proceeding.

2. Using the pipette, carefully place 3 spots of red food coloring on the bottom of the box as shown in figure 2. Insert the pipette all the way down to the bottom of the box before squeezing out the dye. Each spot should be about 2-4 cm in diameter. Try to minimize disturbing the water as you insert and remove the pipette.

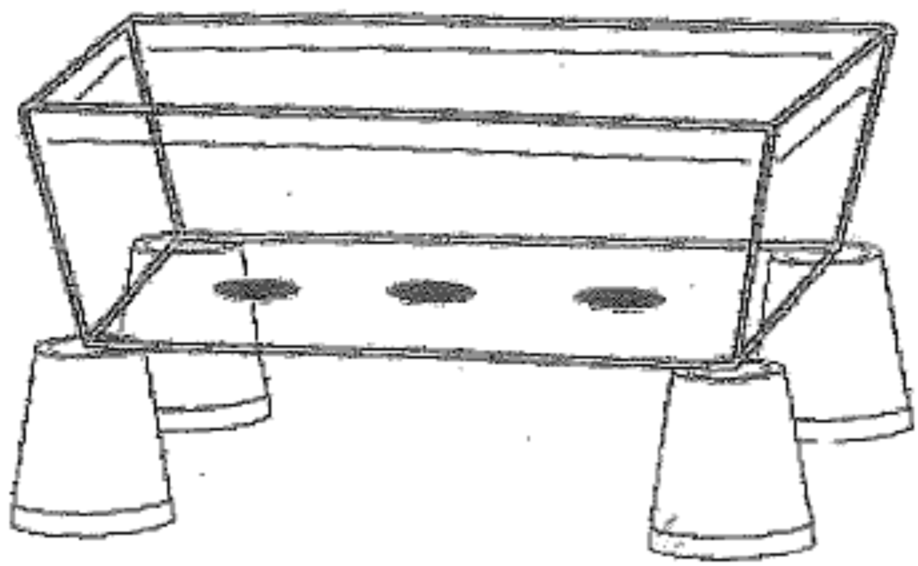

Figure 2

3. Fill one empty Styrofoam cup with hot water and then carefully position it beneath the center dye spot. The plastic lid spacers you fitted on the corner cups should provide you with enough clearance to gently slide the cup with to water under the spot.

4. **Now position yourself so that you can view the box from the side at eye level, and observe what happens to the 3 spots over the next 5 minutes. **Be sure to look for changes in all 3 spots.** *Write* your observations below.

5. Sketch what you observed in diagram 1 below. Use arrows to show the direction of flow.

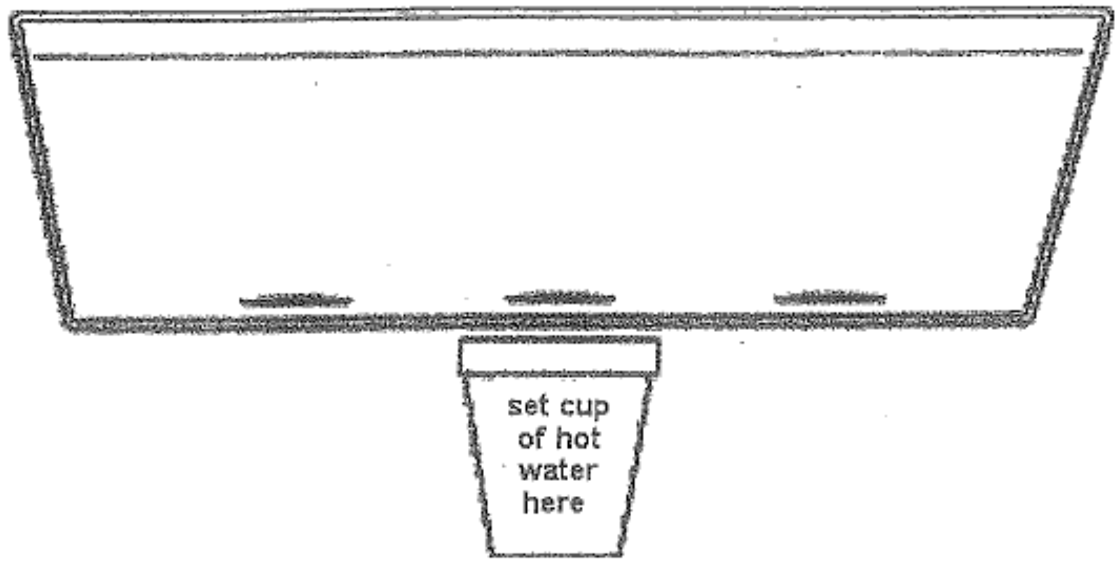

Diagram 1

6. Using two hands under the box, carefully empty the water into a sink and begin Setup B.

Setup B

1. Repeat procedures 1 & 2 from Setup A to set up the box one again.
2. This time, fill two cups with hot water and position them beneath the two outside spots. Observe what happens over the next 10 minutes, and then sketch what you observed in Diagram 2 below. Be sure to look for changes in the middle spot. Use arrows to show direction of flow.

