ANAEROBIC GLYCOLYSIS

1. We are going to study a metabolic pathway involved in catabolism. For that, we are assembling a puzzle, which works like this: there will be available some clues about the metabolic pathway that we are studying and about the chemical structure of some compounds of that pathway. The goal of each group is to analyze and assemble all compounds in a logic sequence. For that, the group needs to schematize the pathway in the metabolic map, including all products and information's about reversibility of the reactions. You can use the "Study Mode" of the App ARMET Pathways to help you.

2. After assembling the pathway, indicate all involved enzymes.

3. After determining every enzyme and reaction, answer the questions in the App. For that, use the "Game Mode". Finally, with the assistance of the textbook and your friends, discuss this study guide.

Clues:

- ✓ High intensity activities requires quickly supply of ATP to the muscular cells involved in movement.
- ✓ Chemical reactions involved in metabolism follow two simple principles: logic and saving. The correct path always is the simplest and most economic, from the energetic point of view.
- ✓ Anaerobic glycolysis is responsible for about 80% of ATP production in activities up to 3 minutes long.
- ✓ Anaerobic glycolysis is the partial breakdown of a glucose molecule (6 carbons), with net production of 2 ATPs and 2 lactate molecules (3 carbons) at the end of this process.
- ✓ Anaerobic glycolysis involves 11 enzymes, of which just 3 are involved in irreversible reactions.
- ✓ Mg++ is hexokinase cofactor.
- ✓ Only 2 enzymes of glycolysis require the NAD+ coenzyme.
- ✓ Glucose and fructose-6-phosphate phosphorylation reactions have $\Delta G^{o\prime} > 0$
- ✓ During anaerobic glycolysis 2 ATPs and 2 inorganic phosphates (Pi) are spent.
- ✓ During anaerobic glycolysis occurs the production of 2 energy rich compounds.

GLOSSARY

Allosteric Enzymes: As well as hemoglobin some enzymes are allosteric, i.e., they have in their chemical structures a binding site for regulators (effectors). This site is different from the substrate site. Such enzymes can be regulated by positive allosteric effectors (which increase reaction rate) or by negative ones (which decrease reaction rate).

Some Types of Enzymes

KINASES: Enzymes that catalyze transfer of a high-energy phosphate group to a receptor molecule. Usually such phosphate group comes from ATP or another compound rich in energy).
ISOMERASES: Enzymes that catalyze isomerization reactions, i.e., chemical groups switch.
MUTASES: They are Isomerases that catalyze transfer of low energy phosphate groups from a position to another, in the same molecule.
DEHYDROGENASES: Enzymes that catalyze oxidation-reduction reactions by transferring hydrogen from substrate to a coenzyme, usually NAD^+ or FAD. In most cases these reactions are reversible.
ALDOLASES: Enzymes which cut phosphorylated sugars, giving rise to dihydroxyacetone-phosphate and another sugar, which has 3 carbon atoms fewer than the original substrate.
PHOSPHATASES: Enzymes that catalyze phosphate esters hydrolysis reactions.

Glycolytic Pathway Regulator Enzymes

ENZYME	**ALOSTERIC EFFECTOR**	
	Positive	**Negative**
Hexokinase	-	Glucose 6-phosphate
Phosphofructokinase I	AMP, ADP e fructose 2,6 bisphosphate	ATP e citrate
Pyruvate kinase	Fructose 1,6-bisphosphate	Alanine (only in liver)

- After assembling the pathway, carefully read the glossary and correctly correlate the enzymes with their respective step in Anaerobic Glycolysis. Remember that there are 11 steps in this pathway.
- Identify each enzyme by correlating them with the names of their substrates/products.

QUESTIONS

1. Answer the following questions basing on anaerobic glycolysis' map:
   a) What is the biological goal of the processes described in the map?
   b) What is the biological fate of glucose molecule's chemical elements, which are carbon, oxygen and hydrogen?
   c) Which compounds accept hydrogen atoms?
   d) Which steps are irreversible?
2. Use the map to indicate the formed compounds, which are rich in energy.
3. What is the glycolytic pathway's cellular localization?
4. Pretend that you received a test-tube containing the first 10 anaerobic glycolytic pathway's enzymes. Which compounds should be provided to the glycolytic pathway in order to:
   a) Initiate it b) Keep it running
5. Discuss why anaerobic glycolysis' final product is lactate.
6. Which kind of muscular cells are more likely to present anaerobic glycolysis: fast or slow contraction cells?

Hint: If there is enough O_2 within the cell, pyruvate is not transformed into lactate, but is completely oxidized into CO_2 and H_2O.

7. Discuss if the following statements are true (T) or false (F):

a) The glycolytic pathway is inhibited if there is overproduction of fructose-1,6-bisphosphate. ( )
b) The amount of oxydated NAD is a limiting factor of anaerobic glycolysis. ( )
c) The amount of oxydated NAD is a limiting factor of aerobic glycolysis. ( )
d) If the ratio ATP/ADP is low within the cell the glycolytic pathway is inhibited. ( )

CURIOSITIES: DID YOU KNOW...

- Fermentation is the name given to the process of consuming glucose in an anaerobic medium. Many bacteria, fungi and yeasts can make different kinds of fermentation: lactic, alcoholic, propionic, formic, butyric, mixed etc. Fermentation is the basis of the production of cheese and yogurts (lactic fermentation), beer, wine and bread (alcoholic fermentation).
- All kinds of fermentation have in common the **regeneration of NAD^+** to the glycolytic pathway. Also, they excrete final products such as lactate, ethanol, formiate, butyrate and propionate.
- The tissues that use only glucose as energy source are: brain (120g/day) e erythrocytes (36g/day). In erythrocytes occurs anaerobic glycolysis, while it is aerobic in brain.
- Our organism reserves glucose as glycogen. It is largely present in our muscles and hepatocytes.

METABOLIC MAP (ASSEMBLE YOUR PATHWAY HERE)