Photosynthesis and Respiration

Plants make sugar, storing the energy of the sun into chemical energy, by the process of photosynthesis. When they require energy, they can tap the stored energy in sugar by a process called cellular respiration.

The process of photosynthesis involves the use of light energy to convert carbon dioxide and water into sugar, oxygen, and other organic compounds. This process is often summarized by the following reaction:

$$6\ H_2O + 6\ CO_2 + \text{light energy} \rightarrow C_6H_{12}O_6 + 6\ O_2$$

Cellular respiration refers to the process of converting the chemical energy of organic molecules into a form immediately usable by organisms. Glucose may be oxidized completely if sufficient oxygen is available by the following equation:

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

All organisms, including plants and animals, oxidize glucose for energy. Often, this energy is used to convert ADP and phosphate into ATP.

OBJECTIVES

In this experiment, you will

- Use an O_2 Gas Sensor to measure the amount of oxygen gas consumed or produced by a plant during respiration and photosynthesis.
- Use a CO_2 Gas Sensor to measure the amount of carbon dioxide consumed or produced by a plant during respiration and photosynthesis.
- Determine the rate of respiration and photosynthesis of a plant.

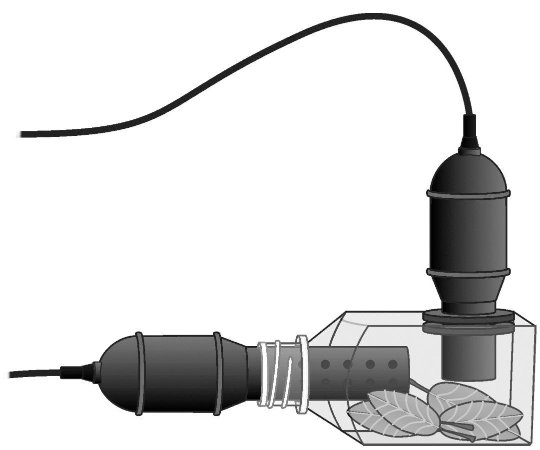

Figure 1

MATERIALS

computer
Vernier computer interface
plant leaves (spinach or parsley)
500 mL tissue culture flask

Logger *Pro*
Vernier O_2 Gas Sensor
Vernier CO_2 Gas Sensor
BioChamber 250
lamp
aluminum foil
forceps

PROCEDURE

1. If your CO_2 Gas Sensor has a switch, set it to the Low (0–10,000 ppm) setting. Connect the CO_2 Gas Sensor to Channel 1 and the O_2 Gas to Channel 2 of the Vernier computer interface.

2. Prepare the computer for data collection by opening the file "31C Photo (CO2 and O2)" from the *Biology with Vernier* folder of Logger*Pro*.

3. Obtain several leaves from the resource table and blot them dry, if damp, between two pieces of paper towel. **Weigh the leaves.**

4. Place the leaves into the BioChamber 250, using forceps if necessary. Wrap the respiration chamber in aluminum foil so that no light reaches the leaves.

5. Place the O_2 Gas Sensor into the BioChamber 250 as shown in Figure 1. Insert the sensor snugly into the grommet. The O_2 Gas Sensor should remain vertical throughout the experiment. Place the CO_2 Gas Sensor into the neck of the respiration chamber as shown in Figure 1.Wait 3 minutes before proceeding to Step 6.

6. Click ▶ Collect to begin data collection. Collect data for ten minutes and click ■ Stop. **Copy the data table in your notebook and record the amount of CO_2 and O_2 detected every minute.**

Time (min)	**CO2 (ppt)**	**O2 (ppt)**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

7. When data collection has finished, determine the rate of respiration:
   a. Click anywhere on the CO_2 graph. Move the mouse pointer to the point where the data values begin to increase. Hold down the left mouse button. Drag the pointer to the point where the data ceases to increase and release the mouse button.
   b. Click on the Linear Fit button, , to perform a linear regression. A floating box will appear with the formula for a best fit line.
   c. Record the slope of the line, *m*, as the rate of respiration in Table 1.
   d. Close the linear regression floating box.
   e. Repeat Steps 7a–d for the O_2 graph. However, you will need to move the mouse pointer to the point where the data values begin to decrease. Hold down the mouse button and drag to the point where the data ceases to decrease.

