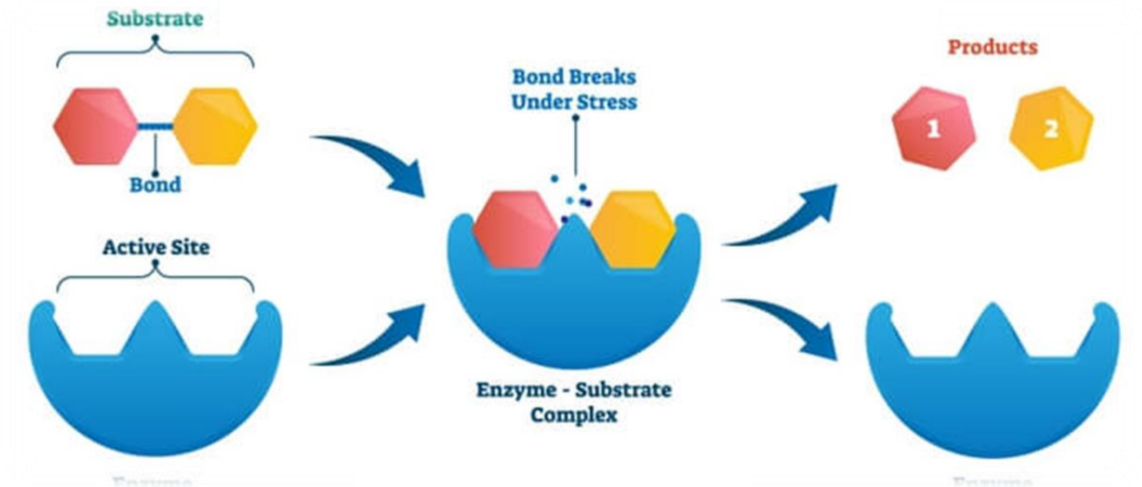
BIOCHEMISTRY - YEAR 2



Enzymes
Part 1

Lecture No: 14

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- Every second, thousands of chemical reactions occur in the cells of human body. For example, many reactions occur to digest the food we eat, convert the products to chemical energy, and synthesize proteins and other macromolecules in our cells. In the laboratory, we can carry out reactions that hydrolyze polysaccharides, fats, or proteins, but we must use a strong acid or base, high temperatures, and long reaction times. In the cells of our body, these reactions must take place at rate that meet our physiological and metabolic needs. To make this happen, enzymes catalyze the chemical reactions in our cells, with a different enzyme for every reaction.

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- Digestive enzymes in the mouth, stomach, and small intestine catalyze the hydrolysis of carbohydrate, fats and proteins. Enzymes in the mitochondria extract energy from bio- molecules to give us energy. Every enzyme responds to what comes into the cells and to what the cells need. Enzymes keep reactions going when our cells need certain products, and turn off reactions when they don't need those products. Many enzymes require cofactors to function properly. A cofactor can be an inorganic metal ion or an organic compound such as a vitamin. We obtain minerals such as zinc (Zn^{2+}) and iron (Fe^{3+}) and vitamins from our diets. A lack of minerals and vitamins can lead to certain nutritional diseases. For example, rickets is a deficiency of vitamin D and scurvy occurs when a diet is low in vitamin C.

Biological Catalysts

- As a catalyst, an enzyme increases the rate of a reaction by changing the reaction takes place, but is itself not changed at the end of the reaction. Analyzed reaction in a cell may take place eventually, but not at a rate fast enough survival. For example, the hydrolysis of proteins in our diet would eventually occur without a catalyst, but not fast enough to meet the body's requirements for amine acids. The chemical reactions in our cells must occur at incredibly fast rates under mild conditions of pH 7.4 and a body temperature of 37°C.

Biological Catalysts

- As catalysts, enzymes lower the activation energy for the reaction. As a result, less energy is required to convert reactant molecules to products, which allows more reacting molecules to form product. However, as a catalyst an enzyme does not affect the equilibrium position, which means that there is an increase in the rates of both the forward and reverse directions. The rates of enzyme-catalyzed reactions are much faster than the rates of the uncatalyzed reactions.

