Effect of Temperature on Cold-Blooded Organisms

In cold-blooded organisms, *poikilotherms*, there is a link between the temperature of the environment and the organism’s metabolic rate. Reptiles are a common example of a cold-blooded organism with which most people are familiar. If you have ever seen a lizard or snake in the early morning when the air and ground are cool, you may have noticed how slowly they move. They move slowly when the environment is cold because they require heat from their surroundings to increase their internal temperature and metabolism. Once their internal body temperature has warmed, they can metabolize foods more quickly and produce the energy they need. Oxidative respiration is the process of metabolism where sugars are broken down. Under aerobic conditions, respiration yields chemical energy, carbon dioxide, and water.

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\text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2 \rightarrow 6 \text{ CO}_2 + 6 \text{ H}_2\text{O} + \text{ energy}
\]

Glucose  oxygen  carbon  water  dioxide

Crickets will be used to study the effect of temperature on the metabolism of cold-blooded organisms. You will determine how temperature affects the respiration rate of crickets by monitoring oxygen gas consumption with an O\textsubscript{2} Gas Sensor.

**OBJECTIVES**

In this experiment, you will

- Use an O\textsubscript{2} Gas Sensor to measure concentrations of oxygen gas.
- Determine the rate of respiration by crickets at different temperatures.
- Determine the effect of temperature on metabolism of crickets.
MATERIALS

- computer
- Vernier computer interface
- Logger Pro
- Vernier O₂ Gas Sensor
- 10 adult crickets
- balance
- 250 mL respiration chamber
- 600 mL beaker
- 1 L beaker
- thermometer
- ice
- basting bulb

PROCEDURE

1. Connect the O₂ Gas Sensor to the computer interface.

2. Prepare the computer for data collection by opening the file “23A Temp Cold-Blood (O2)” from the Biology with Vernier folder of Logger Pro.

3. Obtain and weigh ten adult crickets in a 600 mL beaker and record the mass at the bottom of Table 1.

4. Data will be collected at three different temperatures according to your assigned group number (I, II, or III). You 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.

Group I: Cold Temperatures

a. Your group will collect respiration data at 5–10°C, 10–15°C, and 15–20°C. Set up a water bath for the desired temperature. A water bath is simply a large beaker of water at a certain temperature. This ensures that the crickets will remain at a constant and controlled temperature. To prepare the water bath, obtain some cool water and some ice from your teacher. Combine the cool water and ice into the 1 liter beaker until it reaches 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.

b. 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 or Beral pipet to remove excess water.

c. Record the water bath temperature in Table 1. Perform Steps 5–12 for each of the three temperature ranges.

Group II: Warm Temperatures

a. Your group will collect respiration data at 20–25°C, 25–30°C, and 30–35°C. Set up a water bath for the desired temperature. A water bath is simply a large beaker of water at a certain temperature. This ensures that the crickets will remain at a constant and controlled temperature. To prepare the water bath, obtain some hot and cold water from your teacher. Combine the hot and cold water into the 1 liter beaker until it reaches 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. One group member can hold the respiration chamber down in the water bath during the course of the experiment.

b. 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 or Beral pipet to remove excess water.

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cold water, first remove about as much water as you will be adding or the beaker may overflow. Use a basting bulb or Beral pipet to remove excess water. 
c. Record the water bath temperature in Table 1. Perform Steps 5–12 for each of the three temperature ranges.

**Group III: Hot Temperatures**

a. Your group will collect respiration data at 35–40°C, 40–45°C, and 45–50°C. Set up a water bath for the desired temperature. To prepare the water bath, obtain some hot and cold water from your teacher. Combine the hot and cold water into the 1-liter beaker until it reaches 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.

b. 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 or Beral pipet to remove excess water.

c. Record the water bath temperature in Table 1. Perform Steps 5–12 for each of the three temperature ranges.

5. Place the crickets into the respiration chamber.

6. Place the shaft of the O₂ Gas Sensor in the opening of the respiration chamber.

7. Wait one minute, then begin measuring oxygen concentration by clicking [Collect]. Data will be collected for 10 minutes.

8. Remove the O₂ Gas Sensor from the respiration chamber. Place the crickets in a 600 mL beaker.

9. Use a notebook or notepad to fan air across the openings in the probe shaft of the O₂ 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. Determine the rate of respiration:
   a. Move the mouse pointer to the point where the data values begin to decrease. Hold down the left mouse button. Drag the mouse pointer to the end of the data and release the mouse button.
   b. Click the Linear Fit button, [Linear Fit], to perform a linear regression. A floating box will appear with the formula for a best fit line.
   c. Record the absolute value of the slope of the line, \( m \), in the slope column of Table 1.
   d. Close the linear regression floating box.

12. Move your data to a stored run by choosing Store Latest Run from the Experiment menu.

13. Repeat Steps 4–12 for the other assigned temperatures.

14. To print a graph of oxygen concentration vs. time showing all data runs:
   a. Label each curve by choosing Text Annotation from the Insert menu, and entering the
temperature tested in the edit box. Repeat for each temperature tested. Then drag each box to a position near its respective curve. Adjust the alignment of the arrow heads.
b. Print a copy of the graph, with all data sets displayed. Enter your name(s) and the number of copies of the graph you want.

DATA

| Table 1 |
|---------------------|---------------------|---------------------|
| Temperature (°C) | Actual Temperature (°C) | Slope (%/min) | Respiration Rate (%/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 | | | |

Mass of crickets _______ g

| Table 2 |
|---------------------|---------------------|
| Temperature (°C) | Respiration Rate (%/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 | |
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PROCESSING THE DATA

1. For each temperature you tested, divide the slope of the regression line by the mass of the crickets. Record this value as the rate of respiration in Table 1.

2. Record the temperatures your group tested along with the respiration rates on the classroom board. When all other groups have posted their results, calculate the average for each temperature range. Record the average rate values in Table 2.

3. On Page 2 of the experiment file, create a graph of respiration rate vs. temperature using the data recorded in Table 2. The respiration rate values should be plotted on the y-axis, and the temperature on the x-axis.

QUESTIONS

1. At what temperature was the rate of oxygen consumption highest? How does this relate to the internal body temperature of warm-blooded organisms?

2. How does temperature affect the rate of respiration in crickets? How does this compare to your prediction?

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

4. Predict the rate of respiration for crickets at 60°C. Explain.

EXTENSIONS

1. Perform the same experiment with different species of insects.

2. Investigate the difference in metabolic rate of an insect at different life stages.

3. Compare cellular respiration between insects and plants.
This copy does not include:

- Safety information
- Essential instructor background information
- Directions for preparing solutions
- Important tips for successfully doing these labs