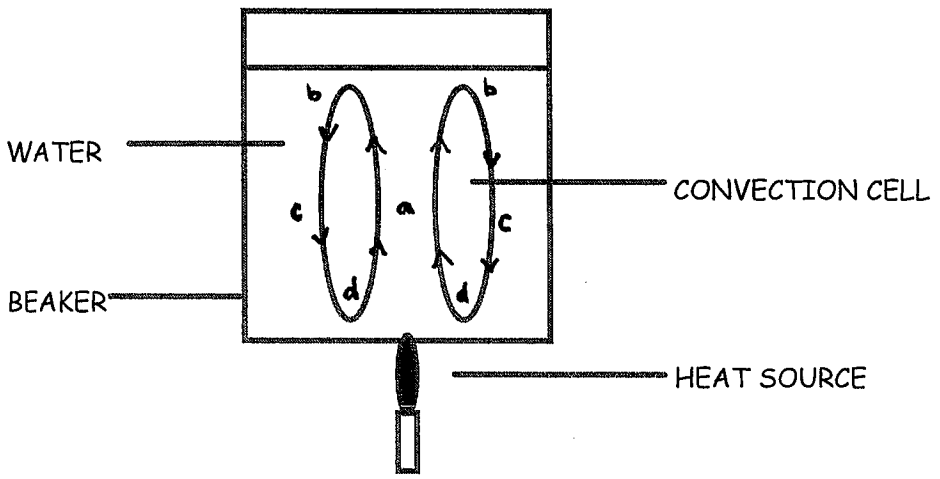
Teaching Activity: Convection Currents

Introduction: Temperature affects the density of a liquid. Density differences can cause convection cells to form. Convection is a pattern of heat movement that takes place within fluids (liquids and gases). An example is the constant turning of the waters in the oceans. Cold water from polar regions mixes with warmer water at lower latitudes. The colder, denser water sinks below the lighter warmer water and moves toward the equator. As it becomes warmer and less dense, it begins to rise again.

Convection currents occur in any fluid environment and have been identified within the Earth's lithosphere, as well as in the atmosphere. For example, air near the equator is warmed and becomes less dense. Cooling, denser air from more northerly and southerly latitudes rushes and pushes the warm, less dense air upward. The warm air travels upward for several miles, and then begins to cool. As it cools, it becomes denser than the air around it, spreads out and falls toward the equator again. These constantly moving cells of warm and cold air are known as *Hadley cells* and the continual flow of this air along the surface of the Earth is known as *wind.*

Geologists believe that the rocks within the Earth behave in the same way. Some of the rock within the mantle is thought to be in a semisolid state due to intense pressure and temperature. This rock has the consistency of warm wax or heated plastic and is able to move or flow. Convection may be occurring from the top[of the mantle to the bottom in numerous "cells". When the hot rock reaches the upper mantle, where the temperatures are lower, the heat is lost through the crusts. As the rock cools, it becomes denser and sinks back down. Just as a hot air balloon will rise when surrounded by cooler air, any hot fluid will travel upward in relation to the cooler surrounding fluid.

The diagram below is a simple representation of convection cells in water. If there is a heat source in or below a container of a fluid, the resulting heat flow (a) travels upward until it reaches the surface of the liquid. Once it reaches the surface, the fluid spreads out to the sides (b). As the fluid gets farther and farther from the heat source, it cools and the cooler, denser liquid sinks. (c). The *convective loop* or "cell" is completed when the cooler sinking fluid flows inward toward the heat source, is heated and replaces the upward moving hotter fluid (d).



Important Terms: Convection currents, heat transfer, dense, fluid, ,liquid, gas, Hadley cell, wind, equator, crust, mantle, continental plates, core;

Materials: 1000 mL beaker, 250 mL beaker, ice, food coloring, eye dropper, water, heat source, **Student Activity Sheet**;

Procedure:

NOTE: **This activity can be done as a demonstration in front of the entire class or as a student group activity.**

1. Read through the Introduction with the class and discuss the diagram of convection.
   - Review the meaning of convection and ask students for examples of place where convection might occur.
2. Fill the large beaker with water and begin heating it.
3 Draw a side view of a beaker with a heat source under it on the board.
   - Have students do the same in their notebooks.

