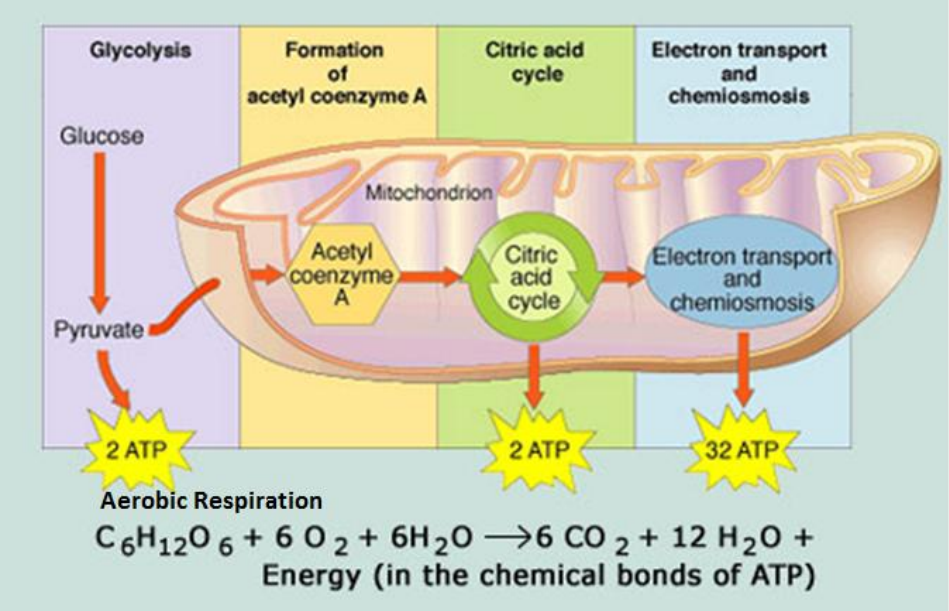
Cellular Respiration: Aerobic vs. Anaerobic

Respiration is a process which happens inside the cells in which carbohydrates, especially glucose, is broken down for the energy to be released which can be used by the cells. This energy generated can be used for a lot of different processes but in all of those processes energy is transferred. The processes involved range from muscle contraction to the production of protein for the new cells. This respiration is an important feature of life. This is carried out by all the living cells. There are two varieties or types of respiration in organisms-aerobic and anaerobic. The aerobic respiration is a complicated procedure involving chemical reactions in which oxygen is used to transform glucose into carbon dioxide and H2O. This process generates energy in the form of energy carrying molecules called as ATP. At other times the respiration takes place without oxygen, this is termed as anaerobic respiration. In the case of anaerobic respiration, glucose is broken and the products generated from this are energy and either lactic acid or ethanol (alcohol) and CO2. This process is termed as fermentation.

In anaerobic respiration (which occurs during fermentation), less energy is extracted (only 2 ATP molecules per glucose molecule) because the products of the process, such as ethanol, contain more energy than does carbon dioxide, the product of aerobic respiration. In muscle, the product of anaerobic respiration is lactic acid. In yeast, it is ethanol.



In human beings the anaerobic respiration carries on only for a short duration to time. As the respiration builds up the muscles producing the lactic acid stop working. But a lot of micro-organisms can continue respiring anaerobically for longer period or even all the time. Yeast undergoes aerobic respiration if oxygen is present but in the absence of oxygen it respires anaerobically. And while respiring anaerobically it produces alcohol.

Equation for energy produced:

Most of the metabolic processes occurring inside the cells are dependent on the use of enzymes. Respiration which is release of energy inside the cells, is a complicated set of reactions which uses about 70 varieties of enzymes which are the catalysts. Energy is generated in the several stages of the reaction process. Almost 75 % of it is in the form of heat. Unfortunately the heat energy which could not be used by the cell is wasted but, the other energy released is stored by the cell in the form of a easily available substance termed as adenosine triphosphate also popularly known as ATP.

In the aerobic respiration (with the use of oxygen) the glucose molecules are broken totally generating all of the useful energy and producing CO2 and H2O as waste products. The word equation for aerobic respiration shows:

Glucose + oxygen -> carbon dioxide + water + energy

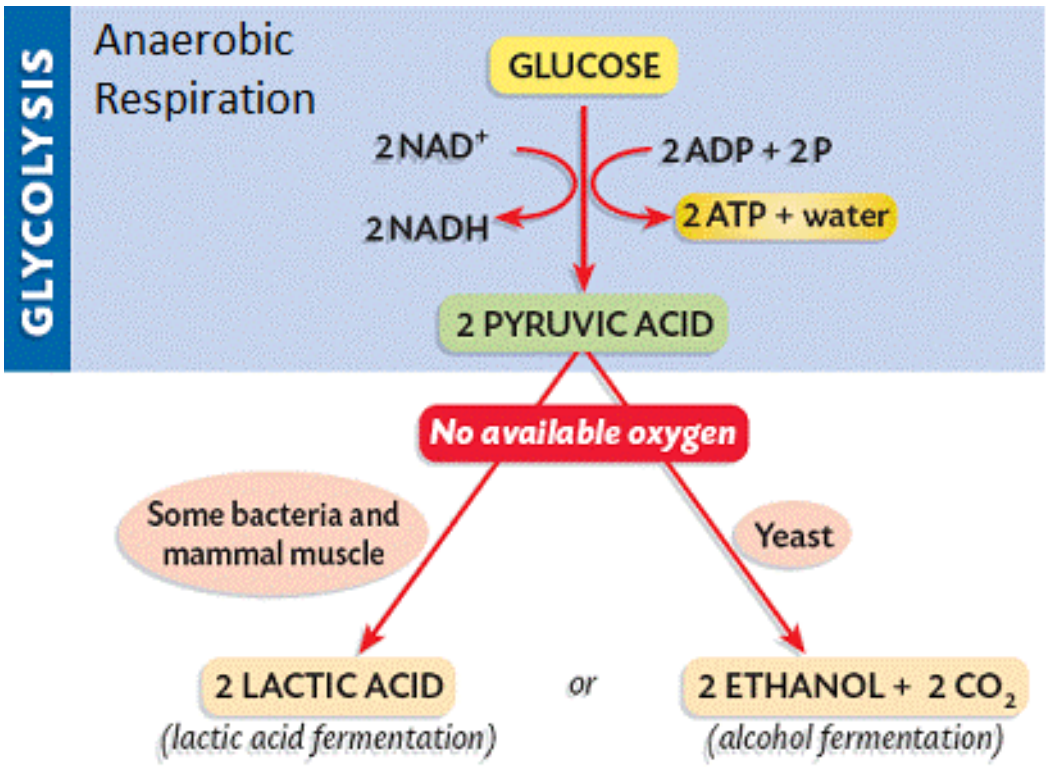
However in the anaerobic respiration the glucose molecules are only partly broken so only a part of energy is released and instead of CO2 and H2O, the by-products are either CO2 and ethanol or lactic acid. The equation for this is:

