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# K-12 Partnership Lesson Plan

# Jake Nalley (modified from activity by Lois Wolfson)

# *Water in the Classroom: Lake Mixing*

# *Temperature, Heat, and Water Currents*

## Overview

Ever wonder why when you dive in a lake, there is a sudden drop in temperature? It all has to do with density! Cold water has a higher density than warmer water, and as solar radiation continually warms the surface of our lakes it makes this separation even more pronounced.  This lab simulates how waters can become layered, or stratified, and then simulate how this stratification can be broken down through natural processes.  Groups of students work with their own pond (a clear plastic tub), which is heated by the sun (a heat lamp) and receives warm wind via a blow dryer. We start with “Winter” conditions, where the entire water body is cold water.  As we move into “Spring” and “Summer” the heat from the sun begins warming the surface waters. Students record the temperature of the water at several depths to observe how the temperatures change over a 30-minute period. Students witness how the warm waters sit on top of the cold waters with a distinct separation of the cold and warm water forming, or what is called a thermocline. Then as “Autumn” approaches the winds pick up, blow dryers are set to High, and, with the aid of a blue crystal dye, we are able to visualize a lake turnover event as the warm, dyed water from the surface is forced to the bottom of the lake via strong winds. Students record the temperature of the different depths one final time, observing that the thermocline that had formed disappeared through the mixing event.

**Objectives**

At the conclusion of the lesson, students will be able to:

* Understand seasonal patterns in lake stratification
* Understand how differences in temperature contribute to lake stratification
* Understand the role wind and water currents play in lake mixing

**Length of Lesson**

Two class periods

**Grade Levels**

6-8

**Standards covered (NGSS)**

Disciplinary Core Ideas:

* **MS-PS1-4**: develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed

Cross Cutting Concepts:

* Patterns
* Cause and effect
* Systems and system models
* Energy and matter in systems

Science and Engineering Practices

* Developing and using models
* Analyzing and interpreting data

**Materials**

* Plastic tub
* 2 different colored dyes
* Plastic wrap
* Thermometer
* Hair dryer
* Salt
* Heat lamp
* Cold tap water
* Hot water

**Background**

### Some temperate lakes show thermal stratification. This means that the lake consists of several layers, each a distinct temperature, rather than an evenly-mixed body of water where the temperature is consistent throughout. Cooler water is denser and therefore sinks to the bottom of the lake (hypolimnion), while water near the surface is warmed by the sun and remains on top (epilimnion). The dividing line between these two layers is known as a thermocline and is characterized by a sharp change in temperature as you pass from one layer to the next.

### The degree of separation in these layers can be very seasonal. Warming of the upper layer begins in spring and leads to the most pronounced stratification during summer. The cooling of the upper layer in autumn, in addition to stronger wind events, leads to mixing of the layers and a more uniformly cold winter lake.

### Activities of the session

***Experiment I. This experiment illustrates density differences in***

***water and the formation of layers that develops in a stratified lake.***

1. Fill about 2/3 of the plastic tub with **COLD** tap water and add one of the colored dyes.
2. Obtain a few liters of **HOT** water in a beaker and add a different color dye to it.

3. Lay a piece of plastic wrap on top of the water in the aquarium and very slowly add the hot water without disturbing the lower water. **Remove the plastic wrap VERY SLOWLY.**

4. Wait approximately 10 minutes and then carefully measure the temperature from top to bottom at approximately 1 cm intervals.

5. Graph temperature versus depth

6. Take turns blowing across the water to see if you can spark mixing.

***Experiment II. This experiment shows what occurs in a meromictic lake,***

***a partial but incomplete mixing of the water, in this case due to chemical stratification.***

1. Fill about 2/3 of the aquarium with cold tap water
2. Add 10 mL of salt and STIR
3. Add one of the dyes and mix again.

2. Lay a piece of plastic wrap on top of the water in the aquarium.

3. Add the **SAME** temperature water to the rest of the tank, only use a different color dye. **Remove wrap very slowly again.**

4. Wait approximately 10 minutes and observe if any stratification occurs.

5. As a group, write down what you see. Do the layer mix? Why or why not?

6. Just for fun…Take a 1 square inch of brown paper towel and tie it into a tight ball. Add it to the tank and observe the results.

***Experiment III: For this lab, we are going to combine these ideas and simulate an entire year of a lake to visualize how water moves and stratifies naturally. We will be using wind and heat to create currents within the water (known as a seiche). The wind and heat are going to show how an interaction of the atmosphere and hydrosphere can have big implications for lakes and oceans in forming currents. As we perform the lab keep asking yourself, if I was a fish how would my surroundings influence my behavior?***

1. Fill entire tank with COLD tap water (no dyes added).
2. Take a heat lamp and secure it in place on the top of the aquarium. Make sure that it will not fall into the water. Turn it on. Do not touch the cover around the light. It is **VERY HOT**.
3. **START OF THE LAB:** Turn the blowdryer on low, and introduce a very light wind, blowing from one side for **20 seconds** and then from the other side for **20 seconds**. (SPRING MONTHS)
4. Every 10 minutes record the temperature in 2 inch segments from top to bottom for 20 minutes. \*\*\*\***BE VERY CAREFUL TO SLOWLY MOVE THE THERMOMETER UP AND DOWN! DO NOT DISTURB THE WATER!!!**
5. With the lamp still on, drop in aniline blue crystals on top of the water. Observe how the dye moves. (SUMMER MONTHS)
6. Turn off the lamp, and with the blow dryer on LOW, introduce wind on both sides again. (AUTUMN MONTHS)
7. Turn blow dryer on again and point at a 15 degree angle. Do this on only ONE side! This is forming the internal seiche.
8. Turn blow dryer on HIGH and on one side at a 15 degree angle. The lake should now mix. (FALL TURN-OVER)
9. Now take temperature readings at all levels again.

**Assessment**

* Attached worksheet