5.7 Enzymes

Learning objectives

By the end of this section, you will be able to:

- *Understand what enzymes are and why they are important*
- *Discuss enzyme function*
- *Know the role enzymes play on the activation energy*
- *Explain what a metabolic pathway is and how enzymes are involved in these pathways*
- *Be able to define and explain all bolded terms*

All chemical reactions require some input of energy. For example, exergonic reactions that have a net release of energy still require some energy in order to begin. This amount of energy necessary to begin a chemical reaction is called the **activation energy**.

Enzymes

A substance that helps a chemical reaction to occur is called a **catalyst**. Molecules that catalyze chemical reactions in cells are called **enzymes**. Most enzymes are proteins that *lower the activation energy needed* for the chemical reaction to occur. To maintain homeostasis, chemical reactions must occur in a timely fashion. On their own, most of the chemical reactions in a cell happen too slowly for life to be maintained. Enzymes are used to speed up chemical reactions, allowing life to exist (Figure 5.35).

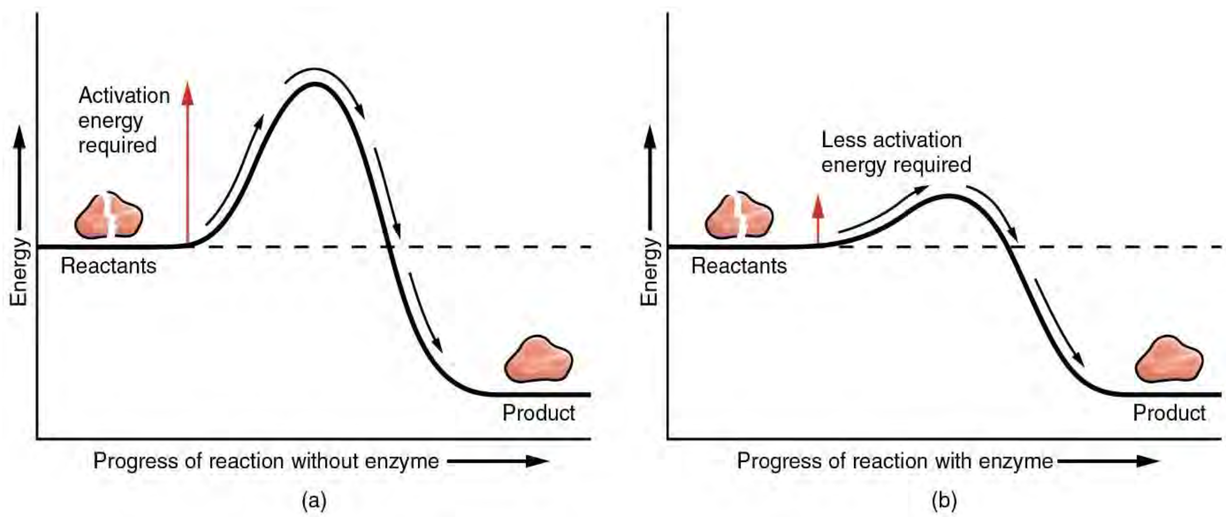

Figure 5.35 Enzymes decrease the activation energy required for a given chemical reaction to occur. (a) Without an enzyme, the energy input needed for a reaction to begin is high. (b) With the help of an enzyme, less energy is needed for a reaction to begin. (credit: Betts et al. / Anatomy and Physiology OpenStax)

Enzymes speed up the rate of chemical reactions by binding to the reactant molecules and holding them in such a way that it makes the chemical bond-breaking and -forming processes take place more quickly. Enzymes do this by reducing the activation energy required for the reaction to happen (Figure 5.36). An enzyme itself is unchanged by the reaction it catalyzes. Once one reaction has been catalyzed, the enzyme can catalyze the reaction again.

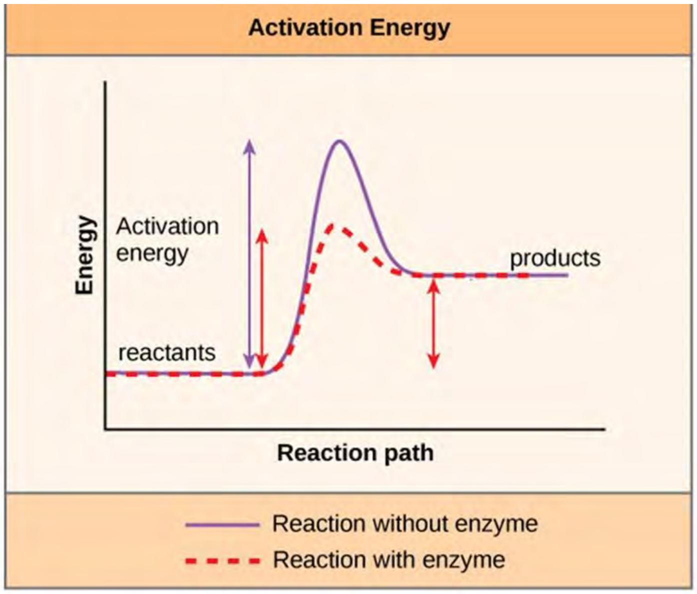

Figure 5.36 Enzymes lower the activation energy of the reaction but do not change the free energy of the reaction. (credit: Modified by Elizabeth O'Grady original work of [Concepts of Biology OpenStax](#))

During a chemical reaction, the enzyme binds to the reactants, which are called the enzyme's **substrates**. There may be one or more substrates, depending on the chemical reaction. In some reactions, two substrates may come together to create one larger molecule (Figure 5.37). In others, a single substrate is broken down into multiple products (Figure 5.38). The location within the enzyme where the substrate binds is called the enzyme's **active site**. The active site is where the "action" happens.

