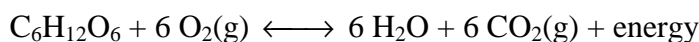


Cell Respiration (Method 2–CO₂)

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 and is summarized by the following reaction:



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

Using the CO₂ Gas Sensor, you will monitor the carbon dioxide produced by peas during cell respiration. Both germinated and non-germinated peas will be tested. Additionally, cell respiration of germinated peas at two different temperatures will be tested.

OBJECTIVES

In this experiment, you will

- Use a CO₂ Gas Sensor to measure concentrations of carbon dioxide during cell respiration.
- Study the effect of temperature on cell respiration rate.
- Determine whether germinating peas and non-germinating peas respire.
- Compare the rates of cell respiration in germinating and non-germinating peas.

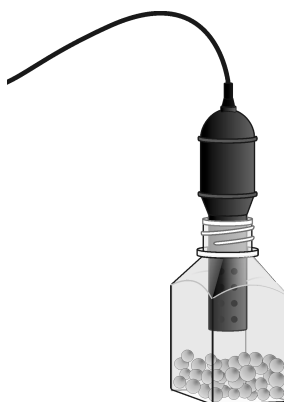


Figure 1

MATERIALS

LabQuest
LabQuest app
Vernier CO₂ Gas Sensor
two 100 mL beakers
250 mL respiration chamber

25 germinated peas
25 non-germinated peas
ice cubes
thermometer
Logger *Pro* (optional)

PROCEDURE

1. If your sensor has a switch, set it to the Low (0–10,000 ppm) setting. Connect the CO₂ Gas Sensor to LabQuest and choose New from the File menu. If you have an older sensor that does not auto-ID, manually set up the sensor.
2. Measure the room temperature using a thermometer and record the temperature in Table 1.
3. Obtain 25 germinated peas and blot them dry between two pieces of paper towel.
4. Place the germinated peas into the respiration chamber.
5. Place the shaft of the CO₂ Gas Sensor in the opening of the respiration chamber.
6. Wait one minute, then start data collection. Data will be collected for 5 minutes.
7. When data collection has finished, a graph of carbon dioxide gas vs. time will be displayed.
8. Remove the CO₂ 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.
9. Use a notebook or notepad to fan air across the openings in the probe shaft of the CO₂ Gas Sensor for 1 minute.
10. Fill the respiration chamber with water and then empty it. Thoroughly dry the inside of the respiration chamber with a paper towel.
11. Perform a linear regression to calculate the rate of respiration.
 - a. Choose Curve Fit from the Analyze menu.
 - b. Select Linear for the Fit Equation. The linear-regression statistics for these two data columns are displayed for the equation in the form
$$y = mx + b$$
where x is time, y is CO₂ concentration, m is the slope, and b is the y-intercept.
 - c. Enter the slope, m , as the rate of respiration in Table 2.
 - d. Select OK.
12. Store the data from the first run by tapping the File Cabinet icon.
13. Repeat Steps 3–12 substituting the germinated peas with non-germinated peas. In Step 8 place the non-germinated peas on a paper towel and not in the ice bath.

Part II Germinated peas, cool temperatures

14. Remove the peas from the cold water and blot them dry between two paper towels.
15. Repeat Steps 3–11 using the cold peas. When you have completed Step 11 skip directly to Step 16.

16. Graph all three runs of data on a single graph.
 - a. To view a graph of pH vs. volume showing all three data runs, tap Run 3 and select All Runs.
 - b. All three runs will now be displayed on the same graph axes.
 - c. Use the displayed graph and Tables 1 and 2 to answer the questions below.

DATA

Table 1	
Condition	Temperature (°C)
room	
cold water	

Table 2	
Peas	Rate of respiration (ppm/s)
Germinated, room temperature	
Non-germinated, room temperature	
Germinated, 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 germinated peas undergo cell respiration?

EXTENSIONS

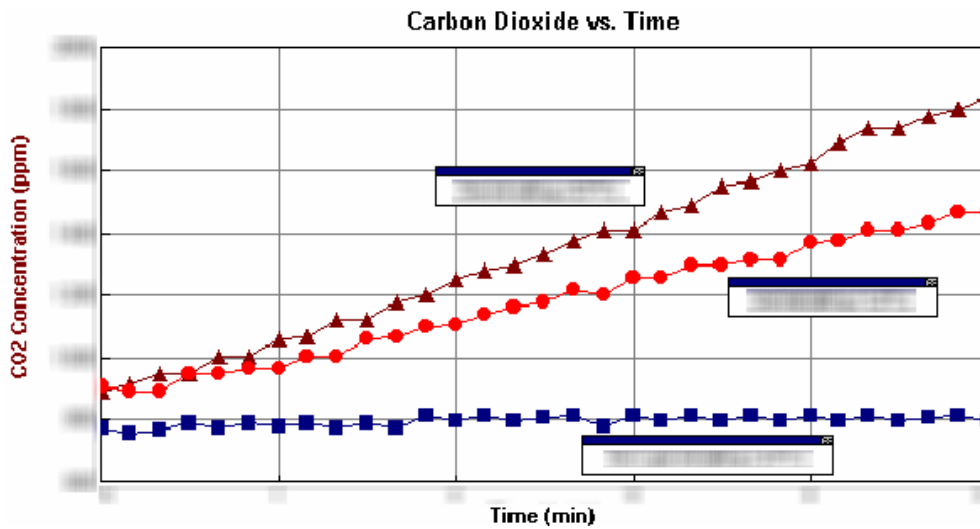
1. Compare the respiration rate among various types of seeds.
2. Compare the respiration rate among seeds that have germinated for different time periods, such as 1, 3, and 5 days.
3. Compare the respiration rate among various types of small animals, such as insects or earthworms.

TEACHER INFORMATION

Cell Respiration (Method 2–CO₂ 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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ Gas Sensor.

SAMPLE RESULTS



CO₂ respired by germinating and non-germinating peas

Condition	Temperature (°C)
room	x
cold water	x

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.