

Exercise To Help You Understand *Glycolysis*

Textbook 168-169

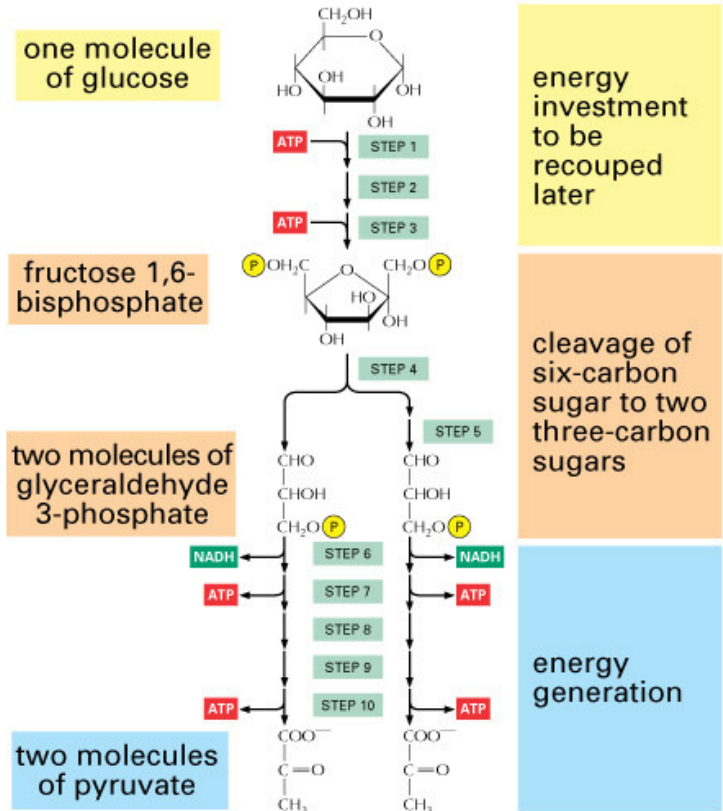
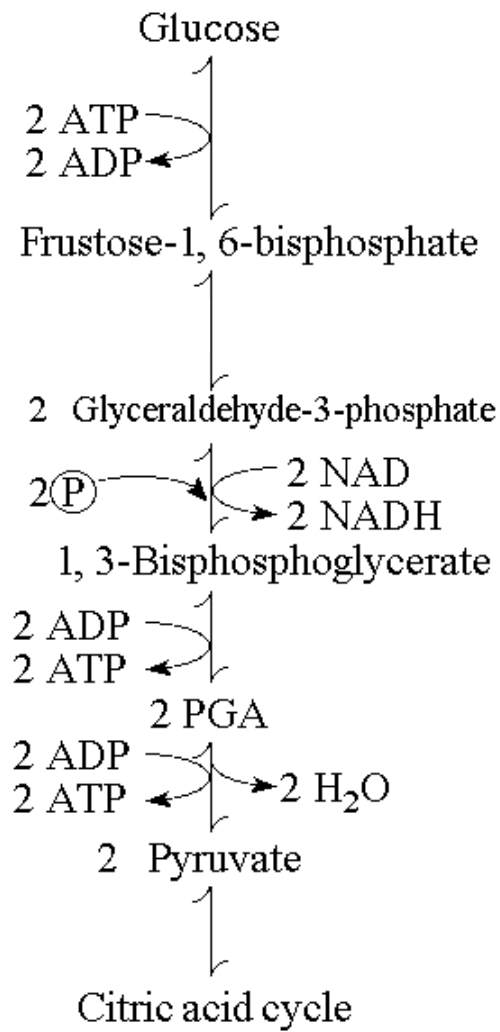
- _____ 1. Cells use most of their energy fighting entropy and maintaining o_____.
 _____ 2. The direct molecular energy source for most of a cell's activities is the molecule _____.
- _____ 3. The most common cellular fuel is _____.
 _____ 4. Glucose is synthesized during the process of _____.
 _____ 5. The complete metabolism of a molecule of glucose yields _____ kcal/mole of energy.
 _____ 6. When viewed as a whole, cellular respiration must be considered an _____ (*exergonic / endergonic*) process.
 _____ 7. In glucose, energy is extracted primarily from C-____ bonds.
 _____ 8. Which has more free energy: glucose or water?
 _____ 9. All living organisms utilize _____ (*aerobic / anaerobic*) respiration for at least part of their ATP production.
 _____ 10. Aerobic respiration requires the presence of _____.
 _____ 11. The organism group that is most proficient at utilizing anaerobic respiration for ALL of their energy needs is the _____.

