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CASE

# Activity 4.1.4 Cellular Respiration

## Purpose

Yeast is a single-celled fungus that enjoys a good meal of sugar. Like any cell, yeast absorbs raw materials from its environment and metabolizes these materials to create energy. However, yeast can be a fussy eater, preferring certain types of sugars to others.

You will conduct an experiment in order to determine which sugar yeast prefers by measuring the metabolic rate. As sugar consumption increases, more yeast cells are created and more carbon dioxide ($CO_2$ gas) is produced. You will measure carbon dioxide as the dependent variable and use the results to determine the favorite type of sugar for a yeast cell.

## Materials

**Per pair of students:**

- LabQuest® interface
- Vernier $CO_2$ gas sensor
- Vernier temperature sensor
- 250ml respiration chamber
- 5% glucose solution
- 5% sucrose solution
- (4) plastic pipettes
- Distilled water
- 600ml beaker
- (2) 400ml beakers
- Hot and cold water
- Thermometer
- (4) 10x100mm test tubes
- Test tube rack
- Yeast suspension
- Paper towel
- Permanent marker pen

**Per student:**

- Pencil
- *Agriscience Notebook*

## Procedure

You will prepare yeast and sugar solutions in order to measure the rate of $CO_2$ gas accumulation.

**Part One – Water Bath**

1. Use the 600ml beaker and fill it 1/3 of the way full of warm water.
2. Fill each 400ml beakers with water – one beaker with hot tap water and the other with cold tap water.

3. Turn on the LabQuest® and plug in the temperature sensor to CH1.
4. Insert the temperature sensor into the 600ml beaker and use the hot and cold water to adjust the water temperature in the 600ml beaker to stabilize at 38-40°C. The temperature sensor will remain in the 600ml beaker to monitor the temperature throughout the experiment.
5. Once the water temperature is stabilized, adjust the water level in the 600ml beaker so it is ½ - ¾ full. This beaker will serve as a water bath for you and your partner.

**Part Two – Preparing the Test Tubes**

1. Using a permanent marker pen, label three test tubes with a "G", "S", and "W" for glucose, sucrose, and water. Label the fourth test tube "Y" for yeast suspension. Place the test tubes in the test tube rack.
6. Obtain the four solutions from your teacher. Using a pipette measure out and place substances into the respective test tubes. Be sure to rinse the pipette with water before each transfer.
    - 8ml of yeast suspension for test tube "Y"
    - 2ml of distilled water for test tube "W"
    - 2ml of glucose for test tube "G"
    - 2ml of sucrose for test tube "S"

7. Set all four test tubes into the water bath.
8. Incubate the test tubes in the water bath during while you complete Part Three. 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, remove excess water.

**Part Three – LabQuest Preparation**

1. If the $CO_2$ sensor you are using has a switch, set it to the "Low" setting (0-10,000 ppm).
9. Plug in the $CO_2$ sensor to CH2.
10. Choose "New" from the "File" menu at the top of the LabQuest® screen.
11. Change the data collection settings as described below:
    - Choose "Sensors" from the top of the LabQuest® screen.
    - From the dropdown menu, choose "Data Collection".
    - Be sure the mode is "Time Based".
    - In the "Duration" dialog box change default setting of 600 to 240.
    - Be sure the units are in seconds.
    - Select "OK".

**Part Four – Measuring Carbon Dioxide**

1. Using a pipette, add 2ml of the yeast suspension to the test tube labeled "W" tube. Mix the solution to ensure a consistent yeast suspension.

12. Transfer 1ml of the solution from test tube “W” and place it into the respiration chamber using a pipette.
13. As one partner completes Steps 1-2, the other partner will record the temperature of the water bath in Table 1.
14. Quickly place the $CO_2$ sensor in the respiration chamber and lay the chamber sideways so the sensor is horizontal. Carbon dioxide gas is heavier than oxygen and will accumulate in the bottom of the chamber. Holding the chamber horizontal will improve your data reading.
15. Tap the Collect button at the lower left hand corner of the LabQuest® screen to begin recording data.
16. After the data is finished recording, hang the $CO_2$ sensor over the edge of the lab table to allow the concentration reading to return to ambient or baseline level.
17. Rinse out the respiration chamber by filling completely with tap water and emptying to remove all of the yeast solution and CO2 buildup. Shake the bottle dry or dry with a paper towel. Some moisture may remain inside.
18. Tap the file icon in the upper right hand corner of the LabQuest® screen to save the data for the “W” solution and prepare for the next data collection. This will preserve the settings you selected in Part Three.
19. Repeat Steps 1-8 for the “G” and “S” test tubes.

**Part Five – Data Analysis and Recording**

1. Once data is collected, you will use the file cabinet icon in the upper right hand corner of the LabQuest® screen, select “Run 1” which is the data collected from the “W” solution.

20. Perform a linear regression to calculate the rate of respiration. From the “Analyze” menu across the top of the LabQuest® screen, select “Curve Fit” and “$CO_2$”.
21. 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 rate (slope), and $b$ is the y-intercept.
22. In Table 1, record the rate (*m*) as the rate of respiration for the sugar tested. As mentioned, *m* measures the slope of the line, which is the rate of average change in $CO_2$ concentration per unit of time. As the concentration of gas accumulates in the chamber the rate on the graph increases. The slope of the line tells you how fast the gas accumulated in the chamber. The rate will be calculated in ppm/s, which means how many parts of $CO_2$ per million parts of air per second of time.
23. Select “OK”.
24. Repeat steps 1-5 for the “G” (Run 2) and “S” (Run 3) data.
25. Share your findings for each test with the class as directed by your teacher.
26. Your teacher will assist with determining the class averages.

**Table 1.** ***Trial Data***

| Food Source | Actual Temperature (C°) | Respiration Rate (ppm/s) | Class Average<br><br>Respiration Rate (ppm/s) |
|---|---|---|---|
| **Glucose** | | | 16.4 |
| **Sucrose** | | | 15.6 |
| **Water** | | | 3.9 |

## 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.

   From my information, no there is not because me and my partner didn't get to do all of them, but with the class average I would say yes there is enough information to claim that one sugar is better than the other.

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

    We didn't get to fully finish the lab so I did not have any errors. But maybe if I did complete it, it would have been keeping the water temperature at 38-40°C.

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

    It's a different, special type of water so there will be different affects than if it were normal water.

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