ENZYMES

Introduction:

The vast majority of enzymes are proteins with catalytic capabilities that are essential for maintaining various life processes. Metabolic processes and other chemical reactions in the cell are carried out by a set of enzymes that are necessary to sustain life.

The initial stage of metabolic process depends upon the enzymes, which react with a molecule and is called the substrate. Enzymes convert the substrates into other distinct molecules and are called the products.

The regulation of enzymes has been a key element in clinical diagnosis because of their role in maintaining life processes. The macromolecular component of all enzymes consists of protein, except in the class of RNA catalysts called ribozymes. The word ribozyme is derived from the ribonucleic acid enzyme. Many ribozymes are molecules of ribonucleic acid which catalyze reactions in one of their own bonds or among other RNAs.

Enzymes exist in all fluids and tissues of the body. Intracellular enzymes catalyze all the reactions that occur in metabolic pathways. The enzymes in plasma membrane regulate catalysis in the cells in response to cellular signals and enzymes in the circulatory system regulate clotting of blood. Almost all the significant life processes are based on the enzyme functions.

Cofactors:

Cofactors are non-proteinous substances that associate with enzymes. A cofactor is essential for the functioning of an enzyme. An enzyme without a cofactor is called an apoenzyme. An apoenzyme and its cofactor together constitute the holoenzyme.

There are three kinds of cofactors present in enzymes:

Prosthetic groups: These are cofactors tightly bound to an enzyme at all times. A fad is a prosthetic group present in many enzymes.

Coenzyme: A coenzyme is bound to an enzyme only during catalysis. At all other times, it is detached from the enzyme. NAD+ is a common coenzyme.

Metal ions: For the catalysis of certain enzymes, a metal ion is required at the active site to form coordinate bonds. Zn2+ is a metal ion cofactor used by a number of enzyme

Holo enzyme and apo enzyme

A complete catalytically-active enzyme together with its coenzyme or metal ion is called a holoenzyme.

The protein part of the enzyme on its own without its cofactor is termed an apoenzyme.

Iso enzyme

Isoenzymes are different forms of an enzyme which catalyze the same reaction, but which exhibit different physical or kinetic properties, such as isoelectric point, pH optimum, substrate affinity or effect of inhibitors.

PROPERTIES

Enzymes are catalysts that increase the rate of a chemical reaction without being changed themselves in the process.

Enzymes are highly specific with respect to the substrates on which they act and the products that they form.

Enzyme activity can be regulated, varying in response to the concentration of substrates or other molecules.

They function under strict conditions of temperature and pH in the body.

The activity of enzymes depends upon the acidity of medium (pH specific). Each enzyme is most active at a particular pH. For example, pH 2 for pepsin, pH 8.5 for trypsin. Most intracellular enzymes function at near neutral pH.

Physical Properties of Enzymes

- The physical properties of enzymes are:
- Physically enzymes behave as colloids or as substance of high molecular weight.
- Enzymes are destroyed or inactivated at temperature below the boiling point of water.
- At 60 degree Celsius most enzymes in liquid medium are inactivated.
- Dried enzymes extract can endure temperature 100 degree Celsius to 120 degree Celsius or even higher. Thus enzymes are thermolabile.
- There is always a specific temperature of optimum activity of every enzyme, which usually ranges from 25 degree Celsius to 45 degree Celsius. Enzymatic action is highest at 37 degree Celsius and enzymes become inactive when temperature rises above 60 degree Celsius.

Chemical Properties of Enzymes

There are two main chemical properties of enzymes:

Catalytic properties : Enzymes are biological catalyst. The small quantity of enzymes catalyses the larger quantities of substances. It means, enzymes have high capability to convert large quantities of substrate into product. Enzymes increase the rate of reaction and remain unaffected by the reaction which they catalyze.

specificity of enzyme : Enzymes are highly specific in nature, i.e., a particular enzyme can catalyze a particular reaction. For example, Enzyme sucrase can catalyze only hydrolysis of sucrose.

