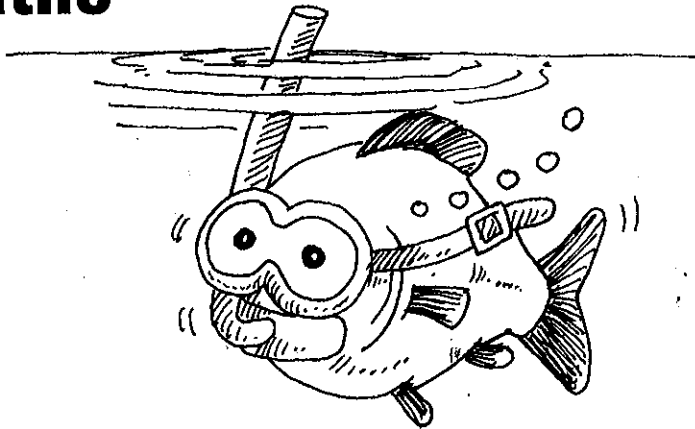
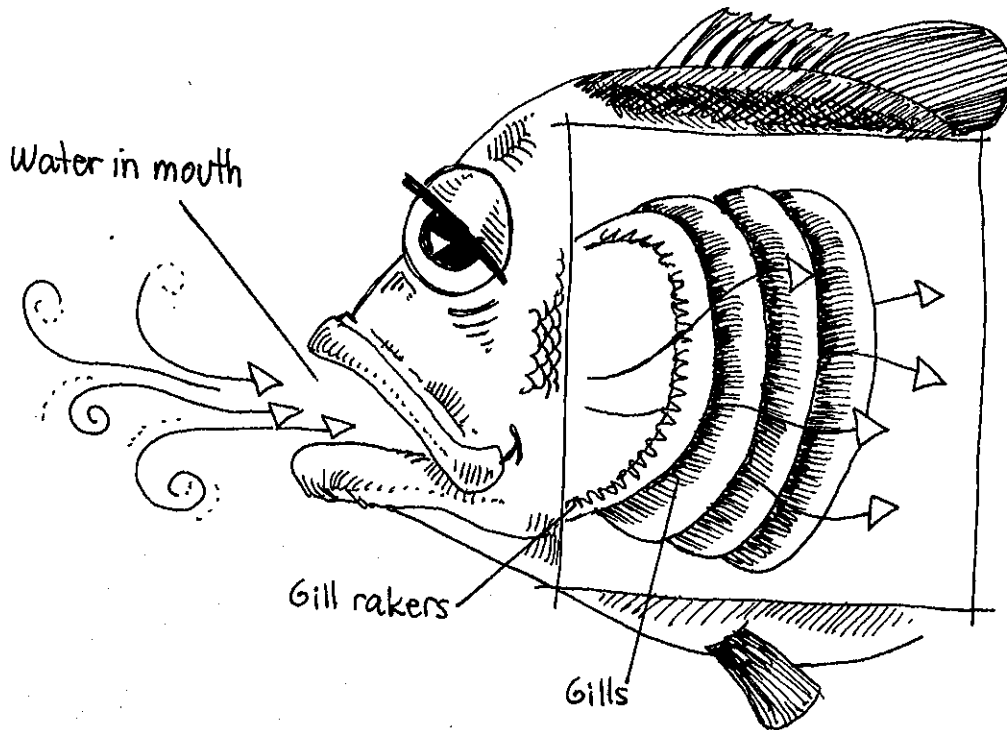


Lesson 2: How Fish Breathe



Background

Like all animals, fish need oxygen to survive. Yet unlike terrestrial animals, which breathe oxygen from the air, fish take oxygen from the water. A fish breathes by opening and closing its mouth. This motion forces a continuous stream of water to pass over the gills. The water brings in oxygen that is absorbed by the blood flowing through the blood vessels in the gills. These blood vessels are called gill filaments.