8. Move your data to a stored run. To do this, choose Store Latest Run from the Experiment menu.

9. Remove the aluminum foil from around the respiration chamber.

10. Turn the lamp on. Place the lamp as close to the leaves as reasonable. Do not let the lamp touch the tissue culture flask. Note the time. The lamp should be on for 3 minutes prior to beginning data collection.

11. After the five-minute time period is up, click Collect to begin data collection. Collect data for 10 minutes and click Stop. **Copy the data table in your notebook and record the amount of CO_2 and O_2 detected every minute. Begin to design an experiment to test one of the factors you or your partner listed in pre-lab question #10 that might influence the rate of oxygen production or consumption.**

Time (min)	**CO2 (ppt)**	**O2 (ppt)**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

12. When data collection has finished, determine the rate of photosynthesis:
    a. Click anywhere on the CO_2 graph. Move the mouse pointer to the point where the data values begin to decrease. Hold down the left mouse button. Drag the pointer to the point where the data ceases to decrease and release the mouse button.
    b. Click on the Linear Fit button, , to perform a linear regression. Choose "Latest CO2" and a floating box will appear with the formula for a best-fit line.
    c. Record the slope of the line, *m*, as the rate of photosynthesis in Table 1.
    d. Close the linear regression floating box.
    e. Repeat steps 13a–d for the O_2 graph. However, you will need to move the mouse pointer to the point where the data values begin to increase, hold down the mouse button and drag to the point where the data ceases to increase.

13. Print a graph showing your photosynthesis and respiration data.
    a. Label each curve by choosing Text Annotation from the Analyze menu. Enter "Photosynthesis" in the edit box. Repeat to create an annotation for the "Respiration" data. Drag each box to a position near its respective curve. Adjust the position of the arrow heads.
    b. Print a copy of the graph, with both data sets displayed. Enter your name(s) and the number of copies of the graph you want.

14. Remove the plant leaves from the respiration chamber, using forceps if necessary. **Reweigh the leaves**. Clean and dry the respiration chamber.

DATA

Table 1		
Leaves	CO_2 rate of production/consumption (ppt/min)	O_2 rate of production/consumption (ppt/min)
In the dark		
In the light		

Pre-lab Questions

1. What relationship, if any, is there between photosynthesis and cellular respiration?
2. What is the difference between chloroplasts and mitochondria?
3. Step 3 asks you to blot the leaves. Why do you think this is necessary?
4. In you own words, briefly explain what happens in each stage of photosynthesis.
5. Why is it important to wait 3 minutes before beginning step 6?
6. (Step 6) What do you expect to see in terms of the CO_2 and O_2 rate of production/consumption in the dark?
7. (Step 10): What do you think could happen if the leaves overheated?

8. Would the number of leaves affect your data? Why or Why not?

9. (Step 11): What do you expect to see in terms of the CO_2 and O_2 rate of production/consumption in the light?

10. What are some other factors that might influence the rate of oxygen production or consumption?

POST LAB QUESTIONS

1. Was either of the rate values for CO_2 a positive number? If so, what is the biological significance of this?

2. Was either of the rate values for O_2 a negative number? If so, what is the biological significance of this?

3. Do you have evidence that cellular respiration occurred in leaves? Explain.

4. Do you have evidence that photosynthesis occurred in leaves? Explain.

5. List five factors that might influence the rate of oxygen production or consumption in leaves. Explain how you think each will affect the rate?

EXTENSIONS

1. Design and perform an experiment to test one of the factors that might influence the rate of oxygen production or consumption in Question 5.

2. Compare the rates of photosynthesis and respiration among various types of plants.