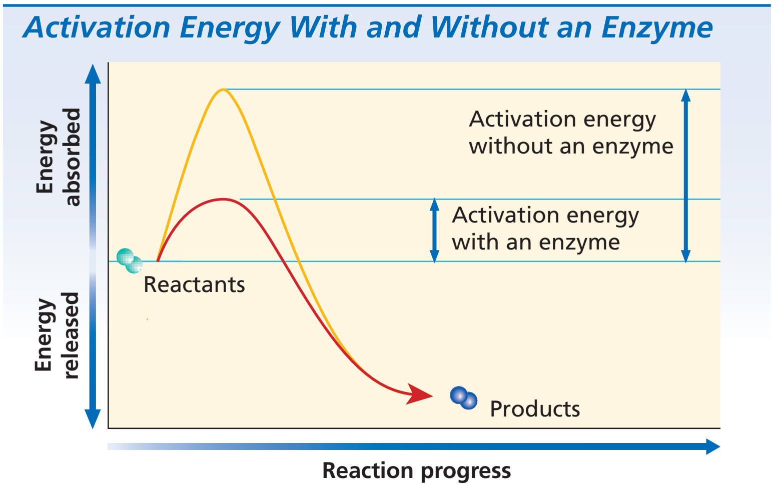


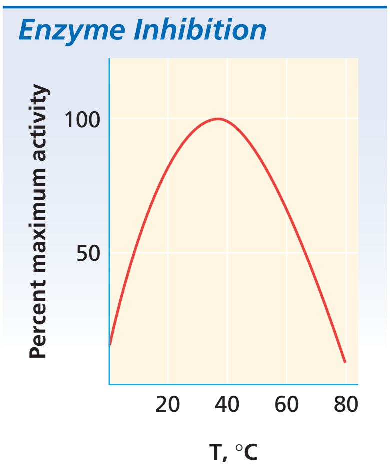
FIGURE 13 Enzymes decrease the activation energy of a chemical reaction. However, the energy change from reactants to products is the same for both the catalyzed and the non-catalyzed reaction.

reaction just discussed. The shape of the enzyme is such that a molecule of hydrogen peroxide can fit into the enzyme at a specific part of the enzyme molecule, called the *active site*. The resulting compound is called the *enzyme-substrate complex*. In the enzyme-substrate complex, hydrogen-oxygen bonds break, and oxygen-oxygen bonds form. Then, the enzyme releases the products and is ready to react with another substrate molecule. This model of enzyme action is called the *lock and key model*.

Enzymes and Reaction Rates

The presence of an enzyme in a chemical reaction can increase the rate of a reaction by a factor of up to 10^{20}. In Chapter 17, you saw that a reaction can occur when two atoms or molecules collide. But only collisions that have enough energy to overcome the *activation energy* and have the proper orientation change reactants into products. As you can see from the graph in **Figure 13,** an enzyme that catalyzes a chemical reaction causes an increase in the rate of the reaction by reducing the activation energy. The enzyme lowers the activation energy by forming the enzyme-substrate complex, which makes breaking bonds in the reactants and forming new bonds in the products easier. The net amount of energy required for the reaction or released by the reaction is not changed by the action of an enzyme.

FIGURE 14 Most enzymes have maximum activity within a narrow temperature range. Denaturation in many occurs at temperatures above 50°C and causes a decrease in activity.



Temperature and Enzyme Activity

Proteins, including enzymes, are also affected by changes in temperature. The graph in **Figure 14** shows the relatively narrow range of temperatures within which enzymes typically have maximum activity. Enzymes in the human body work optimally at the normal body temperature of 37°C (98.6°F). At temperatures above 50°C to 60°C enzymes typically show a decline in activity. High heat can denature, or alter, the shape of a protein, which in turn alters the protein's function. **Denaturation** *is a change in a protein's characteristic three-dimensional shape due to changes of its secondary, tertiary, and quaternary structure.* If you have ever cooked an egg, you have caused protein denaturation. The white of an egg is a solution of the protein albumin. When the egg is placed in a hot frying pan, a dramatic change takes place and the semitransparent solution turns into a white solid. Because the primary structure is retained in denaturation, the nutritional value of the egg white is not affected. The process is not reversible, however, cooling a fried egg does not reverse the denaturation. When food is cooked, the three-dimensional structure of the protein is altered, making the food easier to digest.