INTRODUCTION

Aerobic cellular respiration is 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, by the following reaction:

\[
\text{C}_6\text{H}_12\text{O}_6 + 6 \text{ O}_2(\text{g}) \rightarrow 6 \text{ H}_2\text{O} + 6 \text{ CO}_2(\text{g}) + \text{ energy}
\]

All organisms, including plants and animals, oxidize glucose for energy. Often, this energy is used to convert ADP and phosphate into ATP. In this experiment, the rate of cellular respiration will be measured by monitoring the consumption of oxygen gas.

Many environmental variables might affect the rate of aerobic cellular respiration. Temperature changes have profound effects upon living things. Enzyme-catalyzed reactions are especially sensitive to small changes in temperature. Because of this, the metabolism of ectotherms, organisms whose internal body temperature is determined by their surroundings, are often determined by the surrounding temperature. In this experiment, you will determine the effect temperature changes have on the aerobic respiration of yeast.

OBJECTIVES

- Use a Dissolved Oxygen Probe to measure changes in dissolved oxygen concentration.
- Study the effect of temperature on cellular respiration.
- Make a plot of the rate of cellular respiration as a function of temperature.

MATERIALS

<table>
<thead>
<tr>
<th>LabQuest</th>
<th>Temperature Probe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissolved Oxygen Probe</td>
<td>Magnetic Stirrer and Stir Bar</td>
</tr>
<tr>
<td>Beral pipet</td>
<td>100 mL beaker</td>
</tr>
<tr>
<td>5 mL graduated pipet</td>
<td>100 mL graduated cylinder</td>
</tr>
<tr>
<td>2 utility clamps</td>
<td>warm and cool water</td>
</tr>
</tbody>
</table>
Ice
Wash bottle with distilled water
Goggles

Additional materials for DO Probes
- Calibration bottle with DO electrode filling solution
- Pipet
- 250 mL beaker with Distilled water

**PROBE PREPARATION**

1. Prepare the Dissolved Oxygen Probe for use.
   a. Remove the blue protective cap
   b. Unscrew the membrane cap from the tip of the probe
   c. Using a pipet, fill the membrane cap with 1 mL of DO Electrode Filling solution
   d. Carefully thread the membrane cap back onto the electrode.
   e. Place the probe into a beaker of water.

2. Connect the Dissolved Oxygen Probe and Temperature Probe to LabQuest.
   Choose New from the file menu.

3. On the Meter screen, tap Rate. Change the data-collection rate to 0.5 samples, second.

4. It is necessary to warm up the Dissolved Oxygen Probe for 10 minutes before taking readings. To warm up the probe, leave it connected to LabQuest for 10 minutes. The probe must stay connected at all times to keep it warmed up. If disconnected for more than a few minutes, it will be necessary to warm up the probe again. Continue to the Procedure while you wait for the probe to warm up.

**PROCEDURE**

1. Obtain and wear goggles.

2. Use the 100 mL graduated cylinder to add 60 mL of room-temperature water to the 100 mL beaker.

3. Add 4 g sucrose to the water. Add the stir bar and use the Stir station to stir until dissolved.

4. Use the utility clamps to secure the Temperature Probe and Dissolved Oxygen Probe to the stir station and lower them into the beaker. Make sure the silver dot on the side of the Dissolved Oxygen Probe is completely submerged.
5. Adjust the stir station so it is stirring at a slow rate and wait for the readings to stabilize (about 2 minutes).

6. Using a graduated pipet, add 4 mL of the yeast solution into the beaker.

7. Immediately start data collection.

8. When data collection is finished, thoroughly rinse the Dissolved Oxygen Probe with distilled water. Place the probe back in the beaker of distilled water until the next run.

9. Determine the average (mean) temperature by choosing Statistics from the Analyze menu. Record the average temperature in Table 1.

10. Perform a linear regression to calculate the rate of respiration.
   a. Choose Curve Fit from the Analyze menu.
   b. Select Linear as the Fit Equation.
   c. Enter the slope, $m$, as the rate of respiration in Table 1. Select OK.

11. Store the run by tapping the Filing Cabinet icon.

12. Repeat Steps 2-11, using cool water instead of room-temperature water. Add a small amount of ice to cool the water to between 10—15°C before measuring out the 60 mL.

13. Repeat Steps 2-10, using 60 mL of warm water between 30-35°C.

**DATA**

<table>
<thead>
<tr>
<th>Temperature range (°C)</th>
<th>Average temperature (°C)</th>
<th>Rate of respiration per second (mg/L/s)</th>
<th>Rate of respiration per minute (mg/L/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool (10–15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Room (20–25)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warm (30–35)</td>
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</table>

**PROCESSING THE DATA**

1. The rate of respiration calculated in the software is the rate per second. Convert this rate into rate per minute and record in Table 1.
2. Make a graph of the rate of respiration per minute vs temperature. Plot the rate on the y-axis and the temperature on the x-axis.

QUESTIONS

1. Do you have evidence that aerobic cellular respiration occurs in yeast? Explain

2. How did temperature affect the rate of respiration in yeast? Explain.

3. It is sometimes said that metabolism of ectotherms doubles with every 10°C increase in temperature. Do your data support this statement? Explain.

4. What will happen to the yeast after the oxygen concentration in the solution drops to zero? Why will they continue to respire sugar? Explain.

EXTENSIONS

1. Design an experiment to measure and compare the effect of other environmental conditions on the respiration rate of yeast.

2. Design an experiment to measure and compare the respiration rate of a different aquatic organism at different temperatures. What changes to the procedure might be necessary?

3. Carry out the experiment you designed in Extension 1 or Extension 2.

4. Compare the initial concentration of dissolved oxygen you measured at every temperature. What trends do you see? How does this compare to what you expected? Explain.