Glycolysis

- _____ 1. Glycolysis is the metabolism of glucose in the absence of _____ (*a respiratory gas*).
 _____ 2. Does glycolysis require the utilization of mitochondria? (*yes or no*)
 _____ 3. Glycolysis begins with a g_____ molecule and ends with the production of two p_____ molecules.
 _____ 4. Is there any CO₂ generation during glycolysis?
 _____ 5. Is by-product water produced during glycolysis?
 _____ 6. What is the *gross* energy yield of glycolysis?
 _____ 7. What is the *net* energy yield of glycolysis?
 _____ 8. Is the change of NAD⁺ to NADH an *oxidation* or a *reduction*?
 _____ 9. The very first event in glycolysis is the p_____ of glucose, an event that requires _____ (#) ATP molecules.
 _____ 10. Does biphosphorylated glucose have *more* or *less* free energy than glucose?
 _____ 11. The net energy yield of glycolysis is _____% of the stored free energy in glucose.
 _____ 12. When muscles are working beyond the body's capacity to provide enough oxygen, the exercise is referred to as _____ exercise.
 _____ 13. During this form of exercise, the greatest quantity of energy is provided by what energy-liberating cellular process? g_____

Overview of Glycolysis

- | | |
|--|---|
| _____ 1. How many ATPs <i>in</i> ? | _____ 7. How many H ₂ O molecules <i>out</i> ? |
| _____ 2. How many ATPs <i>out</i> ? | _____ 8. How many CO ₂ molecules <i>out</i> ? |
| _____ 3. How many NAD ⁺ s <i>in</i> ? | |
| _____ 4. How many NADHs <i>out</i> ? | |
| _____ 5. How many carbon atoms <i>in</i> ? | |
| _____ 6. How many carbon atoms <i>out</i> ? | |



The transition reactions are so named because they link the biochemical events of g_____ with the cyclic events of the _____.

The organic molecule end-product of glycolysis was p_____.

The electrons of glucose were transferred to ___ ___ to form ___ ___.

