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# K-12 Partnership Lesson Plan

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# *Frogsicles*

# *How frogs survive the winter*

## Overview

How do frogs survive the winter when they're frozen solid? Their heart may even cease to be beating, and yet they still bounce back just in time for some springtime hanky-panky. You will complete three short lab experiments to explore topics that help explain how frogs freeze over the winter: solute concentration, osmosis, and freezing point depression.

**Objectives**

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

* Define and explain osmosis
* Predict the relative freezing points of pure water, salt water, and sugar water
* Understand that frogs have adaptations that help them survive the winter

**Length of Lesson**

1.5 hours

**Grade Levels**

High school, but could be simplified for middle school or upper elementary

**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-LS1-5**: construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms

*High School*

* **HS-PS1-5:** apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs
* **HS-LS1-3**: plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis

Cross Cutting Concepts:

* Patterns
* Structure and function

Science and Engineering Practices

* Asking questions and defining problems
* Planning and carrying out investigations
* Analyzing and interpreting data
* Engaging in argument from evidence

***Previous Michigan Standards Met:***

* **P.PM.01.21**: demonstrate that water as a solid keeps its own shape (ice)
* **P.PM.01.22:** demonstrate that water as a liquid takes on the shape of various containers
* **E.ES.01.22**: describe and compare weather related to the four season in terms of temperature, cloud cover, precipitation, and wind
* **E.FE.02.14**: describe the properties (hard, visible, freezing, ice) of water as a solid (ice, snow, iceberg, sleet, hail)
* **L.OL.03.32**: identify and compare structures in animals used for controlling body temperature, support, movement, food-getting, and protection (for example: fur, wings, teeth, claws)
* **L.EV.03.12**: relate characteristics and functions of observable body parts to the ability of animals to live in their environment (for example : sharp teeth, claws, color, body covers)
* **P.PM.04.23**: compare and contrast the states (solid, liquids, gases) of matter
* **L.EV.05.11**: explain how behavioral characteristics (adaptation, instinct, learning, habit) of animals help them to survive in their environment
* **L.EV.05.12**: describe the physical characteristics (traits) of organisms that help them survive in their environment
* **P.CM.06.11**: describe and illustrate changes in state, in terms of the arrangement and relative motion of the atoms or molecules
* **B2.3A**: describe how cells function in a narrow range of physical conditions, such as temperature and pH (acidity), to perform life functions
* **B2.3B**: describe how the maintenance of a relatively stable internal environment is required for the continuation of life
* **B2.3C**: explain how stability is challenged by changing physical, chemical, and environmental conditions as well as the presence of disease agents
* **C3.3B**: describe melting on a molecular level
* **C4.4a**: explain why at room temperature different compounds can exist in different phases
* **C4.7a**: investigate the difference in the boiling point or freezing point of pure water and a salt solution

**Materials**

* Lots of paper/plastic drinking cups (9 per group)
* Tap water
* 1 M salt water solution (58 g NaCl/L or 225 g/gallon water), 1 quart per group
* 1 M sugar water solution (342 g sucrose/L or 1325 g sucrose/gallon water), 1 quart per group
* Chipped or shaved ice, or ice cubes
* Thermometers (1 per group)
* Slices of potato
* Slices of beet
* Video of how osmosis works <http://highered.mheducation.com/sites/0072495855/student_view0/chapter2/animation__how_osmosis_works.html>

**Background**

DavidsonLee98Color.pdf is a great reference—it explains everything teachers need to know (link at end of lesson plan). **Osmosis** is the diffusion of a solvent (frequently water) through a semi-permeable membrane, from a solution of low solute concentration (high water potential) to a solution with high solute concentration (low water potential), up a solute concentration gradient. **Freezing-point depression** describes the phenomenon that the freezing point of a liquid (a solvent) is depressed when another compound is added, meaning that a solution has a lower freezing point than a pure solvent.