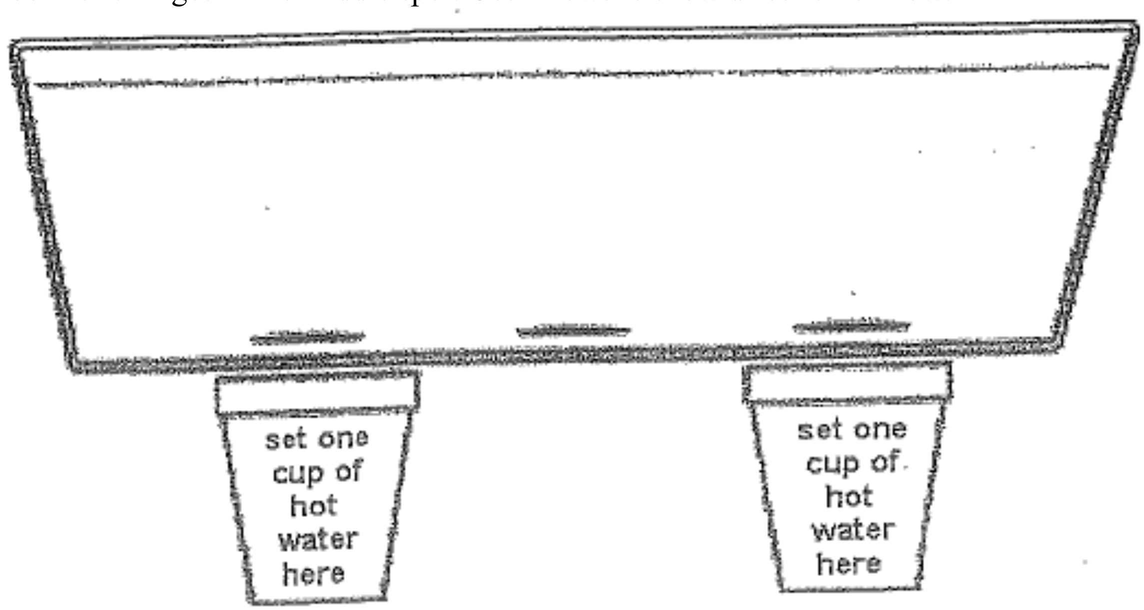

Diagram 2

3. Carefully empty the water from the box into a sink, and begin Setup C.

Setup C

1. Set up the plastic box once again as in Setups A & B and fill with cold tap water to within 3-4 cm of the top. Let the water become calm. Next, place two spots of food coloring near one end of the box. Position one cup of hot water beneath each spot.

2. Use a plastic spoon to obtain a blue ice cube from your instructor. Carefully set the cube into the water at the opposite end of the box from your dye spots. Use the spoon to steady the cube until it stops moving.

3. Position yourself at eye level with the side of the box, and observe the water as the ice cube melts. Sketch your observations in Diagram 3 below. Use arrows, once again, to indicate flow direction.

