

Chapter 6, section 4

Topic: Enzymes

Main concepts:

- **Proteins** are polymers made up of **amino acids**. Enzymes are a category of proteins.
- Enzymes are **catalysts**. They speed up the rate of a chemical reaction by reducing the **activation energy**, which is the energy needed to carry out the reaction. An example of a catalyst: if you put a lit match to a sugar cube, it's hard to make the sugar catch fire. But if you rub a corner of the sugar cube with ash or charcoal, it catches more easily. The ash or charcoal acts as a catalyst.
- Many important chemical reactions in living cells can happen spontaneously, but these reactions happen too rarely and too slowly to sustain life. Enzymes make the reactions happen more quickly and more often.
- Some reactions happen too violently to support life. Sugar, when burned, released a lot of energy, but the energy is mostly heat. A rapid reaction like that would overheat our cells. Enzyme-controlled reactions can release energy from sugar in a way that captures most of the energy and loses less of the energy as heat, so that the energy is useful to the cell and does not overheat the cell.
- The structure of enzymes allows them to carry out reactions. Each enzyme is shaped to carry out only one specific reaction. This is known as **enzyme specificity**. Amylase, for example, is an enzyme that breaks down starch into glucose. Amylase only breaks down starch; it does not break down any other molecule, nor does it build starch out of glucose.
- Remember **hydrolysis** and **dehydration synthesis**? These are both enzyme-controlled reactions.
- The **active site** of an enzyme is a spot on the enzyme that is shaped to accept the **substrate**, which is the molecule or molecules that the enzyme is specific to. Amylase, for example, has an active site shaped to fit a part of the starch molecule. Starch is the substrate that amylase works on.
- The **product** is the substance produced at the end of the reaction that the enzyme catalyzes. The product produced when amylase works on starch is glucose.
- The enzymes themselves are not used up in the reactions that they catalyze. Each individual enzyme can carry out the same reaction hundreds of times. Enzymes are like tools. A hammer can be used to pound thousands of nails, but it does not become part of the structure that a person is building.
- Cells only produce the enzymes that they need. Feedback mechanisms use chemical signals to tell cell when it needs to make a certain enzyme. The nucleus receives the signal to activate a certain gene to send out a copy of the code for a particular enzyme. The code is read by the protein-making machinery in the cells, and the enzyme is made.
- Enzymes are sensitive to the environment inside the cell (or in the digestive system, where enzymes are used to digest foods). Changing conditions can interfere with enzyme activity, including pH, temperature, and salinity (the amount of salt). **Inhibitors** are proteins that regulate enzyme activity by blocking enzyme action. They may be allosteric (also called non-competitive) regulators, which attach to the enzyme and change its shape, or competitive inhibitors, which fit into the active site.

Common misconceptions:

- Most beginning biology students have heard the word "enzyme," but do not know what enzymes are or what they do. Lack of a concept is more common than misconceptions in this case!
- Some students have heard that heat "kills" enzymes. Heat does denature, and therefore deactivate, proteins, including enzymes, but since proteins are not alive to begin with they cannot be killed.
- After learning about temperature and enzymes, some students believe that the optimum temperature for all enzymes is human body temperature (98° F or 37°C). This is true for human enzymes, but is not necessarily true in other organisms, which may have very different internal temperatures.
- Many students forget that enzymes are proteins. This is an important connection to make, especially when studying genetics.

Chapter study guide:

- Define **metabolism**. Describe the role that enzymes play in metabolism.
 - Explain why enzymes are necessary to carry out important reactions in the body.
-

- Define **catalyst**. Explain how catalysts regulate chemical reactions.
- Describe the additional attributes that enzymes have that set them apart from non-biological catalysts.
- Define **active site**. Explain why the active site of an enzyme must have a particular shape.
- Describe how an enzyme catalyzes a reaction.
- Explain why cells regulate the synthesis of enzymes. Describe the following ways that cells regulate enzyme synthesis: secretion of inactive forms; feedback inhibition; allosteric regulation; competitive inhibition.
- Describe several ways in which the environment may affect enzyme activity.
- Define **coenzyme**, and describe what coenzymes do.
- Read the “Case Study Revisited.” Think about where enzymes would be important in the energy-producing processes described (we will study these soon).
- Read “Links to Life.” Describe the cause of lactose intolerance. Think about why lactose *intolerance* is the *normal* state for humans and other mammals.

Useful websites:

- “How Do Enzymes Work?” <http://www.tvdsb.on.ca/westmin/science/sbi3a1/digest/enzymes.htm> is a simple animation showing starch being broken down by amylase. The animation emphasizes that this is a **hydrolysis** reaction.
 - “Enzymes” <http://programs.northlandcollege.edu/biology/Biology1111/animations/enzyme.html> is an animated tutorial describing the action of enzymes. Let each segment of this Shockwave animation run before clicking the “next” button. Some of them are slower than others. “The Basics” includes the breakdown of lactose into glucose and galactose. “Feedback Inhibition” gives a nice demonstration of feedback loops that are involved in controlling enzyme action.
 - “Proximity/Orientation” <http://www.stolaf.edu/people/giannini/flashanimat/enzymes/prox-orient.swf> is a very simple animation representing chemical reactions with and without enzymes. After choosing “without enzyme” or “with enzyme,” use the large red triangles to navigate.
-