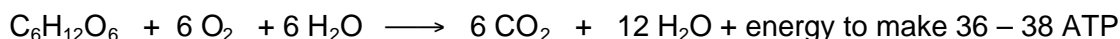


The Effect of Temperature on Animal Respiration Rate

Metabolic rate is temperature dependent. Homeotherms (or endotherms), including mammals and birds, maintain a fairly constant core body temperature thereby maintaining a fairly constant basal metabolic rate. In contrast, basal metabolic rate of poikilotherms (or ectotherms), which include amphibians, reptiles and the invertebrates (as well as plants, fungi and protists) is linked to the external environmental temperature.

We can use the rate of cellular respiration as a measure of metabolic rate in organisms. For most organisms, the process of cell respiration is aerobic. 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 effect of temperature on respiratory rate of small invertebrates such as crickets, mealworms or pill bugs. To do so we will measure the concentration of carbon dioxide gas (using the CO₂ Gas Sensor) in a sealed plastic jar (the Respiration Chamber – see below) that contains invertebrates. As respiration occurs, the concentration of carbon dioxide gas will increase in the sealed chamber. 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 temperature ranges: cold (5 - 10°C, 10 - 15°C, and 15 - 20°C), warm (20 - 25°C, 25 - 30°C, and 30 - 35°C) and hot (35 - 40°C, 40 - 45°C, and 45 - 50°C). Your instructor will assign one temperature range per lab group. Each group will set up a water bath at a different temperature prior to each data collection run until you have collected data at all three assigned temperatures.

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 rate and determine the rates of cellular respiration in invertebrates at different temperatures.



Materials Required For Each Laboratory Group:


Data Recorder (Computer)	1000 ml Beaker
Vernier Labpro Box and Power Supply	Two 400-ml Beakers
CO ₂ Gas Sensor	Thermometer
250-ml Respiration Chamber	Basting bulb
10 organisms (mealworms, pill bugs, etc.)	Ice
Balance	
600 ml Beaker	

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 and plug the Vernier interface into the appropriate data recorder port. **Do not breathe on the CO₂ sensor! Ever!** Start your data recorder. Be sure to do the connections before starting the computer.
3. Prepare the computer for data collection by opening “Exp 23B” 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 4 samples/minute.
4. Obtain and weigh ten of the designated organisms in a 600 ml beaker. Record the mass at the bottom of Table 1.
5. Prepare a water bath of the assigned temperature. The water bath is a large beaker you will maintain at a certain temperature to ensure that the organisms will remain at a constant and controlled temperature. Each water bath will be some combination of ice, cool, warm or hot water in a 1000 ml beaker needed to reach the desired temperature range. The beaker should be filled with about 600 – 700 ml water. Leave the thermometer in the water bath during the experiment. It may be necessary for one group member to hold the respiration chamber down in the water bath during the course of the experiment.

Place the 250-ml respiration chamber in the water bath. Be sure to keep the temperature of the water bath constant while you are collecting data. If you need to add more hot or cold water, first remove about as much water as you will be adding or the beaker may overflow. Use a basting bulb to remove excess water. Do not allow water from the water bath to enter the respiration chamber. Record the temperature of the water bath in Table 1 below.

6. Put the animals into the respiration chamber.
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. Place the animals back in the 600-ml beaker.
10. Use a notebook to fan air across the openings in the probe shaft of the CO₂ gas sensor for 1 minute to allow the excess CO₂ inside to escape and restore the chamber to ambient CO₂ levels.

11. 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 1. Note: You will record the "m" number displayed - this is the rate of change in ppm/min.
 - Close the linear regression floating box.
12. Move your data to a stored run by choosing Store Latest Run from the Data menu. If desired, you can copy your data to a floppy diskette for later use.
13. Repeat steps 5 - 12 for the remaining assigned temperatures.

Processing the Data

1. For each temperature you tested, divide the slope of the regression line by the mass of the invertebrates. Record this value as the respiration rate in Table 1 below.
2. Record your Table 1 temperature and respiration rate data on the board or Overhead for the entire class to use. When all other groups have posted their results, calculate the average for each temperature range. Record the average rate values in Table 2 below.

Table 1			
Animal Mass =			
Temperature (°C)	Actual Temperature (°C)	Slope (ppm/min)	Respiration Rate (ppm/min/g)
5 – 10°C			
10 – 15°C			
15 – 20°C			
20 – 25°C			
25 – 30°C			
30 – 35°C			
35 – 40°C			
40 – 45°C			
45 – 50°C			

Table 2 Class Data	
Temperature (°C)	Respiration Rate (ppm/min/g)
5 – 10°C	
10 – 15°C	
15 – 20°C	
20 – 25°C	
25 – 30°C	
30 – 35°C	
35 – 40°C	
40 – 45°C	
45 – 50°C	

4. How do you think the respiration rate of a small mammal would compare to that of invertebrates used in this exercise at the different temperatures?

5. Predict the rate of respiration for invertebrates at 60°C. Explain.

5. What errors might affect the results of this experiment? How could you help reduce those errors?

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