Name: Hour:

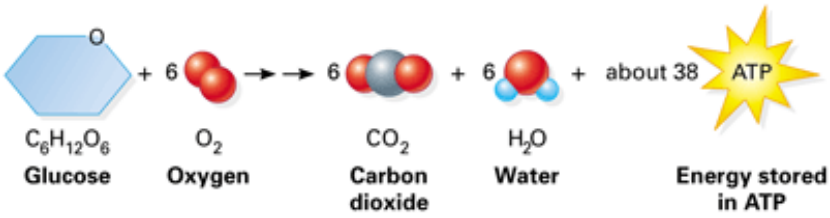
Cellular Respiration POGIL

Why?

Cells store and use energy in a way that is similar to the way you deposit and withdraw money from a savings account. When your cells need energy, they make a withdraw and break down nutrients in food to release energy. Once large group of nutrients in our food is carbohydrates, which supply our cells with glucose ($C_6H_{12}O_6$). So the question is: How does the food we chew and swallow fuel our cells?

Model 1 – Cellular Respiration Equation

The process by which cells "withdraw" energy from glucose is called respiration. Here, cells break down simple food molecules and release the energy they contain. The term respiration is also used to mean breathing, that is, moving air in and out of your lungs. To avoud confusion, the respiration that occurs in your cells is referred to as cellular respiration. However, the two kinds of respiration are related



Reactants	Products

1. Where does the glucose in the equation above come from?

2. Where does the oxygen in the equation above come from?

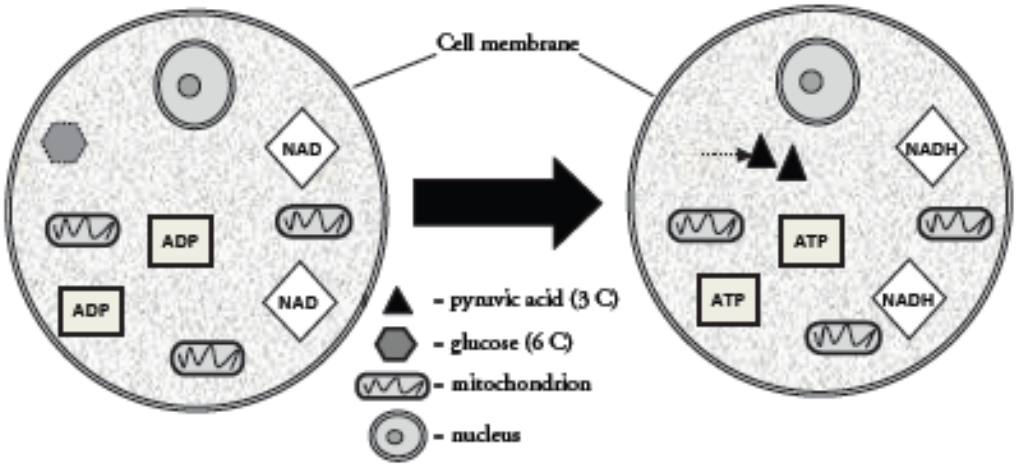
3. Why is it important that living things carry out respiration continuously?

4. What do you think happens to the carbon dioxide, water, and ATP as your body continues to function?

Read This!

There are three steps to Cellular Respiration. Step one, glycolysis, occurs in the cytoplasm of the cell. There, glucose molecules are broken down into smaller molecules. Glycolysis is an **anaerobic** process because it does not need oxygen to take place – this means only a small amount of energy is released. This energy is in the form of ATP **(Adenosine Triphosphate)**. ATP can be directly used by cells.

Model 2 – Glycolysis



1. Where in the cell does the first stage of respiration take place?

2. Refer to Model 2.
   a. What is represented by the hexagon?

   b. How many carbon atoms are in one molecule of glucose?

3. Refer to Model 2.
   a. What happened to the glucose molecule after glycolysis occurs in the cell?

   b. How many carbon atoms are in one molecule of pyruvic acid?

   c. How many pyruvic acid molecules are there after glycolysis occurs?