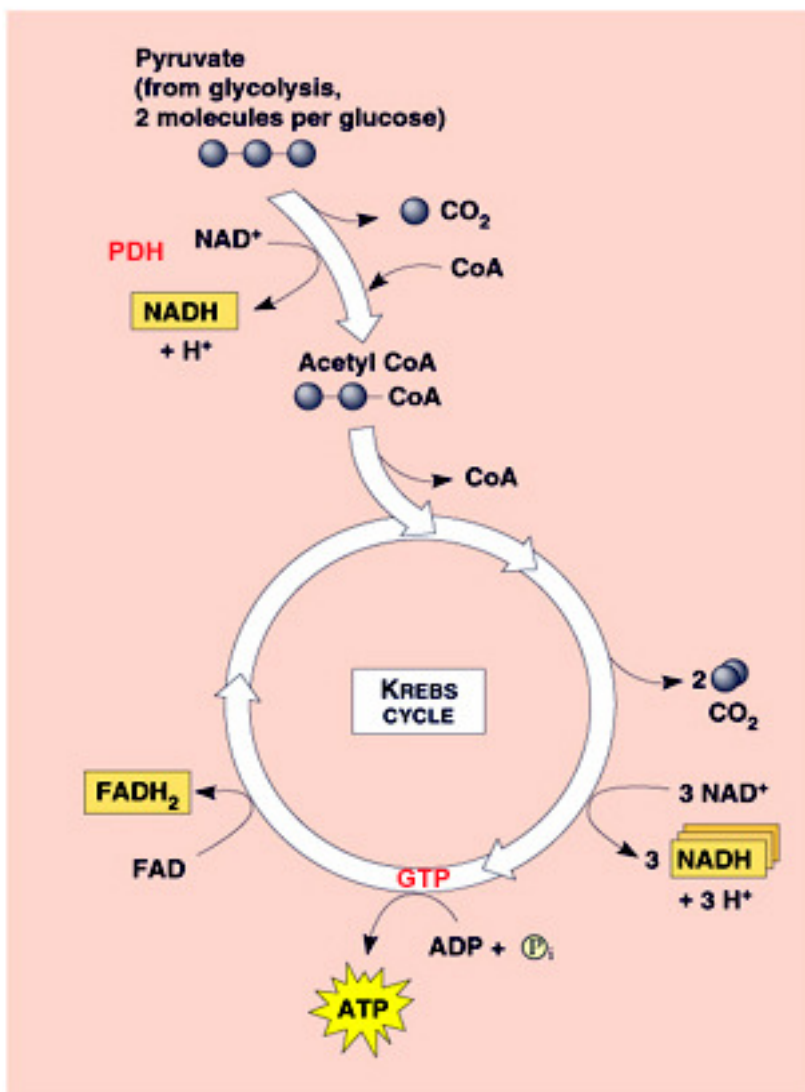
Did glycolysis occur in the cytoplasm or within the mitochondrion? _____

Can pyruvate enter the mitochondrion? _____

Can NAD^+ enter the mitochondrion? _____

Pyruvate joins with a large molecule named _____ to form a 2-C - Enzyme/Coenzyme complex named _____. During this linking, the 3-C pyruvate loses one of its carbons in the form of the respiratory gas by-product _____. Since this event occurs *twice*, the total amount of CO_2 generated during the transition reactions is ___ (#) molecules. Thus, so far, we have accounted for ___ (#) of the ___ (#) CO_2 molecules produced during aerobic cellular respiration.

The 2-Carbon Acetyl-CoA then enters the _____ cycle.



Another name for the Krebs Cycle is the _____ Cycle.

When Hans Krebs submitted his paper regarding the biochemical events of the cycle he was _____ by his contemporaries. Unlike other scientists, who would have _____, he persevered and stayed true to his _____. He was rewarded for his _____ by receiving the Nobel prize in the year _____. He took the cash reward (\$100,000) and bought himself a _____ and put the rest into _____ stocks.

Name the two *coenzymes* that are reduced as a result of electron release during the Krebs cycle.

- 1.
- 2.

Where do these coenzymes transport these electrons? To the _____.

What is the name of the organic molecule-enzyme-coenzyme complex that donates 2-carbons to the Krebs cycle? _____

Each time *one* Acetyl-CoA enters the Krebs cycle, _____ (#) CO₂ molecules are released.

For each molecule of glucose, the Krebs cycle "turns" _____ (#) times.

For each molecule of glucose, the Krebs cycle releases _____ (#) CO₂ molecules.

These _____ (#) CO₂ molecules, plus the _____ (#) CO₂ molecules released during the transition reactions, total _____ (#) CO₂ molecules released during the *aerobic* cellular respiration of one molecule of C₆H₁₂O₆.

