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 H2O + 6 CO2 + light energy C6H12O6 + 6 O2

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:

C6H12O6 + 6 O2 →6 H2O + 6 CO2 + 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 O2 Gas Sensor to measure the amount of oxygen gas consumed or produced by a plant during respiration and photosynthesis.
* Use a CO2 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.

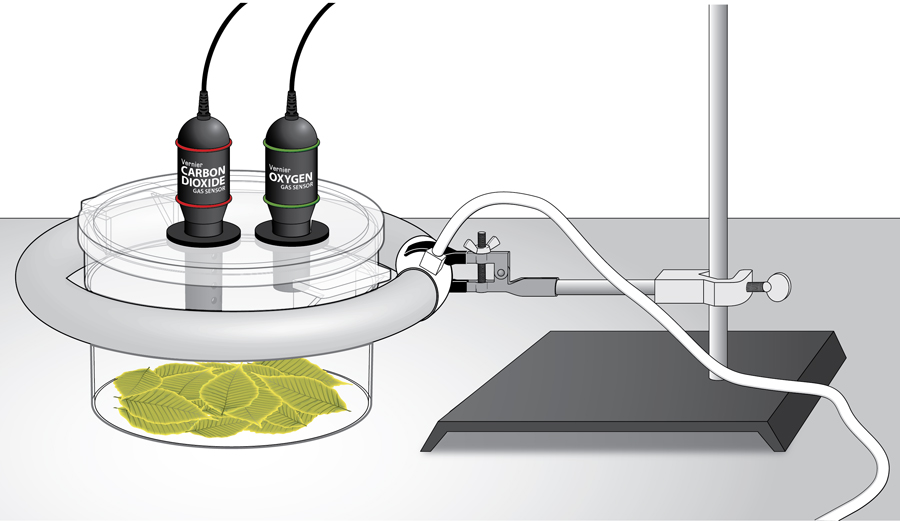


Figure 1

MATERIALS

|  |  |
| --- | --- |
| TI-83 Plus or TI-84 Plus graphing calculator | aluminum foil |
| EasyData application | ringstand |
| data-collection interface | utility clamp |
| Vernier O2 Gas Sensor | 12-inch ring fluorescent bulb setup |
| Vernier CO2 Gas Sensor | spinach leaves |
| BioChamber 2000 |  |

PROCEDURE

1. Turn on the calculator and connect it to the data-collection interface. Connect the O2 Gas Sensor to Channel 1 of the interface and the CO2 Gas Sensor to Channel 2.

2. Set up EasyData for data collection.

1. Start the EasyData application if it is not already running.
2. Select from the Main screen, and then select **New** to reset the application.



1. Select from the Main screen, then select **Time Graph…**



1. Select on the Time Graph Settings screen.



1. Enter **15** as the time between samples in seconds and select .



1. Enter **60** as the number of samples and select (data will be collected for 15 minutes).



1. Select to return to the Main screen.



3. Wrap the BioChamber with aluminum foil so that no light will reach the leaves.

1. Wrap the outside of the chamber with foil.
2. Cover the lid with foil, poking the holes open to insert the sensors.

4. Cover the bottom of the chamber with one layer of fresh turgid spinach leaves. Remove any stems that could interfere with an even lining of the bottom.

5. Secure the lid on the chamber and insert the sensors into the holes.

6. Wait five minutes for the sensors to equilibrate, then select to begin data collection. **Note**: The graph may not show the slight change in O2 level that occurs during the experiment.



7. When data collection is complete, a graph of O2 *vs*. time will be displayed. Sketch a copy of your graph in the Graph section below. When finished, select , then select **CH2:CO2 Gas(ppm) vs time** to view the graph of CO2 *vs*. time. Sketch a copy of your graph in the Graph section below.



8. Perform a linear regression to calculate the rate of respiration/photosynthesis.

1. View the O2 *vs*. time again by selecting , then **CH1:O2 Gas(ppm) vs time**.



1. Select , and then select **Linear Fit**.



1. The linear-regression statistics for these two lists are displayed for the equation in the form:

y=ax+b

1. Enter the value of the slope, *a*, as the rate of respiration/photosynthesis in Table 1.
2. Select to view a graph of the data and the regression line.



1. Select , select **CH2:CO2 Gas(ppm) vs time**, then repeat Steps 8b–e to calculate the respiration/photosynthesis rate using the data from the CO2 Gas Sensor.



1. Select to return to the Main screen.



9. Assemble the lamp as shown in Figure 1. **Important:** Do not turn the lamp on until instructed to do so.

10. Remove the aluminum foil from the respiration chamber and invert the chamber to remove the leaves and accumulated CO2 gas.

11. Line the bottom of the chamber with fresh turgid spinach leaves.

12. Secure the lid on the chamber and insert the sensors into the holes.

13. Place the chamber inside the bulb and turn on the lamp.

14. Repeat Steps 6–8 to collect and analyze data. Note: After selecting , select to start collecting data.



15. Clean and dry the respiration chamber.

DATA

|  |  |  |  |
| --- | --- | --- | --- |
| Table 1 | | | |
| Leaves | O2 rate of production/consumption (ppt/s) | CO2 rate of production/consumption (ppt/s) | |
| In the dark |  |  | |
| In the light |  |  | |

Graphs

Darkness

|  |  |
| --- | --- |
|  |  |
| O2 Gas *vs*. Time | CO2 Gas *vs*. Time |

Light

|  |  |
| --- | --- |
|  |  |
| O2 Gas *vs*. Time | CO2 Gas *vs*. Time |

Questions

1. Were either of the rate values for CO2 a positive number? If so, what is the biological significance of this?

2. Were either of the rate values for O2 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.