Cellular Respiration in Yeast

Adapted from "Alcoholic Fermentation in Yeast Investigation" in the School District of Philadelphia Biology Core Curriculum

All living cells, including the cells in your body and the cells in yeast, need energy for cellular processes such as pumping molecules into or out of the cell or synthesizing needed molecules. **ATP** is a special molecule which provides energy in a form that cells can use for cellular processes.

Cellular respiration is the process that cells use to transfer energy from the organic molecules in food to ATP. The following equation summarizes the chemical changes that occur in cellular respiration of the monosaccharide glucose when oxygen is available.

$$\mathbf{C_6H_{12}O_6} + 6\ \mathbf{O_2} \rightarrow 6\ \mathbf{CO_2} + 6\ \mathbf{H_2O} + \mathbf{ATP}$$

glucose — oxygen gas — carbon dioxide gas — water — energy

There is another important feature of cellular respiration which is not shown in these equations. Cellular respiration involves many small steps; these multiple steps allow the cell to use the energy from each glucose molecule efficiently in order to make as many ATP molecules as possible. The multiple steps of cellular respiration are described in your textbook. Our description will focus on some major steps and how these steps differ, depending on whether oxygen is available or not.

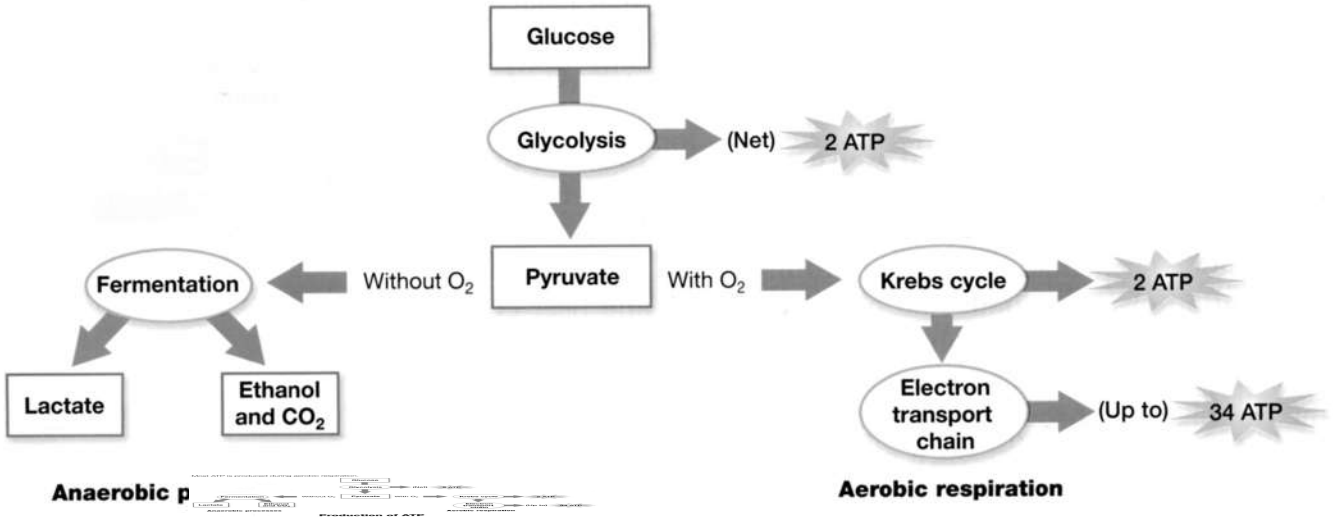
The first major step in cellular respiration is **glycolysis** (see the figure on the top of page 2):

$$1\ \text{glucose} \rightarrow 2\ \text{pyruvate} + 2\ \text{ATP}$$

What happens next depends on whether or not oxygen is available to the cells. When oxygen is available, cells can use the **Krebs cycle** and the **electron transport chain** to make up to 36 ATPs (see the right side of the figure).

$$2\ \text{pyruvate} + 6\ O_2 \rightarrow 6\ CO_2 + 36\ \text{ATP}$$

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 can use a process called **fermentation** to keep making energy. This is called **anaerobic respiration**. (The "an" in front of aerobic means "not aerobic".)



