Biology
Ms. Ye

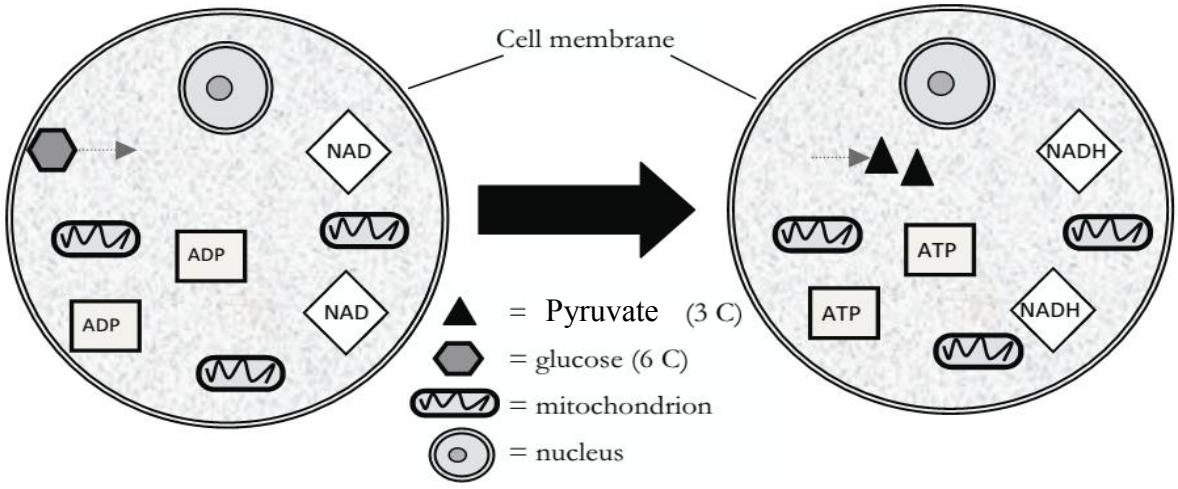
Name _____
Date _____ Block _____

Cellular Respiration: How is energy transferred and transformed in living systems?

Why?

Living organisms display the property of metabolism, which is a general term to describe the processes carried out to acquire and use energy. We know that people need to eat and in our foods are various kinds of nutrients that our cells can use. One large group of nutrients in our foods 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 - Glycolysis



Glycolysis Questions:

1. What is represented by the hexagon?
2. What is represented by the triangles?
3. How many carbon atoms (C) are there in one molecule of glucose?
4. How many carbon atoms (C) are there in one molecule of pyruvate (pyruvic acid)?
5. What happens to glucose after it crosses the cell membrane into the cytoplasm of the cell?
6. What is the name of this process?
7. How many ATP molecules are produced during this process?

8. Hydrogen-carrying molecules are also produced during this process. What is the name of these hydrogen-carrying molecules?

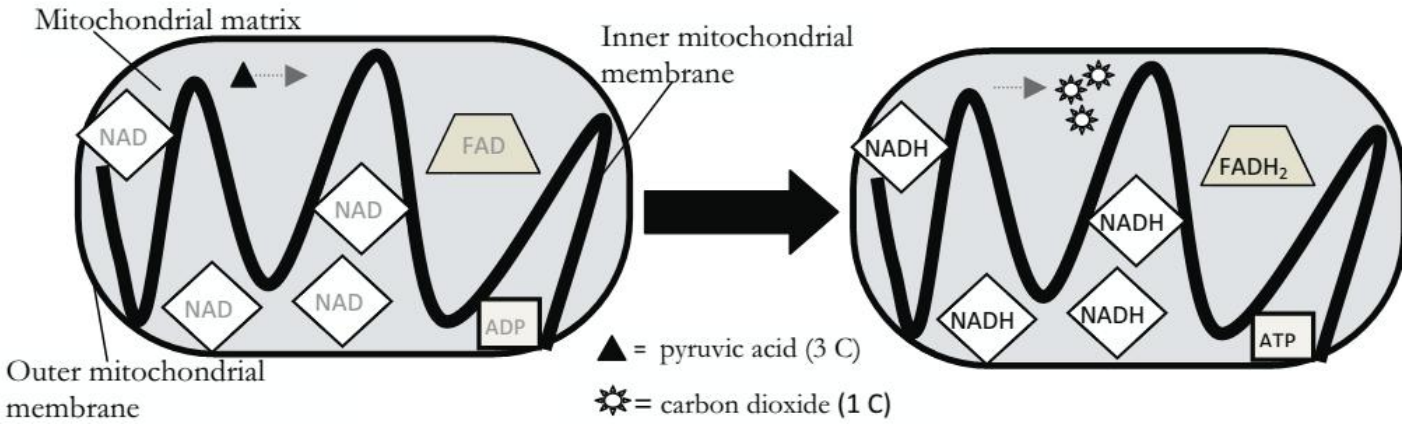
9. Does glycolysis occur inside or outside the mitochondria?

