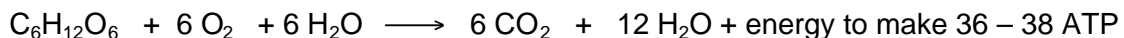


Aerobic Cell Respiration

The cells of all living organisms require a constant supply of energy to carry out the many functions necessary for life. The molecule used to provide energy is ATP (adenosine triphosphate). The major source of ATP for all cells is the oxidation of glucose, via the process of cell respiration. The initial steps of cell respiration, called glycolysis, occur in the cells of all organisms (with a few bacterial exceptions).

For most organisms, the process of cell respiration is an oxygen-consuming process. Following glycolysis, a process that occurs in the cytoplasm, in which glucose is converted to pyruvic acid, the Krebs cycle and electron transport chain occur in the mitochondria. CO₂ is given off during the Krebs cycle and the hydrogen electrons removed from the pyruvic acid backbone are transferred to the electron carriers NADH and FADH₂. These electrons are then passed through the electron transport chain to power the movement of hydrogen ions against a concentration gradient. Without oxygen, which functions as the final electron acceptor in the electron transport chain, the process of aerobic respiration cannot happen. For each glucose molecule oxidized, 36 - 38 ATP are produced. Most organisms can not survive without aerobic respiration.

The chemical reaction for aerobic respiration is:



During aerobic respiration oxygen gas is consumed and carbon dioxide gas is produced. In this laboratory exercise we will measure the concentration of carbon dioxide gas (using the CO₂ Gas Sensor) in a sealed plastic jar (the Respiration Chamber) that contains the sample to be tested (either germinating peas or non-germinating peas). If respiration occurs, the concentration of carbon dioxide gas will increase. You will see this as an increase in ppm (parts per million) recorded on the computer screen.



Respiration Chamber



This exercise will be performed at three different temperatures (ice water: 4 – 12°C, room temperature: 20 – 22°C and warm temperature: 35 – 40°C). Your instructor will assign one temperature per lab group. Each lab group will do 3 repetitions at their assigned temperature with non-germinating and with germinating peas.

The data from the entire class will be collected for analysis. You will need to record the data from **all** groups. During this laboratory exercise you will study the effect of temperature on cellular respiration, determine whether germinating peas and non-germinating peas respire and compare the rates of cellular respiration in germinating and non-germinating peas.

Materials Required For Each Laboratory Table:


Data Recorder (Computer)
Vernier Interface and Power Supply
CO₂ Gas Sensor
250-ml Respiration Chamber
25 Germinating peas
25 Non-germinating peas (dormant peas)
1000 ml Beaker
Two 100-ml Beakers
Thermometer
Hot tap water (35°C - 40°C)
Ice

Procedure:

1. Remove the data recorder from the data recorder cubicles. You may have to ask your instructor to unlock the cubicles.
2. Plug the CO₂ Gas Sensor into Port 1 of the Vernier interface. You may need an adapter cable. Plug the Vernier interface into its power supply if necessary and into the data recorder. Start your data recorder. Be sure to do the connections before starting the computer. *For additional instructions about the data recorders see the handout, Using the Gateway Data Recorders.*
3. Prepare the computer for data collection by opening "Exp 11B" from the *Biology with Computers* experiment files of *Logger Pro*. You should see a graph window with a vertical axis showing Carbon Dioxide (CO₂) concentration scaled from 0 to 5000 ppm. The horizontal axis has time scaled from 0 to 5 minutes. The data rate is set to 6 samples/minute.
4. Obtain 25 non-germinating peas. Place them into the respiration chamber. Keep them as dry as possible.
5. For room temperature measurements, use a thermometer to measure room temperature. Your peas should already be at this temperature. For hot and cold temperatures, prepare a water bath of the correct temperature using either ice water or hot tap water. Put the respiration chamber containing the peas into this water bath. Let the chamber sit for at least 3 minutes so the peas will be at the correct temperature before proceeding with the exercise. Do not allow water from the water bath to enter the respiration chamber.
6. Use a thermometer to measure the temperature of the sample you are collecting (either the air temperature or the temperature of the water bath) containing the non-germinating peas. Record the temperature in Table 1.
7. Place the shaft of the CO₂ gas sensor in the opening of the respiration chamber. Gently twist the stopper on the shaft of the CO₂ gas sensor into the chamber opening. Do not twist the shaft of the CO₂ gas sensor or you may damage it.
8. Wait one minute, then begin measuring carbon dioxide concentration by clicking . Data will automatically be collected for 5 minutes. The button will automatically read  after 5 minutes. Do not click stop, this is a toggle button.
9. Remove the CO₂ gas sensor from the respiration chamber. Use a notebook or notepad to fan air across the openings in the probe shaft of the CO₂ gas sensor for 1 minute. Fan air over the respiration chamber to allow the excess CO₂ inside to escape.

