Investigation
17

PRELIMINARY ACTIVITY FOR

Investigating Primary Productivity

Open Inquiry Version

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:

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

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.

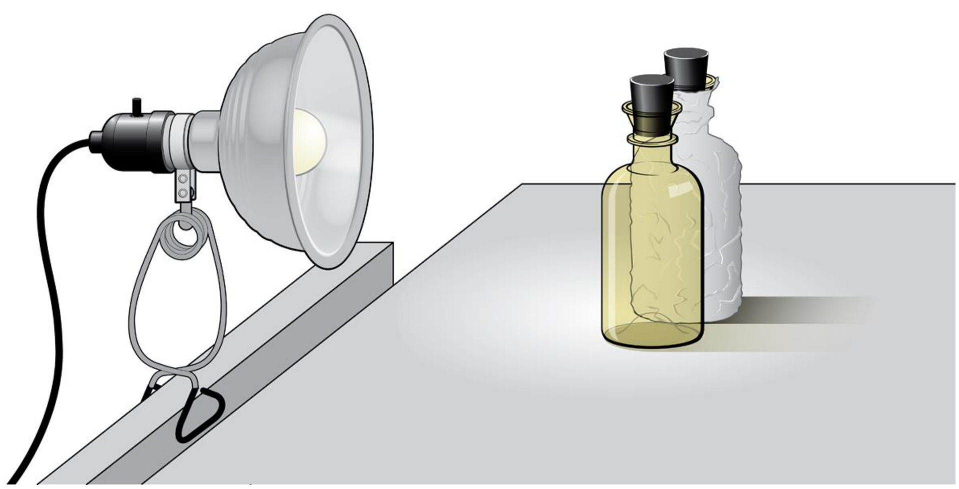

Figure 1 *The light and dark bottle method of measuring oxygen production*

One method of measuring the production of oxygen is the *light and dark bottle* method, as shown in Figure 1. In this method, sample water is placed into two BOD (biochemical oxygen demand) 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. 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 this 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 using the *light and dark bottle* method.

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
- respiration rate
- eutrophication

PRE-LAB PROCEDURE

Important: Prior to each use, the Dissolved Oxygen Probe must warm up for a period of 5–10 minutes as described below. If the probe is not warmed up properly, inaccurate readings will result. Perform the following steps to prepare the Dissolved Oxygen Probe.

1. Prepare the Dissolved Oxygen Probe for use.
   a. Remove the blue protective cap.
   b. Unscrew the membrane cap from the tip of the probe.
   c. Using a pipet, fill the membrane cap with 1 mL of DO Electrode Filling Solution.
   d. Carefully thread the membrane cap back onto the electrode.
   e. Place the probe into a 250 mL beaker containing distilled water.

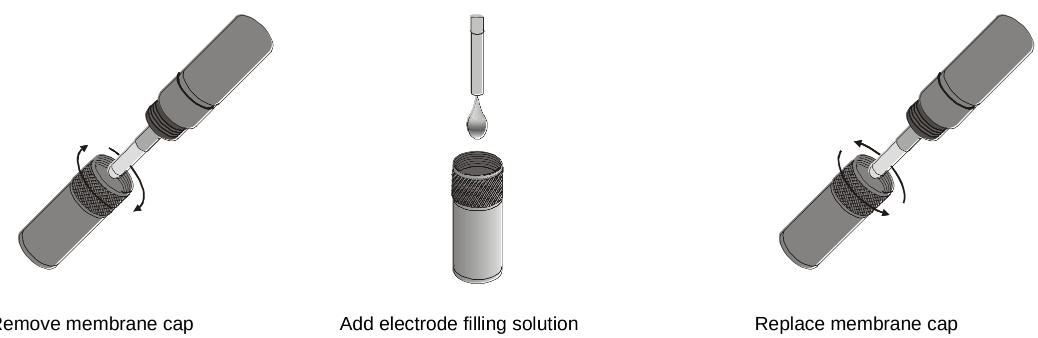

Figure 1

2. Connect the Dissolved Oxygen Probe to the interface and open the data-collection program.
3. It is necessary to warm up the Dissolved Oxygen Probe for 5–10 minutes before taking readings. To warm up the probe, leave it connected to the interface, with the data-collection program running. The probe must stay connected at all times to keep it warmed up. If disconnected for a few minutes, it will be necessary to warm up the probe again.

PROCEDURE

Day 1

1. Obtain three BOD bottles.

2. Fill each bottle with sample water using the following technique:
   a. Obtain a siphon tube.
   b. Insert the tube into the water sample and fill the tube completely with water.
   c. Pinch the tube (or use a tube clamp) to close off the siphon tube.
   d. Place one end of the tube in the bottom of the water quality bottle. Keep the other end in the water sample, well below the surface. Position the bottle lower than the water sample Place a shallow pan under the test tube to collect any water that spills over.
   e. Siphon the water into the bottle. Fill the bottle until it overflows.
   f. Tighten the stopper for the bottle securely by twisting it once in place. Verify that no air is trapped in the bottle.

3. The percentage of available natural light for each water sample is listed in Table 1 below:

Table 1: DO Levels using *Dark and Light Bottle* Method

Water sample	Light exposure (%)	DO (mg/L)
Initial	n/a	
Light	100	
Dark	0	

4. Mix the contents of each bottle. Be sure that there are no air bubbles present in any of the bottles. Fill with more water if necessary.

5. Remove the Dissolved Oxygen Probe from the beaker. Place the probe into one of the bottles, so that it is submerged half the depth of the water. Gently and continuously move the probe up and down a distance of about 1 cm in the bottle. This allows water to move past the probe's tip. Note: Do not agitate the water, or oxygen from the atmosphere will mix into the water and cause erroneous readings.

6. After 60 seconds, or when the dissolved oxygen reading stabilizes, record the reading. This is the *initial* DO. Discard the contents of this bottle and rinse it. Rinse the Dissolved Oxygen Probe with distilled water and place it back in the distilled water beaker. The probe should remain in the beaker overnight, so that measurements can be made the following day.

7. Wrap one of the remaining bottles with aluminum foil so that it is lightproof. This water sample is the *dark* sample. It will remain in the dark.

8. Place the dark and light bottle near a light source, as shown in Figure 1. Leave the light on for 24 hours.

Day 2

9. Prepare the Dissolved Oxygen Probe for data collection. See Steps 2–3 of the pre-lab procedure. Allow the probe 10–15 minutes to warm up. Keep the probe in the beaker of distilled water during this time.

10. Place the probe into the *light* water bottle. Verify that the probe is submerged half the depth of the water. Gently and continuously move the probe up and down a distance of about 1 cm in the bottle. After 60 seconds, or when the dissolved oxygen reading stabilizes, record this reading.

11. Repeat Step 10 for the *dark* bottle.

12. Clean your water bottles as directed by your instructor. Rinse the Dissolved Oxygen Probe with distilled water and place it back in the distilled water beaker.

QUESTIONS

1. Only respiration can occur in a dark bottle. Respiration rate is the decrease in DO over time. Calculate the respiration rate (in mg/L/hr) using the formula below.

   Respiration rate = (*dark* DO – *initial* DO) / time

2. Calculate gross productivity (in mg/L/hr) using the formula below.

   Gross productivity = (*light* DO – *dark* DO) / time

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

   Net Productivity = (*light* DO – *initial* DO) / time

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

5. List at least one researchable question concerning primary productivity.