4 Put a bottle of food coloring into the small beaker with ice. Allow it to cool.

5 When the food coloring is sufficiently cooled (5 -10 minutes) carefully place some into the heated water.
   - Go as far to the bottom of the beaker with the dropper as possible.

6. Observe and record what happens as the cooler, denser food coloring reacts to the heat source.
   - Draw in on the board what you see happening in the beaker. Students should do the same in their notebooks.

7. Help students to describe in writing the convective process as it proceeds using the following questions as guides:
   - What does the heat source under the beaker do to the water?
   - What does the heated water do?
   - What happens to the water when it reaches the surface?
   - What happens to the water as it moves farther and farther away from the heat source?

8. Instruct students to complete **Convection Observations #1 and #2**, and the **Analysis** questions.

Student Activity Sheet: Convection Currents

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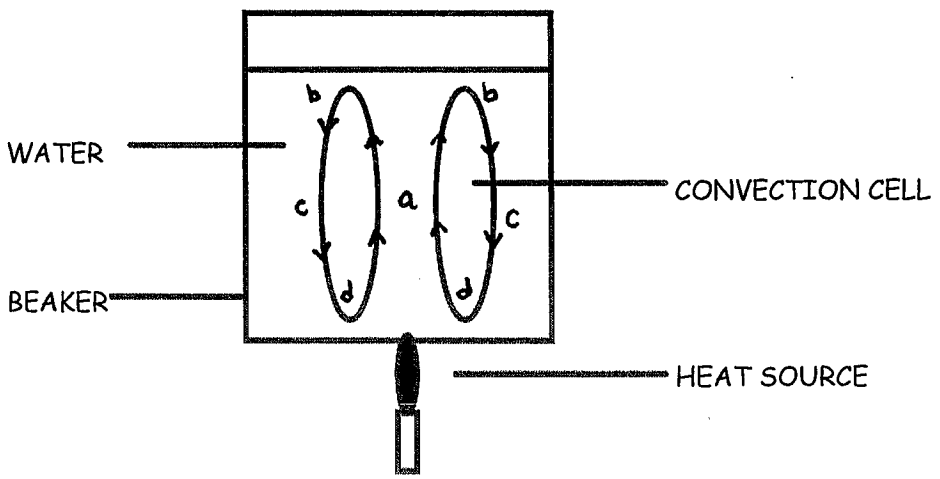


Objective:

To illustrate convection currents in water;

Procedure:

1. Read through the **Introduction** and discuss the diagram of convection with your teacher.
   - Be sure that you understand what convection is and how it affects the Earth's atmosphere and lithosphere.

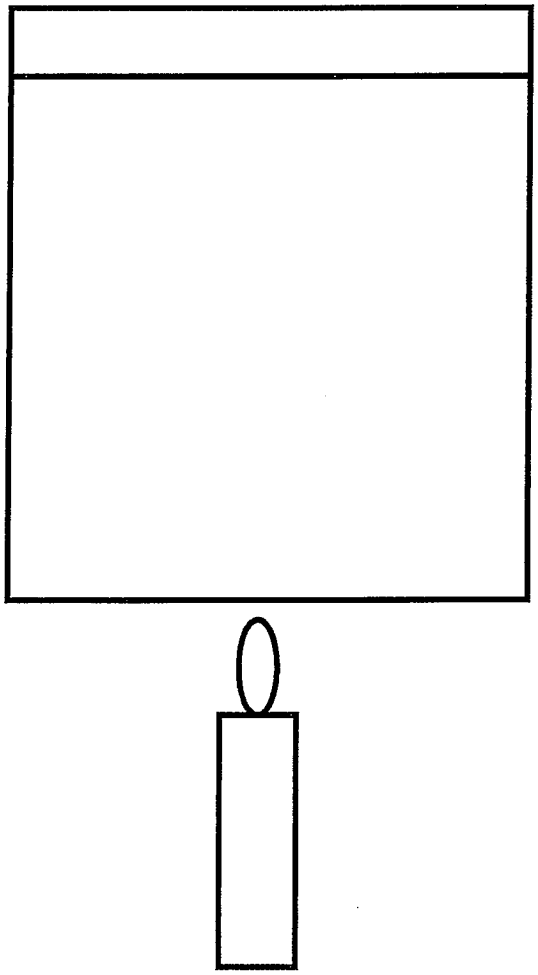
2. Keep detailed notes of the demonstration and write down each step as it is completed.

