CB 4 Sugar Metabolism

Do all sugars contain the same amount of energy? An example of a simple sugar (monosaccharide) is glucose: $C_6H_{12}O_6$. An example of a more complex sugar (a disaccharide) is sucrose: $C_{12}H_{22}O_{11}$. Do organisms get more energy out of monosaccharides versus disaccharides? Which sugars seem to contain the most energy?

In this experiment, you will use the production of CO_2 as a measure of metabolic activity and determine the rate at which yeast metabolize various foods. You will observe yeast activity using two simple sugars or monosaccharides (glucose and fructose), two disaccharides (sucrose and galactose), and a complex sugar, molasses.

Materials (per student team)

- 6 fermentation tubes and test tube stand or beaker to hold fermentation tubes upright
- dropping pipette • metric ruler •yeast suspension
- 10% solutions of fructose, glucose, sucrose, galactose, maltose, lactose, and molasses.
- Casio fx2 Graphing Calculator: Input and display of data
- Casio Data Collector EA-100 and CO_2 probe: CO_2 concentration readings
- Casio QV2800 Digital Camera: Visual images of changes in fermentation tube

Procedure

1. Label each of the fermentation tubes, 1-6. In your *Log*, prepare a data table like the one shown below.

Tube	Contents	Amt Gas Produced in cm		Vol Gas Produced in ml		Observations
---	-----	Before	After	Before	After	-----
1						
2						
3						
4						
5						
6						

2. Fill test tube #1 three-fourths full of glucose solution. Place 5 drops of yeast suspension in the solution. Place your thumb over the opening of the tube and tip it so that the glucose and yeast mixture fills the closed end of the tube. If you are using the test tube substitute for a fermentation tube, invert a small test tube into the large test tube and tip the assembled tubes so that the small tube becomes filled with the glucose solution and sinks to the bottom. You may have to place your thumb over

the mouth of the large tube to keep the solution from spilling as you tip it to fill the smaller tube.

3. Assemble tubes 2-7 in the same manner, filling tube #2 with fructose, tube #3 with sucrose, tube #4 with galactose, tube #5 with maltose, tube #6 with lactose, and tube #7 with molasses.
4. Construct a hypothesis for the amount of carbon dioxide produced by the yeast under each of the food sources.
5. Set the tubes in your test tube rack. Take a close up digital picture of your setup.
6. Use the CO_2 probe to assess the CO_2 levels in each of the tubes and record these data
7. Set your tubes in a safe place overnight.
8. The next day, observe each of your tubes, take another digital picture and record any relevant observations.
9. Measure the amount of gas trapped in each tube. If you are using the test tube substitute for a fermentation tube, measure the gas without removing the small tube in which the gas is trapped. Record these amounts in your *Log* data table.
10. Clean up the tubes and determine the actual volume of gas (in milliliters) that was produced by the yeast in each tube. Calculate the volume of gas produced per hour during the experiment.

Interpretations Enter answers to the questions below in your *Log*.

1. Compare and contrast your results with those of other lab teams, recording your findings in your journal. Create a histogram to summarize your data.
2. Evaluate your hypothesis and explain your reasons.
3. What conclusions can you make about the ability of yeast to metabolize the foods you provided?
4. As noted in the introduction to this experiment, some of the sugars in the experiment are monosaccharides and some are disaccharides. How do your results reflect the differences in the complexity of the sugar being metabolized?

Applications Enter answers to the questions below in your *Log*.

1. Wine and beer are both products of fermentation. They both have significant caloric value. Why would this be so?
2. Despite the fact that the diet of termites consists of wood, they have no enzymes to digest such material. How might you explain this apparent discrepancy? Research how termites obtain energy if you do not have any idea.

Casio FX2.0 Calculator Procedures for CB 4

Volume of Gas Produced

To determine the volume of gas produced in milliliters for each tube, you first need to determine what formula will work best for the container which holds the gas. If the container is a cylinder (shaped like a can of soup) then you will need to this formula:

$$V = \pi r^2 h$$

where *r* is the radius of the cylinder and *h* is the height. If the container is a rectangular shape (like a carton of juice) then you will need this formula:

$$V = lwh$$

where *l* is the length, *w* is the width, and *h* is the height. If the container is an odd shape or a mixture of shapes, you may use these formulas or combinations of formulas to estimate an approximate volume. The FX2.0 allows you to enter π as a value, rather than the approximation 3.14. To enter π, you press [SHIFT] (the gold button) followed by [EXP] at the bottom of the screen. Also remember, to raise a number to the second power you may enter the number followed by the [x^2] button (located just above the [8]) or you may use the exponent feature, [^], located near the top of the key pad, followed by a [2]. Collect all your measurements in centimeters, since 1 cm^3 is equivalent to 1 ml.

Histogram of Results

There are a couple of different comparisons that you may be interested in seeing with a histogram. Comparing the various volumes of CO_2 that individual students found from one particular food source would be a helpful visualization in determining if those volumes seemed to be uniform. Students could also make a histogram of their volume data, comparing the various volumes produced by various food sources. Also the class volumes could be accumulated under each food source and a class histogram comparing the various volumes could be compared to individual students' histograms. This would give students more comparative information in determining which food source produced the highest volume of CO_2.

For this example we will create a histogram for one set of data which compares the various volumes produced by different food sources.

- ☞ From the Main Menu, choose STAT. You will enter data into two lists for the histogram. The first list will be for data along the X-axis, which will just be the numbers of the test tubes, 1,2,3,4,5,6, and 7. The second list will be the volume amounts listed so that they correspond to the appropriate test tube number. We will think of the volume amounts as the *frequency* at which the CO_2 occurs for that test tube. For the sake of uniformity, we will enter the test tube numbers into List 1 and the volume frequencies into List 2. Remember if you need to clear the list before entering data, simply highlight an entry, press [F4] for Del-A (delete all), followed by [EXE] for Yes. Also recall that you need to press [EXE] after you make each entry into the list.
- ☞ Once you have entered the test tubes numbers into List 1 and the volumes into List 2, press [F1] for GRPH (graph), then [5] for Set. If StatGraph1 already appears at the top of the screen, you can leave that and cursor down to Graph Type. (If the StatGraph is another number, you may leave it, just remember

what number it is when you are ready to graph the histogram. If you want to change it to StatGraph1, simply press [F1] for GPH1.)

- ☞ When Graph Type is highlighted, you want to choose the histogram graph type. The histogram choice may not be showing at the bottom of your screen. If it is not, press [F6] for more options, until you see Hist for histogram, listed above the [F1] button. Press [F1] for Hist.
- ☞ Next cursor down to XList and you will enter List 1. Press [F1] for LIST, then press [1], and [EXE].
- ☞ Cursor to Frequency. You want to choose List 2, so press [F2], then [2], then [EXE]. Press [ESC] to return to the main screen.
- ☞ Press [F1] for GRPH, then [1] (or which ever number graph you set up in the previous step) for S-Gph1 (StatGraph1).
- ☞ A window will pop up on the screen titled "Set Interval." Set both Start and Pitch at 1, pressing [EXE] after entering the 1. You will need to press [EXE] to draw the histogram also.