Cell Respiration (Method 2–CO_2 Gas Sensor)

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 and is summarized by the following reaction:

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

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

Using the CO_2 Gas Sensor, you will monitor the carbon dioxide produced by peas during cellular respiration. Both germinated and non-germinated peas will be tested. Additionally, cellular respiration of germinated peas at two different temperatures will be tested.

OBJECTIVES

In this experiment, you will

- Use a CO_2 Gas Sensor to measure concentrations of carbon dioxide during cellular respiration.
- Study the effect of temperature on cellular respiration rate.
- Determine whether germinating peas and non-germinating peas respire.
- Compare the rates of cellular respiration in germinating and non-germinating peas.

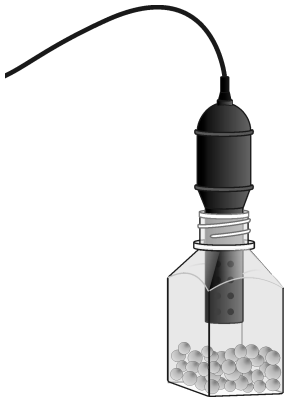


Figure 1

MATERIALS

TI-83 Plus or TI-84 Plus graphing calculator
EasyData application
data-collection interface
Vernier CO_2 Gas Sensor
25 germinated peas
25 non-germinated peas
250 mL respiration chamber
ice cubes
thermometer
two 100 mL beakers
Logger *Pro* (optional)

PROCEDURE

1. Turn on the calculator. Connect the CO_2 Gas Sensor, data-collection interface, and calculator.
2. Set up EasyData for data collection.
   a. Start the EasyData application if it is not already running.
   b. Select [File] from the Main screen, and then select **New** to reset the application.
3. Measure the room temperature using a thermometer and record the temperature in Table 1.
4. Obtain 25 germinated peas and blot them dry between two pieces of paper towel.
5. Place the germinated peas into the respiration chamber.
6. Place the shaft of the CO_2 Gas Sensor in the opening of the respiration chamber. Gently twist the stopper on the shaft of the CO_2 Gas Sensor into the chamber opening. Do not twist the shaft of the CO_2 Gas Sensor or you may damage it.
7. Wait one minute, then select [Start] to begin data collection. Data will be collected for 5 minutes and when data collection has finished, a graph of CO_2 gas *vs*. time will be displayed.
8. 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.
9. Use a notebook or notepad to fan air across the openings in the probe shaft of the CO_2 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. Select [Anlyz], and then select **Linear Fit**.
    b. The linear-regression statistics for these two lists are displayed for the equation in the form:

$$y=ax+b$$

    c. Enter the absolute value of the slope, *a*, as the rate of respiration in Table 2.
    d. Select [OK] to view a graph of the data and the regression line.

12. Store the data from the first run so that it can be used later.
    a. Select Main to return to the Main screen.
    b. Select File, and then select **Store Run**.
    c. Select OK to store your latest data and overwrite the data in Lists 3 and 4 (L3 and L4).

13. Repeat Steps 4–12 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. **Note:** After selecting Start to begin data collection, select OK to start collecting data. Your stored data will not be overwritten.

Part II Germinated peas, cool temperatures

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

15. Select Main to return to the Main screen, then repeat Steps 4–11 using the cold peas. When you have completed Step 11 skip directly to Step 16. **Note:** After selecting Start, select OK to start collecting data. Your stored data will not be overwritten.

16. Graph all three runs of data on a single graph. To do this:
    a. Select Adv and then select **L2, L3 and L4 vs L1**.
    b. All three runs should now be displayed on the same graph. Each point of the germinating peas is plotted with a small plus sign, each point of the non-germinating peas is plotted with a square, and each point of the cold peas is plotted without a marker. Examine the graph closely and make a conclusion.
    c. Use the displayed graph and Tables 1 and 2 to answer the questions below.
    d. When finished with the graph, select Main to return to the Main screen.

DATA

Table 1	
Condition	Temperature (°C)
room	

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 cellular respiration occurred in peas? Explain.
2. What is the effect of germination on the rate of cellular respiration in peas?
3. What is the effect of temperature on the rate of cellular respiration in peas?
4. Why do germinated peas undergo cellular respiration?

EXTENSIONS

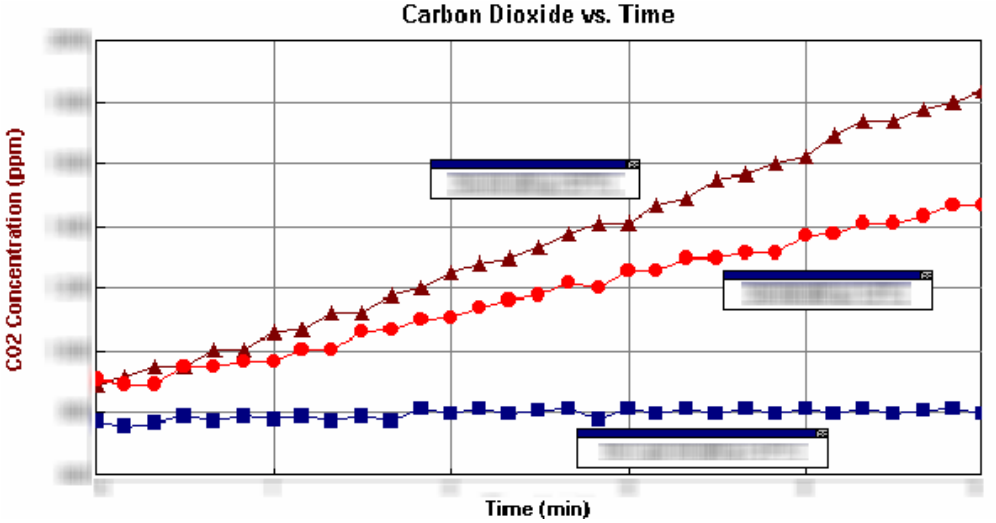
1. Compare the respiration rate among various types of seeds.
2. Compare the respiration rate among seeds that have germinated for different time periods, such as 1, 3, and 5 days.
3. Compare the respiration rate among various types of small animals, such as insects or earthworms.

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.