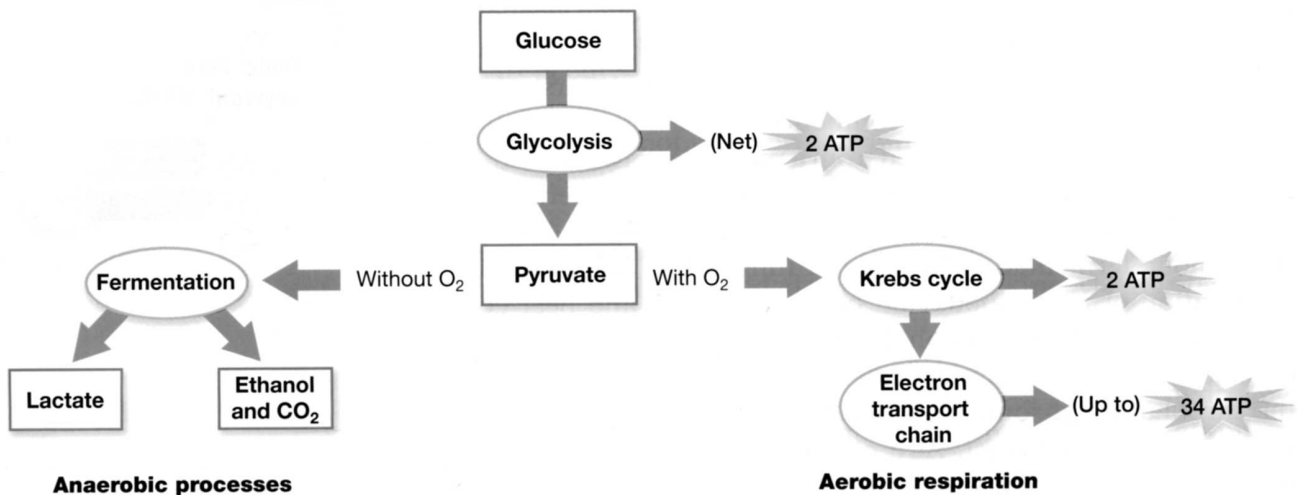




Cellular respiration that uses  $O_2$  is called **aerobic respiration**. Most of the time, the cells in our bodies use aerobic respiration:



When oxygen is not available, cells use **anaerobic** processes to produce ATP. (The "an" in front of aerobic means "not aerobic".)

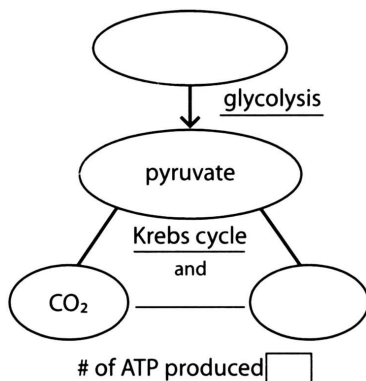
Under anaerobic conditions, many cells use a process called **fermentation** to make ATP. As shown in the figure above, there are two types of fermentation:

**lactate fermentation** (e.g. in muscles when an animal exercises hard) and **alcoholic fermentation** (e.g. by yeast to make wine and beer).

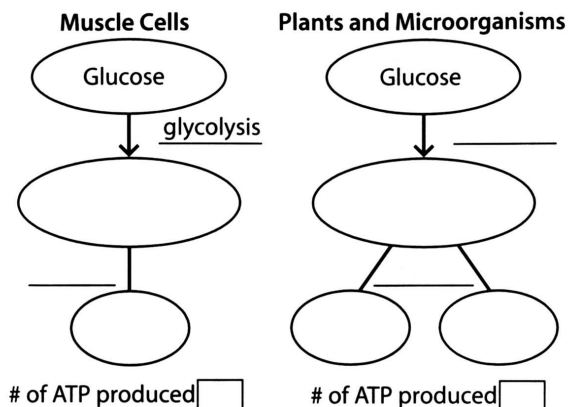
Fermentation has two disadvantages compared to aerobic respiration. Fermentation produces much less ATP than aerobic respiration, and fermentation produces a toxic byproduct (either lactate, which becomes lactic acid, or alcohol). However, fermentation is very useful if oxygen is not available.

Use the above information to complete the figures below. Fill in the ovals with the appropriate molecule. On the blank lines write the name of the appropriate process. In the boxes at the bottom of the figure write how much ATP is made in each pathway.

### With Oxygen (Aerobic)



### Without Oxygen (Anaerobic)



Humans use **yeast** every day. What is yeast? What are some common uses of yeast?