3. Make careful observations of the convection process and keep notes on what happens throughout the procedure.
   - Use drawings as well as a written description.

4. When the demonstration is completed, read and complete the **Convection Observation sheets #1 and #2** and the **Analysis** questions.

Student Activity Sheet: CONVECTION OBSERVATIONS #1

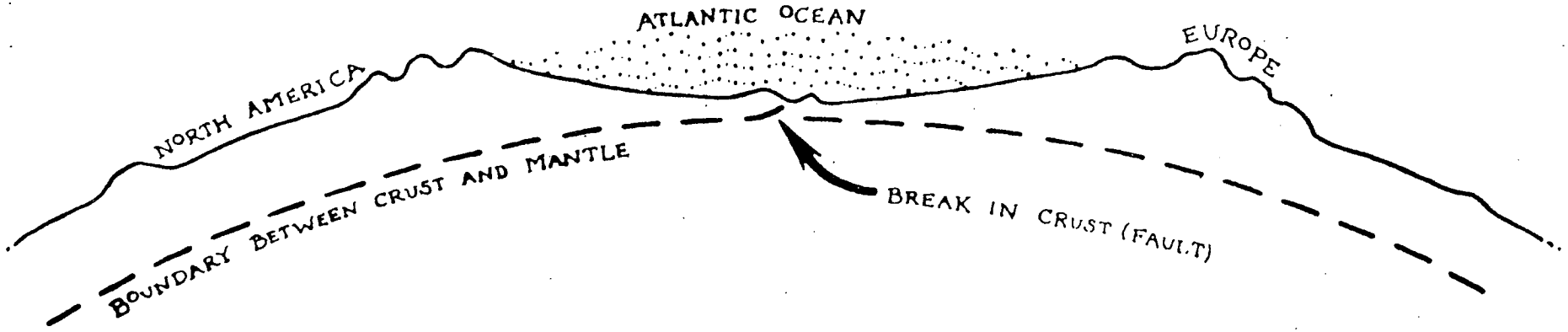
SIDE VIEW



PART I: Draw in and label what you saw happen in the beaker.

PART II: DESCRIBE IN WORDS WHAT HAPPENEND IN THE BEAKER.

Student Activity Sheet: CONVECTION OBSERVATION #2
(Magma Convection)



Student Activity Sheet #3

PART III: ANALYSIS/APPLICATION

1. What physical condition affects the density of a liquid?

_____

2. Define convection. _____

_____

3. Where within the Earth system are convection currents known to exist?

_____

_____

4. What are convection cells in the atmosphere called?_____

5. What two things are thought to be the cause of the semisolid consistency of the rock in the mantle?_____

6.. In Convection Observation #1, what does the food coloring represent?

_____

7. What does the heat source under the beaker represent ?_____

8. What would happen if the heat source in the demo were put out? _____

_____

9. In the atmosphere, what would happen if the heat source was extinguished?

_____

10. Would the continental plates of the Earth change location if the internal heat source were extinguished? _____

11. How do you think this would affect volcano and earthquake activity?

_____

_____

12. Design a simple demo to illustrate convection currents.