Cell Respiration (Method 2–CO_2 Gas Sensor)

Cell 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 according to the following equation:

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

All organisms, including plants and animals, oxidize glucose for energy. Often, this energy is used to convert ADP and phosphate into ATP. Peas undergo cell respiration during germination. Do peas undergo cell respiration before germination? Using your collected data, you will be able to answer the question regarding respiration and non-germinating peas.

OBJECTIVES

In this experiment, you will

- Measure gas production.
- Study the effect of temperature on cell respiration.
- Determine whether germinating peas and non-germinating peas respire.
- Compare the rates of cell respiration in germinating and non-germinating peas.

MATERIALS

computer
Vernier computer interface
Logger*Pro*
Vernier CO_2 Gas Sensor
two 100 mL beakers
25 germinating peas
25 non-germinating peas
250 mL respiration chamber
ice cubes
thermometer

PROCEDURE

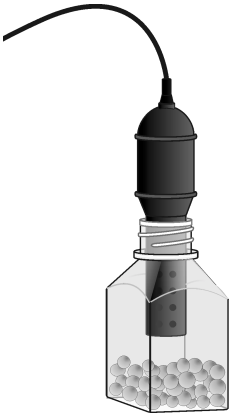


Figure 1

1. If your sensor has a switch, set it to the Low (0–10,000 ppm) setting. Connect the CO_2 Gas Sensor to Channel 1 of the Vernier computer interface.
2. Prepare the computer for data collection by opening the "05 (CO2) Cell Resp" file in the *Advanced Biology with Vernier* folder.
3. Obtain 25 germinating peas and blot them dry between two pieces of paper towel. Use the thermometer to measure the room temperature. Record the temperature in Table 1.
4. Place the germinating peas into the respiration chamber.
5. Place the shaft of the CO_2 Gas Sensor in the opening of the respiration chamber.
6. Wait one minute, then begin measuring carbon dioxide concentration by clicking Collect.

Data will be collected for 5 minutes.

7. Remove the CO_2 Gas Sensor from the respiration chamber. Place the peas in a 100 mL beaker filled with cold water and an ice cube. The cold water will prepare the peas for part II of the experiment.

8. Use a notebook or notepad to fan air across the openings in the probe shaft of the CO_2 Gas Sensor for 1 minute.

9. Fill the respiration chamber with water and then empty it. Thoroughly dry the inside of the respiration chamber with a paper towel.

10. Determine the rate of respiration:
    a. Move the mouse pointer to the point where the data values begin to increase. Hold down the left mouse button. Drag the mouse pointer to the end of the data and release the mouse button.
    b. Click 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 for germinating peas at room temperature in Table 2.
    d. Close the linear regression floating box.

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

12. Obtain 25 non-germinating peas and place them in the respiration chamber

13. Repeat Steps 5–11 for the non-germinating peas.

Part II Germinating peas, cool temperatures

14. Remove the peas from the cold water and blot them dry between two paper towels.

15. Repeat Steps 5–11 to collect data with the cold germinating peas.

16. To print a graph showing all three data runs:
    a. Label all three curves by choosing Text Annotation from the Insert menu, and typing "Room Temp Germinated" (or "Room Temp Non-germinated", or "Cold Germinated") in the edit box. Then drag each box to a position near its respective curve. Adjust the position of the arrowhead.
    b. Print a copy of the graph, with all three data sets and the regression lines displayed. Enter your name(s) and the number of copies of the graph you want.

DATA

Table 1	
Condition	Temperature (°C)
room	

Table 2	
Peas	Rate of Respiration (ppm/min)
Germinating, room temperature	
Non-germinating, room temperature	
Germinating, cool temperature	

QUESTIONS

1. Do you have evidence that cell respiration occurred in peas? Explain.
2. What is the effect of germination on the rate of cell respiration in peas?
3. What is the effect of temperature on the rate of cell respiration in peas?
4. Why do germinating peas undergo cell respiration?

