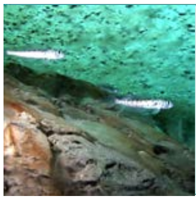

Icefish Blood Adaptations: Antifreeze Proteins

Activity
Student Handout

INTRODUCTION

Most animals could not survive in the ocean around Antarctica. The average temperature of the water there is only –1.8°C (28.8°F). At such low temperatures, you would expect the blood of most fish to freeze. However, icefish and their relatives, the notothenioids, thrive in Antarctic waters. How do they do it?

In this hands-on activity, you will create a model of notothenioid blood. You will then explore the blood's properties to understand some of the ways in which these fish have adapted to the harsh Antarctic environment. This activity contains two labs, which model different properties. In both labs, you will test one solution that models the blood of a “normal” fish and another solution that models the blood of a notothenioid.

LAB 1

This lab models how "normal" and notothenioid blood respond to cold temperatures.

MATERIALS

- samples of solutions A and B
- Styrofoam cup
- crushed ice
- rock salt or coarse table salt
- teaspoon or electronic balance
- stirring rod or plastic spoon
- two test tubes
- felt-tipped marker
- thermometer (cleaned and cooled ahead of time)
- paper towels

PROCEDURE

1. Fill about three-fourths of the Styrofoam cup with crushed ice. Mix 1 teaspoon (about 8 grams) of salt into the ice with the stirring rod or spoon. This will help the temperature inside the cup get colder.
2. Using your marker, label one test tube “A” and the other test tube “B.”
3. Get samples of solutions A and B from your teacher. Fill one-third of test tube A with solution A, and one-third of test tube B with solution B. Make sure that the test tubes are filled to the same level.
4. Put the test tubes in the cup of ice. Make sure that the liquids in both tubes are below the top of the ice.
5. Let the solutions cool for 10 to 15 minutes. Record any changes in the solutions over this time period.

Solution A	**Solution B**

6. With the clean and cooled thermometer, measure and record the temperature of solution A. Rinse and dry the thermometer with a paper towel, then measure and record the temperature of solution B.

Solution A	**Solution B**
____°C	____°C

7. When you're done, pour the solutions and the cup of ice down the sink.

LAB 2

This lab models how "normal" and notothenioid blood react to ice crystals.

MATERIALS

- samples of solutions A and B
- two clear plastic cups or beakers
- felt-tipped marker
- 100-mL graduated cylinder
- ¼ teaspoon or electronic balance
- simulated "ice crystals"
- plastic bag for disposal

PROCEDURE

1. Get cups of solutions A and B from your teacher.
2. Add ¼ teaspoon (about 0.58 grams) of simulated "ice crystals" to each cup and gently swirl.
3. Record any changes you observe in each solution.

Solution A	**Solution B**

4. When you're done, pour the solutions into a plastic bag and throw it in the trash. **Do not pour the solutions down the sink.**

QUESTIONS

1. Remember that solutions A and B model different types of blood.
   a. Summarize the differences between the solutions that you observed.
   b. Would the blood modeled by solution A or B be more advantageous for an animal living in a cold environment? Support your answer with evidence from your observations.

2. To learn more about notothenioid blood, watch the BioInteractive short film *The Making of the Fittest: The Birth and Death of Genes*. As you watch, pay attention to any mentions of adaptations that affect how blood freezes. Use what you learn from the film to answer the questions below.

    a. How do antifreeze proteins keep fish from freezing?

    b. Explain how antifreeze proteins are an adaptation to the Antarctic environment.

    c. Make a claim about which solution, A or B, modeled blood from a notothenioid, and which modeled blood from a "normal" fish. Use the properties of the solutions and information from the film to provide evidence and reasoning for your claim.

    d. Predict what would happen if you put a fish *without* antifreeze proteins into Antarctic waters. Explain your reasoning with evidence from the lab model.

    e. What are some properties of notothenioid blood or "normal" fish blood that were not captured in this model? Propose one or two modifications to the model that would help include these properties.

3. Most fish, including the ancestors of notothenioids, do not produce antifreeze proteins.

    a. How did notothenioids "get" the gene for antifreeze proteins?

    b. Explain the evolutionary process by which antifreeze proteins became common among notothenioids.

    c. Will species always evolve the adaptations they need to survive in their environment? Justify your answer.

EXTENSION

Research and report on one of the following questions:

1. Penguins also live in the Antarctic, but they do not have antifreeze proteins. What adaptations make it possible for penguins to survive in this harsh, cold environment?
2. Do any animal species besides notothenioids make antifreeze proteins?
3. Are any plant species able to make antifreeze?
4. Antifreeze proteins work by binding to ice crystals. How does that compare with how the antifreeze used in cars works?
5. Scientists have hypothesized that there are possible disadvantages to having antifreeze proteins. What is one of these disadvantages, and how might notothenioids compensate for it? Suggested reference: https://doi.org/10.1073/pnas.1410256111.