Fish Focus

- Oxygen exists in water just as it exists in air.
- Fish, like people, need oxygen to survive.
- Fish respire by taking in oxygen rich water through their mouth and passing it through their gills.
- The gills of a fish function like lungs.
- Fish give off carbon dioxide, which is used by aquatic plants.
- Aquatic plants give off oxygen, which is used by fish.
- A fish's rate of respiration is dependent on water temperature, available oxygen, and level of fish activity.

**fin fact**

In the environment, fish use oxygen in the water, which is provided by aquatic plants. In turn, fish give off carbon dioxide that is used by the aquatic plants. In aquariums where live plants may not exist, oxygen is provided by an air pump.

**word to know**

respiration—the physical and chemical process by which an organism provides itself with oxygen

**Materials**

16-ounce clear plastic cups, tap water, drinking straws

**fin fact**

The warmer the water the less dissolved oxygen it can hold.

Respiration is the process of taking in oxygen and giving off carbon dioxide. As the blood vessels in the gill filaments absorb oxygen, they are also releasing carbon dioxide into the water passing through the gills. The billions of living cells that make up a fish need oxygen in order to carry out their various functions. These functions stop quickly if the supply of oxygen fails. As oxygen rich blood is pumped from the gill filaments through the body capillaries, the oxygen escapes through the thin vessel walls into the cells of the fish. These living cells then take the oxygen and combine it with the carbon in their food to form energy, heat and carbon dioxide.

By breathing in air from the surface of the water, some fish manage to live in stagnant water that has very little oxygen in it. The lungfish for example, which lives in African lakes, has very small gills, so it gulps air at the surface, then swallows it into its swimbladder through an opening in the gullet. The swimbladder acts as a lung, and oxygen is absorbed by its walls. Please note, however, that this is not normal behavior for most fish. In fact, it may indicate that something is wrong with your fish.

Discussion

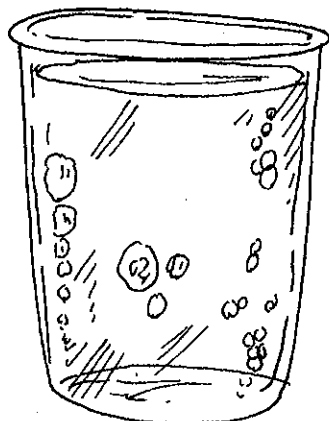
Explain to the group that fish, like humans, need oxygen to live. To do so, fish remove oxygen from the water that surrounds them just as humans remove oxygen from the air that surrounds them. Mention that this process is called "respiration." To do so, however, fish like humans are especially equipped to perform this task in their respective environments. So equipped, in fact, that a fish trapped out of water has the same chances of surviving as a human trapped under water.

Activity: Oxygen in Water

This activity is a good discussion starter. It helps illustrate the fact that gases, like oxygen and carbon dioxide, can exist in water as well as air.

1. A day before this activity, provide each group member with a 16-ounce plastic cup filled half way with tap water. As the water settles, have them observe the condition of the water especially its lack of bubbles.

2. On the day of the activity have the group members closely examine their cups. They should notice a large number of bubbles attached to the side of the cup.



Explanation

What they see are bubbles of oxygen that settled out from the water. Because the water was oxygen rich, the molecules of oxygen in the water tended to clump together to form bubbles.

Digging Deeper

Have the group force air into their cup of water by blowing through a straw. By blowing air into the water they increase the oxygen level of the water. Have them stop blowing and listen to the hissing sound of the extra air escaping from the water. Also note the additional size and number of bubbles clinging to the sides of the cup. Explain how this action is similar to what an air pump does in an aquarium.

Activity: Fish/Plant Relationship

Use this activity to illustrate how carbon dioxide is given off as a byproduct of respiration. To prepare for this activity, prepare the following recipe.

Purple Cabbage indicator solution (Prepare up to 12 hours before needed.):

- Cut a head of purple cabbage into small pieces. Place the cabbage pieces in a two quart bowl.
- Add enough boiling water to cover the cabbage. Allow the cabbage to stand no more than 12 hours.
- Discard the cabbage pieces and save the purplish liquid.
- You are now ready for this activity.