EXTENSIONS

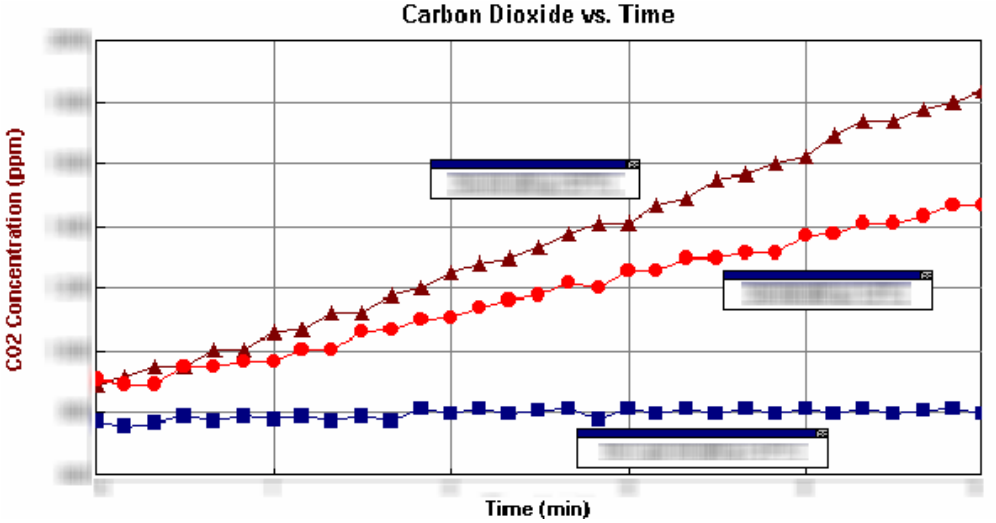
1. Compare the respiration rate among various types of seeds.
2. Compare the respiration rate among seeds that have germinated for different time periods, such as 1, 3, and 5 days.
3. Compare the respiration rate among various types of small animals, such as insects or earthworms.

TEACHER INFORMATION

Cell Respiration (Method 2–CO_2 Gas Sensor)

1. The student pages with complete instructions for data-collection using LabQuest App, Logger *Pro* (computers), EasyData or DataMate (calculators), and DataPro (Palm handhelds) can be found on the CD that accompanies this book. See *Appendix A* for more information.
2. Allow the seeds to germinate for three days prior to the experiment. Prior to the first day, soak them in water overnight. On subsequent days, roll them in a moist paper towel and place the towel in a paper bag. Place the bag in a warm, dark place. Check each day to be sure the towels remain very moist. If time is short, the peas can be used after they have soaked overnight. For best results, allow them to germinate for the full three days.
3. Heavy condensation buildup in the respiration chamber can interfere with readings from the CO_2 Gas Sensor. This can be a source of error if the peas are very wet when placed in the respiration chamber. Before placing the peas in the respiration chamber, blot them dry with a paper towel.
4. The stopper included with the older-style CO_2 Gas Sensor is slit to allow easy application and removal from the probe. When students are placing the probe in the respiration chamber, they should gently twist the stopper into the chamber opening. Warn the students not to twist the probe shaft or they may damage the sensing unit.
5. The CO_2 Gas Sensor relies on the diffusion of gases into the probe shaft. Students should allow a couple of minutes between trials so that gases from the previous trial will have exited the probe shaft. Alternatively, the students can use a firm object such as a book or notepad to fan air through the probe shaft. This method is used in Step 8 of the student procedure.
6. The morning of the experiment fill a 1 L beaker with ice and water so that students will have cold water. Students will also need access to ice.
7. The calibration stored in this experiment file works well for this experiment. Initial readings that seem slightly high or low will still reflect an accurate change in gas levels.
8. To conserve battery power, we suggest that AC Adapters be used to power the interfaces rather than batteries when working with the older-style CO_2 Gas Sensor.

SAMPLE RESULTS



CO_2 respired by germinating and non-germinating peas

Table 1	
Condition	Temperature (°C)
room	x
cold water	x

Table 2	
Peas	Rate Respiration (ppm/min)
Germinating, room temperature	x
Non-germinating, room temperature	x
Germinating, cool temperature	x

ANSWERS TO QUESTIONS

Answers have been removed from the online versions of Vernier curriculum material in order to prevent inappropriate student use. Graphs and data tables have also been obscured. Full answers and sample data are available in the print versions of these labs.