What is the ATP yield of *one turn* of the Krebs cycle? _____ ATP(s)

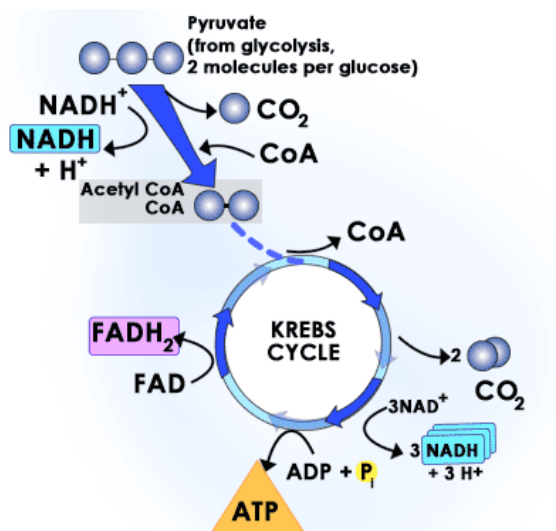
What is the *total* ATP yield from the Krebs cycle as the result of aerobically metabolizing one molecule of glucose? _____ ATP(s).

During the Krebs cycle, does ATP generation occur as a result of *substrate-level phosphorylation* or *chemiosmosis*? _____

All of the following are events which occur during the Krebs cycle. Which ONE of these events MUST be considered *the MOST IMPORTANT EVENT of Krebs Cycle*? (check one!)

- _____ The entry and exit of water.
- _____ The release of electrons, the reduction of NAD and FAD, and the transfer of the electrons to the electron transport system.
- _____ The production of by-product CO₂.
- _____ The production of 2 ATP molecules.

Does the Krebs cycle occur outside of *or* within the *mitochondrion*? _____



An Exercise To Help You Understand **The Electron Transport Chain**
 Pages 172-176

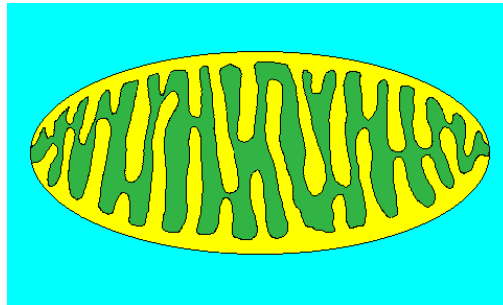
Because **The Electron Transport Chain** functions within and depends upon the internal structure of the mitochondrion, it is important that we reconsider this vital organelle:

Which one of the following is a **mitochondrion**?



A chemiosmotic system requires that an organelle possess an internal m_____.
 The infoldings of the internal m_____ of the mitochondrion are called the _____
 (singular: _____).

On the diagram below, identify the outer membrane, the inner membrane, the outer compartment and the inner compartment, and the crista.



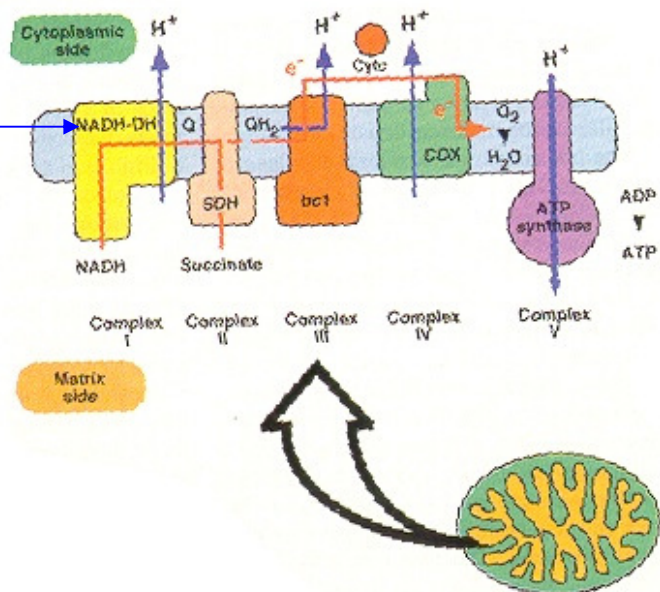
Which is MORE permeable to greater numbers of atoms and molecules, the *outer membrane* or the *internal membrane*? _____

The electron transport systems (AKA "chains") are embedded in the _____ (*outer / inner*) membrane.

The "carrier molecules" that transfer electrons belong to the p_____ category of organic molecules. These same "carrier molecules" also function as p_____ p_____, moving hydrogen ions from the _____ compartment to the _____ compartment.

