Name _____ Class _____ Date_____

A Twist on Fermentation

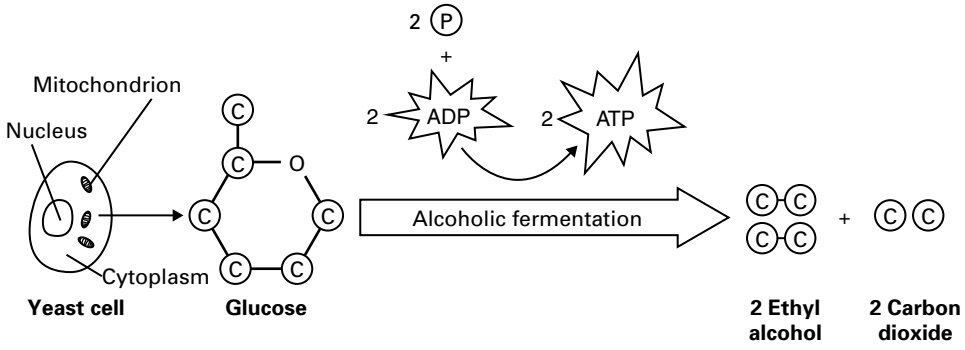
Studying the Rate of Yeast Growth in Dough

Question How does sugar concentration affect the rate of yeast fermentation?

Lab Overview In this investigation you will make small batches of yeast dough containing varying amounts of sugar. Then you will measure and compare the rates at which the batches of dough rise in small cylinders.

Background Yeasts are single-celled fungi. Some yeasts live on the surface of plants (especially fruit), others live on animal tissue, and others live in the soil. In this lab you will work with *Saccharomyces cerevisiae,* called "baker's yeast," which is used to raise bread dough.

Yeast cells require sugar as a source of energy. In the presence of oxygen, yeast cells perform cellular respiration. However, when they are surrounded by bread dough, yeast cells do not have access to oxygen. As shown in the diagram below, the yeast cells perform fermentation instead of cellular respiration, producing ethyl alcohol, carbon dioxide gas, and the energy-storing molecule ATP. As the yeast cells release carbon dioxide, the gas is trapped in the dough. Bubbles form in the dough and cause the dough to rise.



Prelab Activity In the lab you will measure the rate of fermentation by yeast in samples of bread dough containing different concentrations of sugar. You will place the dough samples into five small canisters and mark the initial levels of the dough. You will place the canisters in an "incubator" to warm the dough. (The heat from the incubator increases the reaction time of fermentation enzymes.) Then you will mark the levels to which the dough rises every 5 minutes. Complete the Prelab Activity, and then answer the questions.

Make a Prediction

Based on what you have read in the Background and Prelab, predict what will happen to dough samples containing varying concentrations of sugar. Do you think the dough will rise the fastest in the sample with the highest, the lowest, or a moderate concentration of sugar? Explain your prediction.

Prediction:

_____

_____

Prelab Questions

1. Based on the diagram of the yeast cell on the previous page, list two ways that these single-celled fungi are different from bacterial cells.

_____

_____

2. How do yeast cells benefit from fermentation?

_____

_____

3. Since fermentation occurs in the cytoplasm of yeast cells, explain the role of mitochondria in yeast cells.

_____

_____

Materials

- plastic shoe box (one for 4 groups)
- heating pad (one for 4 groups)
- 5 clear (white) plastic film canisters or empty prescription bottles
- permanent marker
- masking tape
- dough
- 1 g granulated sugar
- laboratory balance
- food coloring
- clock or watch
- metric ruler

