Week 6

BIO-1305 - Biology 1 – Campbell Textbook

Hello and welcome to the weekly resources for BIO-1305 - Biology 1 – Campbell Textbook!

This week is Week 6 of class, and typically in this week of the semester, your professors are covering the topics below. If you do not see the topics your particular section of class is learning this week, please take a look at other weekly resources listed on our website for additional topics throughout the semester.

We also invite you to **look at the group tutoring chart on our website to see if this course has a group tutoring session offered this semester**.

If you have any questions about these study guides, group tutoring sessions, private 30 minute tutoring appointments, the Baylor Tutoring YouTube channel, or any tutoring services we offer, please visit our website www.baylor.edu/tutoring or call our drop in center during open business hours (M-Th 9am-8pm on class days at 254-710-4135).

Keywords: Glycolysis, Citric Acid Cycle, Oxidative Phosphorylation, Fermentation

Topic of the Week: Cellular Respiration

Cellular respiration is an extremely important topic in biology. In order to understand what exactly cellular respiration entails, we need to remember some important definitions:

Remember that a **catabolic pathway** is a pathway that involves the *breaking down* of something. A way to remember that is that "catabolic" and "catastrophe" sound similar. Also remember that compounds have **potential energy** in the form of their *chemical bonds.*

Now that we remember those concepts, we can look into the basic of cellular respiration:

The term "**cellular respiration**" includes both *aerobic and anaerobic* processes. An aerobic process is one that requires oxygen, and an anaerobic process is one that does not require oxygen. Typically, when you hear cellular respiration, aerobic respiration is being referred to. Aerobic respiration is a *catabolic pathway* that uses **oxygen** as the final electron acceptor to produce ATP. Along with this, it is important to realize that there are *forms of anaerobic respiration* to be aware of!

Fermentation is one of these processes. This involves the breaking down of sugars and organic fuels without using oxygen! See more about fermentation in highlight #3.

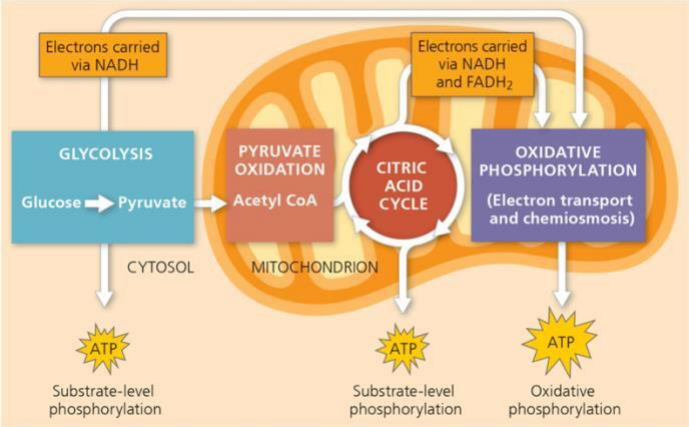
The overall equation for **aerobic respiration** is:

$$\text{Organic compounds} + \text{Oxygen} \rightarrow \text{Carbon dioxide} + \text{Water} + \text{Energy}$$

For our purposes, we will use glucose as the organic compound. We will follow a glucose molecule through the cycle! Because of this, we can get more specific with the equation:

$$C_6H_{12}O_6 + 6\,O_2 \rightarrow 6\,CO_2 + 6\,H_2O + \text{Energy (ATP + heat)}$$

Notice that **heat** is being released! This is because aerobic respiration is an **exergonic process**!
Here is an overall image for the main steps of cellular respiration:



HIGHLIGHT #1: Glycolysis, Pyruvate Oxidation, and the Citric Acid Cycle

Glycolysis is the first stage of cellular respiration. It actually means *"sugar splitting*" and occurs in the **cytosol**. This process breaks down glucose into two molecules of pyruvate. This is then oxidized into acetyl CoA which will enter the citric acid cycle. A small amount of ATP is produced here!

The ATP produced here is made by *substrate level phosphorylation*. Here, an enzyme catalyzes the formation of ATP by *directly transferring* a phosphate group to ATP.

There are **two phases of glycolysis**:

1. Energy investment: requires ATP
2. Energy payoff: produces ATP

It is important to know the **net inputs and outputs** of this stage!

Net Inputs and Outputs	
Glucose	→ 2 Pyruvate + 2 H_2O
4 ATP formed – 2 ATP used	→ 2 ATP
2 NAD^+ + 4 e^- + 4 H^+	→ 2 NADH + 2 H^+

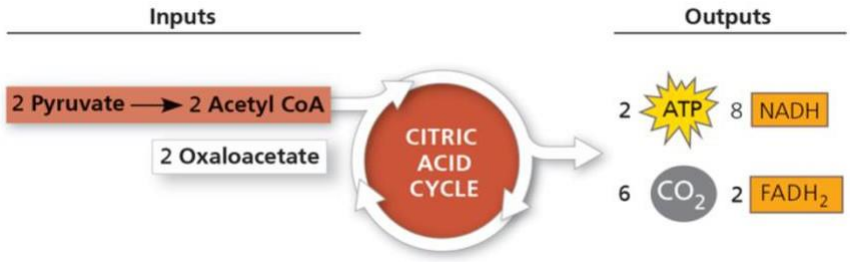
There are several complex steps with various intermediates and enzymes. There is a detailed photo in the book that explains each step directly, so make sure to review that!