As shown in the figure above, there are two types of fermentation:

Lactic acid 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.

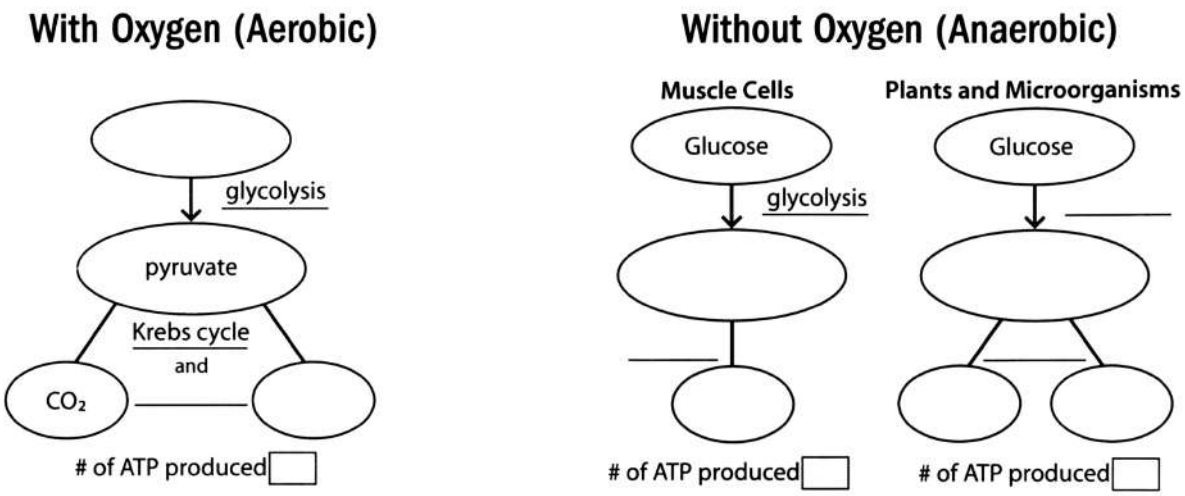
Alcoholic fermentation is used to make bread, beer, wine, and even cheese. Yeast is a fungus that converts sugars to carbon dioxide and alcohol. The carbon dioxide from the yeast can carbonate liquids like beer, or cause dough to rise. In liquids, the alcohol remains, but in bread it evaporates away. Humans use yeast every day. 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.

Under anaerobic conditions, yeast carries out alcoholic fermentation, so it produces ethanol and carbon dioxide. You can measure the rate of anaerobic respiration in yeast by measuring the amount of carbon dioxide gas the yeast produces.

Sugar is sucrose which comes from the sugar cane plant. Yeast can convert sucrose into glucose and use it during cellular respiration.

Pre lab Questions

1. What molecule do all cells use for energy?
2. What process makes this molecule?
3. Copy and complete the flow charts



4. What is the difference between aerobic and anaerobic respiration?
5. Where does sugar come from?
6. What is yeast?
7. What are the 2 types of anaerobic respiration? How do they differ?
8. What type of anaerobic respiration does yeast use?
9. Why is bread considered non-alcoholic?
10. How can you measure the rate of anaerobic respiration in yeast?

Experimental Design Guide

Your experiment will investigate the effect of sucrose concentration on the rate of cellular respiration in yeast.
You will design an experiment to answer the question: Does the concentration of sucrose affect the rate of cellular respiration in yeast?
Materials: yeast (1/4 teaspoon per tube), 4 test tubes, balloons, string, 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. How will you measure the dependent variable?
5. What will be the control treatment in your experiment?
6. What is the purpose of this control treatment?
7. Write your specific procedures here:
8. Create a data table

With your teacher's approval, perform your experiment and record your data in the data tables.

Analysis Questions

9. Graph the rate of respiration in a line graph. Use your data table to plot the points.
10. How did you measure the rate of respiration?
11. Did the yeast produce different amounts of carbon dioxide with different sucrose concentrations?
12. If you were baking bread, what concentration would make the fluffiest loaf? What would make the densest? Explain.

CONCLUSION: Was your hypothesis supported by your results? If you did the experiment again, what would you change?