Week 5

BIO-1305 - Biology 1 – Campbell Textbook

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

This week is Week 5 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: Thermodynamics, Free Energy Change, Enzymes, Intro to Cellular Respiration

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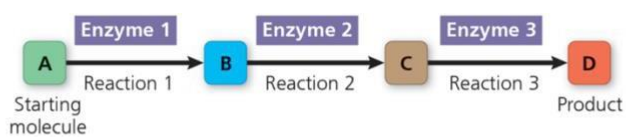
Topic of the Week: Introduction to Metabolism and Energy

We often hear the word ***metabolism***, but what does it actually mean? The biological definition of metabolism is: the entirety of an organism's **chemical reactions**. This consists of both catabolic and anabolic pathways that manage *materials and energy* resources of the organism. Overall, an organism's metabolism consists of chemical reactions that transform energy into useable material to help the organism survive.

Now that we understand what metabolism is, we can talk about ***metabolic pathways***. A metabolic pathway consists of the **steps/chemical reactions** that build or break down molecules. There are two main types of metabolic pathways:

1. **Anabolic pathways**: involved in *building*
2. **Catabolic pathways:** involved in *breaking down*

Both of these pathways are often catalyzed by **enzymes**, which we will dive into later.



Metabolism and metabolic pathways involve **energy**. But what exactly is energy? The biological definition of energy is: *the ability to cause change*. There are several **different types of energy to remember:**

1. **Kinetic energy:** associated with *motion* of an object
2. **Thermal energy:** associated with *random movement* of atoms and molecules

3. **Potential energy:** associated with the *location, structure, or position* of an object
    Chemical energy is a type of potential energy because there is energy available to be released from chemical reactions that break bonds.

Energy can be converted from one form to another. Each of the tree types of energy we discussed above can be turned into a different one of the three!

Highlight #1: Thermodynamics and Free Energy Change

Thermodynamics

Like we said earlier, energy can be *converted* into different forms. However, there are some **limitations** on this.

> According to the **first law of thermodynamics**, energy can be *transferred and transformed* into different types, but it **CANNOT be created or destroyed**.

Additionally, the **second law of thermodynamics** mentions entropy. **Entropy** (often denoted as "S") is a *measure of disorder and randomness.*

> According to the second law of thermodynamics, the entropy of the universe is always increasing.

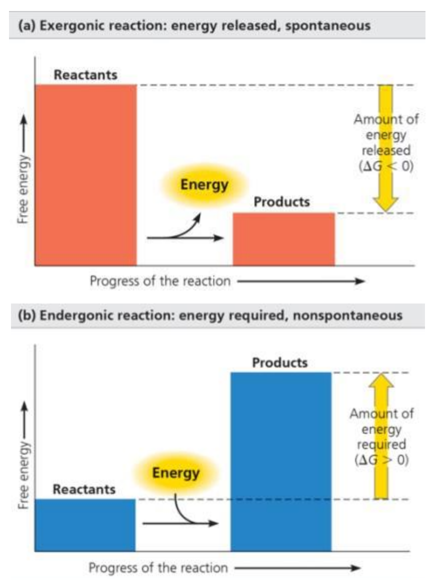
One other important fact about thermodynamics is the idea of **spontaneity**. When a reaction is spontaneous, it occurs *without input of energy*. In other words, it is energetically favorable, and it "wants" to happen!

Free Energy Change (ΔG)

The concept of free energy change is often confusing. Here are a few terms to have down in order to relate this concept back to bio:

> **Free energy:** the portion of a system's energy that can do work at constant temperature and pressure
> **ΔH:** change in enthalpy
> **ΔS:** change in entropy

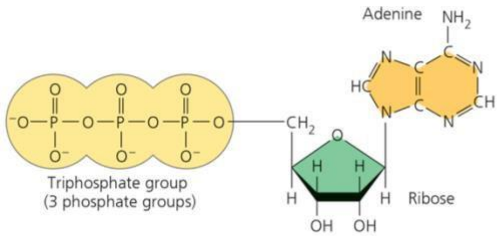
The equation for free energy change is: **$\Delta G = \Delta H - T\Delta S$**, where T is the temperature in Kelvin!



Relating this all back to bio, we can start discussing *different types of reactions* according to energy.

> For example, an **exergonic reaction** is a spontaneous reaction that *releases energy*.
> An **endergonic reaction** is a NON-spontaneous reaction that *absorbs energy*.

Energy coupling involves both types of reactions and is how cells manage their resources. Energy coupling involves the *use of exergonic reactions to drive endergonic reactions*.



(a) The structure of ATP. In the cell, most hydroxyl groups of phosphates are ionized (—O⁻).

You might be wondering where all of this energy that we have been talking about comes from! Energy for the cell is provided in the form of **adenosine triphosphate, or ATP.** When hydrolysis breaks bonds between the phosphate groups in the molecule, a lot of energy is released. That is where the energy in a cell comes from!