Something important to note about glycolysis is that it **DOES NOT require oxygen**. It will occur whether oxygen is available or not, making it a source of energy when oxygen is not accessible! However, it is *not very efficient*.

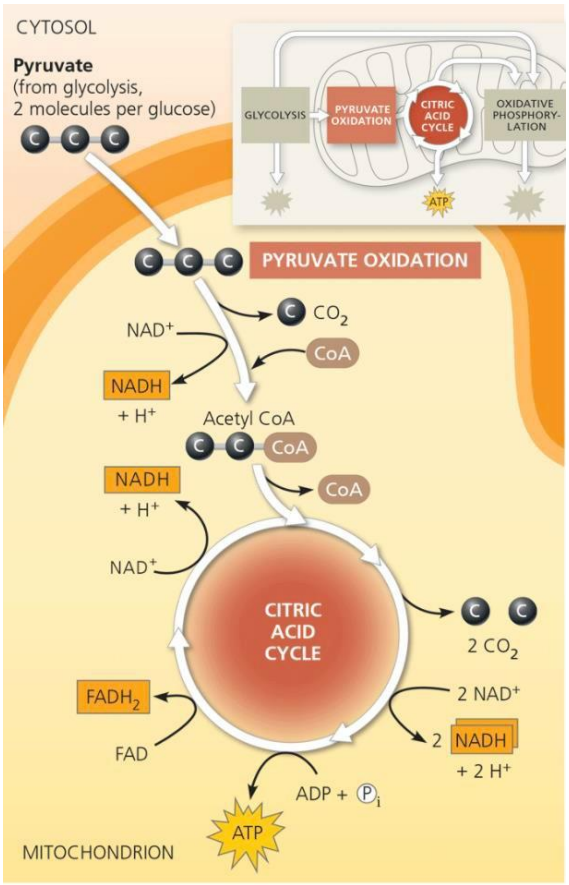
After pyruvate is made, it moves into the mitochondria where it is further oxidized into a molecule called ***acetyl CoA***. Through this process, carbon dioxide is released.

This process occurs in the mitochondria! Make sure to take note of where certain processes occur. This process also occurs in eight separate steps, and like glycolysis, each step is catalyzed by specific enzymes.

Again, it is important to know the **net inputs and outputs** of this stage too!



Here is an overall image for the main steps of the citric acid cycle:



HIGHLIGHT #2: Oxidative Phosphorylation – Electron Transport Chain and Chemiosmosis

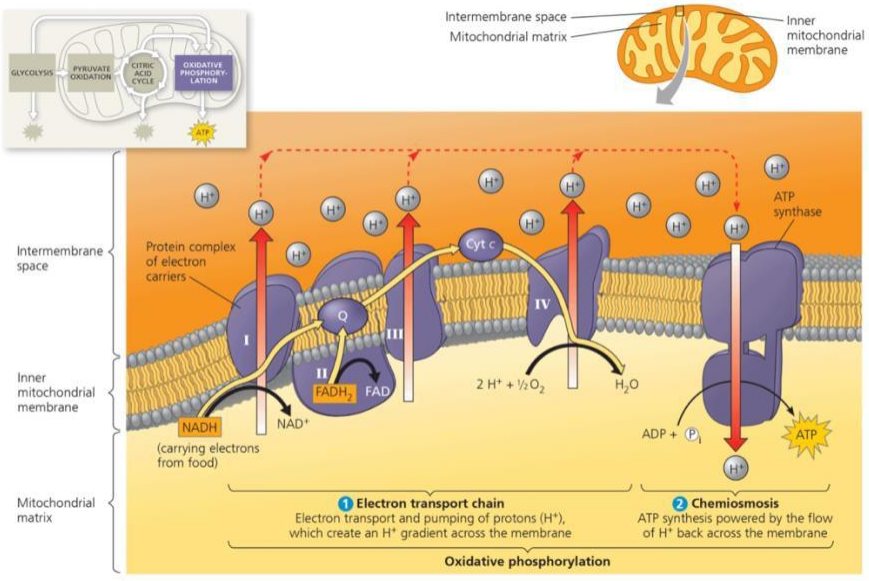
A major part of glycolysis and the citric acid cycle is the formation of NADH and FADH2. These molecules are **electron carriers**!!! They play a role in the *oxidation of glucose* in the previous steps and carry electrons to the electron transport chain.

