Name: ____

Activity 4.1.3 Cellular Respiration Study

Purpose

Yeast is generally a single-celled fungus that obtains its fuel from sugar. Like any cell, yeast absorbs raw materials from its environment and metabolizes these materials to yield energy. This metabolic process is cellular respiration. As you learned in the presentation *Cell Respiration*, animals use food resources and convert them to usable energy. Does the type of food affect respiration and the amount of energy available?

Using yeast, you can measure how quickly select sugar sources are consumed, giving you a metabolic rate. Three main processes occur inside the cell during respiration. Although other products are produced during cell respiration, such as, carbon dioxide and water, energy is the main goal. To produce energy the cell breaks down glucose molecules. As sugar consumption increases, more carbon dioxide is released. You can measure carbon dioxide to determine whether yeast prefers a certain sugar.

Materials

Per pair of students:

- LabQuest2
- *LabQuest2 Quick-Start Guide*
- Vernier temperature sensor
- Vernier CO_2 gas sensor
- 250ml respiration chamber
- 5% glucose solution
- 5% sucrose solution
- 3 pipettes
- Distilled water
- Test tube rack
- Hot and cold water
- 3 test tubes
- Yeast suspension
- Syringe
- Paper towel
- Permanent marker
- Masking tape
- 2 250ml beakers
- 600ml beaker

Per student:

- Pencil
- *Agriscience Notebook*

Procedure

In this activity, you will be investigating the respiration rate of yeast. This activity will be an introduction to LabQuest2 and provide an example of the functions LabQuest2 instruments can perform.
The first part of this activity will refresh you on LabQuest2 operations. Once you have navigated some functions of the equipment, you and your partner will prepare test tubes of yeast and sugar solution. After metabolism has been initiated, you will measure the rate of carbon dioxide accumulation using the LabQuest2 and CO_2 sensor.

Part One – Welcome to LabQuest2

This section provides a brief overview of the basic functions of LabQuest2. Throughout the course, you use LabQuest2 to collect data.

1. Wake up your LabQuest2 by pressing the power button located at the left corner on the top of the LabQuest2. If your LabQuest2 does not wake, connect the LabQuest2 to its power adapter.
2. Locate each of the hardware features on pages 5 and 6 of the *Quick-Start Guide* on the LabQuest2.
3. Press the **LabQuest App** logo that appears on the screen with your finger or the stylus.
4. Attach a temperature sensor to CH 1 in the upper edge of the LabQuest2 device.
5. Review the navigation of the LabQuest App as shown on pages 8 – 17 in the *Quick Start Guide*.
6. Notice a red box with a temperature reading appears on the screen. Use your finger or the stylus to press on the ºC portion of the read out. A dropdown menu that allows you to change units will appear.
7. Press the start data collection button at the bottom left of the screen. Notice this automatically changes the menu screen to data collection and begins graphing collected data.
8. On the right-hand side of the graph, you will see the real-time temperature reading. Once the data is collected, the graph will automatically change to display the data in the best graph.
9. The last basic feature you will investigate is the function you use to analyze data. Select **Analyze** from the top of the data collection screen.
10. From the dropdown menu, press on **Statistics** and select temperature. On the right-hand side of the graph, basic statistics are shown including the sample minimum, maximum, and mean (average) temperature.
    - **NOTE:** Further use of data analyzing features will be specifically discussed for each LabQuest2 activity, but these basic statistics are important to know how to view and use for every activity.

Part Two – Preparing a Water Bath

1. Use the 600ml beaker and fill it 1/3 of the way full of warm water.
2. Fill each of the 250ml beakers with water — one beaker with hot tap water and the other with cold tap water.
3. Insert the thermometer into the 600ml beaker and use the hot and cold water in the 250ml beakers to adjust the water temperature in the 600ml beaker to stabilize at 38-40°C. The thermometer will remain in the 600ml beaker to monitor the temperature throughout the experiment.
4. Once the water temperature is stabilized, adjust the water level in the 600ml beaker so it is ½ full. This beaker will serve as the water bath.

