A Cool Glass of Water: A Mystery

by

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Part I—A Surprise

In an undergraduate science course, a group of student teachers just finished some experiments using salt and ice. They had observed that salt made ice melt at temperatures below its normal melting point.

"That makes sense—remember how we use salt to melt ice on the sidewalk? Salt helps the ice to melt," said Marian to her group members. They all agreed.

The instructor then introduced them to a teaching project. She announced, "Now I want you to take a look at the state curriculum standards. Try to find a science concept that is interesting to you and your group members. You are asked to put together a lesson to teach that concept to elementary school students. Feel free to use the knowledge you have acquired in this class for your teaching project."

Marian: Why don't we teach children the three states of water? We can do experiments with them, like melting ice cubes.

John: Yeah, we can ask children to predict which ice cube will melt first, the one in salt water or the one in fresh water. That will catch their attention.

Gail: Good idea. Then we can do the experiment with them to check their predictions.

Sally: Let's try the experiment first ourselves.

Gail: I'll make some salt water and measure out 200 milliliters of salt water and fresh water. John, can you measure their temperatures to make sure they are the same?

John: Yes, they are; they're at room temperature, 22 degrees Celsius.

Sally: I'll have to find two ice cubes with the same size and shape. Okay, I have them. Ready? Get set; go!

Sally put one ice cube in each of the two liquids at the same time while Gail started the stop watch to measure the time elapsed. Both ice cubes floated in the liquid. To their surprise, the ice cube in fresh water melted much more quickly than the one in salt water.

"How come?!" said everyone.

Part II—Related Phenomena

That afternoon, the group members went home thinking about this mystery. Marian wanted to bake some cookies for her family. As she poured some water and oil in the measuring cup, she noticed that the oil was sitting on top of the water. She thought about that for a moment. Then suddenly she exclaimed, "I know what happened with the ice cubes! I must tell my group the first thing next Monday."

John went to a hot air balloon show that evening. As he was watching the hot air balloons rising, John said to himself, "I guess I might have an idea to solve the problem involved in our experiment."

Gail's family went on a vacation that weekend. As Gail went swimming in the ocean, she noticed that her body seemed to float higher in ocean water than in fresh water. She thought, "I bet I know why that ice cube in the salt water took so long to melt."

Sally accidentally knocked over a glass of iced tea on the counter of her bathroom. She noticed that the brown iced tea seemed to go to the bottom of the bath tub filled with warm water. "I wonder if that has anything to do with our experiment."

The four of them saw each other on Monday. After exchanging ideas, they thought they now had a perfect explanation for the mystery. They wanted to test their idea. They made colored ice cubes by putting several drops of food coloring in the water before freezing it into ice. Then they repeated the original experiment with the colored ice cubes. They couldn't wait to see if the test would confirm their idea or not.