In ***the ETC***, electrons are dropped off by the electron carriers and travel down through various complexes. They are being "pulled" by **oxygen,** the final electron acceptor. Recall that oxygen is a *very electronegative* element, so it wants to pull the electrons down the chain.

Now we can shift our focus to **ATP synthase** and the production of ATP, which is the main goal of all of this!

> When the electrons are moving down the ETC, protons are being *pumped* into the **inner membrane space**. This gradient of protons is called the **proton-motive force** because when the protons are driven back across the membrane through ATP synthase, ATP is produced. Overall:
>
> > Energy that is stored in the form of a ***hydrogen ion gradient*** across the inner mitochondrial membrane is used to drive the synthesis of ATP.

Here is an overall view of the process:

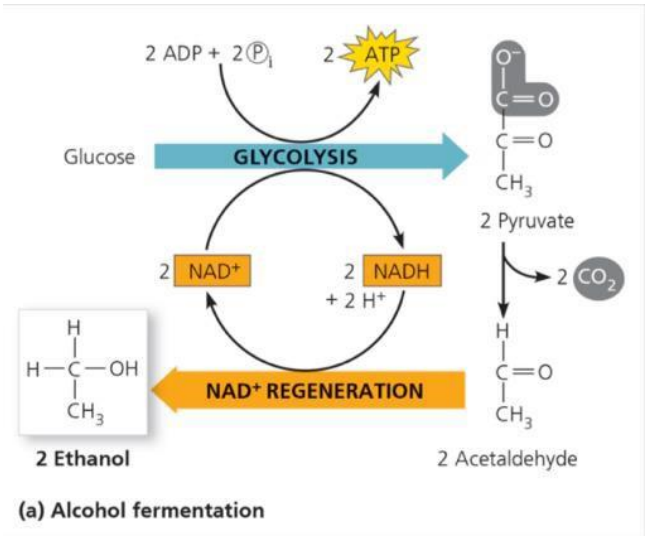


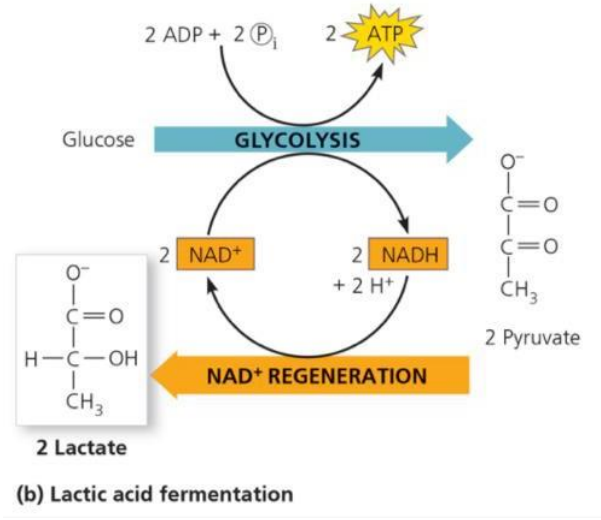
HIGHLIGHT #3: Fermentation

Fermentation, as mentioned earlier, occurs *without oxygen*. It is essentially an extension of glycolysis because it allows small amounts of ATP to continue being produced! As a general rule of thumb, NAD+ needs to be recycled. It needs to accept electrons as it usually does, but since

oxygen is not accepting the electrons in the ETC, there is **nowhere for the electrons to go**! There are **two types of fermentation** that differ in *how NAD+ is regenerated*:

1. **Alcohol fermentation**
   Here, pyruvate is reduced into ethanol through the use of NADH. This regenerates NAD+!
2. **Lactic acid fermentation**
   Here, NADH reduces pyruvate into lactic acid! This also regenerates NAD+.





CHECK YOUR LEARNING

1. What are the three main stages of cellular respiration and their locations in the cell?
2. What roles do NADH and FADH2 play in cellular respiration?
3. What are the two types of fermentation?

THINGS YOU MAY STRUGGLE WITH

1. Remember that glycolysis occurs in the cytosol, but the rest of the processes occur in the mitochondria! The locations of the citric acid cycle and the ETC are different, however.
2. Don't forget that after glucose is broken down into pyruvate, each pyruvate molecule will go through oxidation and the citric acid cycle! So technically, for one glucose molecule, glycolysis occurs once but the other steps occur TWICE.

Thanks for checking out these weekly resources!
Don't forget to check out our website for group tutoring times, video tutorials and lots of other resources: www.baylor.edu/tutoring! Answers to *Check your Learning* questions are below!

Answers:

1. Glycolysis: cytosol, pyruvate oxidation/citric acid cycle: mitochondrial matrix, oxidative phosphorylation: inner mitochondrial membrane
2. These molecules are electron carriers!!! They take electrons from glucose during its break down and put them into the ETC
3. Alcoholic and lactic acid fermentation