Read This!

Glycolysis happens in the cytoplasm of cells and does not require the presence of oxygen. It is said to be **anaerobic.** It is the first step used by cells to extract energy from glucose in the form of ATP. ATP can be directly used by cells.

10. Thinking about the number of carbon atoms in glucose and in pyruvic acid, tell 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.

Model 2 – Krebs Cycle



11. What happens to the pyruvate molecules that were made from glycolysis (pyruvic acid) during the Krebs cycle?

12. According to the diagram, where in the mitochondria does the change identified in the previous question occur?

13. Thinking again about the number of atoms of carbon in pyruvic acid, why are three molecules of carbon dioxide produced?

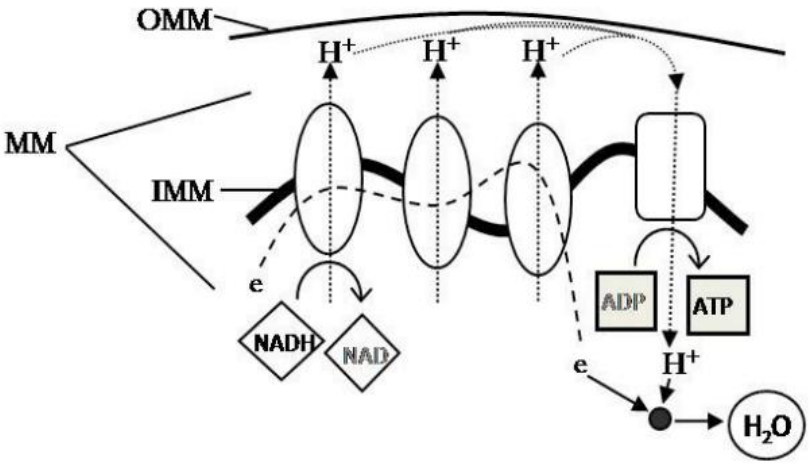
14. Considering that glycolysis produces two pyruvic acid molecules per glucose molecule, how many total CO_2 molecules will be produced from the complete breakdown of each glucose molecule? Support your answer.

15. Name the H-carrying molecules that are formed during the Krebs cycle.

16. Fill out the chart by looking back at the entire process of glycolysis and Krebs cycle to list the total number of ATP's and hydrogen-carrying molecules produced.

Process	ATP	NADH	$FADH_2$
Glycolysis			
Krebs cycle (1^{st} pyruvic acid)			
Krebs cycle (2^{nd} pyruvic acid)			

Model 3 - The Electron Transport Chain



e = electron
● = oxygen
OMM = outer mitochondrial membrane
MM = mitochondrial matrix
IMM = inner mitochondrial membrane

Read This!

The inner mitochondrial membrane contains a series of carrier proteins that make up the Electron Transport Chain (ETC). Electrons move along the ETC, providing energy to move hydrogen atoms. The movement of hydrogen atoms dropped off by the NADH and $FADH_2$ leads to the production of large amounts of ATP. Those H's had no value until they reached the Electron Transport Chain.