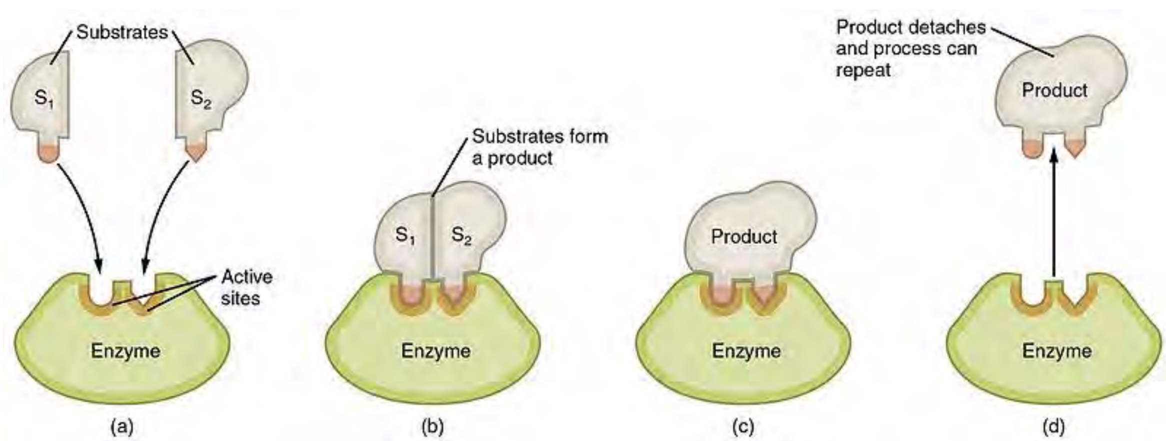

Figure 5.37 (a) Substrates approach active sites on an enzyme. (b) Substrates bind to active sites, producing an enzyme-substrate complex. (c) Changes internal to the enzyme-substrate complex facilitate the interaction of the substrates. (d) Products are released, and the enzyme returns to its original form, ready to facilitate another enzymatic reaction. (credit: Betts et al. / Anatomy and Physiology OpenStax)

Enzymes are not the only catalyst that can affect a chemical reaction. Increasing environmental temperature also generally increases chemical reaction rates. However, temperatures outside of an optimal range reduce an enzyme's ability to function. If the temperature is too hot, the enzymes will eventually **denature**. When an enzyme is denatured, it loses its three-dimensional shape and is no longer able to function properly. Enzymes are suited to work best under certain optimal conditions. Changes in pH and salt concentration range, as with temperature, can cause enzymes to denature.

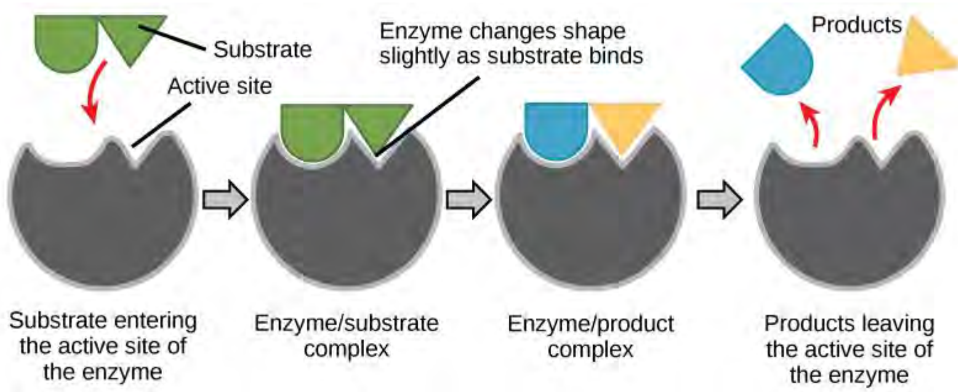

Figure 5.38 The induced-fit model explains how enzymes and substrates undergo dynamic modifications during the transition state to increase the affinity of the substrate for the active site. (credit: Fowler et al. / Concepts of Biology OpenStax)

For many years, scientists thought that enzyme-substrate binding took place in a simple "lock and key" fashion. This model stated that the enzyme and substrate fit together perfectly in one instantaneous step. However, current research supports a model called induced fit (Figure 5.38). The induced-fit model expands on the lock-and-key model by describing a more dynamic binding between enzyme and substrate. As the enzyme and substrate come together, their interaction causes a mild shift in the enzyme's structure. The mild shift in structure forms an ideal binding arrangement between enzyme and substrate.

CONCEPTS IN ACTION - View an animation of induced fit.

When an enzyme binds its substrate, an enzyme-substrate complex is formed. This complex lowers the activation energy of the reaction and allows the chemical reaction to happen quickly. It is important to remember that the enzyme will always return to its original state by the end of the chemical reaction. One of the hallmark properties of enzymes is that they remain ultimately unchanged by the reactions they catalyze. After an enzyme has catalyzed a reaction, it releases its product(s) and can catalyze a new reaction.