3.3.2a Soaking in Salt Water

Overview

It is not easy living in ocean water. The addition of the salts in the water means that many animals living in ocean water must regulate their internal water composition through osmosis. Bony fish in the ocean are hypotonic with respect to their environment because their body fluids contain less dissolved substances than the ocean water around them. Water naturally seeks a chemical balance, or equilibrium. To maintain balance, water flows from areas of low salt concentration to areas of high salt concentration in the process of osmosis. This movement happens easily through semi-permeable membranes. Water molecules can travel through the semi-permeable membranes, but larger salt molecules cannot. Water from inside a fish's body constantly moves to outside the fish through its gills and skin. All this movement of water out of the fish could severely dehydrate the fish. To stay hydrated, fish must drink lots of salt water, which is a problem, too. Fish kidneys have evolved to pump lots of salt into the urine of the fish to get rid of the excess salt. Other animals in the ocean, like sharks, do not lose water like fish. Instead, they stay in balance with the ocean water through the chemical, urea. Urea in the fluids inside a shark balances the salts in the water outside the shark. Because their internal water chemistry is the same as the chemistry of ocean water, sharks are isotonic.

Learning Objectives

- Osmosis is the movement of a solvent (usually water) across a semi-permeable membrane that equalizes the concentration of solutes on both sides of the membrane.
- The ability of a substance to pass through a semi-permeable membrane depends on the size of the substance at a molecular level and the size of the openings in the membrane.
- Gills and skin are examples of semi-permeable membranes in fish through which osmosis occurs.

Student Activity: Soaking in Salt Water

Materials

Diffusion Demonstration	Osmosis Demonstration
1 20-cm length of dialysis tubing 2 small pieces of string Corn syrup 1 500mL Beaker filled with water	1 10-cm length of dialysis tubing 2 small pieces of string 1 500 mL beaker filled with distilled water Starch solution (see Advanced Preparation) Glucose solution (see Advanced Preparation) Lugol iodine indicator solution Glucose test strips

Note: Materials can be found at Home Science Tools (https://www.homesciencetools.com)

Advance Preparation

Gather the materials for the demonstration. Dialysis tubing (sold 1in x 10ft) can be purchased from a science supply company.

To make the starch solution, add one gram of cornstarch to 10 mL of distilled water. Shake well and pour into 100 mL of boiling, distilled water. Cool.

To make the glucose solution, add one gram of table sugar to 10 mL of distilled water. Shake well and pour into 100 mL of boiling, distilled water. Cool.

Practice using the glucose test strips and the Lugol iodine starch indicator solution. Learn what happens when you test your glucose solution with the test strips. Find out what happens when you mix the Lugol solution with your starch solution.

Process and Procedures

Diffusion Demonstration

1. Soak an 20-cm length of dialysis tubing in water to soften it. Close up one end by folding it over and tying it with a length of string.
2. Fill the tubing with about 5 cm of corn syrup.
3. Leaving a little space above the 5 cm of corn syrup, close up the other end of the tubing by folding it over and tying it with the remaining length of string. Don't trap air in with corn syrup, if possible. If there seems to be too much tubing left, cut it to size first and then seal it. You should have approximately an 8-cm cylinder about two-thirds full of corn syrup when you are done.
4. Rinse the outside of the dialysis tubing with distilled water to clean away any residual corn syrup. Pat dry.
5. Place the dialysis tubing in the beaker of distilled water, making sure that it is completely submerged.
6. Wait approximately 25-30 minutes, then remove the dialysis tubing from the beaker.
7. Discuss your observations by answering the following questions:
    - What happened to the water around the tubing?
    - What happened to the corn syrup inside the tubing?
    - Why do you think the change to the inside of the tubing happened?
    - What would a diagram of the process look like? Make a drawing using arrows and labels.

