

Lecture 15

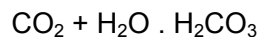
ENZYMES

One of the **unique characteristics** of a living cell is its **ability to permit complex reactions** to proceed rapidly at the temperature of the surrounding environment.

- The **principal agents** which participate in the remarkable transformations in the cell belong to a **group of proteins named enzymes**. In the absence of enzymes in the cell, these reactions would proceed too slowly.
- **Enzymes are proteins specialised to catalyse biological reactions** with the following characteristics.

Characteristics of enzymes

- Enzymes being proteins **exhibit all properties of proteins**.
- They have their **specific isoelectric points** at which they **are least soluble**.
- Like proteins, they can be **denatured by changes in pH and temperature**.
- The enzyme-catalysed reactions occur below 100°C, at atmospheric pressure and nearby **neutral pH**.
- Enzymes **undergo physical changes during the reaction** but **revert to their original form at the end of the reaction**.
- Enzymes exhibit **enormous catalytic power**. The rates of enzymatically catalysed reactions are **10⁶ - 10¹² times greater** than those of the corresponding uncatalysed reactions and several times greater than those of the corresponding chemically catalysed reactions.
- For example the **carbonic anhydrase enzyme** catalyses the conversion of **carbondioxide to carbonic acid**.



- In this reaction, each enzyme molecule can hydrate 10⁵ molecules of CO₂ per second.
- **Enzyme activity is regulated** in a variety of ways, ranging from controls over the **amount of enzyme protein synthesised by the cell** or **modulation of activity** through reversible interaction with **metabolic inhibitors and activators** or through **isoenzymes**.

Specificity of the enzymes

- One of the characteristic feature which distinguishes enzymes from catalysts is their **specificity**.

- Enzymes are specific in the **reaction catalysed** and in their **choice of substrates**.
- It usually catalyses a single chemical reaction or a set of closely related reactions

Three kinds of specificities are observed.

i. Absolute specificity

- When enzymes **catalyse only one particular reaction** they are said to exhibit **absolute specificity**.
- e.g. **Urease** acts only on urea.

ii. Group specificity

- Enzymes acting on a **group of substances** that **possess a particular type of linkage** common to that group of substances are said to exhibit group specificity.
- **Amylase** hydrolyses the group of substances like starch, dextrin and glycogen, which have the same type of glycosidic linkages (α 1,4).

iii. Optical specificity

- Almost all enzymes show a high degree of optical specificity.
- There are certain enzymes which catalyse the **hydrolysis of same group of substances possessing same optical activity**
- **Eg. D-amino acid oxidase acts on D-amino acid and L-amino acid oxidase acts on L-amino acid.**
- **Maltase** catalyses the **hydrolysis of α -but not β - glycosides**.

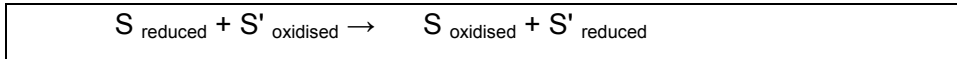
Classification of enzymes

- In **olden days** enzymes have been named by **adding the suffix -ase** to the name of the substrate (the molecule on which the enzyme acts).
- **Ex. Urease** (Substrate urea) **Arginase** (Substrate arginine)
- Recent studies on the **mechanism of enzyme catalysed reactions** have led to a more rational classification of enzymes.
- **The International Union of Biochemistry (IUB)** established a commission on enzyme nomenclature to adopt a systematic classification and nomenclature of all the existing and yet to be discovered enzymes.
- This system is **based on the substrate and reaction specificity**.
- Although, this **International Union of Biochemistry** system is complex, **it is precise, descriptive and informative**.

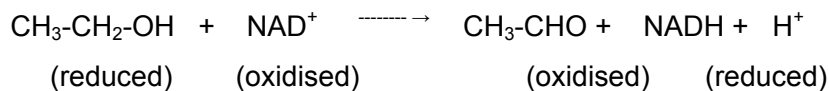
- IUB system classifies enzymes into **six major classes** (should be written in specific order only)
 - Oxidoreductases**
 - Transferases**
 - Hydrolases**
 - Lyases**
 - Isomerases**
 - Ligases**
- Again each class is divided into subclasses according to the **type of reaction catalysed**.
- Each enzyme is assigned a **recommended name** usually a short for everyday use, a **systematic name** which identify the reaction it catalyses and a **classification number** which is used where accurate and unambiguous identification of an enzyme is required.

I. Oxidoreductases

- Enzymes **catalysing oxido-reductions between two substrates, S and S'**.



Example:



Enzyme: Recommended name **Alcohol dehydrogenase**

Systematic name **Alcohol:NAD⁺ oxido-reductase**

Enzyme Commission number **E.C.1.1.1.1**

First digit 1 indicates **oxido-reductase (Major class)**

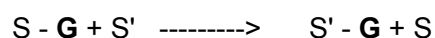
Second digit 1 indicates **enzymes acting on CH-OH group of donors (Sub-class)**

Third digit 1 indicates **NAD⁺ as the electron acceptor (Sub-sub class)**

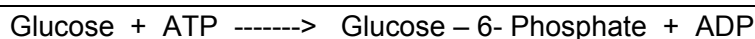
Fourth digit 1 indicates the **specific enzyme**

II Transferases

- Enzymes catalysing the **transfer of a functional group (G) other than hydrogen between substrates**.



Example: Phosphorylation of glucose by **hexokinase**



Enzyme : Recommended name: **Hexokinase**

Systematic name: **ATP:D-hexose, 6- phosphotransferase**

Enzyme commission No: **2.7.1.1**

2 → Transferase group (major class)

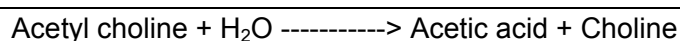
7 → Transfer of phosphate group (sub-class)

1 → Alcohol group as acceptor of phosphate group (Sub-sub-class)

1 → Hexokinase

III Hydrolases

- Enzymes **catalysing hydrolysis of ester, peptide or glycosidic bonds.**
- Example



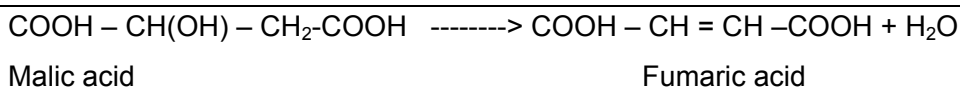
Enzyme: **Acetyl choline esterase**

Systematic name : **Choline:acetyl hydrolase**

E.C : 3.1.1.8

IV Lyases

- Enzymes catalysing the **removal of groups from substrates by mechanism other than hydrolysis leaving a double bond in one of the products.**
- Example: conversion of malic acid to fumaric acid by fumarase



Enzyme : **Fumarase (Fumarate hydratase)**

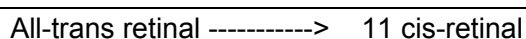
Systematic name: **L. Malate hydrolyase**

E.C.No.4.2.1.2

V. Isomerases

- Enzymes catalysing **interconversion of optical, geometrical or positional isomers**

Example



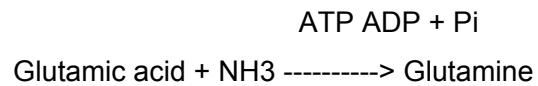
Enzyme **Retinene isomerase**

Systematic name : **All-trans retinene:11-cis isomerase**

E.C.No. 5.2.1.3

VI. Ligases

- Enzymes catalysing **the joining together of two compounds with the hydrolysis of a high energy compound.**
- Example



Enzyme: **Glutamine synthetase**

L.Glutamate: Ammonia ligase

E.C.6.3.1.2