Materials

Purple cabbage indicator (see recipe), drinking straws, 16-ounce clear plastic cups



1. Keep the group divided into teams of three. Empty their cups and refill with one tablespoon of the purple cabbage solution and $\frac{1}{8}$ cup of water.
2. Explain to them that one of the byproducts of respiration is carbon dioxide. Fortunately for us, and fish, the carbon dioxide we exhale is what plants need to survive. Just as the oxygen plants give off is what we need to survive.
3. To detect the carbon dioxide in their breath, have the teams blow air through their straw into the solution of purple cabbage indicator. If all goes well, the solution should turn a reddish color.
4. See which teams can set their solution the reddest. Line up the cups and compare results against original solution.

Explanation

The indicator contains water and a dye extracted from the purple cabbage. Carbon dioxide from the exhaled breath combines with the water to form a weak acid called carbonic acid. The cabbage dye turns red when mixed with any acid. Pour 1 teaspoon of vinegar into a cup of purple cabbage solution to dramatically illustrate this point.

Guiding Questions

- What if there was no air pump or live plants in the aquarium? (fish would use up oxygen and die)
- What would eventually happen to the levels of oxygen and carbon dioxide in the tank? (oxygen decreases, carbon dioxide increases)
- Could enough live plants be added to the tank to replace the need for an air pump? (yes, if balance of fish to tank to plants was correct)

This questioning could lead to the following experiment using live aquatic plants.

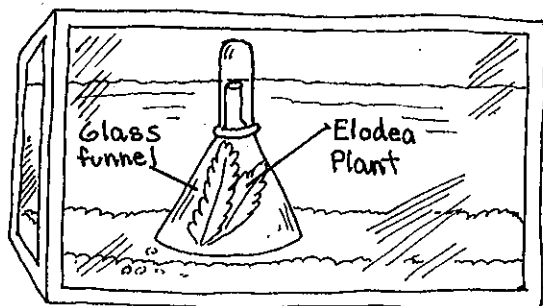


Materials
aquatic plant, funnel, container,
test tube, water

Digging Deeper

A trickier, yet effective experiment can be performed to illustrate that plants give off oxygen. Because this experiment takes time to generate oxygen, you should start it at least ten days before this lesson.

1. Obtain a plant that grows under water from a pet store. Put the plant in a glass container and add enough water to cover as shown in the illustration. Cover the plant as shown with a glass funnel. Place a test tube over the top of the funnel. Be sure to tilt the tube in the water to remove all air trapped inside.
2. Once assembled, place the apparatus near a window. As the plant gives off oxygen as a byproduct of photosynthesis, the water level in the tube will begin to decrease. Once the tube is filled with oxygen, it may be removed for further testing.



3. To test the contents, fold a piece of paper so it may be inserted into the tube. With a match, light the paper then blow out the flame so a glowing edge remains.
4. Explain to the group that oxygen exists in the tube, and that oxygen is a combustible gas, meaning it burns quickly.
5. After darkening the room, carefully remove the tube, remembering not to tilt it, and insert the glowing paper. If done correctly, the paper should burn brighter.

Activity: Slow Fish/Fast Fish

This activity is designed to illustrate the effects of activity and temperature on the movement of a fish's mouth and operculum. Introduce this activity by asking the following questions:

- Do you think a fish uses more oxygen when its active or resting? (*active*)
 - Does the temperature of the water have any effect on a fish's respiration? (*yes, slow it down*)
1. Keep the group divided into teams of three. Empty their cups and refill halfway with aquarium water. Next, place a goldfish in each team cup.
 2. Once their fish settles down, have the teams count the number of times the mouth of their fish opens and closes in a minute.
 3. Next, have the teams excite their fish by tapping on the side of the cup with a pencil. Once again have them count the number of times the mouth of their fish opens and closes in a minute.
 4. Finally, place a small chip of ice into each cup. Once the fish settles down and the ice has melted, have them count the number of times the mouth of their fish opens and closes in a minute.
 5. Record all of their times on a blackboard or large sheet of poster-size paper. Average the group recordings for each phase of this activity; calm, excited, cold. Remember to return the fish and the water back to the aquarium immediately following the experiment.

