Cell Respiration
(Method 1–CO$_2$ and O$_2$)

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

<table>
<thead>
<tr>
<th>Computer</th>
<th>25 germinating peas</th>
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<tbody>
<tr>
<td>25 non-germinating peas</td>
<td></td>
</tr>
<tr>
<td>Logger $Pro$</td>
<td>250 mL respiration chamber</td>
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<tr>
<td>Vernier CO$_2$ Gas Sensor</td>
<td>ice cubes</td>
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<tr>
<td>Vernier O$_2$ Gas Sensor</td>
<td>thermometer</td>
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<tr>
<td>BioChamber 250</td>
<td>two 100 mL beakers</td>
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PROCEDURE

Using the CO$_2$ Gas Sensor and O$_2$ Gas Sensor, you will monitor the carbon dioxide produced and the oxygen consumed by peas during cell respiration. Both germinating and non-germinating peas will be tested. Additionally, cell respiration of germinating peas at two different temperatures will be investigated.
1. If your CO₂ Gas Sensor has a switch, set it to the Low (0–10,000 ppm) setting. Connect the CO₂ Gas Sensor to Channel 1 and the O₂ Gas Sensor to Channel 2 of the Vernier computer interface.

2. Prepare the computer for data collection by opening the file “05 Cell Resp M1 CO2 O2” from the Advanced Biology with Vernier folder of LoggerPro.

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 O₂ Gas Sensor into the BioChamber 250 as shown in Figure 1. Insert the sensor snugly into the grommet. The O₂ Gas Sensor should remain vertical throughout the experiment. Place the CO₂ Gas Sensor into the neck of the respiration chamber as shown in Figure 1.

6. Wait four minutes for readings to stabilize, then begin collecting data by clicking Collect. Collect data for ten minutes and click Stop.

7. When data collection has finished, remove the sensors from the respiration chamber. Place the peas in a 100 mL beaker filled with cold water and ice.

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

9. Determine the rate of respiration:
   a. Click anywhere on the CO₂ graph to select it. Click the Linear Fit button, to perform a linear regression. A floating box will appear with the formula for a best fit line.
   b. Record the slope of the line, m, as the rate of respiration for germinating peas at room temperature in Table 2.
   c. Close the linear regression floating box.
   d. Repeat Steps 9a–c for the O₂ graph.

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

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

12. Repeat Steps 5–10 for the non-germinating peas.
Part II  Germinating peas, cool temperatures

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

14. Repeat Steps 5–9 to collect data with the germinating peas at a cold temperature.

15. To print a graph of concentration vs. volume showing all three data runs:
   a. Click anywhere on the CO₂ graph. 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 arrow head.
   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.
   c. Click on the O₂ graph and repeat the process to print a copy of the O₂ graph.

DATA

<table>
<thead>
<tr>
<th>Condition</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Peas</th>
<th>CO₂ Rate of respiration (ppt/min)</th>
<th>O₂ Rate of consumption (ppt/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germinating, room temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-germinating, room temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germinating, cool temperature</td>
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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.
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