If you want to make your own bread, you can buy yeast in the grocery store. This yeast consists of little brown grains. The little brown grains of yeast may not seem to be alive, but if you put them in water with sugar, the yeast will carry out cellular respiration and grow.

You can grow yeast in a test tube filled with water and sealed with a balloon. Do you think these growth conditions are aerobic or anaerobic?

Under anaerobic conditions, yeast carries out alcoholic fermentation, so it produces \_\_\_\_\_ and \_\_\_\_\_. You can measure the rate of fermentation in yeast by measuring the amount of carbon dioxide gas the yeast produces. Carbon dioxide production can be measured by measuring the depth of the layer of bubbles trapped in foam on top of the yeast solution and also by observing the balloons, which catch the carbon dioxide produced and get bigger.

### **Part I - Sucrose Concentration**

What is sucrose?

Your first experiment will investigate the effect of sucrose concentration on the rate of cellular respiration in yeast. Yeast can convert sucrose into glucose and use it during cellular respiration.

You will design an experiment to answer the question: Does the concentration of sucrose affect the rate of cellular respiration in yeast?

Your teacher will provide you with yeast, test tubes, balloons, rulers, and four concentrations of sucrose water: 0% (plain water), 1%, 5% and 10% sucrose.

1. Write a hypothesis that you will test to help you answer the research question.
2. What will be the independent variable in your experiment?
3. What will be the dependent variable in your experiment?
4. What will be the control treatment in your experiment?

What is the purpose of this control treatment?

5. The basic procedure to measure cellular respiration is:
  - 1) Add 25 mL of the appropriate sucrose solution to each tube.
  - 2) Add ¼ tsp of yeast to each tube.
  - 3) Put a balloon on the top of each tube.
  - 4) With your palm sealing the top, shake each tube until the yeast is dissolved.
  - 5) Measure the depth of bubbles produced and observe how the balloons change after 10 minutes and 20 minutes.

Write your specific procedures here:

6. Complete the first column of these data tables.

Sucrose treatment	Depth of CO <sub>2</sub> bubbles in:	
	10 minutes	20 minutes

Sucrose treatment	Balloon description	
	10 minutes	20 minutes

7. Perform your experiment and record your data in the data tables.

8. Did the yeast produce different amounts of carbon dioxide with different sucrose concentrations?

Do the results match your hypothesis?

9. Discuss your results with your group. What conclusions concerning the relationship between sucrose concentration and the rate of cellular respiration are supported by your results?

## **Part II- Yeast and Other Ingredients in Bread**

When you make bread, if you just mix flour, sugar and water, the dough does not rise, and the bread will be flat and hard. If you include yeast in the bread dough, then the dough rises and the bread is bigger and fluffier. Can you explain how the yeast helps the bread dough to rise?

Consider the results of your last experiment with yeast and sucrose. If you added flour, which treatment would have made the fluffiest bread?

Today you will design and carry out an experiment to investigate other variables, besides the concentration of sugar, which may affect the fluffiness of bread. Bread dough usually has other ingredients besides yeast, sugar, water and flour. Some other common ingredients in bread dough are salt, fats (e.g. oil or butter), eggs, and flavorings such as cinnamon and raisins. Any of these ingredients could affect the rate of fermentation of the yeast and thus affect the fluffiness of the bread. The temperature at which the bread dough is kept to rise might also affect the fluffiness of bread.

You will not actually test how one of these ingredients or temperature affects the fluffiness of bread. Instead, you will use the same experimental setup as before (that is, test tubes with yeast mixture, a ruler and balloons) to test the effect of one of these variables on the rate of CO<sub>2</sub> production.

1. What question will you investigate?
2. Write a hypothesis that you will test to help you answer this question.

3. Plan an experiment to test your hypothesis.

What is the independent variable in your experiment?

4. What is the dependent variable in your experiment?

5. What is the control treatment in your experiment? (Hint: You are not testing how sugar affects cellular respiration, so you will want to use 10% sucrose in each of your treatments)

6. What are your procedures?

7. Create a data table.

8. Perform your experiment and collect your data.

9. Did the yeast produce different amounts of carbon dioxide with different treatments?  
Do the results match your hypothesis?

10. What do your results mean for people who make bread using the ingredient or temperature you investigated?

If you have used clean test tubes, ingredients and mixing procedures, you can use the yeast solution in one of your treatment test tubes to produce a small loaf of bread. Your teacher will give you instructions on how to add flour and water to your yeast solution and knead a bread ball. Make sure you label your baking cup with your name so you know which is yours when it comes out of the oven.