

Figure 3.1. Activation energies of enzymatically catalyzed and uncatalyzed reactions. Note that $|\Delta G^{\circ}A_2| < |\Delta G^{\circ}A_1|$.

The molecular aspects of enzyme–substrate interaction are not yet fully understood. This interaction varies from one enzyme–substrate complex to another. Various studies using x-ray and Raman spectroscopy have revealed the presence of the enzyme–substrate (ES) complex. The interaction between the enzyme and its substrate is usually by weak forces. In most cases, van der Waals forces and hydrogen bonding are responsible for the formation of ES complexes. The substrate binds to a specific site on the enzyme known as the *active site*. The substrate is a relatively small molecule and fits into a certain region on the enzyme molecule, which is a much larger molecule. The simplest model describing this interaction is the lock-and-key model, in which the enzyme represents the lock and the substrate represents the key, as described in Fig. 3.2.

In multisubstrate enzyme-catalyzed reactions, enzymes can hold substrates such that reactive regions of substrates are close to each other and to the enzyme's active site, which is known as the *proximity effect*. Also, enzymes may hold the substrates at certain positions and angles to improve the reaction rate, which is known as the *orientation effect*. In some enzymes, the formation of an enzyme–substrate complex causes slight changes in the three-dimensional shape of the enzyme. This induced fit of the substrate to the enzyme molecule may contribute to the catalytic activity of the enzyme, too. The enzymes lysozyme and carboxypeptidase A have been observed to change their three-dimensional structure upon complexing with the substrate. Enzyme catalysis is affected not only by the primary structure of enzymes but also by the secondary, tertiary, and quaternary structures. The properties of the active site of enzymes and the folding characteristics have a profound effect on the catalytic activity of enzymes. Certain enzymes require coenzymes and cofactors for proper functioning. Table 3.2 lists some enzymes and their cofactors and coenzymes.

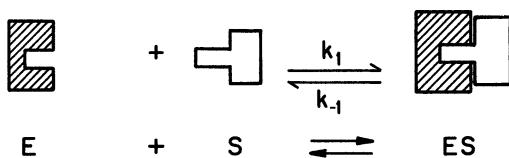


Figure 3.2. Schematic of the lock-and-key model of enzyme catalysis.