Fresh vs. Salty

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Editor's notes: The APS encourages teachers to give students a copy of the "ABC" (Appropriate, Beneficial, Caring) rules for use of animals in the classroom, to discuss the rules, and to ask students to sign the "ABC" rules contract (see References). Also, teachers should have a plan for short term care of the animals (with supporting references for appropriate care guidelines) and for disposal or long-term care of all classroom organisms.

Teachers should carefully review any stimulus or environmental change for an animal being used in experiments or observations before students are allowed to use that stimulus. This is especially important if the stimulus could cause pain or distress to the organism. Teachers may be able to identify a less stressful stimulus for the students to use in their experiment. In all cases, the teacher should check local and state guidelines before using animals in the classroom.

Also, although the objectives (below) refer to an understanding that saltwater organisms can't live in freshwater, this activity only directly explores whether freshwater organisms can live in salt water.

For additional information on how fresh and saltwater fish maintain their osmotic balance, see:

- David H. Evans' editorial, "Teleost fish osmoregulation: what have we learned since August Krogh, Homer Smith, and Ancel Keys" (Am J Physiol Regul Integr Comp

Physiol 295: R704-R713, 2008). Read this paper through a link in the APS Archive: http://apsarchive.org/resource.cfm?submissionID=4287

- Read about Nobel Prize winning physiologist, August Krogh, at http://nobelprize.org/nobel_prizes/medicine/laureates/1920/krogh-bio.html

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Purpose:
- To introduce the difference between saltwater and freshwater organisms.
- Recommended for grades 8-10.

Objectives (content):
1. Students will understand that freshwater organisms usually can’t live in salt water and vice versa.
2. Students will recognize that some organisms are adapted to both environments.
3. Students will learn about the physiology that allows freshwater organisms to survive in freshwater and saltwater organisms to survive in salt water. They will also learn how some organisms survive in both.
4. Students will realize the importance of niches in an ecosystem.

Objectives (process):
- Engage students in planning an experiment and problem solving.
- Allows students to clearly present their results to their peers.
- Allows students to work cooperatively.

Materials (per group of 3-4 students):
- 5 Petri dishes
- 500 mL pond water with microorganisms
- 100 mL of each salt solution – 3.5%, 2% .9%, .2%, 0% (pure pond water)
- 1 microscope
- 5 microscope slides (with microorganisms, see Preparation)
- 1 student worksheet
- 2 sheets graph paper
- 1 clock with a second hand

Preparation:
All the slides should be placed horizontally on the bottom of a large dish. The slides should have pond water poured over them and be allowed to sit for a couple of hours. This gives the microorganisms time to settle onto the slides, allowing for a more interesting lab.

Students need to know how to use slides and microscopes. The petri dishes are used to soak the slides in the salt solutions, for a limited time. Students need to be able to figure percentages of solutions. They need to have experience creating labs using their previous knowledge and supplies given to them. They need to know how to create line graphs and how to present their information verbally.

Background Information:
Despite the continual deposit of fresh water, oceans maintain a fairly constant concentration of salts. The water that evaporates is approximately the same amount that is deposited. The water cycle demonstrates this concept.

The concentration of salt in the ocean generally varies from 32 $_{o\,/oo}$ (32/1000) to 38 $_{o\,/oo}$ (38/1000 or 3.8%). In this experiment you may want to consider ocean water to be 35 $_{o\,/oo}$ or 3.5% sodium chloride (i.e., 3.5 gm of NaCl/100 mL of solution). Note: Marine biologists use the 32 o/oo versus the 3.2%. Use whichever you feel more comfortable with.

The intermediate salinities you might want to call estuaries or brackish water.
They are more dilute. The concentration of salt in brackish water generally varies from .51 o/oo (.051%) to 17 o/oo (1.7%) (i.e., 1.5% NaCl = 1.5 gm of NaCl/100 mL of solution). The concentration of fresh water is .5 o/oo (.05%) salt or less. An example of mixing a salt solution would be 1.5% NaCl = 1.5 gm of NaCl/100 mL of solution.