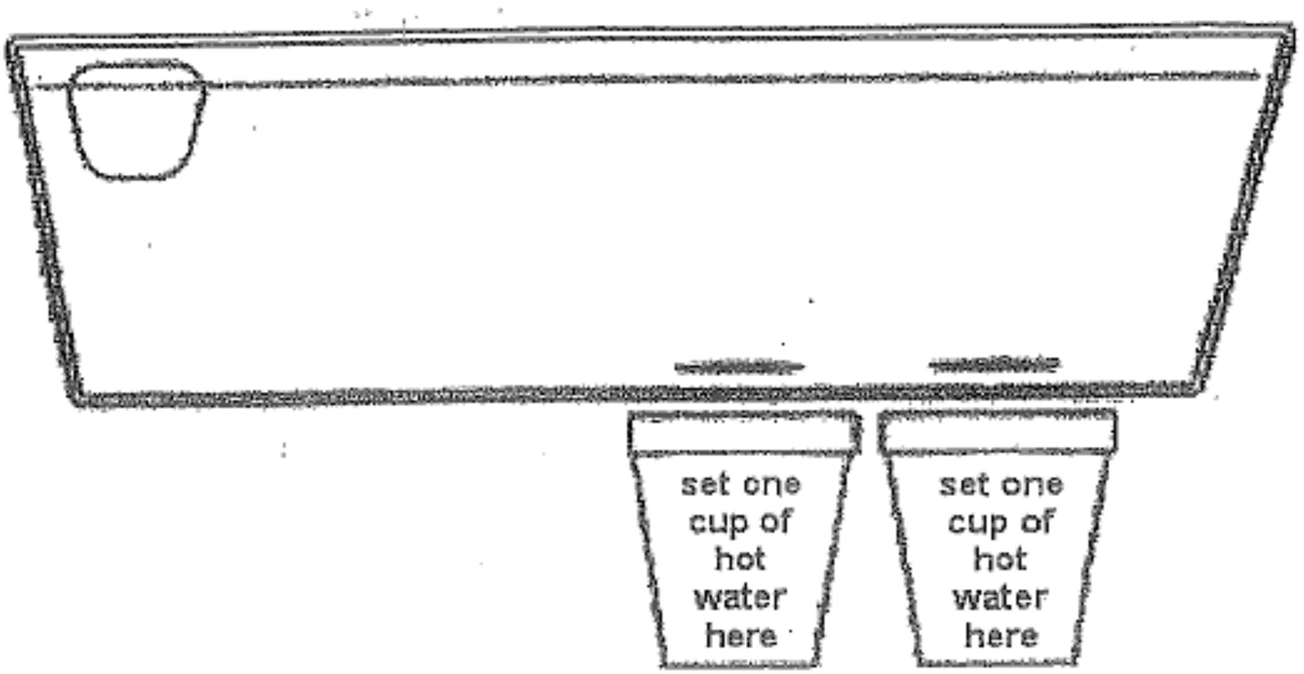

Diagram 3

4. Carefully empty the water from the box into a sink.

Follow-Up Questions

As you answer these questions, keep in mind that convection in our atmosphere and our oceans works in much the same way as what you observed in the clear box of water.

1. During the lab, what effect did the cups of hot water have on the density of the water directly above them? (hint: think about particles moving)

2. What happened as a result of this change?

3. You may have noticed convection cells in a pot of boiling macaroni. Put arrows on the dashed lines in Figure 4 to show the direction of the flow in the pot. The hottest part of the burner is beneath the center of the pot.

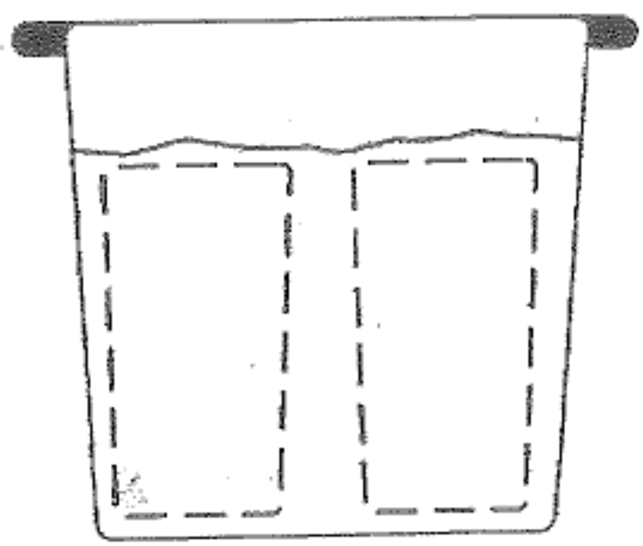

Figure 4

4. Which situation would result in a decrease in pressure at the ocean's surface? Circle the correct answer.
    a. Water gets hot and begins to evaporate
    b. Cold water is sinking below the surface

5. Go back to the three diagrams you constructed in your lab. Label the spots in each diagram that became areas of lower pressure.

6. Think globally now. Which region in our ocean is heated most intensely by the sun? Circle the correct answer.
   a. The polar region
   b. The mid-latitudes
   c. The equatorial region

7. As water near the equator is heated, does this become an area of higher or lower pressure? Explain.

8. What moves in to replace the evaporating water?

9. Number the following stages of oceanic circulation (1-4) in the order in which they are most likely to occur.
   ______ wind (movement of air/surface water)
   ______ convection (air rises/surface water evaporates)
   ______ uneven heating
   ______ area of low pressure develops