A protein that contains iron is called a _____. Most of the proteins in the ETC are proteins of this type. For this reason, the reaction series is sometimes called the _____ series.

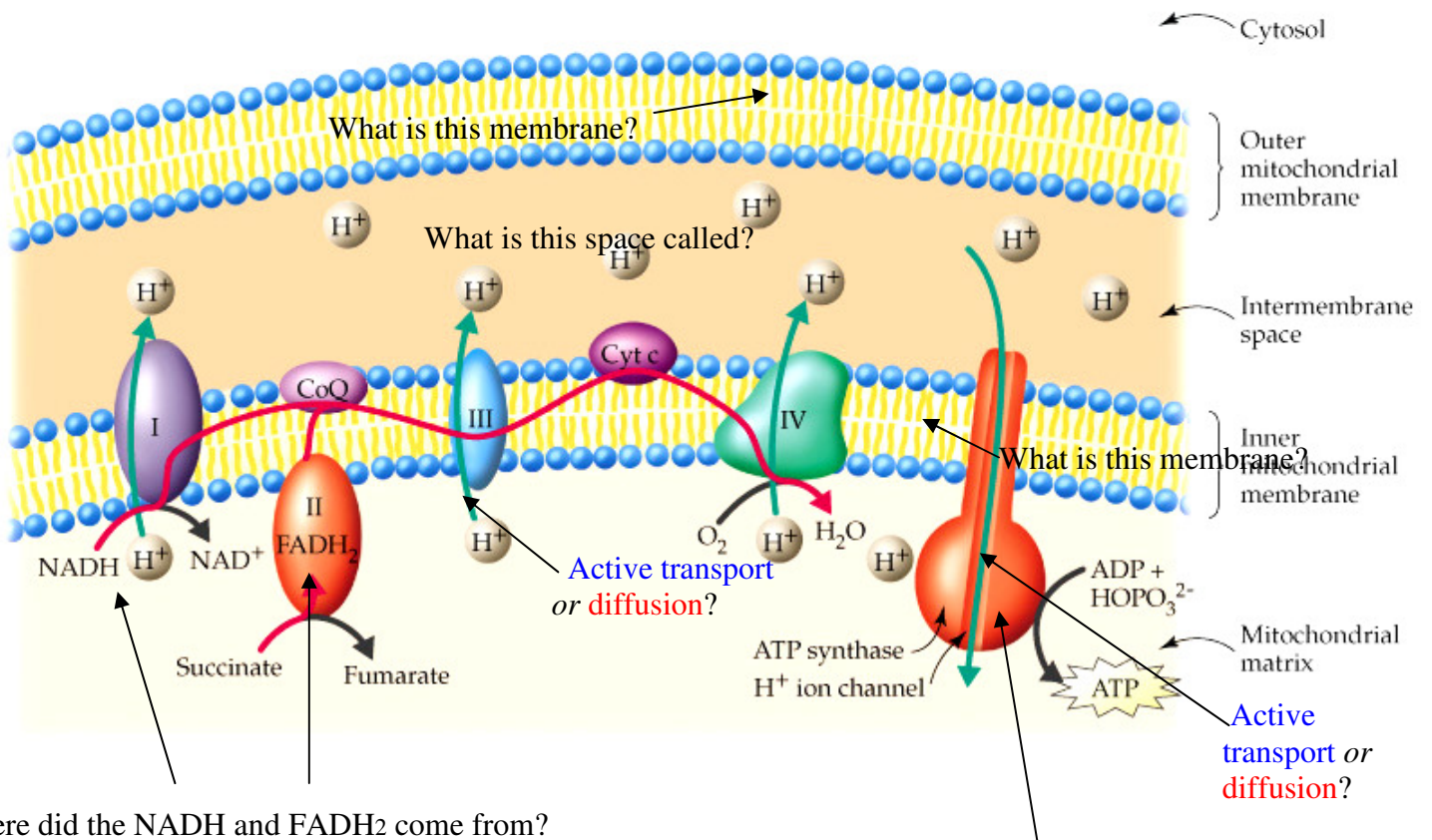
Note: the movement of protons is shown with blue arrows (to the right) and the movements of electrons through the electron transport chain are shown with orange arrows.



