# PRIMARY PRODUCTIVITY WITH LABQUEST

## LAB 25

From *Biology with Vernier*



**Westminster College**

# INTRODUCTION

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, O2. 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:

6H2O + 6 CO2(g) + energy → C6H12O6+ 6 O2(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. In this method, a sample of water is placed in 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. The decrease in dissolved oxygen (DO) in the dark bottle over time is a measure of the rate of respiration. 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.

# OBJECTIVES

* Measure the rate of respiration in an aquatic environment using a Dissolved Oxygen Probe.
* Determine the net and gross productivity in an aquatic environment.

# MATERIALS

LabQuest Dissolved Oxygen Probe

Shallow pan scissors

Siphon tube aluminum foil Wash bottle with distilled water screens

Window screen 7 airtight bottles with stoppers 500 mL pond, lake or seawater rubber bands

## Additional Materials for Dissolved Oxygen Probe

Calibration bottle DO Electrode Filling Solution

Pipet 250 mL beaker with distilled water Sodium Sulfite Calibration Solution (only if calibration is needed)



*Figure 2*

# PROBE PREPARATION

1. Prepare the Dissolved Oxygen Probe for use.
	1. Remove the blue protective cap.
	2. Unscrew the membrane cap from the tip of the probe.
	3. Using a pipet, fill the membrane cap with 1 mL of DO Electrode Filling Solution.
	4. Carefully thread the membrane cap back onto the electrode.
	5. Place the probe into a container of water.
2. Connect the Dissolved Oxygen Probe to LabQuest and choose New from the File menu.
3. It is necessary to warm up the Dissolved Oxygen Probe for 10 minutes before taking readings. To warm up the probe, leave it connected to LabQuest for 10 minutes. The probe must stay connected at all times to keep it warmed up. If disconnected for more than a few minutes, it will be necessary to warm up the probe again.
4. You are now ready to calibrate the Dissolved Oxygen Probe.
* If your instructor directs you to use the default calibration, continue to the Procedure.
* If your instructor directs you to perform a new calibration for the Dissolved Oxygen Probe, use the calibration instructions provided by your instructor.

# PROCEDURE

**Day 1**

1. Fill seven Water Quality bottles with the water sample, ensuring that air does not mix into the sample.
	1. Obtain a siphon tube.
	2. Insert the tube into the water sample and fill the tube completely with water.
	3. Pinch the tube (or use a tube clamp) to close off the siphon tube.
	4. Place one end of the tube in the bottom of a 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 bottle to collect any water that spills over.
	5. Siphon the water into the Water Quality bottle. Fill the bottle until it overflows. Ensure the bottle is filled completely to the top of the rim.
	6. Insert a stopper in the Water Quality bottle. Be sure no air is in the bottle.
2. The percentage of available natural light for each water sample is listed in Table 1:

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| Table 1 |
| Sample | Number of screens | % Light |
| 1 | 0 | Initial |
| 2 | 0 | 100% |
| 3 | 1 | 65% |
| 4 | 3 | 25% |
| 5 | 5 | 10% |
| 6 | 8 | 2% |
| 7 | Aluminum foil | Dark |

1. Label the samples as follows: dark, initial, 2%, 10%, 25%, 65%, 100%.
2. Wrap sample 7 with aluminum foil so that it is lightproof. This water sample will remain in the dark.
3. Apply layers of screen to simulate the amount of natural light available for photosynthesis at different depths in a body of water.
* If using the Primary Productivity Kit, select the screen number that corresponds to the number of screens in Table 1.
* If using your own screens, wrap screens around samples according to Table 1. Trim the screens so each one only wraps around once. Hold the screens in place with rubber bands or clothespins. The bottoms need not be covered unless they are to be stored on their side.
1. Place the Dissolved Oxygen Probe into sample 1, the initial sample, so that it is submerged half the depth of the water. Gently stir the sample to allow the water to move past the probe’s tip while monitoring the DO value, but do not agitate the water or oxygen from the atmosphere will mix into the water and cause erroneous readings.
2. When the dissolved oxygen reading stabilizes, record the reading in Table 2. Discard the initial sample. Rinse the Dissolved Oxygen Probe with distilled water, and place it back in the beaker of distilled water.
3. Place samples 2–7 near the light source, as directed by your instructor.

**Day 2**

1. Obtain the same Dissolved Oxygen Probe you used yesterday and repeat the Probe Preparation as necessary to set up the probe.
2. Place the probe into the 100% light sample. Gently stir the sample to allow the water to move past the probe’s tip while monitoring the DO value, but do not agitate the

water or oxygen from the atmosphere will mix into the water and cause erroneous readings.

1. When the dissolved oxygen reading stabilizes, record the reading in Table 2.
2. Repeat Steps 10–11 for the remaining samples.
3. Rinse the probe with distilled water, and place it back in the beaker of distilled water.

# DATA

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| Table 2 |
| Sample | % light | DO(mg/L) |
| 1 | Initial |  |
| 2 | 100% |  |
| 3 | 65% |  |
| 4 | 25% |  |
| 5 | 10% |  |
| 6 | 2% |  |
| 7 | Dark |  |

**PROCESSING THE DATA**

1. Determine the number of hours that have passed since the onset of this experiment. Subtract the DO value of sample 1 (the initial DO value) from that of sample 7 (the dark sample’s DO value). Divide the DO value by the time in hours. Record the resulting value as the respiration rate in Table 3.

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

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| Table 3 |
| Respiration rate (mg•L–1•hr–1) |  |

1. Determine the gross productivity for each sample. To do this, subtract the DO in sample 7 (the dark sample’s DO value) from that of each sample, 2–6 (the light

samples’ DO values). Divide each DO value by the length of the experiment in hours. Record each resulting value as the gross productivity in Table 4.

Gross productivity = (DO of sample – dark DO) / time

1. Determine the net productivity in each sample. To do this, subtract the DO in samples 2–6 (the light sample’s DO value) from that of sample 1 (the initial DO value). Divide the result by the length of the experiment in hours. Record each resulting value as the net productivity in Table 4.

Net Productivity = (DO of sample – initial DO) / time

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| Table 4 |
| Sample | % light | Gross productivity (mg•L–1•hr–1) | Net productivity (mmg•L–1•hr–1) |
| 2 | 100% |  |  |
| 3 | 65% |  |  |
| 4 | 25% |  |  |
| 5 | 10% |  |  |
| 6 | 2% |  |  |

1. Prepare two graphs: one of gross productivity and one of net productivity as a function of light intensity.

# QUESTIONS

1. Is there evidence that photosynthetic activity added oxygen to the water? Explain.
2. Is there evidence that aerobic respiration occurred in the water? If so, what kind of organisms might be responsible for this—autotrophs? Heterotrophs? Explain.
3. What effect did light have on the primary productivity? Explain.
4. Refer to your graph of productivity and light intensity. At what light intensity do you expect there to be no net productivity? no gross productivity?
5. How would turbidity affect the primary productivity of a pond?

# EXTENSIONS

1. Determine the effects of nitrogen and phosphates on primary productivity. Why would the presence of phosphates and nitrogen, in the form of nitrates and ammonium ions, be important to an aquatic ecosystem during the spring season? How do they accumulate in the watershed? What is eutrophication?
2. Measure the dissolved oxygen of a pond at different temperatures. What is the effect of temperature on the primary productivity of a pond?
3. Calculate the amount of carbon that was fixed by each of the samples. Use the following conversion factors to do the calculations.

O2 mg/L × 0.698 = mL O2 /L

mL O2 /L × 0.536 = mg carbon fixed/L