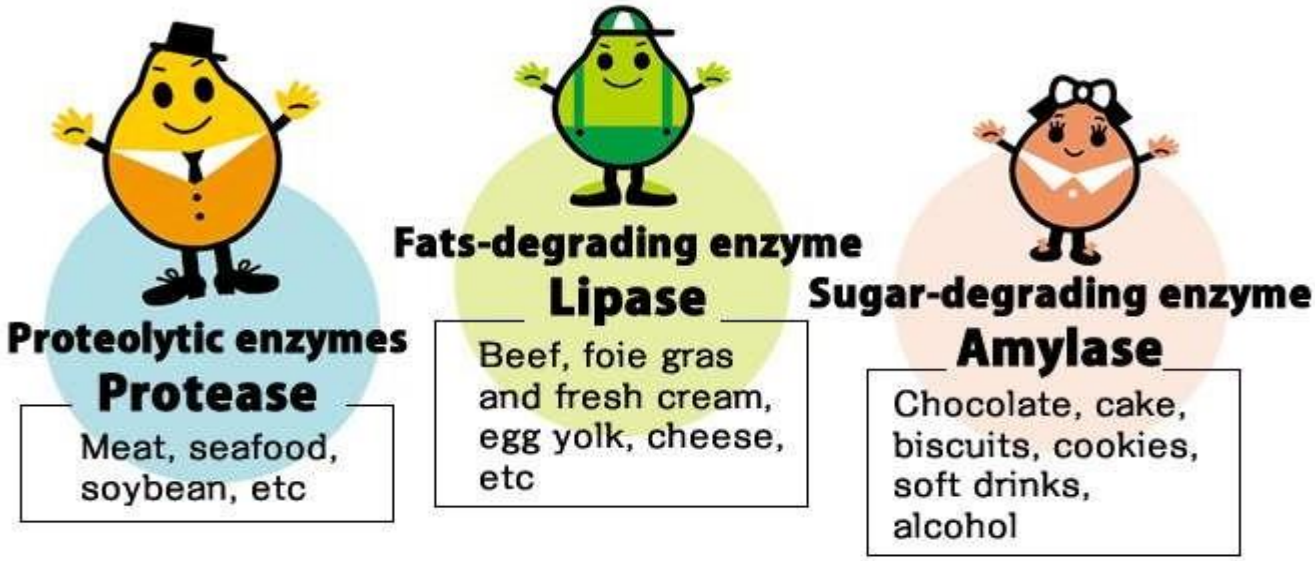
NOMENCLATURE AND CLASSIFICATION

1) Enzyme acted upon the substrate

The molecule upon which enzyme acts is known as substrate. Naming of an enzyme by adding the suffix – ase in the name of the substrate which is catalyzed by the enzyme.

For example, enzymes catalyzing lipids were named lipases, nucleic acids as nucleases and so on.

A few of the names were even more specific like maltase (acting upon maltose), tyrosinase (tyrosine), sucrase (sucrose) etc.,



2) **Type of reaction catalyzed by enzyme :**

The enzymes are highly specific to the reaction they catalyze. Hence, this has been necessary in naming them by adding suffix- ase in the name of the reaction; for example hydrolases (catalyzing hydrolysis), isomerases (isomerization), oxidases (oxidation), dehydrogenases (dehydrogenation), transaminases (transamination), Phosphorylases (phosphorylation) etc.,

Although these two systems are quite simple and easy to follow, there are certain discrepancies present in them. The former system does not take into account the type of the reaction catalyzed, whereas in the latter system no idea can be derived regarding the nature of the substrate acted upon by the enzyme.

3)Substrate acted upon and type of reaction catalyzed :

The names of some enzymes give clue of both the substrate utilized and the type of reaction catalyzed. For example, the enzyme succinic dehydrogenase catalyzes the dehydrogenation of the substrate succinic acid. Similarly, L-glutamic dehydrogenase indicates an enzyme catalyzing a dehydrogenation reaction involving L-glutamic acid.

4)Substance that is synthesized :

A few enzymes have been named by adding the suffix –ase to the name of the substance synthesized, viz., fumarase that forms fumarate irreversibly from L-malate.

5). Chemical composition of the enzyme :

Based on their chemical composition, the enzymes have been classified into following categories:

a). Enzyme molecule consisting of protein only- e.g., pepsin, trypsin, urease, papain, amylase etc.,

b). Enzyme molecule containing a protein and a cation- e.g., carbonic anhydrase (containing Zn^{2+} as cation), arginase (Mn^{2+}), tyrosinase (Cu^{2+}) etc.

c). Enzyme molecule containing a protein and a nonprotein organic compound known as prosthetic group-.

On the basis of the nature of prosthetic group present these enzymes has been subdivide into:

i). Iron porphyrin enzymes- catalase, cytochrome c peroxides I and II.

Ii). Flavoprotein enzymes- glycine oxidase, pyruvate oxidase, histamine.

Iii). Diphosphothiamin enzymes- β-carboxylase, pyruvate mutase.