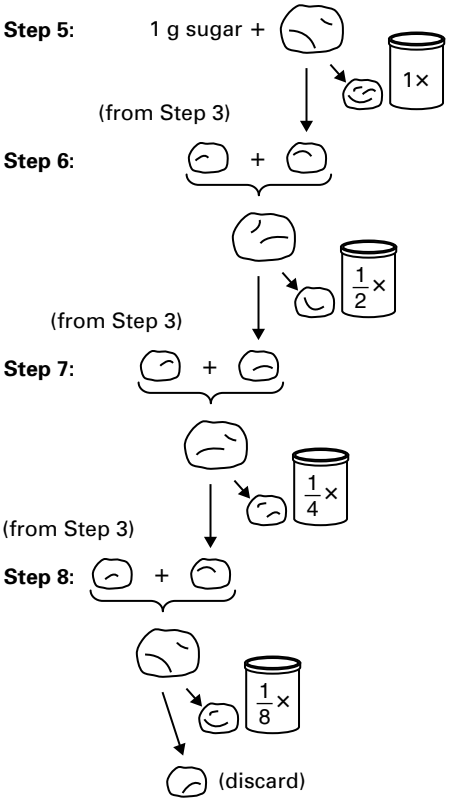
Name _____ Class _____ Date_____

Procedure

Part A: Setting up the Incubator and Preparing Dough Samples

1. To set up the incubator, turn on the heating pad to medium. Place the shoe box upside down on top of the heating pad.
2. With masking tape and a permanent marker, label each canister with one of the following labels: 1×, $\frac{1}{2}\times$, $\frac{1}{4}\times$, $\frac{1}{8}\times$, and 0. These labels indicate the approximate concentration of sugar in the dough of each canister compared to the 1× container. For example, the canister labeled $\frac{1}{2}\times$ will contain dough with approximately $\frac{1}{2}$ the sugar concentration of the dough in the canister labeled 1×, and so on.
3. The diameter of the starting ball of dough should be about 6 cm. Divide this ball into 5 balls—four of equal size and one that is twice as big as the other four (see the diagram below).

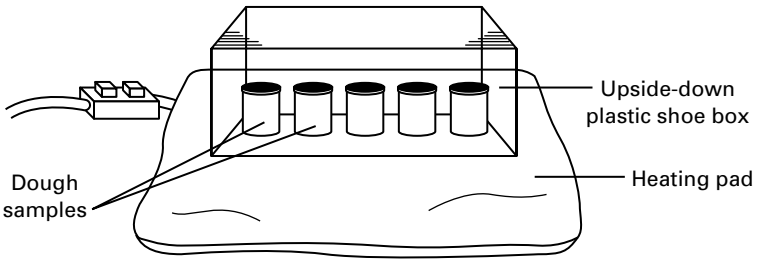
4. Use a laboratory balance to measure 1 g of sugar.
5. Mix 1 g of sugar into the large ball with your fingers. Divide this ball in half. Put one of the halves in the canister labeled "1×." Use the diagram at right for guidance.
6. Combine a small ball from Step 3 with the leftover dough from Step 5 to make a ball with half the sugar concentration of the 1× ball. Split this ball in half. Place one half in the canister labeled "$\frac{1}{2}\times$."
7. Combine another small ball from Step 3 with the leftover dough from Step 6 to make a ball with half the sugar concentration of the $\frac{1}{2}\times$ ball. Split this ball in half. Place one half in the canister labeled "$\frac{1}{4}\times$."
8. Combine another small ball from Step 3 with the leftover dough from Step 7 to make a ball with half the sugar concentration of the $\frac{1}{4}\times$ ball. Split this ball in half. Place one half in the canister labeled "$\frac{1}{8}\times$." Discard the leftover dough.



9. Place the remaining small ball from Step 3 in the canister labeled "0."

Part B: Testing Rates of Yeast Fermentation

1. Press down the dough ball in each canister so that the dough surface is relatively flat.
2. Place a drop of food coloring against the inside edge of each canister to help measure the dough level.
3. Use a permanent marker to mark the initial level of the dough on the outside of each canister.
4. Loosely place a lid on each canister. Place the five canisters in the "incubator," as shown in the diagram below. (**NOTE:** *The canisters should rest directly on the heating pad with the shoe box placed upside down over them.*) Record the start time below.



