Name:_____

Primary Productivity

AP Bio Lab 12B

Date:_____

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. For each milliliter of oxygen produced, approximately .0536 milligrams of carbon has been assimilated. 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. 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

In this experiment, you will

- 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

computer
Vernier computer interface
Vernier Dissolved Oxygen Probe
Logger*Pro*
17 pieces of 12 cm × 12 cm (5″ × 5″) plastic window screen
250 mL beaker
aluminum foil
seven 25 × 150 mm screw top bottles
shallow pan
scissors
rubber bands
500 mL pond, lake, seawater or algal culture
distilled water

PRE-LAB QUESTIONS

- Purpose of this experiment:

- Hypothesis:

  - Independent Variable:

    How are you manipulating the independent variable?

  - Dependent Variable:

    How are you measuring the dependent variable?

    - Controlled variables

- Possible reasons that error may occur (3 examples):

PRE-LAB procedure

Important: Prior to each use, the Dissolved Oxygen Probe must warm up for a period of 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.

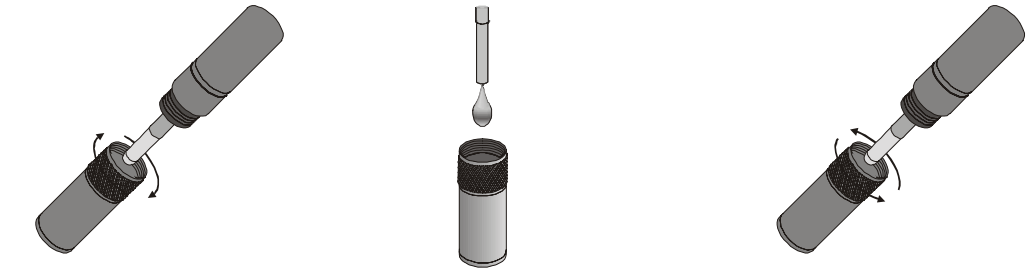


Figure 1

2. Connect the Dissolved Oxygen Probe to the Vernier computer interface.
3. Prepare the computer for data collection by opening the file "25 Primary Productivity" from the *Biology with Vernier* folder of Logger*Pro*.
4. 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 Logger *Pro* 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

6. Obtain seven water sampling bottles.
7. Fill each of the bottles with the water sample. To fill a bottle:
   a. Submerge the bottle into the water sample and fill the bottle completely with water.
   b. Still submerged, screw on the cap of the bottle.
   c. Tighten the cap on the bottle securely. Be sure no air is in the bottle.

8. The percentage of available natural light for each water sample is listed in Table 1 below. Your group will be assigned one bottle to be responsible for.

Table 1

Bottle	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

9. Use masking tape to label the cap of your bottle. Mark the labels as follows: dark, initial, 2%, 10%, 25%, 65%, and 100% based on what you were assigned.

10. Wrap bottle 7, the dark bottle, with aluminum foil so that it is lightproof. This water sample will remain in the dark.

11. Invert the contents of each tube. Be sure that there are no air bubbles present in any of the bottles. Fill a bottle with more sample water if necessary.

12. Wrap screen layers around the bottles according to Table 1. Trim the screens so each one only wraps around the bottle once. Hold the screens in place with rubber bands or clothespins. The bottles will stand on end so the bottoms of the bottles need not be covered. The layers of screen will simulate the amount of natural light available for photosynthesis at different depths in a body of water.

13. Remove the Dissolved Oxygen Probe from the beaker. Place the probe into bottle 1, the initial bottle, 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.

14. After 60 seconds, or when the dissolved oxygen reading stabilizes, record the reading in Table 2. Discard the contents of the initial bottle and clean the bottle. 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.

15. Place bottles 2–7 near the light source, as directed by your instructor.

16. Prepare the computer for data collection by opening the file saved on Day 1 of the experiment. Allow the probe 10–15 minutes to warm up. Keep it in the beaker of distilled water during this time. The calibration from the previous day should have been saved with the experiment file, so no calibration is needed for Day 2 measurements.

17. Place the probe into your bottle. 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 the reading in Table 2.

18. Repeat Step 17 for the remaining bottles.

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

DATA

Table 2

Bottle	% 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 in the bottle 1 (the initial DO value) from that of bottle 7 (the dark bottle'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

2. **Determine the gross productivity in each bottle.** To do this, subtract the DO in bottle 7 (the dark bottle's DO value) from that of bottles 2–6 (the light bottles' DO value). 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 bottle – dark DO) / time

3. **Determine the net productivity in each bottle**. To do this, subtract the DO in bottles 2–6 (the light bottle's DO value) from that of bottle 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 bottle – initial DO) / time

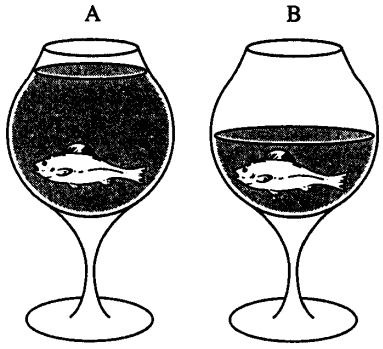
Table 3	
Respiration (mg O_2/L/hr)	

Table 4			
Bottle	% Light	Gross productivity (mg/L/hr)	Net productivity (mg/L/hr)
2	100%		
3	65%		
4	25%		
5	10%		
6	2%		

4. **Prepare a graph of gross productivity and net productivity** as a function of light intensity. Graph both types of productivity on the same piece of graph paper.

QUESTIONS – TYPE UP THE ANSWERS AND INCLUDE WITH YOUR GRAPH.

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. A mammal uses only 1 to 2 percent of its energy in ventilation (breathing air in and out) while a fish must spend about 15 percent of its energy to move water over its gills. Explain this huge difference in their efforts to collect oxygen.
6. Would you expect the DO in water form a stream entering a lake to be higher or lower than the DO taken from the lake itself? Explain why.
7. Would you expect the DO concentration of water samples taken from a lake at 7:00 a.m. to be higher or lower than samples taken at 5:00 p.m.? Explain.
8. In the following drawings of identical container with identical fish but with different volumes of water, which one (A or B) would have more oxygen available to the fish initially? Explain. After 5 hours, who has more? Explain.



9. What is eutrophication? Research and explain why allowing nitrogen or phosphorus fertilizers to run into a body of water can negatively affect life in it.