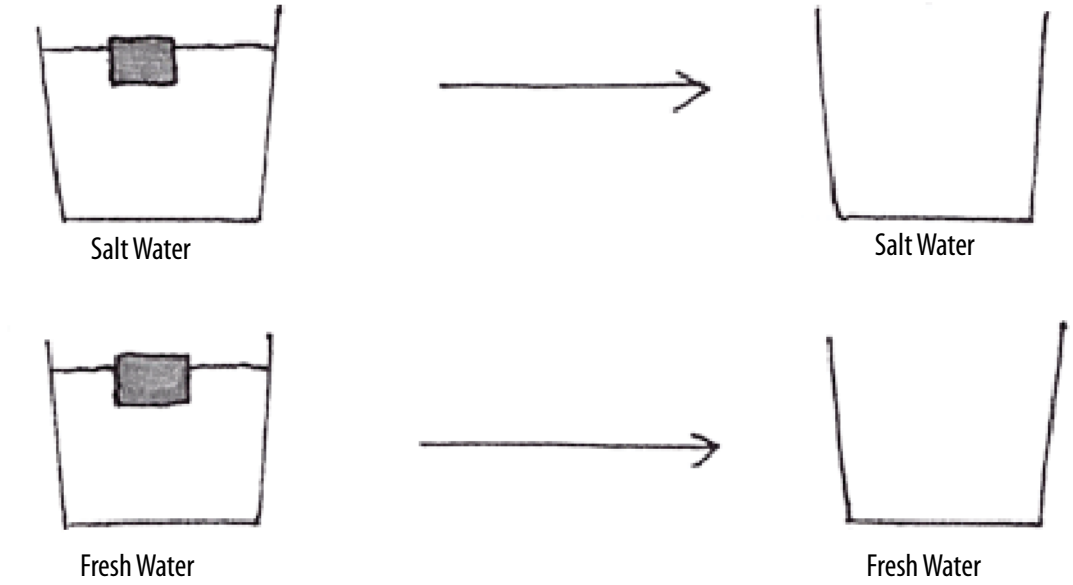
Question

1. What do you think might be the explanation they are trying to test with the colored ice cubes?

Part III— Predictions and Observations

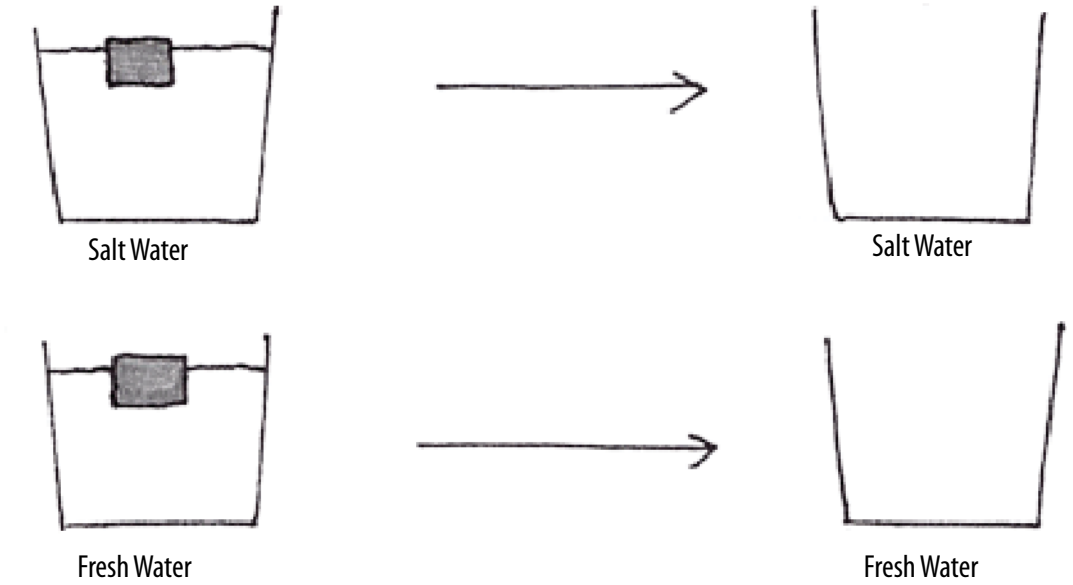
If their explanation were correct, draw what you would expect to see in the experiment with colored ice cubes.

Figure 1—Predicitions for colored ice melting.



After you have drawn your predictions and shared them with your group members, do the experiment and record your observations. Are the observations consistent with your predictions?

Figure 2—Observations of colored ice melting.



Part IV—Experimental Design and Explanation

As Marian, John, Gail, and Sally were doing the experiment, they noticed that the two ice cubes not only melted at different rates, they also melted in different ways.

Sally: Look! This one in fresh water is becoming smaller and smaller all around, but that one in salt water seems to be staying the same size if you look at it from above.

Marian: But actually the one in salt water is also melting, just more slowly. It's becoming thinner and thinner.

John: It looks like it's not melting from the sides. Do you think it's melting from the top down or from the bottom up?

Gail: I'm not sure. What do you think?

Figure 3—Fresh water observations.

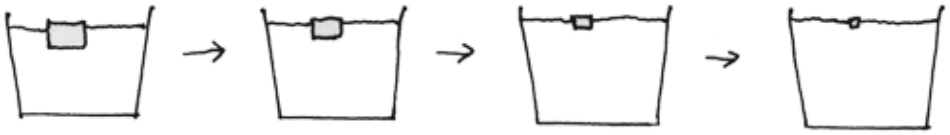
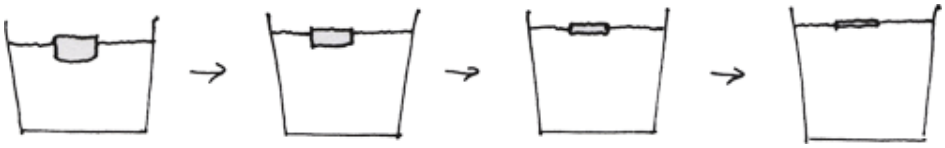


Figure 4—Salt water observations.



Questions

1. Do you think the ice cube in salt water is melting from the top down or from the bottom up?
2. Why do you think so?
3. What test would you do to verify your idea?
4. How would you explain what you see in the test?
5. How does the density of an object or a fluid affect its floating or sinking behavior in another fluid? Can you think of examples of this principle at work in everyday experience?
6. What are the two ways that heat is transferred from a region of higher temperature to a region of lower temperature in this example of an ice cube in a glass of water? Is there yet another way that heat could be transferred between two objects?
7. Can you think of examples of heat transfer in everyday experiences? Which way(s) of heat transfer is (are) involved in each example?