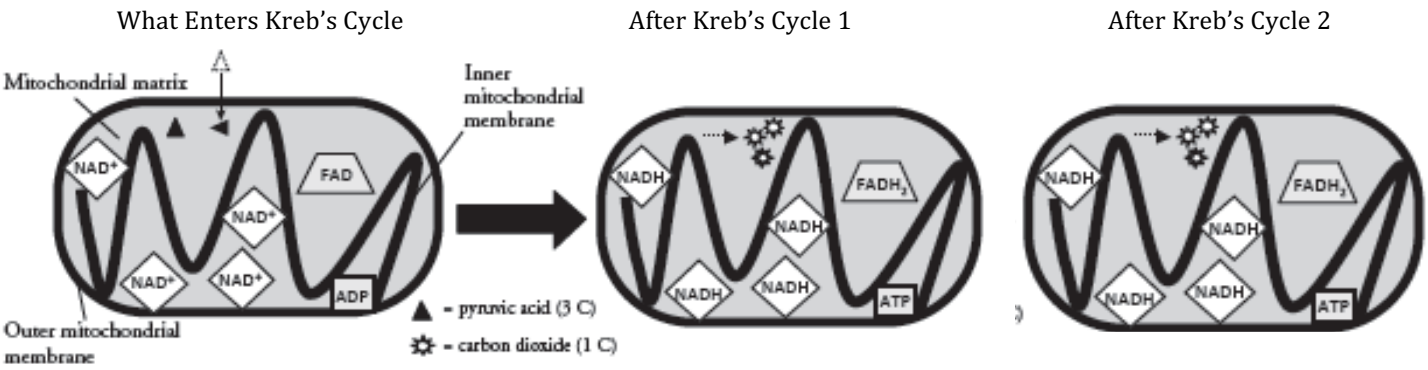
   d. Thinking about the number of carbon atoms in glucose and the number of carbon atoms in pyruvic acid, explain why there is one molecule of glucose on the left side of the arrow and two molecules of pyruvic acid on the right side of the arrow.

4. How many ATP molecules are produced during glycolysis?

Read This!

The last two stages of cellular respiration, Krebs Cycle and Electron Transport Chain take place in the mitochondria. There, small molecules are broken down into smaller molecules. The Electron Transport Chain requires oxygen making this stage an **aerobic** process. A great deal of energy in the form of ATP is released. Two other products of respiration are carbon dioxide and water.

Model 3 – Krebs Cycle



1. Where does the Krebs Cycle take place in the cell?

2. How many pyruvic acid molecules are moved onto the Krebs Cycle?

3. According to Model 3, one pyruvic acid will turn into how many carbon dioxide molecules?

4. Since there are two pyruvic acid molecules, how many cycles will the Krebs Cycle go through?

5. Considering that glycolysis produces two pyruvic acid molecules per glucose molecule, how many total carbon dioxide (CO_2) molecules will be produced from the complete breakdown of one glucose molecule?

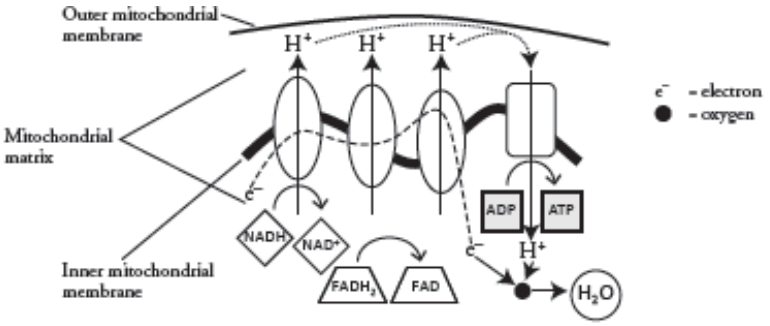
Using Model 2 and 3, provide the number of each type of molecule made to fill out the chart.

Process	**ATP**	**NADH**	**$FADH_2$**
Glycolysis	a.	b.	c.
Krebs Cycle – 1st Cycle	d.	e.	f.
Krebs Cycle – 2nd Cycle	g.	h.	i.
TOTALS – Add up numbers in columns	a+d+g =	b+e+h =	c+f+I =
Grand Total of ATP from Glycolysis and Krebs (add all 3 columns of Totals)			

Read This!

NADH and $FADH_2$ release hydrogen ions that are transported across the inner mitochondrial membrane with the help of electrons. The result of these multiple processes is the production of large amounts of ATP.

Model 4 – The Electron Transport Chain



1. Where does the Electron Transport Chain take place in the cell?

2. Refer to Model 4.
   a. What atom accepts the hydrogen ion at the end of the electron transport chain?

   b. What molecule is formed as a product of that acceptance?