10. Determine the rate of respiration:



- Move the pointer (cursor) to the point where the data values begin to increase. Hold down the trackpad button with your thumb and move your finger on the trackpad to "drag" the pointer to the end of the data. Release the trackpad button. This will ensure the best fit for linear regression.
- Click the Regression button, , to perform a linear regression. A floating box will appear with the formula for a best fit line.
- Record the slope of the line, m , as the rate of respiration at the selected temperature in Table 2. Note: You will record the "m" number displayed - this is the rate of change in ppm/min.
- Close the linear regression floating box.

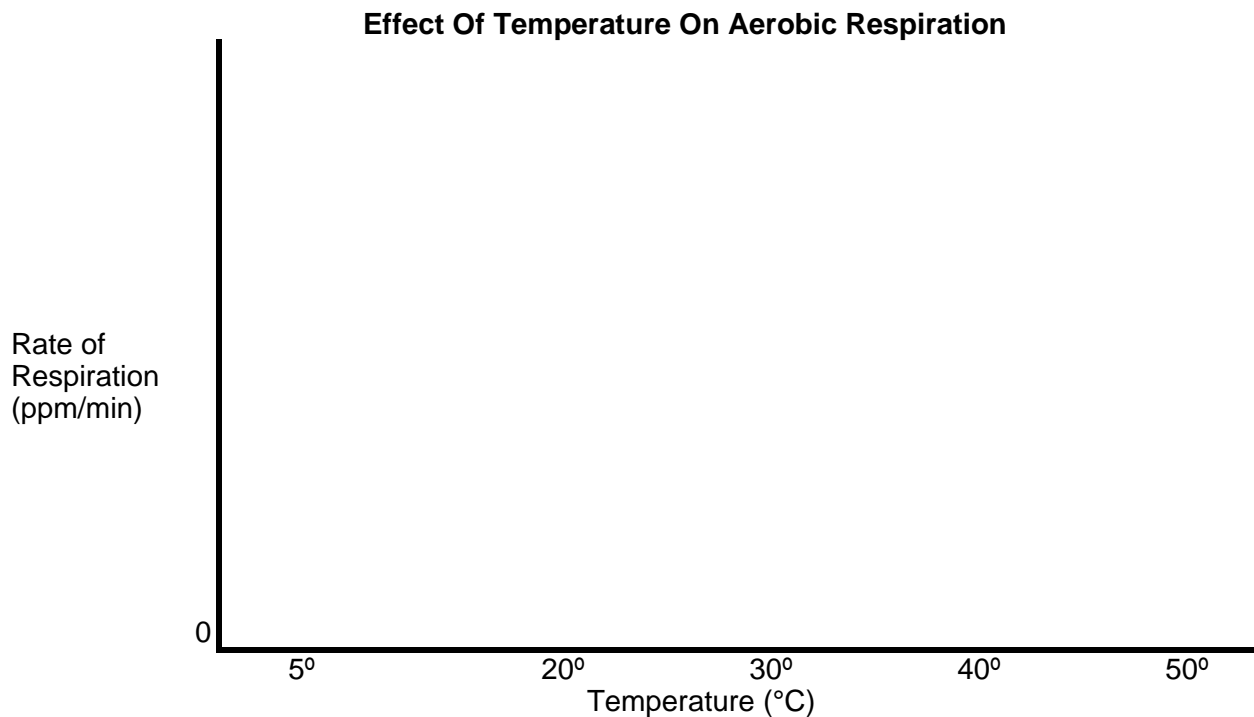
11. Erase your data before making another run. When you start a new run the computer will ask you if you wish to save your data – You do not need to save your data, so respond "Don't Save".
12. Repeat steps 5 - 11 for your selected temperature for each of your repetitions.
13. Remove the non-germinating peas. Obtain 25 germinating peas, blot them dry between two pieces of paper towel and place them in the respiration chamber.
14. Repeat Steps 5 - 11 for the germinating peas at the temperature you have been assigned for the number of repetitions you are to do.

Table 1 - Temperatures Used (data from the entire class)	
Condition	Temperature (°C)
room	
cold water	
hot water	

Table 2 - Rate of Respiration (ppm/min) in Peas (data from the entire class)					
Temperature	Germinating Peas			Non-germinating Peas	
			Aver		Aver
Room Temperature					
Cold Temperature					
Hot Temperature					

Discussion Questions

1. Graph your data below. Plot temperature on the X axis and the rate of respiration on the Y axis.



2. What evidence, if any, do you have that cellular respiration occurs in peas?
3. Do peas undergo cellular respiration before germination? _____
4. What is the effect of germination on the rate of cellular respiration in peas?
5. What is the effect of temperature on the rate of cellular respiration in peas?
6. Why do germinating peas undergo cellular respiration?

* Materials for this laboratory were modified from *Biology with Computers*, by Holman and Masterman © Vernier Software and Technology.