Glucose -> ethanol + carbon dioxide + energy
Glucose -> lactic acid + energy

These symbol equations are represented as:

C6H12O6 -> 2CO2 + 2CH3-CH2-OH (ethanol)
C6H12O6 -> 2C3H6O3 (lactic acid)

So as in aerobic respiration one molecule of glucose can generate 38 molecules of ATP, in anaerobic respiration about 2 molecules of ATP are released per one molecule of glucose.



"Anaerobic Respiration Lab"

Introduction

Ethanol is a fuel produced by the fermentation (anaerobic respiration) of starch. In the auto industry, companies make 13.5 billion gallons of ethanol, which is roughly ten percent of the nations motor fuel supply. Fermentation or anaerobic respiration is a method that is used by yeast cells to produce energy, while producing the ethanol byproduct. Harnessing the natural power of yeast and anaerobic respiration, fuel companies produce billions of gallons of valuable ethanol. You will take on the role of biologist to run tests that determine the ideal conditions for anaerobic respiration and ethanol production. If yeast produce more ethanol, the price of gas will decline and you will be helping the company boost productivity and profits. Such a great accomplishment will result in a large bonus to your paycheck.

Experimental Question:

Hypothesis:

Prelab Questions

1. Compare and contrast anaerobic and aerobic cellular respiration.
2. Note the equation of anaerobic respiration.
3. How does anaerobic respiration differ in our muscles and yeast?

Materials

- Yeast
- Water
- Hot Plate
- Test Tubes
- Test Tube Racks
- Syringe
- Thermometer
- Pipette
- Sugars
- Beaker
- Flask

Procedure

1. Design an experiment to determine ideal conditions for anaerobic respiration or ethanol production.
2. Select an experimental variable you would like to examine from the list below.

- Type of Carbohydrate – What are the rates of fermentation using different food sources such as table sugar, glucose tablets or brown sugar?
- Concentration of Carbohydrate – How does the concentration of carbohydrates affect yeast fermentation across the range of 0 - 0.02 grams/mL (0 - 0.2g/10mL) of the fermentation solution?
- Concentration of Salt – How does the concentration of salt affect yeast fermentation across the range of 0- 0.1 g/mL (0 – 1g/10mL) of the fermentation solution?
- Temperature – How does the temperature of the yeast solution ranging from 20 degrees C to 60 degrees C affect fermentation.

3. Discuss and note all the other factors you must hold constant.
4. Each group will quantify the rate of anaerobic respiration by using a respirometer as pictured above. As the yeast produce ethanol and carbon dioxide by fermentation, the carbon dioxide will force the water droplet up the pipette. The more carbon dioxide produced, the higher the bubble will travel. Using a pipette, we can quantify the volume of gas produced and thus the rate of anaerobic respiration.
5. Every group will use 3 mL of yeast solution in the syringe so we can easily compare results.
6. For convenience, you will prepare all of your solution in 10mL quantities. First, weigh the desired amount of solute (salt or sugar). Next, add your solute to a graduated cylinder. Lastly, fill up the graduated cylinder to 10 mL with yeast solution. The equation below explains the concentration calculations. You may plug in the desired concentration to determine how much solute must be added to the 10 mL of yeast solution.

Volume of Solvent = 10 mL
Concentration (g/mL) = Mass of Solute (g) / Volume of Solvent (mL)
10mL = Mass of Solute (g) / Concentration (g/mL)

7. Once you have your solutions prepared, fill your syringe(s) with 3 mL of yeast mixture.
8. Place a pipette on top of the syringe with a drop of water inside indicating the starting point of fermentation.
9. If needed use a water bath (beaker full of water on a hot plate) to hold your respirometer and control the temperature of the yeast.
10. Measure the rate of anaerobic respiration over time as the volume of carbon dioxide pushes the drop of water up the pipette.

Data: Create a table and graph to represent the rate of respiration over time for your experimental setup.

Conclusions
1. Make your recommendations on what conditions in your experiment should maximize the output of ethanol production by the anaerobic respiration of yeast.
2. Include recommendations for further study on the topic of maximizing ethanol production through yeast fermentation.
3. Predict any sources of human or experimental error that may have affected your results.