17. What chemical molecule acts as the final H+ acceptor, and what molecule is formed as a product of that acceptance?

18. The energy from the H+ is then transferred to an enzyme that initiates the formation of what?

19. Formulate an explanation for 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. It is important to know that each NADH has enough energy stored in the hydrogens to make about three ATP molecules while each $FADH_2$ has enough energy stored in the hydrogens to make about two ATP molecules.

20. Fill in the chart below to calculate the total amount of ATP produced from each glucose molecule during aerobic respiration.

Process	Number of ATP produced from one glucose molecule	Number of H-carriers produced from one glucose molecule
Glycolysis		NADH: $FADH_2$:
Krebs Cycle		NADH: $FADH_2$:
Electron Transport Chain	from H^+ in NADH: from H^+ in $FADH_2$:	
TOTAL ATP PRODUCED		

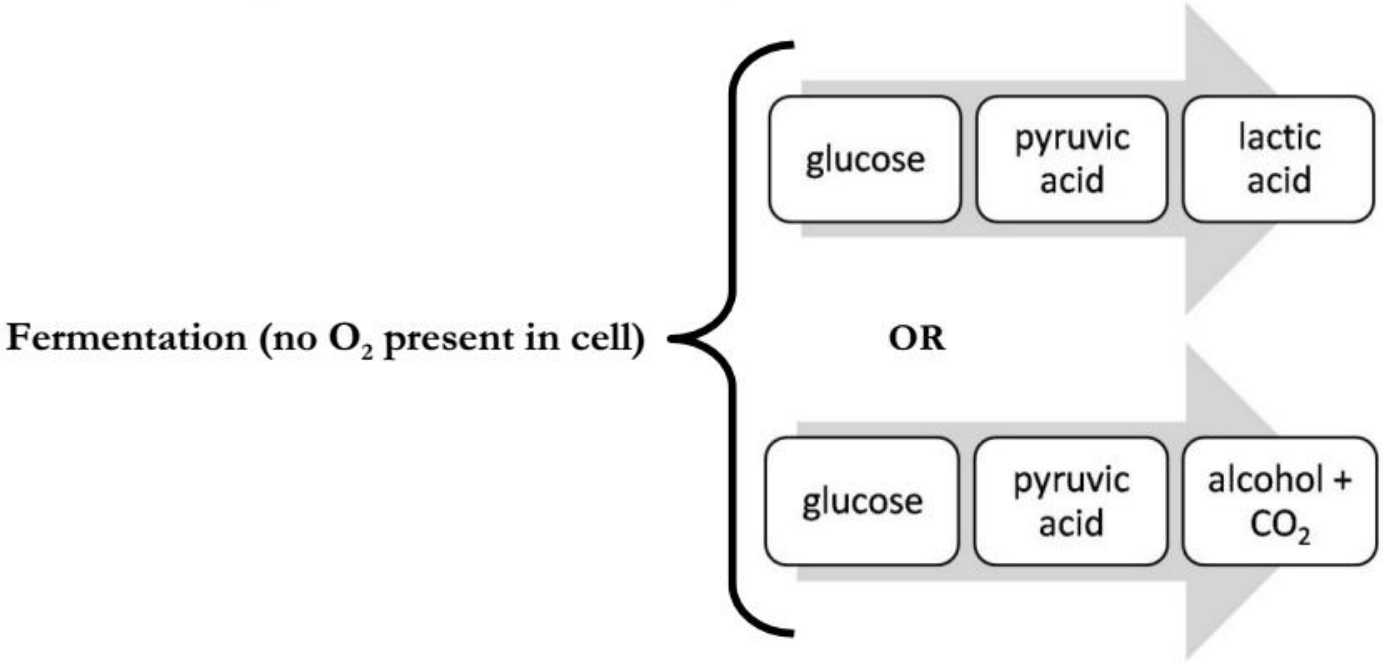
21. Look at the equation for cellular respiration and tell which stage of the process (glycolysis, Krebs Cycle, electron transport chain (ETC)) is each molecule either used or produced.

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

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

Extension:

Two different processes of anaerobic respiration are shown below.



23. List the final products of the breakdown of glucose if no oxygen is present.

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