Part Three – Preparing the Test Tubes

1. Using masking tape and a permanent marker, label three test tubes with a “G”, “S”, and “W” for glucose, sucrose, and water respectively.
2. Using the pipettes, place 2ml of distilled water in test tube “W”, 2ml of glucose in test tube “G”, and 2ml of sucrose in test tube “S”. Be sure to use a clean pipette for each transfer.
3. Add 2ml of the yeast suspension to each test tube. Keep the yeast suspension mixed during measuring to ensure each test tube will receive a consistent yeast suspension.
4. Set all three test tubes into the water bath.

5. Incubate the test tubes for 10 minutes in the water bath. Be sure to keep the water bath temperature between 38-40°C by adding hot or cold water. If the beaker is close to overflowing, use a syringe to remove excess water.

Part Four – Measuring Carbon Dioxide

1. Set the CO_2 sensor switch to the "Low" setting (0-10,000 ppm).
2. Turn on the LabQuest2 device and plug in the CO_2 sensor to CH2.
3. Choose "New" from the LabQuest2 "File" menu.
4. Set up the collection time duration.
    - Choose "Sensors" from the top of the LabQuest2 screen.
    - From the dropdown menu, choose "Data Collection". Be sure the mode is "Time Based".
    - In the "Length" dialog box change from 600 to 240.
    - Be sure the units are in seconds (sec) and then select "OK".
5. After 10 minutes of incubation, transfer 1ml of solution from test tube "W" and place it into the respiration chamber using the pipette.
6. As you complete Step 5, your partner will record the temperature of the water bath in Table 1.
7. Quickly place the CO_2 sensor in the respiration chamber.
8. Tap the collect button at the lower left hand corner of the LabQuest2 device to begin recording data.
9. After the data is finished recording, remove the CO_2 sensor and rinse out the respiration chamber. Make sure all yeast solution is removed. Dry the inside of the chamber with a paper towel.

Part Five – Data Analysis and Recording

1. Once data is collected, you will perform a linear regression to calculate the rate of respiration.
2. From the "Analyze" menu across the top of the LabQuest2 screen, select "Curve Fit" and "CO_2".
3. Select "Linear" for the "Fit Equation".
    - The linear-regression statistics for these two data columns are displayed for the equation in the form $y = mx + b$, where x is time, y is CO_2 gas concentration, m is the slope, and b is the y-intercept.
4. In Table 1, enter the slope (m) as the rate of respiration for the variable tested. As mentioned, m measures the slope of the graph. As the concentration of gas accumulates in the chamber, the line on the graph increases. The slope of the line tells you how fast the gas accumulated in the chamber, therefore you can correlate the metabolic activity of the yeast with the slope of the graph.
    - The rate will be calculated in ppm/s, which means how many parts of CO_2 particles per million parts of air volume per each second of time tested.
    - The slope, or m, represents the ppm/second determination.
5. Select "OK".
6. Record your findings as directed by your teacher.

Part Six – Repeat Trials on Remaining Test Samples

1. Be sure to air out the CO_2 Gas Sensor in between each test by fanning air across the probe for at least one minute.
2. Repeat Part Four and Part Five for the glucose and sucrose samples.

Table 1. *Data*

Food Source	Actual Temperature (C°)	Respiration Rate (ppm/s)	Class Average Respiration Rate (ppm/s)
Water			
Glucose			
Sucrose			

Your teacher will assist with determining the class averages.

Conclusion

1. Is there enough evidence from this experiment to claim one sugar is a better source of food for yeast cells than the other? Explain your answer.

2. Based on your knowledge of respiration, what is happening to oxygen levels in the respiration chamber while data is being collected?

3. If your results varied from the class average, explain where some of the errors may have occurred.

4. What is the role of distilled water in this experiment?

Source: Redding, K., & Masterman, D. (2007). *Biology with vernier*. Beaverton, OR: Vernier Software & Technology.