ACTIVITY 27

A LIGHT SNACK

WHAT IS THE RELATIONSHIP BETWEEN LIGHT AVAILABILITY AND PHOTOSYNTHESIS IN AQUATIC PLANTS

SCIENCE SKILLS:
- measuring
- organizing
- inferring
- predicting
- experimenting
- communicating

CONCEPTS:
- If sufficient light is available, plants will produce more oxygen in photosynthesis than they use in respiration.
- The amount of oxygen produced is proportional to the available light up to a point.

MATH AND MECHANICAL SKILLS PRACTICED:
- use of dissolved oxygen test kit
- averaging

SAMPLE OBJECTIVES:
- Students will be able to design and complete an experiment to test how the amount of light available affects photosynthesis rates in aquatic plants.

INTRODUCTION:
This experiment tests the effect of two different light conditions on the amount of photosynthesis done by aquatic plants. It proves that the amount of light available may limit photosynthesis. This concept is important for an understanding of several ecological conditions. The first is that the production of food by plants and phytoplankton is limited to the surface waters of lakes and oceans because light is absorbed by water. Although vast in size, oceans and large lakes are more limited in their ability to produce food than it might seem because photosynthesis requires light. Only the top layers of these bodies of water have enough light for photosynthesis. A second consideration is the effect of human actions that increase the TURBIDITY or cloudiness of water. These actions cut down on the light needed by plants to make food using photosynthesis.

MATERIALS:

For each group:
- two pint fruit jars with screw tops
- one large bunch of freshwater plants such as ***Elodea*** (use 20-24 inches per pint)

For the class:
- two sources of light, one low and one higher (not a strong heat source)
- aged water
- dissolved oxygen test kits
- boiled tap water cooled and sealed in a jar
- turkey basters or syringes for sampling jars

LESSON PLAN:

BEFORE CLASS: The experiment covers three days. Have the students start the experiment one day, putting the jars in the dark overnight. On the second day, they will test each for dissolved oxygen and then put the jars in two different light intensities. On the third day, they will again test for dissolved oxygen to see what the effect of the two different light intensities was. You may shorten the activity by setting it up yourself, putting the plants in the jars overnight and then testing the dissolved oxygen yourself. This is written in a way that assumes you do the first day's preparation yourself.

Day One: Pour aged tap water into each jar. Add the ***Elodea*** or other aquatic plant. Try to get the same total length of plant in each jar. Make sure the jars are full to overflowing and seal. Place at room temperature in the dark overnight. As you learned in Activity 11, this will remove almost all of the oxygen from the water and saturate it with carbon dioxide because the plants are using the oxygen in respiration and producing carbon dioxide as a waste product. If you started this experiment with the amount of oxygen normally found in room temperature water, oxygen (which is a waste product of photosynthesis) would build up and slow down photosynthesis. If you used boiled water which is low in oxygen, it would also be low in carbon dioxide which is required for photosynthesis.

DURING CLASS:
METHODS: Day Two: Review the results of student observations with regard to light and its absorbance by water. What is the most likely effect of low light availability on the plants that live in water? What do the students know about plants and how they use light? Review photosynthesis. Can they think of a way to test the effect of low light?

Bring out the jars and explain what you have done to prepare for this activity. Ask the students what they might use as a measure of how much photosynthesis takes place. Oxygen is produced as a waste product, and they are good at dissolved oxygen measurements. What do they need to do first? Measure the amount of oxygen at the beginning of the experiment. Replace the lost water when you take a sample for the dissolved oxygen test with cool boiled tap water.

How will they test the effect of low light on photosynthesis? Put one jar of each pair in high

or low light after testing for dissolved oxygen. One location might be full sunlight and the other, indirect light. Incandescent lights may be used also. Either put the jars two different distances from lights of the same intensity (light intensity varies with the squaare of the distance) or put them all the same distance from bulbs of two different intensities such as 75 and 150 watts. Avoid intense heat, but make sure the jars stay between 65 and 80° F.

Day Three: Test the dissolved oxygen in the two jars. Calculate the results as the difference between Day Two and Day Three. Have students put their results on the board so that all the students can share.

RESULTS:

The dissolved oxygen produced should be greater in the jars that received more light. How did the results compare with the results from plants left in the dark in Activity 11? Considering that respiration happens all the time, the amount of actual oxygen produced is really higher than you measured because it is constantly being used in respiration as it is being produced by photosynthesis. All that can be measured in this activity is the amount left over which is called net photosynthesis. (Gross photosynthesis is like gross income and respiration is like taxes, resulting in a much smaller net income.)

If the student were an aquatic plant, where would he/she want to live and why? Near the surface or in shallow where there would be enough light to make enough food to survive. It would be important that the water be clear so that light could get through.

CONCLUSIONS:

The amount of photosynthesis done by water plants is directly related to the available light. Where light does not reach in deep water, no photosynthesis takes place. Only the light surface waters produce food.

USING YOUR CLASSROOM AQUARIUM:

If your classroom aquarium receives good light and you have a good algal population or many underwater plants, you might try turning off the aeration system on two successive days. The first day leave it uncovered and test the dissolved oxygen level after several hours. Turn the aeration back on. If the animals did not show signs of stress, the following day turn off the aeration system and cover the tank with a dark cloth for two hours. Again test the dissolved oxygen. It should be lower if your plants or algae are healthy.

Discuss why plants and animals both belong in an aquarium. What is the role of the aeration system? If you carefully planned the amount of plants and animals in your aquarium, could you do without an aeration system? Theoretically, in a properly balanced aquarium with the right amount of light, the amount of excess oxygen produced in photosynthesis could balance that used by plants and animals in respiration.

EXTENSIONS:

1. Have your students design and draw a balanced aquarium in which aeration of the water by a pump is not required. It is possible to find the right combination of plants and animals, but most people put too many animals in their system.
2. Have your students list all the things they can think of that make water more turbid. Some things are sediment from farms or housing developments, sewage, and industrial wastes. They might not realize that things like plant nutrients that come from fertilizer, animal manure or sewage can make the water more turbid by encouraging phytoplankton to grow too fast. The phytoplankton can actually get so dense that they keep light from reaching aquatic plants growing on the bottom.

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Name Possible answers

What question might you answer by doing this experiment? Do plants make oxygen in the light? If so, does the amount of light have an effect on how much oxygen is made?

Record your results here:

	dissolved oxygen at beginning in ppm	dissolved oxygen after 24 hr in ppm	difference
low light	0.6	5.3	4.7
high light	1.2	8.8	7.6

Average the differences from all of the high light samples and low light samples for the class. The averages are:

High light: 9.1 ppm

Low light: 5.4 ppm

4.7 8.8
6.1 9.2
5.3 9.4
16.1 27.4

Based on these results, what statement can you make about the importance of light in producing oxygen during photosynthesis?

The amount of light is directly related to the amount of dissolved oxygen the plant produced during photosynthesis.

If you were an aquatic plant, where would you want to live and why?

I would want to live in clear, shallow water where there was lots of light so I could photosynthesize lots of food.