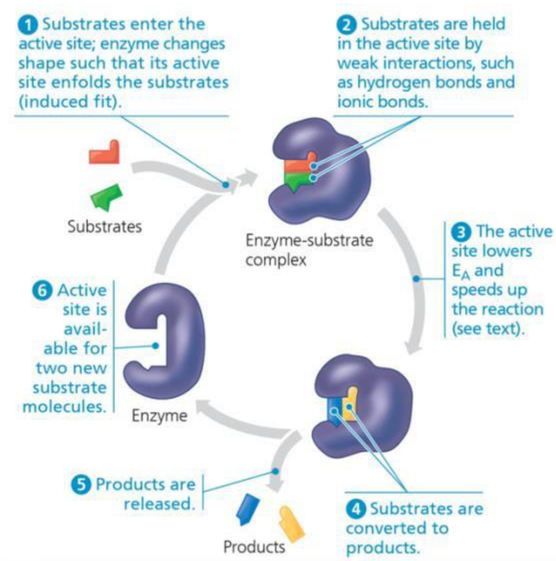
Highlight #2: Enzymes

You have probably heard of enzymes before because they are super important in biology! What exactly is an enzyme?

An **enzyme** is a macromolecule, usually a protein, that acts as a *catalyst* for speeding up the rates of chemical reactions. Enzymes are NOT consumed in chemical reactions.

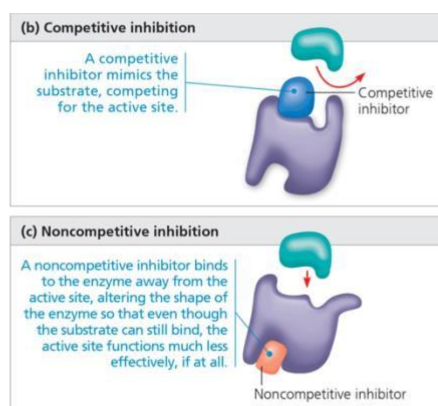
How do enzymes work?

Activation energy is the *amount of energy reactants need to absorb before a chemical reaction can occur completely*. This acts as a **barrier** to the rate of most chemical reactions. **Enzymes work to LOWER this activation energy barrier!**



It is super important to note that an enzyme CANNOT change the ΔG of a reaction! In other words, enzymes cannot make endergonic reactions turn into exergonic reactions. They can only help speed up rates of reactions that would have happened spontaneously anyways!

The **substrate** is what binds to the active site of an enzyme. The **active site** is a pocket or groove where catalysis occurs.



Enzymes can be inhibited! The main types of inhibitors are:

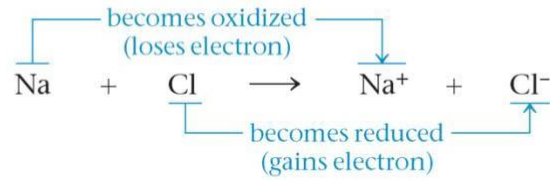
- **Competitive inhibition:** the inhibitor enters the active site and blocks the substrate from binding
- **Noncompetitive inhibition:** the inhibitor binds to a spot that is different than the active site. This binding changes the shape of the enzyme so the active site is no longer available to the substrate.

Highlight #3: Introduction to Cellular Respiration

In general, **cellular respiration** is the way that the stored chemical energy in food is converted into energy for a cell. As you will see in later chapters, cellular respiration and photosynthesis go hand-in-hand. For now, we will just focus on cellular respiration. Here are a few things to note before we dive into the details in the next resource:

Catabolic processes break things down! Respiration is a *catabolic process*. Cellular respiration can be either aerobic (using oxygen) or anaerobic (without oxygen).

Many chemical reactions, including respiration, involve **a transfer of electrons** between reactants. Such a reaction would be called an oxidation-reduction reaction, or a redox reaction for short. Oxidation involves *losing electrons* while reduction involves *adding electrons*. As a hint for remembering these, note that adding electrons, which are negatively charged, would **reduce** the charge of the atom!



CHECK YOUR LEARNING

1. What is the equation for free energy change and what does each variable represent?
2. What is the difference between catabolic and anabolic processes?
3. How does noncompetitive inhibition differ from competitive inhibition?

THINGS YOU MAY STRUGGLE WITH

1. Remember that an enzyme DOES NOT CHANGE the ΔG of a reaction!!!
2. Metabolism and cellular respiration go hand in hand. Respiration is part of a cell's metabolism!
3. Oxidation REMOVES electrons while reduction GAINS electrons. Some students think reduction means you are reducing the amount of electrons, but it is actually the opposite!

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. $\Delta G = \Delta H - T\Delta S$; ΔG = free energy change, ΔH = enthalpy change, ΔS = entropy change, T = temperature in Kelvin
2. Catabolic is breaking down while anabolic is building up
3. Noncompetitve inhibition does NOT compete for the active site, but competitive inhibition does! Noncompetitve inhibition changes the shape of the enzyme so the active site is no longer available.