



Winter Water Ecology

Subject Area: Environmental Science

Core Curriculum Content Standards: 3.3A, 3.4A, 4.1A, 4.2D, 4.4A, 4.5ABC&D, 5.1A&B, 5.3A&B, 5.5A&B, 5.6A, 5.8A, 5.10A&B, 6.6C&E

Session Description

This session emphasizes the unique properties of water necessary for supporting life, including universal solvency, cohesion, adhesion, capillary action, surface tension, and changing density at low temperatures. Students will take water samples and measure temperatures beneath the ice in Lake Wapalanne as well as collect aquatic organisms and evaluate water quality based on a biotic index.

Objectives

1. Students will demonstrate and explain the universal solvency of water by observing and describing what occurs when sugar is mixed with water.
2. Students will demonstrate and explain cohesion by comparing their estimate of the number of water droplets that can fit on the head of a penny to the actual number of water droplets that can fit on the head of a penny, and by observing the structure and behavior of the water droplets.
3. Students will demonstrate and explain surface tension by counting the number of paper clips they can balance on the surface of water and observing the structure and behavior of the water beneath the paper clips.
4. Students will observe and explain capillary action by describing how water can defy gravity and travel up a paper towel suspended in a cup of water.
5. Students will observe and explain the density characteristics of water at temperatures approaching the freezing point.
6. Students will predict and measure the temperature of the water in Lake Wapalanne just beneath the ice and at the bottom of the lake.
7. Students will collect and examine a few aquatic organisms and compile a list of ways in which the organisms' survival is dependent upon the unique properties of water.
8. Students will identify the organisms they have collected, classify them according to tolerance level, and evaluate the water quality of the outflow of Lake Wapalanne.

Materials

water ice cube forks plastic containers pennies pipets toilet paper
sugar spoon bottom sampler thermometer iron ice pick biotic index nets

Procedure

1. Begin by asking students why water is important. List their answers and point out that about 70 % of their bodies consist of water and that approximately 3/4 of the surface of the earth is water.
2. Draw a water molecule on the board and briefly explain how and why it is a dipolar molecule. The molecules of many substances are either positively or negatively charged, meaning the molecules are not especially attracted to one another, and are only attracted to things in the environment that have the opposite charge. But because of the extreme electronegativity of oxygen atoms, in a water molecule, each hydrogen atom's single electron spends more of its time near the oxygen atom. This leaves the hydrogen end of the water molecule positively charged, and the oxygen end negatively charged. Thus, water molecules are actually very attracted to one another (called cohesion) through special bonds called hydrogen bonds, which occur when water molecules arrange themselves so that their oxygen ends meet another water molecule's hydrogen end, which they are constantly doing. They are also very attracted to other molecules in the environment (called adhesion) because, being dipolar (having both a positive and negative pole in each molecule), they are attracted to both positively and negatively charged molecules in the environment.
3. Inform students that you will be doing four demonstrations/experiments. During each, they should consider the following two questions, written on the board:
 - a. What unique property of water is being demonstrated?
 - b. What significance does this property have to living things?
4. Perform the first demonstration by putting a tablespoon of sugar into water and stirring. Ask students what is happening to the sugar. Because of its dipolarity, water can dissolve many substances and thus is said to have **universal solvency**. This property is important for animals living in the water that need to breathe oxygen through gills. They breathe oxygen that has been dissolved in the water they are living in. Organisms also take in important nutrients that have been dissolved in the water, such as phosphorous and nitrogen. Plants rely on this solubility in order to absorb nutrients through their roots, and in animals, nutrients must be dissolved in water during the digestive process before they can enter the bloodstream.
5. Hand out pennies and eyedroppers and/or small containers of water, forks, and paper clips to students or pairs of students. Ask students how many drops of water they think they can fit on the surface of the penny before the water spills over the board. Ask them how many paper clips they think they can balance on the surface of the water before one falls through. Write their hypothesis on the board. Demonstrate the technique for putting water drops on the penny without letting the pipet touch the penny's surface as well as how to place the paper clips gently on the water's surface using a fork. Have students try each activity and write their results on the board. Have them describe or draw what the water looked like on top of the penny and what it looked like beneath the paperclips

6. Introduce the property being observed as **cohesion**, or the affinity of water molecules to one another. Cohesion results in a tight film on the water's surface due to the hydrogen bonding of water molecules. This property is very important in nature because it prevents huge quantities of surface water from evaporating, helping to retain water in its liquid form in surface reservoirs supplying water to humans and animals. Also, many animals are adapted to live on the surface of the water, such as water striders and whirligig beetles. Others are adapted to life just below the surface, such as mosquito larva. Many aquatic insects that breathe through lungs trap a bubble of air that they take with them beneath the surface of the water. They are able to do this because of the water's surface tension at the interface of air and water.

7. Prepare the third experiment by suspending a piece of toilet paper or paper towel into a container of water. What happens? Why? This property is called **capillary action**, and occurs because of water's **cohesion**, or affinity for itself, and **adhesion**, or ability to stick to certain surfaces. In all trees and most plants, water is moved from the roots to the leaves through capillary action.

8. The final experiment will demonstrate water's most unique property. It is the *only* substance on earth which behaves in this way. For this experiment, drop a firmly packed snow ball or ice cube into a container of water. What happened to the ice? Why did it float? In all other substances, density increases as temperature decreases. This is true for water up to a point. At 39 degrees Fahrenheit (4 degrees Celsius), because of its hydrogen bonding, water actually becomes less dense, allowing solid water to float on liquid water. What are the ramifications of this for planet earth? If water sank when it froze, no aquatic wildlife would be able to exist under the protective blanket of ice that winter provides in cold climates. When temperatures warmed, sunlight might not be able to penetrate through the liquid water enough to melt the ice, and the amount of ice on earth could continue to increase.

9. Tell students that we will be confirming the unique property of water density by taking measurements of the temperature of the water in Lake Wapalanne just beneath the ice, and at the bottom of the lake. What is the temperature of the ice? According to what they now know, where will the colder water lie in the lake, just beneath the ice or at the bottom?

10. Take the group out on the ice on the North end of Lake Wapalanne near the lake's deepest point. Using the iron rod, make a hole in the ice large enough for the bottom sampler to easily fit through. Have students help you take a water sample and temperature reading from the top of the lake and the bottom of the lake. Do the results match up with their hypotheses?

11. Explain how the temperature stratification of a lake differs throughout the year. In the summer, because the water in the lake is not near enough to the freezing point, the cooler water is denser and will rest at the bottom of the lake. In spring, as the ice melts, and in fall as the upper layer cools, water density of the upper layer increases and begins to sink. This and mixing from wind cause the water in the lake to circulate and temperatures to become more uniform during spring and fall. But in winter, when the lake is frozen, the warmest water is always at the bottom.

12. Take students to the spillway of Lake Wapalanne and use nets to collect a macroinvertebrate sample. Bring the organisms indoors and use magnifying glasses and/or the video dissecting scope to point out the features of individual organisms and how these organisms use the unique properties of water to survive. If time permits, introduce the biotic index, identify the organisms, and class the water of Lake Wapalanne.

Summary

Review the special characteristics of water and the role it plays in the existence of life. Ask students how they use water in their everyday life. Have them suggest ways in which they can commit to conserving water throughout the day.

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