Incubator

Start time: _____

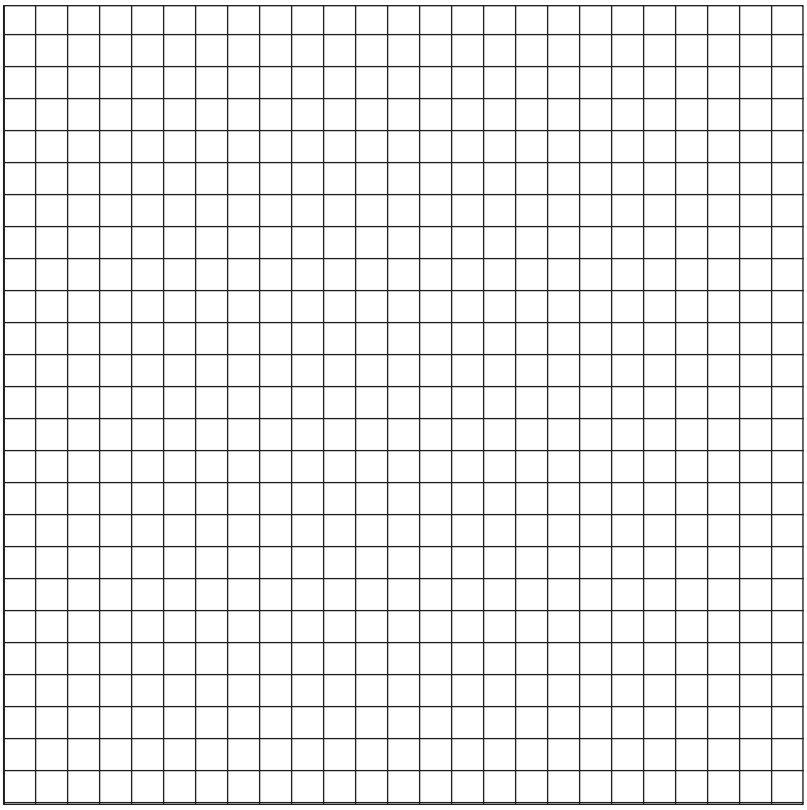
5. After 5 min, mark the level on each canister to which the dough has risen. Make the mark on the same side of the canister as the initial mark. As the dough rises it will form a rounded shape. Place your mark at the highest point of the colored dough where the dough touches the side of the canister.
6. Use a metric ruler to measure the distance (in mm) between the initial level of the dough and the level at 5 min. Record the change in level in mm for each canister in Data Table 1 on the next page.
7. Repeat steps 5 and 6 every 5 min for the next 30 min. (**NOTE:** *Always measure from the initial mark to the most recent mark.*)

Name _____ Class _____ Date_____

Data Table 1

Time	Change in Level of Dough from Initial Level (mm)				
	"0" Canister	**"1/8×" Canister**	**"1/4×" Canister**	**"1/2×" Canister**	**"1×" Canister**
5 min					
10 min					
15 min					
20 min					
25 min					
30 min					
35 min					

8. Plot 5 line graphs on the same grid. The *y*-axis of your graph should represent change in dough level (in mm) and the *x*-axis should represent time (in min). Be sure to label the different graph lines and axes, and title your graph.



Analysis and Conclusions

1. Explain what the rising dough indicates.

2. The rate at which dough rises is calculated by dividing the distance the dough rises by the time period (mm/min). Calculate the *initial* rate of rising of each dough sample (the initial rate is the rate for the first 5 min).

3. Look back at the prediction you made in the Prelab Activity. Do your data support your prediction? Suggest possible reasons for any differences.

Name _____ Class _____ Date_____

4. If you doubled the concentration of yeast in the dough, how do you think your results might change? Explain.

_____

_____

_____

5. Share data with two other lab groups. Do your data differ from the other groups? Suggest possible reasons for any differences.

_____

_____

_____

_____

_____

Extension

Do the experiment again, but change a different variable. For example, you could study the effect of temperature on the activity of the yeast, or the effect of adding different amounts of salt to the dough. Think of a question you would like to study, write a hypothesis, and design an experiment to test it. (**NOTE:** *Always check with your teacher before carrying out any experiments.*)