Iv). Enzymes requiring other coenzymes- Phosphorylase, amino acid decarboxylase.

6). Substance hydrolyzed and the group involved.

a). Carbohydrate-hydrolyzing enzymes

1. Glycosidases- cellulose, amylase, sucrase, lactase, maltase
2. β-glucorinidase

b).Protein-hydrolyzing enzymes

1. peptide bonds

i. Endopeptidases

Animals- pepsin, trypsin, rennin

Plants- papain ficin, bromelin

ii. Exopeptidases- dipeptidase, tripeptidase

2. Nonpeptide C-N linkages (amidases)

Urease, arginase, glutaminase

Lipid-hydrolyzing enzymes

- Lipases,
- esterases,
- lecithinases
- Other ester-hydrolyzing enzymes
- Phosphatases
- Cholinesterases
- Chlorophyllases
- Sulfatases
- Pectinesterases
- methylases

Over-all chemical reaction taken into consideration

The chemical reaction catalyzed is the specific property which distinguishes one enzyme from another. In 1961, International Union of Biochemistry (I.U.B.) used this criterion as a basis for the classification and naming of enzymes. Although complicated, the

I.U.B. system is precise, descriptive and informative.

The major features of this system of classification of enzymes are as follows:

(a) The reactions and the enzymes catalyzing them are divided into 6 major classes, each with 4 to 13 subclasses.

(b) Each enzyme name has two parts- the first part is the name of the substrate and the second part which ends in suffix –ase, indicates the type of the reaction catalyzed.

(c) Each enzyme has been allotted a systemic code number called Enzyme Commission (E.C.) number. The E.C. number for each enzyme consists of a series of numbers at 4 places:

the first place numbers representing the major class to which enzyme belongs, the two median numbers denoting the subclass and the sub-subclass of the enzyme within the major class. The last place number or the fourth digit represents the serial number of the enzyme within the sub-subclass.

Thus E.C.2.7.1.1 represents class 2 (a transferase), subclass 7 (transfer of phosphate), sub-subclass 1 (an alcohol group as phosphate acceptor). The final digit denotes the enzyme, hexokinase or ATP:

D-hexose-6-phosphotransferase. This enzyme catalyzes the transfer of phosphate from ATP to the hydroxyl group on carbon 6 of glucose.

ATP + D-hexose hexokinase ADP+ Hexose-6-phosphate

(d) Where no specific category has been created for an enzyme, it is listed with a final figure of 99 in order to leave space for new subdivisions. For example, 4.2.99 refers to "other carbon-oxygen lyases."

CLASSIFICATION OF ENZYMES

Group of Enzyme	Reaction Catalysed	Examples
1. Oxidoreductases	Transfer of hydrogen and oxygen atoms or electrons from one substrate to another.	Dehydrogenases Oxidases
2. Transferases	Transfer of a specific group (a phosphate or methyl etc.) from one substrate to another.	Transaminase Kinases
3. Hydrolases	Hydrolysis of a substrate.	Estrases Digestive enzymes
4. Isomerases	Change of the molecular form of the substrate.	Phospho hexo isomerase, Fumarase
5. Lyases	Nonhydrolytic removal of a group or addition of a group to a substrate.	Decarboxylases Aldolases
6. Ligases (Synthetases)	Joining of two molecules by the formation of new bonds.	Citric acid synthetase

The 6 major classes of enzymes with some important examples from some subclasses are given below:

1. oxidoreductases:

This class comprises the enzymes which were earlier called dehydrogenases, oxidases, peroxidases, hydroxylases, oxygenases etc. The group includes those enzymes which bring about oxidation-reduction between two substrates, A and B.

2. Transferases:

Enzymes which catalyze the transfer of a group, G between a pair of substrates, A and B are called transferases.

In these are included the enzymes catalyzing the transfer of one carbon groups, aldehydic or ketonic residues and phosphorus or sulfur-containing groups.

3. hydrolases:

These catalyze the hydrolysis of their substrates by adding constituents of water across the bond they split.

4.lyases(=Desmolases):

These are those enzymes which catalyze the removal of groups from substrates by mechanisms other than hydrolysis, leaving double bonds.

5. Isomerases:

These catalyze interconversions of optical, geometric or positional isomers by intramolecular rearrangements of atoms or groups.

6. Ligases: (ligare= to bind) or synthetases:

These are enzymes catalyzing the linking together of two compounds utilizing the energy made available due to simultaneous breaking of a pyrophosphate bond in ATP or a similar compound.