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# K-12 Partnership Lesson Plan

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# *Water and Winter*

# *How our seasons and the properties of H2O shape life in temperate lakes*

## Overview

Using a simple inquiry exercise, a short presentation, readings, and discussion, you will explore how water and winter interact in temperate lakes and ponds. From the properties of solid and liquid water to the effects of biannual nutrient turnover through freezing and thawing, this lesson will highlight how winter dictates the ecology in temperate lakes. It ends with current event tie-ins that will get your students excited about ice in their daily lives.

**Objectives**

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

* List the unique properties of water
  + Hydrogen bonding
  + Ice is less dense than water
  + Water is most dense at 4°C
* Explain how turnover affects nutrients, plants, and animals in a lake
* Explain how the density of water at certain temperatures causes turnover to happen

**Length of Lesson**

To complete this lesson in full will take two 50-minute periods. The lesson could be shortened to focus only on water properties, how turnover works, or how turnover affects living things in the lake.

**Grade Levels**

All levels

**Standards covered (NGSS)**

Disciplinary Core Ideas:

*Middle School*

* **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
* **MS-LS2-4**: construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect population

Cross Cutting Concepts:

* Systems and system models
* Energy and matter in systems

Science and Engineering Practices

* Asking questions and defining problems
* Planning and carrying out investigations

***Previous Michigan Standards Met:***

* **B3L3p3**: interdependence of living systems and the environment- factors influencing ecosystems
* **L3**.**p3C**: explain how biotic and abiotic factors cycle in an ecosystem
* **B3**.**1A**: describe how organisms acquire energy directly or indirectly from sunlight
* **B3**.**2C**: draw the flow of energy through an ecosystem. Predict changes in the food web when one or more organisms are removed
* **B3**.**3b**: describe the environmental processes (e.g., the carbon and nitrogen cycles) and their role in processing matter crucial for sustaining life
* **B3**.**5e**: recognize that and describe who the physical or chemical environment may influence the rate, extent, and nature of population dynamics within ecosystems
* **C2**.**2B**: describe the various state of matter in terms of the motion and arrangement of molecules (atoms) making up the substance
* **P4**.**p1A**: for a substance that can exist in all three phases, describe the relative motion of particles in each of the phases
* **P4**.**p1B**: for a substance that can exist in all three phases, make a drawing that shows the arrangement and relative spacing of the particles in each of the phases.
* **C4**.**3B**: recognize that solids have a more ordered, regular arrangement of their particles than liquids and that liquids are more ordered than gases

**Materials**

* Food coloring
* Ice cube trays
* Clear glasses (i.e., plastic, beakers)
* Tap water (room temperature)
* Tongs or gloves (if you don’t want the students’ fingers to get stained)
* Lab worksheet (included on website)
* Powerpoint presentation (included on “Water and Winter” lesson page on KBS GK-12 website)
* Current event readings (included at end of this document)

**Background**

Water has several unique properties that make it central to maintaining life on earth. Its unique polar, angled chemical structure means that water molecules form hydrogen bonds; this is responsible for surface tension, the high specific heat of water, and the lower density of solid vs. liquid water. Water is at its most dense at 4ºC; a few degrees before freezing.

On consequence for temperate lake ecology is that lakes freeze from the top down, and because water retains heat, most lakes only freeze on the surface. Life persists in the lower liquid portions of the body of water.

Another ecological effect of water’s unique chemical properties is the biannual turnover in temperate lakes. As the ice thaws in the spring, the water on the top of the lake reaches its peak density just above freezing and falls to the bottom, pushing the water at the bottom of the lake to the top. In the fall, cooling water at the lake surfaces falls to the bottom, again mixing water in the lake; once the entire lake has reached 4ºC, it begins to stratify, with water colder than 4ºC (and therefore less dense) sitting on the top of the lake.

Each time turnover happens, nutrients from the bottom of the lake are mixed into the top. This causes phytoplankton which were previously nutrient limited to bloom, which is followed by blooms of zooplankton living on the phytoplankton.

Ice off: when ice thaws and breaks apart enough that watercraft can freely move about without encountering ice.

### Activities of the session

To jumpstart discussion, this short activity should be done before the lesson and can be referred to as an example when discussing water density. This activity is designed to show how the density of water changes between freezing (0°C) and room temperature (~ 20°C).

Preparation:

* To make colored ice cubes, mix water and food coloring (blue, green, or red) until the colored water is rather dark.

Activity (lab worksheet included):

* Students will gently place the colored ice cube into a colorless glass of water, so as not to mix the water.
* Ice, being less dense than water, floats. As it begins to melt, the water melting off is very cold and is more dense than the room temperature water, so it will sink to the bottom. The food coloring in the ice cube makes that evident.
* After the cold water sinks to the bottom, it begins to warm and will start to mix with the room temperature water.
* Warning: A down side to using food coloring is that diffusion will also contribute to the mixing of the colored water and the tap water. If the glasses sit for long enough, all of the water will become the same color. Therefore, students should only observe what happens in the glass for the first several minutes.

**Resources**

* Lab worksheet and powerpoint presentation (found on “Water and Winter” lesson page on KBS GK-12 website
* Current event readings
  + MI DNR winter fish kill article: <http://www.michigan.gov/dnr/0,1607,7-153-10364-119822--,00.html>
  + Citation for Science article on climate change affecting early ice off: Magnuson, JJ; DM Robertson; BJ Benson; RH Wynne; DM Livingstone; T Arai; RA Assel; RG Barry; V Card; E Kuusisto; NG Granin; TD Prowse; KM Steward; VS Vuglinski.2000. Historical trends in lake and river ice cover in the northern hemisphere. Science (289): 1743-1746

**Assessment**

Assessment questions included in student worksheet