3. Explain why the electron transport chain is an aerobic process rather than an anaerobic process like glycolysis?

Read This!

Remember that glycolysis produces two pyruvic acid molecules per glucose molecule along with two of the hydrogen-carrying NADH molecules. Krebs Cycle also produces NADH as well as another hydrogen-carrier called $FADH_2$. It is important to know that during the electron transport chain, each NADH molecule gives up electrons and hydrogen ions – leaving enough of a potential energy change to make three ATP molecules. When each $FADH_2$ gives up electrons and hydrogen ions, there is enough potential energy to make two ATP Molecules.

Using the chart on the previous page, fill out the **total** number of ATP, NADH, and $FADH_2$ made in each cycle.

	Number of ATP produced from one glucose molecule	Number of hydrogen-carriers produced from one glucose molecule	
		NADH	$FADH_2$
Glycolysis	a.	b.	c.
Krebs Cycle	d.	e.	f.
Electron Transport Chain		x3	x2
Total ATP Produced	a+d=	(b+e) x3	(c+f) x2
Grand Total Produced (add all 3 columns of *Total ATP Produced)*			

Look at the equation for cellular respiration below and write in which stage of the process (Glycolysis, Kreb's Cycle, Electron Transport Chain) each molecule is used or produced. Some of the stages may be used more than once or multiple times per box.

$C_6H_{12}O_6$ + $6O_2$ → $6CO_2$ + $6H_2O$ + 38 ATP

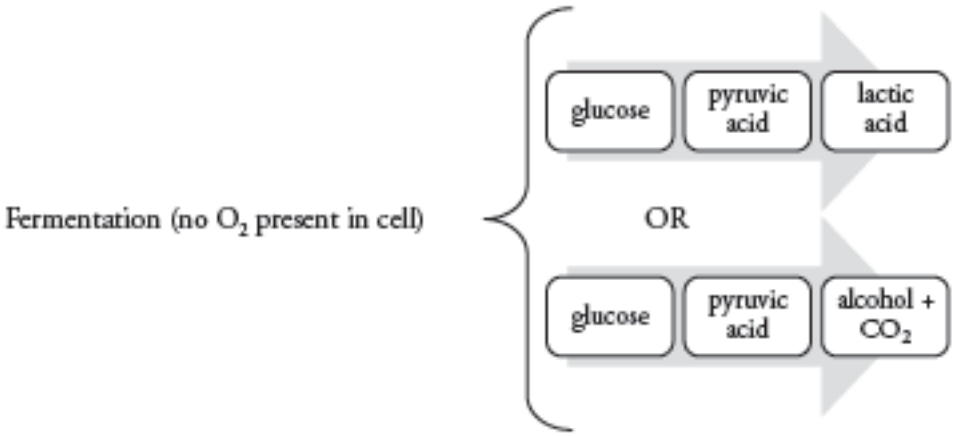
Used in	Used In	Produced In	Produced In	Produced In

4. ***Compare the ATP available to cells when oxygen is present versus when it is absent. How might this help explain why heart and brain functions are so quickly affected when a person cannot breathe?***

Read This!

Some cells obtain their energy though **fermentation**, an energy releasing process that does not require oxygen. This is a form of **anaerobic respiration**. Fermentation provides energy for cells without using oxygen. One type of fermentation occurs in yeast and some other single-celled organisms. This process is called **alcoholic fermentation** because alcohol is one of the produces made when these organisms break down sugars. Another tpe of fermentation takes place at times in your body, for example, when you've run as fast as you could for as long as you could. This is called **lactic acid fermentation**. Lactic acid is a product and when it builds up in your muscles, your muscles feel weak and sore.

Model 5 – Two Kinds of Anaerobic Respiration



1. How does fermentation differ from respiration?

2. What are two substances that may be formed in anaerobic respiration?

3. Recall that two molecules of ATP are formed during glycolysis. Neither fermentation process shown above creates any more ATP. Knowing this, what would you predict about the cellular energy available to organism that carry out fermentation?

4. Which type of fermentation occurs in yeast?

5. What common foods involve the process of fermentation?

6. Which type of fermentation sometimes occurs in people?

7. Why does the other type of fermentation ***not*** occur in people?