When an electron passes from one complex to the next, the complex that loses the electron is said to be _____ (oxidized / reduced) and the complex that gains the electron is said to be _____ (oxidized / reduced).

Complex V (shown on the bottom of page 1) is an _____ port. It houses the enzyme _____ that catalyzes ADP phosphorylation to ATP.

Refer to the diagram below to answer the following questions:



Where did the NADH and FADH₂ come from?

What is oxygen used for?

What is this?

The chemiosmotic ATP yield during the electron transport chain is _____ (#) ATPs.

What happens if oxygen is NOT present?

The free energy stored in one molecule of ATP is _____ kcal/mole.

The free energy value of glucose is _____ kcal/mole.

How efficient is the energy conversion from glucose to ATP? (express your answer as a percentage and show your work).

Brown Fat

This type of fat is named "brown fat" to distinguish it from the creamy or ivory type of fat that is much more common. Brown fat is the special fat of baby mammals and hibernating mammals (such as a bear).



Where is the best place to look for brown fat in a human infant?

What organelle is particularly abundant in brown fat? _____

*(Isn't that strange.....fat tissue (adipose) usually doesn't HAVE very many mitochondria because its role is to **store** fat, not to **burn** it!)*

In brown fat, fat is broken down in the mitochondria **without** its energy being stored in __ __ __.

Instead the energy is released in the form of _____ which is helpful in keeping the animal (infant) all, like, warm.

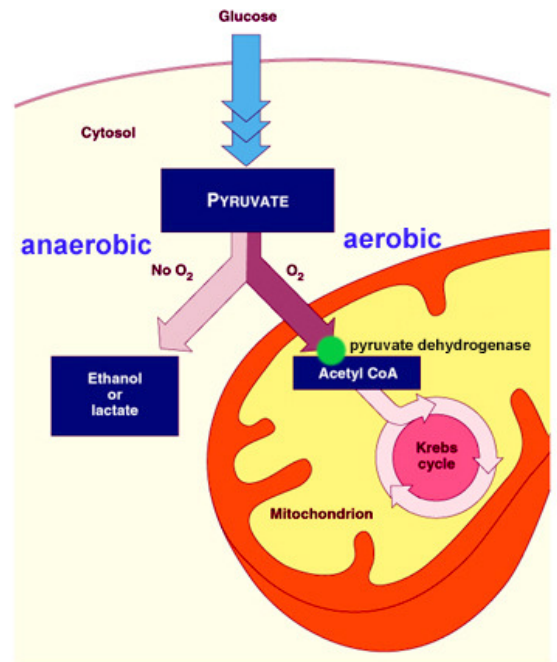
An Exercise To Help You Understand *The Fermentation Pathways*
 Textbook pages 177-179

Does Fermentation Involve.....

- _____ Oxygen?
- _____ Mitochondria?
- _____ Internal membranes?
- _____ Chemiosmosis?
- _____ Electron transport systems?
- _____ An energy-rich final product?

Fermentation involves all of the steps that occur during g_____ plus a few additional steps.

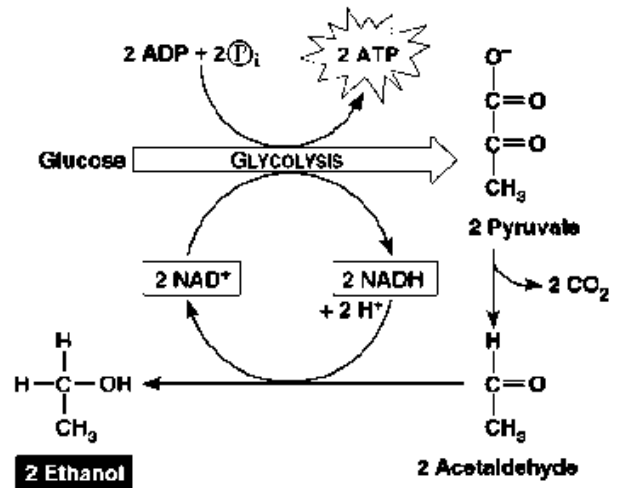
The two most common end-products of fermentation are e_____ (in yeasts and some bacteria) and l_____ (from muscle tissue.)