Osmosis Demonstration

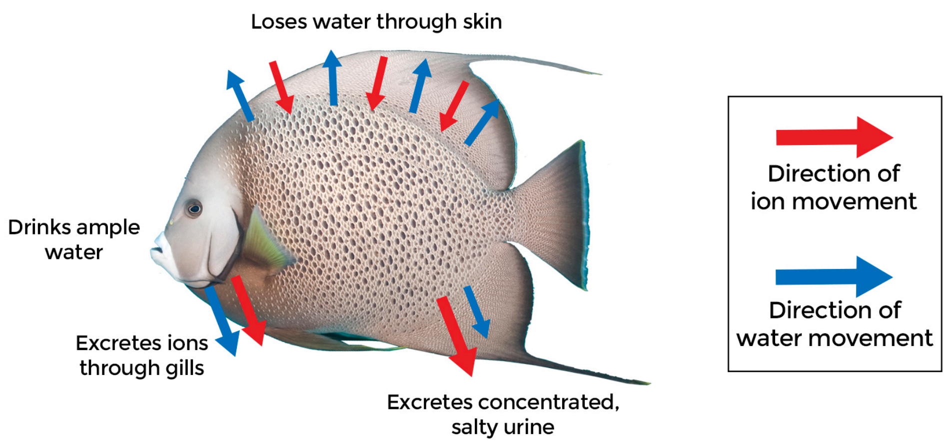
1. Prepare your dialysis tubing like you did in step 1 above.
2. Fill the dialysis tubing with 2.5 cm of starch solution and 2.5 cm of glucose solution. Tie off the open end like you did in step 3 above.

3. Rinse any residual solution off the outside of the dialysis tubing using distilled water. Pat dry.
4. Fill the 500 mL beaker with distilled water. Add a few drops of Lugol iodine indicator solution to the water.
5. Place the dialysis tubing into the 500-mL beaker with distilled water. Be sure that it is completely submerged.
6. Wait approximately 25-30 minutes, then remove the dialysis tubing from the beaker.
7. Discuss your observations by answering the following questions.
    - Test the water in the beaker with the glucose test strips. What do the test strips tell you? Why do you think this happened?
    - What do you observe about the solution in the dialysis tubing? Why do you think this happened?
    - Draw a diagram with arrows and labels to illustrate the movement of materials that took place in your demonstration.
    - If you had to order the size of the molecules of the following substances, what would be your order, from smallest to largest?

        Lugol's solution
        Glucose solution
        Water
        Pores in the dialysis tubing
        Starch solution
    - How are these two demonstrations (both Diffusion and Osmosis) relevant to life in the ocean?

Assessment

Below is a diagram of a marine fish in ocean water.
Based on your understanding of osmosis, predict what would happen if you placed a marine fish in a fresh water environment. Make a similar diagram to the one above to show the movement of water and salt. Use the size of the arrows to indicate smaller or bigger gain or loss.



Expected Outcomes

What's the take-away?

Marine animals face unique challenges living in a saltwater environment. Thus, marine animals have adapted ways to deal with the salt in the water. This enables them to survive and thrive in a marine environment. Processes such as osmosis and the use of chemicals like urea are examples of such adaptations.

What does the student work product look like?

During the diffusion and osmosis demonstrations, look for student conversations to demonstrate an awareness of what the parts of each model represents. (The tubing represents the semi-permeable membrane, the different substances in the tubes represent various sizes and types of dissolved substances.) Students should recognize the importance of the water as the substance in which the processes occur.

Assessment

The body fluids of bony fish contain less dissolved substances than the ocean water around them. This is true when the fish is in saltwater. When the fish is placed in freshwater, students should realize that this means that the fish's body fluids now have more dissolved substances than the freshwater that now surrounds them. Additionally, as the fish is no longer ingesting saltwater to stay hydrated, the kidneys would need to pump out much less salt from the body fluids of the fish. When crafting their diagrams, the arrows should be sure to show the water flowing in the proper directions.