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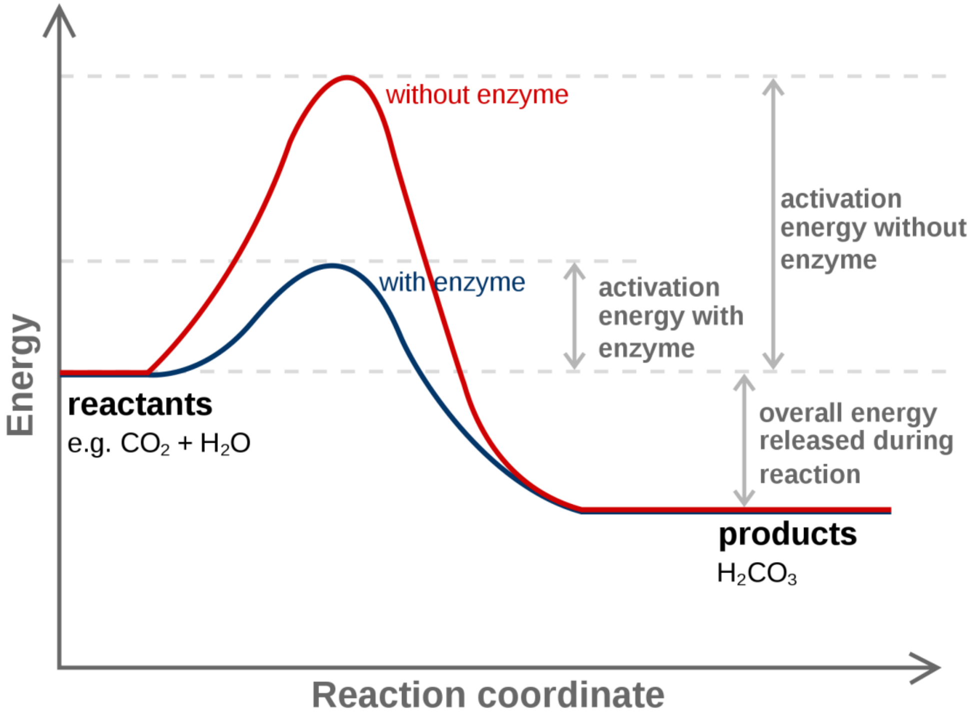
- Some enzymes can increase the rate of a biological reaction by a factor of a billion or trillion or even hundred million trillion compared to the rate of the uncatalyzed reaction. For example, an enzyme in the blood called carbonic anhydrase converts carbon dioxide (CO_2) and water (H_2O) to carbonic acid (H_2CO_3). In one minute, one molecule of anhydrase catalyzes the reaction of about one million (10^6) molecules.



Names and Classification of Enzymes

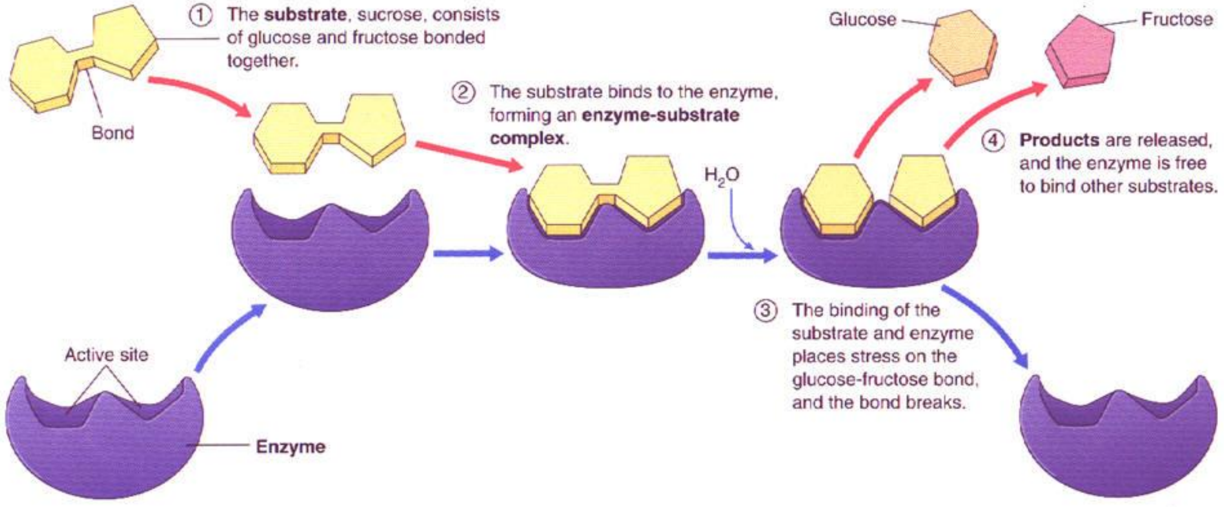
- The names of enzymes describe the compound or the reaction that is catalyzed. The actual names of enzymes are derived by replacing the end of the name of the reaction or reacting compound with the suffix ase. For example, an oxidase catalyzes an oxidation reaction, and a dehydrogenase removes hydrogen atoms. The compound sucrose is hydrolyzed by the enzyme sucrase, and a lipid is hydrolyzed by a lipase, Some early known enzymes use names that end in the suffix in, such as papain found in papaya, rennin found in milk, and pepsin and trypsin, enzymes that catalyze the hydrolysis of proteins. The International Commission on Enzymes has classified enzymes according to the six general types of reactions they catalyze. See table 1.