Guiding Questions

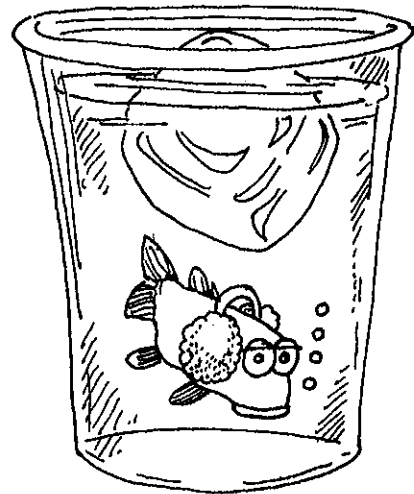
See if the group can establish a relationship between the respiration of fish and humans with the following questions.

- Do we tend to breathe faster or slower when we are excited? (*faster*)
- Do we tend to breathe faster or slower when we are cold? (*slower*)



Materials

Worksheet #2, 16-ounce clear plastic cups, aquarium water, ice



Name _____

Activity

Investigate - changes in respiration

Your instructor will explain how to properly set up and complete this activity.

■ After experimenting with your fish in cold water, warm water, and in an active state, record your observations below and answer the following questions.

1. Number of times mouth opened and closed in 1 min.

cold water _____

warm water _____

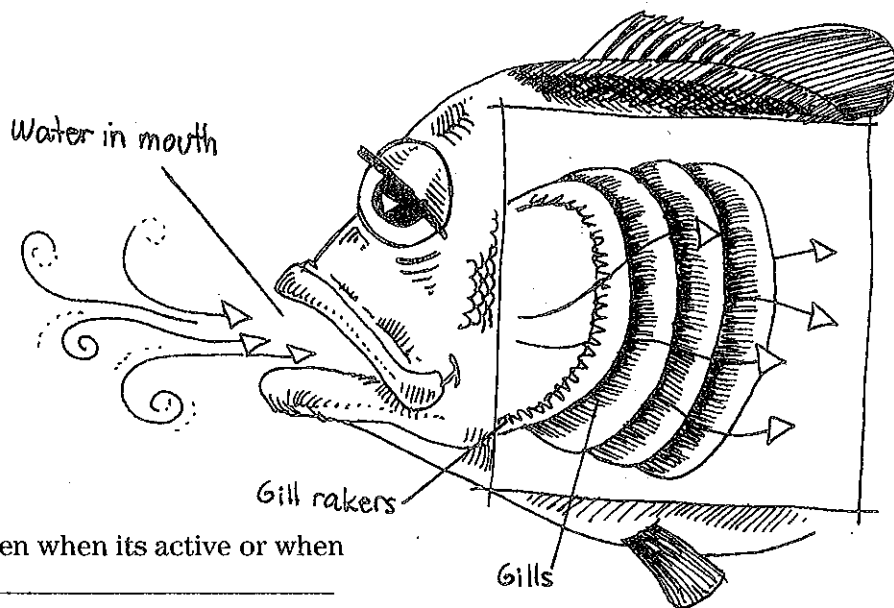
active state _____

Facts to Know:

Most fish use gills to breathe.

The rate at which a fish breathes depends on how active the fish is and the temperature of the water.

When a fish breathes, it opens its mouth and closes it again. This motion forces water to pass over the gills. The water brings in oxygen, which is absorbed by the fish. Water exiting the gills contains carbon dioxide which is given off by the fish.



2. Do you think a fish uses more oxygen when its active or when its resting? _____

3. Does the temperature of the water have any effect on a fish's respiration? If so how? _____