### Activities of the session

1. Introduce the question: How do frogs survive the winter? Ask the students what they already know about frogs. Are they warm-blooded or cold-blooded? Can they heat their own bodies? What kinds of adaptations do other animals have for surviving winter (fur, feathers, fat, hibernation)? Do frogs have these?
2. Show the 4 minute video at <http://www.pbs.org/wgbh/nova/sciencenow/3209/05.html>
3. So how do frogs survive the winter? How can they freeze solid and then come back to life? Students may remember “antifreeze” and “sugar” from the video. How can these things help a frog?
4. Activity #1: What happens to slice of potato in tap water, sugar water, and salt water?
   1. Step one of answering our question, “How do frogs survive the winter” is to see what happens to cells in different solutions. This is the osmosis demonstration—but don’t tell the kids that’s what they’re doing.
   2. Give each student or group of students three cups.
   3. Label the cups with the type of liquid: one cup gets tap water, another gets saltwater, and the third gets sugar water.
   4. Have the students put a slice of potato in each cup.
   5. Add the liquids to the cups, enough to completely submerge the potato.
   6. Put these cups aside and wait at least 30 minutes to see what happens.
5. Activity #2: How can sugar be an antifreeze? Solute concentration and freezing point depression.
   1. Bring out beakers/cups of ice water, ice sugar water, ice salt water.
   2. Have the students measure the temperature of the water and fill out the datasheet in their student handouts.
   3. Bring out beakers from the freezer containing pure water, sugar water, or salt water. Have students record whether “frozen solid” or the temperature of the liquid.
   4. Discuss: does adding sugar lower the freezing point of water?
6. Finish Activity #1: Ask the students to make observations about their potato slices.
   1. Were they more floppy or stiffer than they started?
   2. Why did this happen? (Osmosis caused water to go into potato cells in the tap water to balance the concentration of solutes. Osmosis caused water inside potato cells to go out, to try to balance the concentration of solutes in the salt and sugar water.)
   3. Watch video <http://highered.mheducation.com/sites/0072495855/student_view0/chapter2/animation__how_osmosis_works.html>
   4. Diagram this on the board, have the students diagram it too.
   5. Point out that floppy cells are unhappy cells. If the insides of cells lose too much water, they can suffer from dehydration and die.
7. Develop our hypothesis. How would changing the concentration of sugar help a frog survive the winter?
   1. Continue your diagram from the osmosis diagram. It has become a rough diagram of the cells of the heart—just enough to know that there are two regions: “inside the cell” and “outside the cell”
   2. As it gets colder, ice crystals form on the outside of the cell. This causes the concentration of solutes outside the cell to increase. Draw this in the cell diagram—Ice crystals form out of only water molecules, pushing molecules of other things to the side. This increases the concentration of solutes outside the cell.
   3. Is this OK? What happens when the concentration of solutes inside the cell is much lower than the concentration outside (as it is now, as ice is forming outside the cell)? Students should recognize that osmosis causes water to leave the cell.
   4. But remember, dehydrated cells are unhappy cells. Frozen cells are also unhappy cells.
   5. Where does the frog put the sugar? How does this help prevent its cells from freezing or from becoming too dehydrated? Add this to the diagram.
8. Activity #3: Testing our hypothesis. Set up the experiment one day, freeze experiment overnight, thaw before class so samples are liquid again for data collection.
   1. Have students label 3 cups with their names and the solution type (tap water, salt water, sugar water).
   2. Put a slice of beet in each cup and put in the freezer.
   3. Collect data on the color of the solution.
   4. Discuss: How would the red color get out of the cells (cells burst and die)?
   5. Which solution protected the cells from freezing?
   6. Does this support our hypothesis?
9. Concluding discussion
   1. To review: frogs increase the concentration of sugars inside their cells to prevent cells from freezing (freezing point depression) and to prevent cells from getting too dehydrated.
   2. How does the frog thaw in the spring?
      1. Draw a rough diagram of a frog on the board and locate the heart and lungs
      2. Freezing point depression in internal organs means that these thaw before extremities.
   3. If time allows: Why would a frog want to do this? Are there other ways to spend the winter? Why is overwintering as an adult the best idea? (What kind of activity immediately follows the spring thaw?)
   4. Bonus: Salt seems to work better than sugar in these experiments. Why don’t frogs use salt instead of sugar?

**Resources**

* <http://www.sciam.com/article.cfm?id=how-do-frogs-survive-wint>
* <http://www.pbs.org/wgbh/nova/sciencenow/3209/05.html>
* <http://www.youtube.com/watch?v=Fjr3A_kfspM>
* <http://www.units.muohio.edu/cryolab/publications/documents/DavidsonLee98Color.pdf>

**Assessment**

Student worksheet is included on the “Frogsicles” lesson page on the KBS GK-12 website.