Table 1: Classification of Enzymes

Enzyme class	Reaction type	Examples
Oxidoreductases	Oxidation/reduction	Dehydrogenases oxidases
Transferases	Atom/group transfer(excluding other classes)	Transaminase Kinases
Hydrolases	Hydrolases	Estrases Digestive enzymes
Lyases	Group removal	Decarboxylases Aldolases
Lsomerases	Isomerization	Phosphohexose Isomerase, fumarase
Ligases	Joining of molecules linked to the breakage of a pyrophosphate bond	Citric acid synthetase

Enzymes as Catalysts

Nearly all enzymes are globular proteins. Each has a unique three-dimensional shape that recognizes and binds a small group of reacting molecules, which are called **substrates**. The tertiary structure of an enzyme plays an important role in how that enzyme catalyzes reactions.



Active Site

In a catalyzed reaction, an enzyme must first bind to a substrate in way that favors catalysis. A typical enzyme is much larger than its substrate. However, within its large tertiary structure, there is a region called the active site where the enzyme binds a substrate or substrates and catalyzes the reaction. This active site is often small pocket that closely fits the structure of the substrate. Within the active site, the side chains of amino acids bind the substrate with hydrogen bonds, salt bridges, or hydrophobic attractions. The active site of a particular enzyme fits the shape of only a few types of substrates, which makes enzyme specific about the type of substrate they bind.

Some enzymes show absolute specificity by catalyzing one reaction of one specific substrate. Other enzymes catalyze a reaction for a group of substrates. Still other enzymes catalyze a reaction for a specific type of bond in a substrate.

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Table 2: Types of Enzyme Specificity

Type	Reaction Type	Example
Absolute	Catalyze one type of reaction for a single substrate	Urease catalyzes only the hydrolysis of urea
Group	Catalyze one type of reaction for similar substrates	Hexokinase adds phosphate group to hexoses
Linkage	Catalyze one type of reaction for a specific type of bond	Chymotrypsin catalyzes the hydrolysis of peptide bonds

Lock-and-Key and Induced Fit Models

In an early theory of enzyme action called the lock-and-key model, the active site is described as having a rigid, nonflexible shape. Thus only those substrates shapes that fit exactly into the active site are able to bind with that enzyme shape of the active site is analogous to a lock, and the proper substrate is the that fits into the lock. While the lock-and-key model explains the binding of substrates for many enzymes, certain enzymes have a broader range of specificity than the lock and key model allows.

Lock and Key Hypothesis

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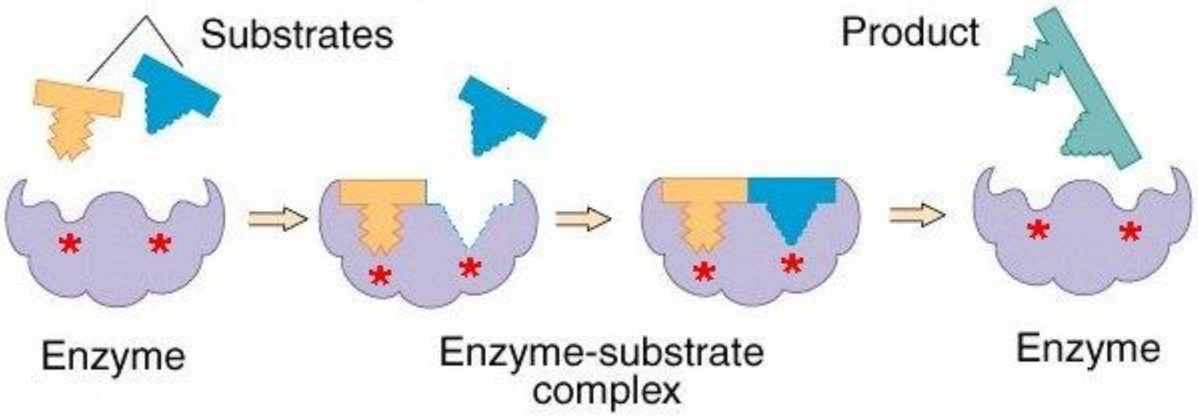
In the induced-fit model, there is an interaction between both the enzyme and substrate. The active site adjusts to fit the shape of the substrate more closely. At the same time the substrate adjusts its shape to better adapt to the geometry of the active site. As a result, the reacting section of the substrate becomes aligned exactly with the groups in the active site that catalyze the reaction.

In the induced-fit model, substrate and enzyme work together to acquire a geometrical arrangement that lowers the activation energy. A different substrate could not induce these structural changes and no catalysis would occur.



Induced-Fit Hypothesis

The End

Thank You All

Reference: General, organic,& biological chemistry structures of life.
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