Most marine organisms have internal body fluids similar to their environment (usually 33 o/oo [3.3%] - 35 o/oo [3.5%]). Freshwater and bony (teleost) fish usually have internal fluids with salinity in the 20 o/oo [2.0%] range. If these organisms are placed in external fluids that are hypotonic (have a lower salinity than internal fluids) or hypertonic (have a higher salinity than internal fluids), the result is often fatal.

Some organisms have adaptations to survive a change in their environment. They may have organs such as contractile vacuoles, nephridia, kidneys, and gills, which tend to counter water absorption. Or they may have outward structures, such as shells, that reduce the amount of exposed permeable area.

If an aquatic organism with an internal fluid concentration of 35 o/oo (3.5%)is in a body of water whose salinity is 20 o/oo (2.0%), water is going to move into the organism, trying to equalize the internal and external fluids. Unless the organs move as much water out as is coming in its internal salinity level will drop, causing swelling and probably death. Because extra water must be removed and salts retained, the organisms urine will be dilute and (excreted) in large quantities.

If an aquatic organism with an internal fluid concentration of 20 o/oo (2.0%) is in an ocean whose salinity is 35 o/oo (3.5%), salt water is going to move into the organism. The organs must keep enough NaCl and water moving out so that the internal salinity won’t change, thereby keeping the organism alive. Because water must be preserved and salts excreted, the organisms’ urine will be fairly concentrated and discharged in small quantities.

Procedure:
This is an inquiry-based activity. Once the teacher has handed out the worksheet and provided the materials it is up to the students to come up with a plan, get it approved by the teacher, who is head of the FASK (Further Advancement of Scientific Knowledge) Board, and test it. The teacher needs to facilitate their learning by asking questions that will guide them in the right direction.

Questions to Ask:

- How can you test whether freshwater organisms are capable of surviving in ocean water, given the equipment and supplies here?
- What are you testing?
- What are the Petri dishes for?
- How are you going to effectively count the microorganisms?

- What do the different solutions represent?
- How are you going to know the organisms are not dying due to elapsed time?

Suggestions for Assessment:
Have the students give group poster presentations explaining their hypothesis, experimental procedure, data, graph, and conclusion.

Where to Go From Here:
Any of the following could be studied next:

- niches, ecosystems, and environments
- animal behavior
- aquatic organisms
- oceans and their diversities
- osmosis and diffusion

References and Resources:
1. McConnaughey, B.H. & Zottoli, R. (1983). *Introduction to Marine Biology (4th ed).* St. Louis, MO: C.V. Mosby Company.
2. Pennak, R.W. Ph.D. (1953). *Freshwater Invertebrates of the United States.* New York: The Ronald Press.
3. American Physiological Society (APS). “ABC” rules for use of animals in the classroom. [Online]. Bethesda, MD: American Physiological Society, 2007. http://apsarchive.org/resource.cfm?submissionID=4288.

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Save the Organisms

It is the year 2025. You have become an environmental scientist who works at finding ways to save our environment. You are working on the problem of global warming when suddenly the Earth stops spinning. You realize that this could be a deadly situation. The Earth was warming up before, but now your country faces a new problem the sun, 24 hrs/day. Not only is the sun shining constantly, but when the Earth stopped turning, the winds ceased. No longer will clouds roll in from the ocean. Meanwhile, gravity still works and all the water is running to the ocean via creeks and rivers. If there is no rain to replenish them, how will streams and rivers continue to run? What will happen to the ponds and lakes? Scientists predict they will be able to get the Earth spinning again within 2 months, but the President has come to your team with an idea until then: Why not bring in ocean water for all freshwater organisms to live in until the Earth begins to spin again? You discuss this with your environmental team and come up with a plan to test whether or not freshwater organisms can survive in the ocean water.

Hypothesis:

Plan of attack:
(How do you plan to test this? Remember, you must have your experiment approved by the FASK board before you begin.)

Data collected/Data table:

Graph:

Conclusion/Suggestion for the President:

Assumptions made:

Questions that arose: