

Instructions

Log onto http://www.phschool.com/science/biology_place/labbench/ and select Lab 12: Dissolved Oxygen. Complete this packet as you perform the virtual lab exercises.

Introduction

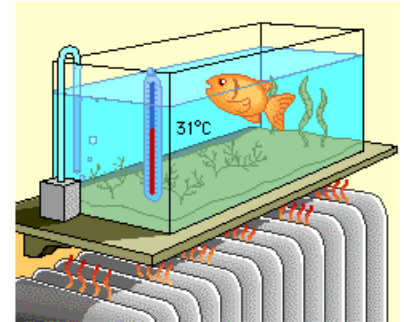
In an aquatic environment, oxygen must be dissolved in order to be available for use by organisms. In this laboratory you will:

1. Measure the amount of dissolved oxygen in water samples at different temperatures.
2. Analyze the effect of varying amounts of light on primary productivity.

Key Concepts

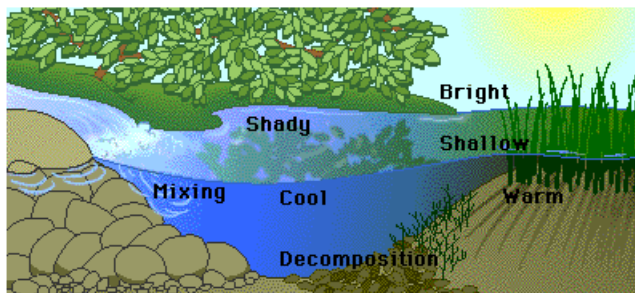
"Why did fish that I kept in an aquarium over my radiator die? An aerator was producing a constant stream of bubbles, so they should have had plenty of oxygen." At the end of this laboratory you should be able to answer this question.

Let's begin by looking at factors that influence the availability of oxygen.



Dissolved Oxygen Availability

Oxygen is essential for cellular [respiration](#) in most organisms. In an aquatic environment, oxygen availability is influenced by a variety of chemical and physical factors.



KNOW IT! Some of the factors that affect the amount of oxygen dissolved in water are:

- *Temperature:* As water becomes warmer, its ability to hold oxygen decreases.
- *Photosynthetic activity:* In bright light, aquatic plants are able to produce more oxygen.
- *Decomposition activity:* As organic material decays, microbial processes consume oxygen.
- *Mixing and turbulence:* Wave action, waterfalls, and rapids all aerate water and increase the oxygen concentration.
- *Salinity:* As water becomes more salty, its ability to hold oxygen decreases.

Ideal Conditions for Maximum Dissolved Oxygen

1. Which environment has the greater concentration of dissolved oxygen: salt water or fresh water? Explain.

2. Which environment has the greater concentration of dissolved oxygen: warm water (31°C) or cool water (18°C)? Explain.

3. Which environment has the greater concentration of dissolved oxygen: a clear pond or a pond with a heavy algal mat? Explain.

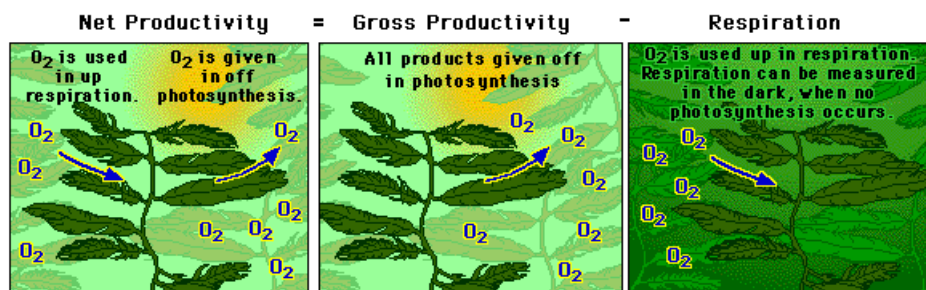
Primary Productivity

Before we learn how to measure dissolved oxygen, let's consider the concept of primary productivity. [Primary productivity](#) is a term used to describe the rate at which plants and other photosynthetic organisms produce organic compounds in an ecosystem. There are two aspects of primary productivity:

- [Gross productivity](#) = the entire photosynthetic production of organic compounds in an ecosystem.
- [Net productivity](#) = the organic materials that remain after photosynthetic organisms in the ecosystem have used some of these compounds for their cellular energy needs (cellular respiration).

Since oxygen is one of the most easily measured products of both photosynthesis and respiration, a good way to gauge primary productivity in an aquatic ecosystem is to measure dissolved oxygen. We cannot measure gross productivity directly because respiration, which uses up oxygen and organic compounds, is always occurring simultaneously with photosynthesis — but we can measure it indirectly. Let's see how to do this.

- We can measure net productivity directly by measuring oxygen production in the light, when photosynthesis is occurring.
- We can also measure respiration without photosynthesis by measuring O₂ consumption in the dark, when photosynthesis does not occur.
- Since net productivity = gross productivity – respiration, we can calculate gross productivity.



Measuring Primary Productivity

How can primary productivity be measured in an aquatic ecosystem? To answer this question, you must first recall the equation for [photosynthesis](#). Write the equation here.

The equation for photosynthesis is:

Note: Because this lab focuses on dissolved O₂, we don't include CO₂ in our discussions. However, don't forget that CO₂ plays a major role in both photosynthesis and cellular respiration. Primary productivity can be measured in three ways:

1. The amount of carbon dioxide used.
2. The rate of sugar formation.
3. The rate of oxygen production***

In this laboratory, we will use the third method, the rate of oxygen production. Do you understand why this measurement will reveal primary productivity? If you aren't sure, look again at the definition of [primary productivity](#) and the equation for photosynthesis.

Design of the Experiments – Dissolved Oxygen & Temperature

In the first part of the laboratory, you will measure dissolved oxygen in water at different temperatures. Many kits and testing procedures are available for measuring dissolved oxygen. In our experiment, we will use the **WINKLER METHOD** for measuring dissolved oxygen.

- The Winkler Method is a technique used to measure dissolved oxygen in freshwater systems. Dissolved oxygen is used as an indicator of the health of a water body, *where higher dissolved oxygen concentrations are correlated with high productivity and little pollution*. This test is performed on-site, as delays between sample collection and testing may result in an alteration in oxygen content.
- The Winkler Method uses titration to determine dissolved oxygen in the water sample. A sample bottle is filled completely with water (no air is left to skew the results). The dissolved oxygen in the sample is then "fixed" by adding a series of reagents that form an acid compound that is then titrated with a neutralizing compound that results in a color change. The point of color change is called the "endpoint," which coincides with the dissolved oxygen concentration in the sample. Dissolved oxygen analysis is best done in the field, as the sample will be less altered by atmospheric equilibration.
- Dissolved oxygen analysis can be used to determine: 1) the health or cleanliness of a lake or stream, 2) the amount and type of biomass a freshwater system can support, 3) the amount of decomposition occurring in the lake or stream.

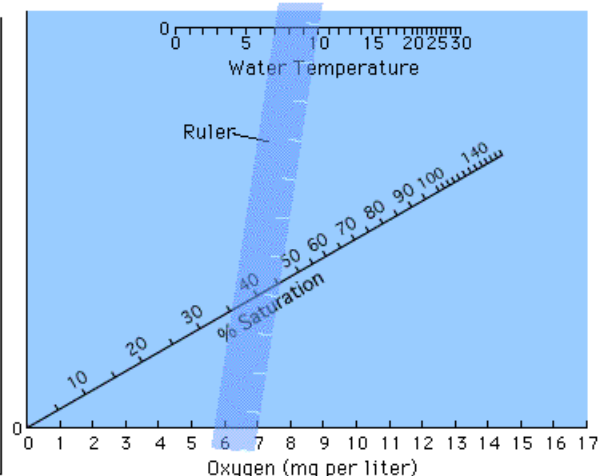
To measure how much oxygen water can hold (saturation), you need to be able to read a **nomograph**.

Practice by making the measurements necessary to answer the questions.

What is the percent oxygen saturation for a water sample at 10°C that has 7 mg O₂/l?

 %
[Check Your Answers](#)

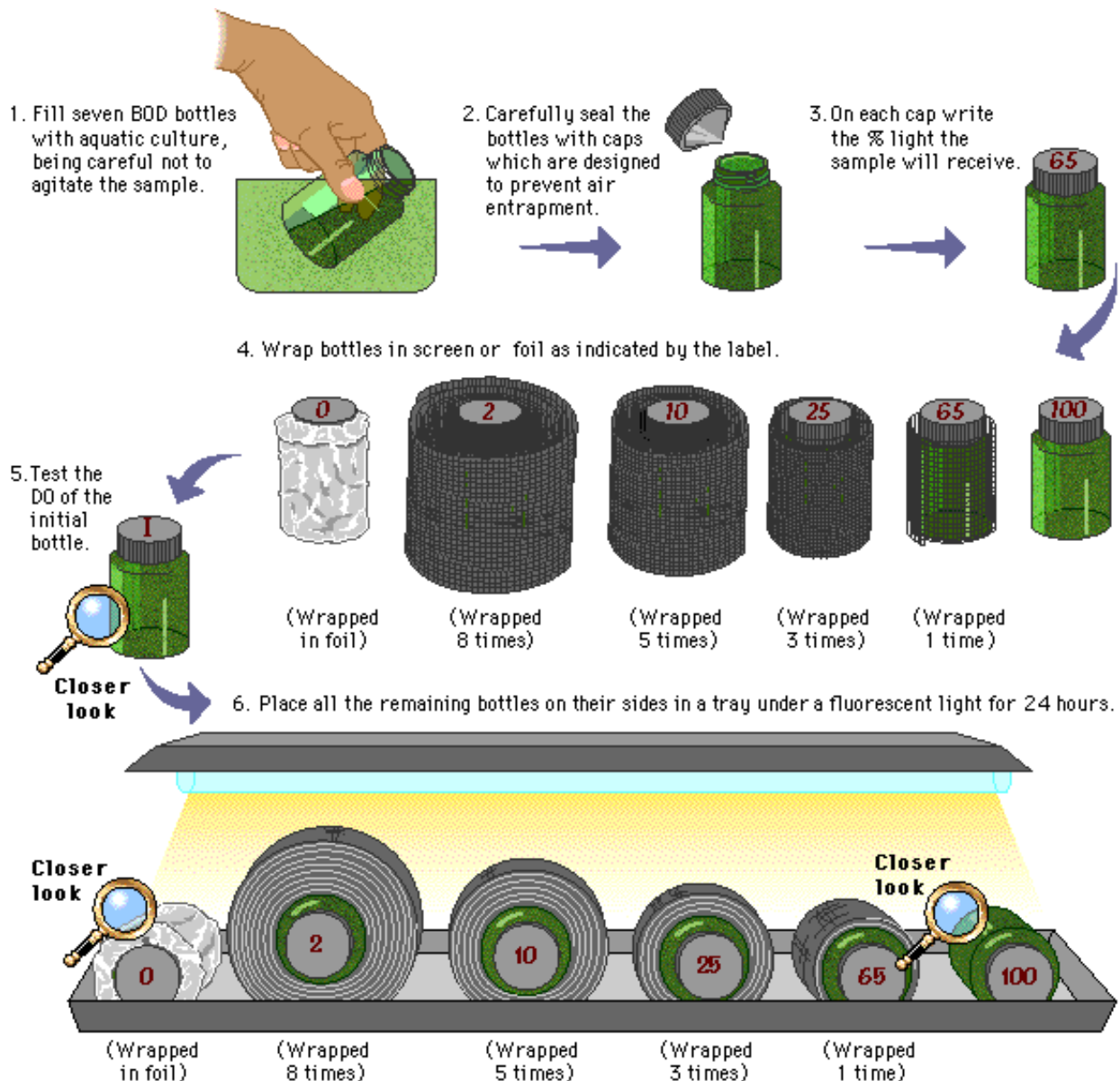
What is the percent oxygen saturation for a water sample at 25°C that has 7 mg O₂/l?

 %
[Check Your Answers](#)

A Model of Productivity as a Function of Depth in Lake

In this portion of the laboratory you monitor the effect of varying light levels on dissolved oxygen in an algae-rich water culture.

The amount of light available for photosynthesis drops off sharply with increasing depth in an aquatic environment. You model this condition by wrapping water-sample bottles with increasing layers of screen, as shown in the overview diagram below.



Review the animations carefully as you click through the “a closer look” screens – note the activities as they relate to the external environment!

A Model of Productivity - Initial



A Model of Productivity - Dark



A Model of Productivity - Light



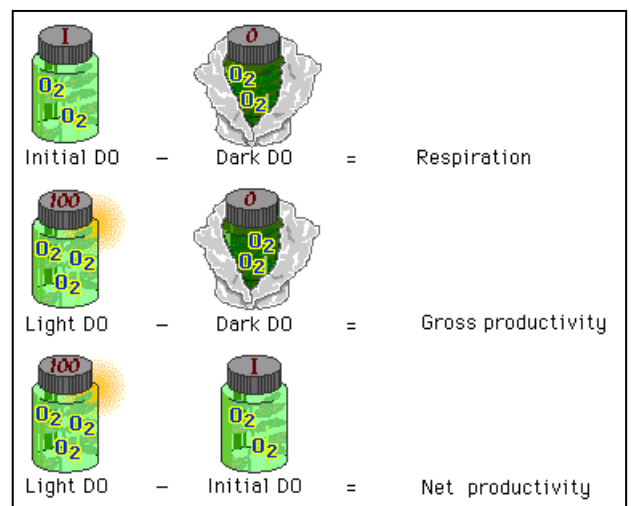
Measuring Dissolved Oxygen Under Varying Light Conditions

On the first day of the laboratory, you measure the amount of oxygen present in your original sample. You then measure the amount of oxygen present after 24 hours of photosynthesis and respiration under the light conditions in each bottle.

- The aquatic sample must be rich in photosynthetic organisms — water that is so algae-rich it appears green is good for this activity.
- Keep the water samples in a very bright light during the 24-hour period. Fluorescent bulbs do not give off much heat, but if you use an incandescent light bulb, you will need to place a heat sink (such as a beaker filled with water) between the light bulb and your bottles.

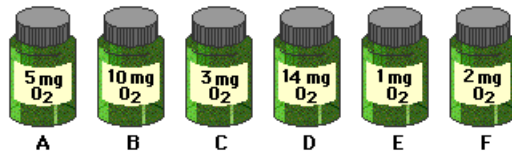
Analysis of Results

To help you analyze and understand the results of your own experiment, look at the illustration below and then do the sample problem on the next page.





Sample Problem

A biology student inadvertently removed all the screens and labels from the water-sampling bottles before he measured the amount of dissolved oxygen. When he tested the unidentified bottles, he obtained the results shown below.

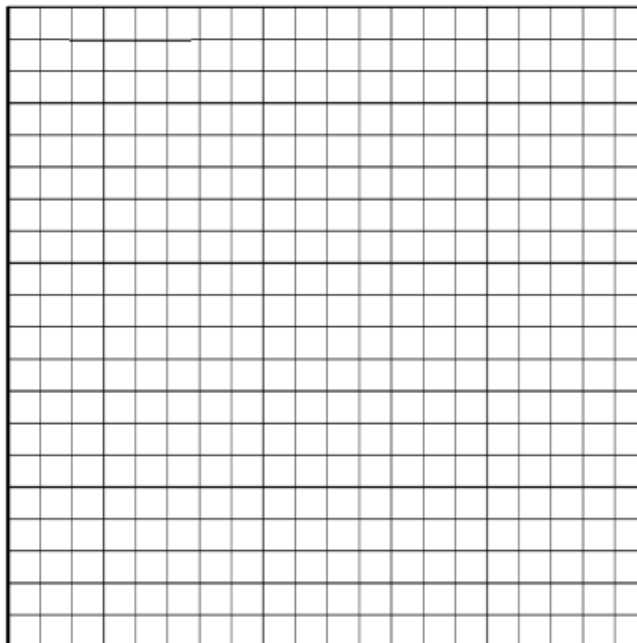


The initial oxygen reading for this water was 4 mg O₂/l.