Alcoholic Fermentation

Fermentation begins with (and glycolysis ends with) the molecule _____.

There are _____ (#) reactions that occur during alcoholic fermentation. The first reaction involves the decarboxylation of _____, turning it into _____ (accompanied by the release of CO₂ gas). The second reaction changes this two-C molecule into _____ and is accompanied by the _____ (oxidation / reduction) of NAD. For each molecule of glucose that glycolysis begins with, _____ (#) molecules of ethyl alcohol are produced, along with _____ (#) molecules of by-product CO₂.



Of what use is this CO₂ to a baker? _____

Of what use is this CO₂ to a brewer? _____

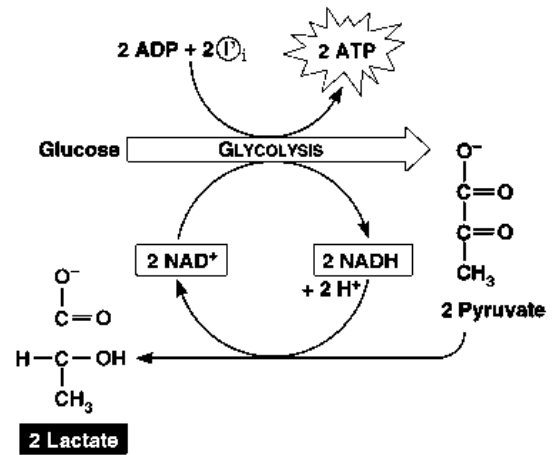
Cite three evidences that ethyl alcohol is an energy-rich end-product.

- 1.
- 2.
- 3.

In the space below, tell a little bit about *yeast*. Be certain to include a picture of this lowly organism and note its position on the "Tree of Life"

Lactic Acid Fermentation

Like alcoholic fermentation, lactic acid fermentation begins with a pair of _____, both of which are end-products of glycolysis. Unlike alcoholic fermentation, there is only _____ (#) step involved in end-product generation. This step _____ (is / is NOT) accompanied by the release of CO₂. The end product of this reaction is the organic molecule _____. *Lactic acid fermentation must occur to insure the continued availability of NAD.* Without a continuous supply of NAD, glycolysis cannot occur, so ATP generation would stop completely.



Lactic acid fermentation also occurs in certain species of bacteria and is responsible for creating, at least in part, the tart tastes associated with yogurt, rye bread, and some types of cheese.

Lactate is produced in animal muscle tissue during _____ (aerobic / anaerobic) exercise.

Lactate levels build up during intense exercise. A large part of the lactate is carried away from the muscle by the *bloodstream* (muscle tissue is very well supplied with blood!) Most of it is sent to the liver for reconversion into liver starch (AKA _____). Some of it ends up in the kidneys, where it is filtered and becomes part of u_____.

Alcoholic (**A**) - Lactic Acid (**L**) Fermentation Matching (*Some blanks will have one answer, some will have both answers, some will have neither!*)

- _____ Requires 2 enzymes (2 steps).
- _____ No CO₂ generation accompanies this process.
- _____ 36 ATPs generated during this process.
- _____ Occurs within the mitochondrion.
- _____ Involves the oxidation of NADH.
- _____ Produces a product with high levels of free energy.
- _____ The brewing industry relies on this process.
- _____ The sports creme (Ben Gay, Icy Hot) industry relies on this process.

In the space below, reveal your understanding of the concept of "*oxygen debt*". An illustration might be helpful in making your point.