PRELIMINARY ACTIVITY FOR

Primary Productivity

Oxygen is vital to life. In the atmosphere, oxygen comprises over 20% of the available gases. In aquatic ecosystems, however, oxygen is scarce. To be useful to aquatic organisms, oxygen must be in the form of molecular oxygen, O_2. The concentration of oxygen in water can be affected by many physical and biological factors. Respiration by plants and animals reduces oxygen concentrations, while the photosynthetic activity of plants increases it. In photosynthesis, carbon is assimilated into the biosphere and oxygen is made available, as follows:

$$6\ H_2O + 6\ CO_2(g) + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2(g)$$

The rate of assimilation of carbon in water depends on the type and quantity of plants within the water. *Primary productivity* is the measure of this rate of carbon assimilation. As the above equation indicates, the production of oxygen can be used to monitor the primary productivity of an aquatic ecosystem. A measure of oxygen production over time provides a means of calculating the amount of carbon that has been bound in organic compounds during that period of time. Primary productivity can also be measured by determining the rate of carbon dioxide utilization or the rate of formation of organic compounds.

One method of measuring the production of oxygen is the *light and dark bottle* method. In this method, a sample of water is placed into two bottles. One bottle is stored in the dark and the other in a lighted area. Only respiration can occur in the bottle stored in the dark. Respiration rate is the decrease in dissolved oxygen (DO) in the dark bottle over time. Both photosynthesis and respiration can occur in the bottle exposed to light, however. The difference between the amount of oxygen produced through photosynthesis and that consumed through aerobic respiration is the *net productivity*. The difference in dissolved oxygen over time between the bottles stored in the light and in the dark is a measure of the total amount of oxygen produced by photosynthesis. The total amount of oxygen produced is called the *gross productivity*.

The measurement of the DO concentration of a body of water is often used to determine whether the biological activities requiring oxygen are occurring and is an important indicator of pollution.

In the Preliminary Activity, you will gain experience using a Dissolved Oxygen Probe as you measure the DO level of a water sample provided by your teacher. You will also learn how to calculate respiration rate, gross productivity, and net productivity.

After completing the Preliminary Activity, you will first use reference sources to find out more about primary productivity before you choose and investigate a researchable question dealing with primary productivity. Some topics to consider in your reference search are:

- primary productivity
- dissolved oxygen
- net productivity
- gross productivity
- photosynthesis
- cellular respiration
- eutrophication

PROCEDURE

1. Prepare the Dissolved Oxygen Probe for use following instructions from your teacher. Place the probe in a beaker filled with about 100 mL of distilled water.
2. Connect the Dissolved Oxygen Probe to the interface and open the data-collection program. Allow the probe to stay in the water for 5 minutes as the probe warms up.
3. Collect DO data.
   a. Place the tip of the probe into the water sample being tested. Submerge the probe tip to a depth of 4–6 cm.
   b. Start data collection. Gently stir the probe in the water sample. **Note:** It is important to keep stirring until you have finished collecting data.
   c. Continue stirring and data collection until the readings have been relatively stable (stable to the nearest 0.2 mg/L) for about 30 seconds, then stop data collection.
   d. Select the stable region of your graph, then display Statistics for that region. Note and record the mean value for that region as the DO of the water sample.

QUESTIONS

1. What was the DO of the water sample you tested in the Preliminary Activity?

2. Only respiration can occur in a dark bottle. Respiration rate is the decrease in DO over time. Suppose a dark bottle sample of the water you tested above was tested 24 hours later and found to have a DO level 1.2 mg/L lower then the initial DO value you obtained. Calculate the respiration rate (in mg/L/hr) using the formula

$$\text{Respiration rate} = \frac{(\text{dark DO} - \text{initial DO})}{\text{time}}$$

3. Suppose a light bottle sample of the water you tested above was placed next to a light source. Suppose it was tested 24 hours later and found to have a DO level 0.5 mg/L higher then the initial DO value you obtained. Calculate gross productivity (in mg/L/hr) using the formula

$$\text{Gross productivity} = \frac{(\text{light DO} - \text{dark DO})}{\text{time}}$$

4. Calculate net productivity (in mg/L/hr) using the formula

$$\text{Net productivity} = \frac{(\text{light DO} - \text{initial DO})}{\text{time}}$$

5. List some local sources of pond, lake, or seawater that might be useful in this experiment.

6. List some factors that might influence primary productivity in an aquatic environment.

7. List at least one researchable question for this experiment.