- Based on the results predicted by the hypothesis that light increases productivity, enter the letter of the bottle that corresponds to each light percentage.
- Then complete the rest of the table and, using the graph below as a model, graph the gross and net productivity for these data.
- If you are having trouble with these calculations, take a side trip take a side trip to learn about gross productivity, net productivity or to get additional help.*

% Light	Bottle	Gross Productivity (light bottle minus dark bottle) 	Net Productivity (light bottle minus initial bottle) 
0	<input type="text"/>	<input type="text"/>	<input type="text"/>
2	<input type="text"/>	<input type="text"/>	<input type="text"/>
10	<input type="text"/>	<input type="text"/>	<input type="text"/>
25	<input type="text"/>	<input type="text"/>	<input type="text"/>
65	<input type="text"/>	<input type="text"/>	<input type="text"/>
100	<input type="text"/>	<input type="text"/>	<input type="text"/>

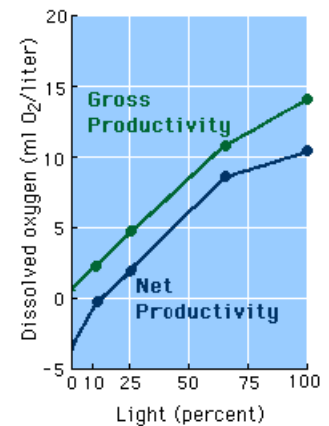
Graph the results of this experimental example below – both Net and Gross Productivity! Be sure to label both x- and y-axes on the graph. Place the independent variable on the x-axis and the dependent variable on the y-axis. Be sure to mark units correctly on the graph — the interval between 2% light and 10% light is NOT the same as the interval between 10% and 25%!



Lab Quiz

- In which aquatic environment would you expect dissolved oxygen to be highest?
 - A mountain lake that is clear and cold
 - A bog where the water is shallow and warm and there is a mat of aquatic plants
 - A marine tidepool
 - A cold mountain stream dropping over a series of small rock falls
 - A coral reef in a still lagoon

- To the right is the correct graph of the data you were given in the Sample Problem. Study this graph to answer the following question. At what light intensity do you expect there to be no net productivity?
 - Any intensity below 100%
 - Only at intensities of 0% and 2%
 - Any intensity below 10%
 - Any intensity above 25%



- What is meant by "net productivity" and how is it calculated in a sample aquatic environment?
 - It is a measure of the organic products of photosynthesis that accumulate after cellular respiration by those organisms is taken into account, and it is calculated by subtracting the amount of oxygen in the dark bottle from the amount in the light bottle.
 - It is a measure of the amount of respiration in a test area, and it is calculated by subtracting the amount of oxygen present in the light bottle from the amount in the dark bottle.
 - It is the total amount of carbon fixed, and it is calculated by measuring the amount of oxygen present in a bottle kept in the light.
 - It is the amount of oxygen produced during the day, and it is calculated by subtracting the amount of oxygen in the light bottle from the amount in the dark bottle.
- A biology class used two aquatic cultures as described below for the experiment with screens that reduce light. They measured dissolved oxygen initially, and then after 24 hours. What results would you predict for this experiment?
 - The net productivity in culture A will be much higher than in that in culture B.
 - Culture B will have both higher gross productivity and higher net productivity than culture A.
 - The net productivity for culture A will be negative at greater light intensity than that for culture B.
 - Cultures A and B will show similar results because of the comparable quantities of zooplankton.
 - Net productivity in culture B will exceed gross productivity in high light intensity.

Culture A	Culture B
Little phytoplankton	Rich in phytoplankton
Rich in zooplankton	Rich in zooplankton
Low initial dissolved oxygen	High initial dissolved oxygen

Lab Analysis & Conclusions

On a separate sheet of paper, answer the essay prompt below.

1. Consumers in aquatic ecosystems depend on producers for nutrition.
 - a. **Explain** the difference between gross and primary productivity.
 - b. **Describe** a method to determine net and gross primary productivity in a freshwater pond over a 24-hour period.
 - c. In an experiment, net primary productivity was measured, in the early spring, for water samples taken from different depths of a freshwater pond in a temperate deciduous forest. **Explain** the data presented by the graph, including a description of the relative rates of metabolic processes occurring at different depths of the pond.
 - d. **Describe** how the relationship between net primary productivity and depth would be expected to differ if new data were collected in mid-summer from the same pond. **Explain** your prediction.

NET PRIMARY PRODUCTIVITY IN A FRESHWATER POND ECOSYSTEM DURING SPRING

