Enzymes

- Enzymes are molecules (mostly proteins) that control the rates of specific reactions by lowering the amount of energy required by the substrate for the reaction to proceed (Fig.1, p.69)
- The substrate is the reactant that an enzyme acts on when it catalyzes a chemical reaction (there may be more than one)
- Enzymes are not used up in the reaction; they can be used over and over
- They are used for both the forward and reverse reactions
- They are highly selective about their substrates
- They contain one or more active sites where a substrate can bind

Lock-and-Key Model

- Enzymes are very specific and this is because both the enzyme and the substrate have complementary geometric shapes that fit exactly into one another
- This idea is called the Lock-and-Key model, and while it explains enzyme specificity, it fails to explain the stabilization of the transition state that enzymes achieve
- While it is still a useful tool for understanding enzymes, this model has proven inaccurate over time

Induced-Fit Model

- Like the Lock-and-Key model, in the induced-fit model, the active site of the enzyme is specially shaped to fit the appropriate substrate(s)
- When the substrate settles into the active site, existing bonds are strained and new ones are created
- The activated state is reached when the substrate fits precisely into the active site; this requires some energy (called activation energy)
- Once the substrate fits; the reaction can progress into the transition state (Fig.3, p.70)

Effects of Temperature and pH on Enzyme Activity

- As temperature increases, reaction rates decrease because the heat energy disrupts the weak bonds that hold the enzyme in its 3-D shape, thereby altering the active site so that the substrates can no longer bond
- Enzymes work best at a specific pH; when pH values are higher or lower the enzyme structure and therefore function is disrupted
- Ex/pepsin is a protein-digesting enzyme and works best in the acidic (pH 2) environment of the stomach

Enzyme Helpers

- Cofactors: non-protein components (can be inorganic or organic) that are needed by some enzymes in order to function
- Coenzymes: are specifically organic non-protein cofactors (mostly from vitamins)
- Many coenzymes shuttle molecules from one enzyme to another

- Ex/ NAD^+ and FAD pick up H atoms given off during glucose breakdown and carries them to other reaction sites (electrons attracted to the positive charge go along), thereby becoming NADH and $FADH_2$

Control of Enzyme Activity: Enzyme Inhibition

- Enzyme inhibition prevents enzymes from doing their job
- There are two types of inhibitors (Fig.6, p.73)
    1. Competitive inhibitors are so similar in structure to the substrate that they block them from entering the active site
    2. Non-competitive inhibitors bind to another part of the enzymes, causing it to change shape (substrate can no longer fit in the active site)

Control of Enzyme Activity: Allosteric Regulation

- Cells control enzyme activity by restricting the production of a particular enzyme or inhibiting enzymes that have already been produced
- Some enzymes posses receptor sites, called allosteric sites that are separate from the active site (Fig.7, p.73)
- Allosterically controlled enzymes are usually composed of proteins in quaternary structure having several subunits, each with an active site
- If an allosteric activator binds to an allosteric site, it stabilizes the protein structure and keeps all active sites available to substrates
- If an allosteric inhibitor binds to an allosteric site, it will stabilize the inactive form of the enzyme

Control of Enzyme Activity: Feedback Inhibition

- In order to conserve energy, metabolic pathways must be shut off when no longer necessary
- In feedback inhibition, a product formed later in a sequence of reactions allosterically inhibits an enzyme needed earlier in the pathway, shutting down the pathway (Fig.8, p.74)