ENZYMES: THE MAJESTIC MOLECULES OF LIFE
Part-I

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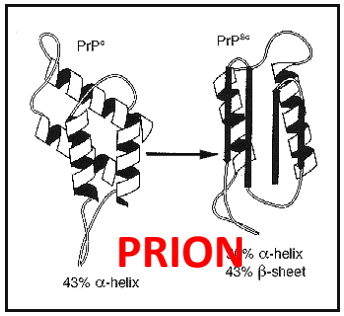
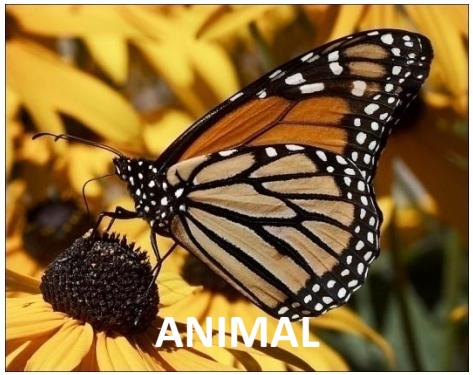
OUR GLOBE

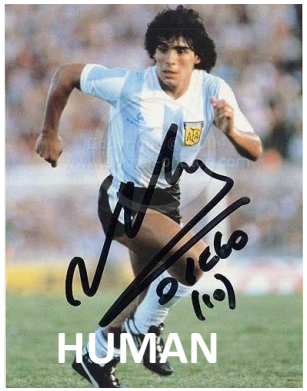
•CONTINENTS, SUB-CONTINENTS, COUNTRIES, STATES, CITIES, VILLAGES, ETC.

•OCEANS, SEAS, MOUNTAINS, HILLS, VALLEYS, DESERTS, RIVERS, LAKES, WATER-FALLS, FORESTS, ETC.

OUR BIOLOGICAL GLOBE







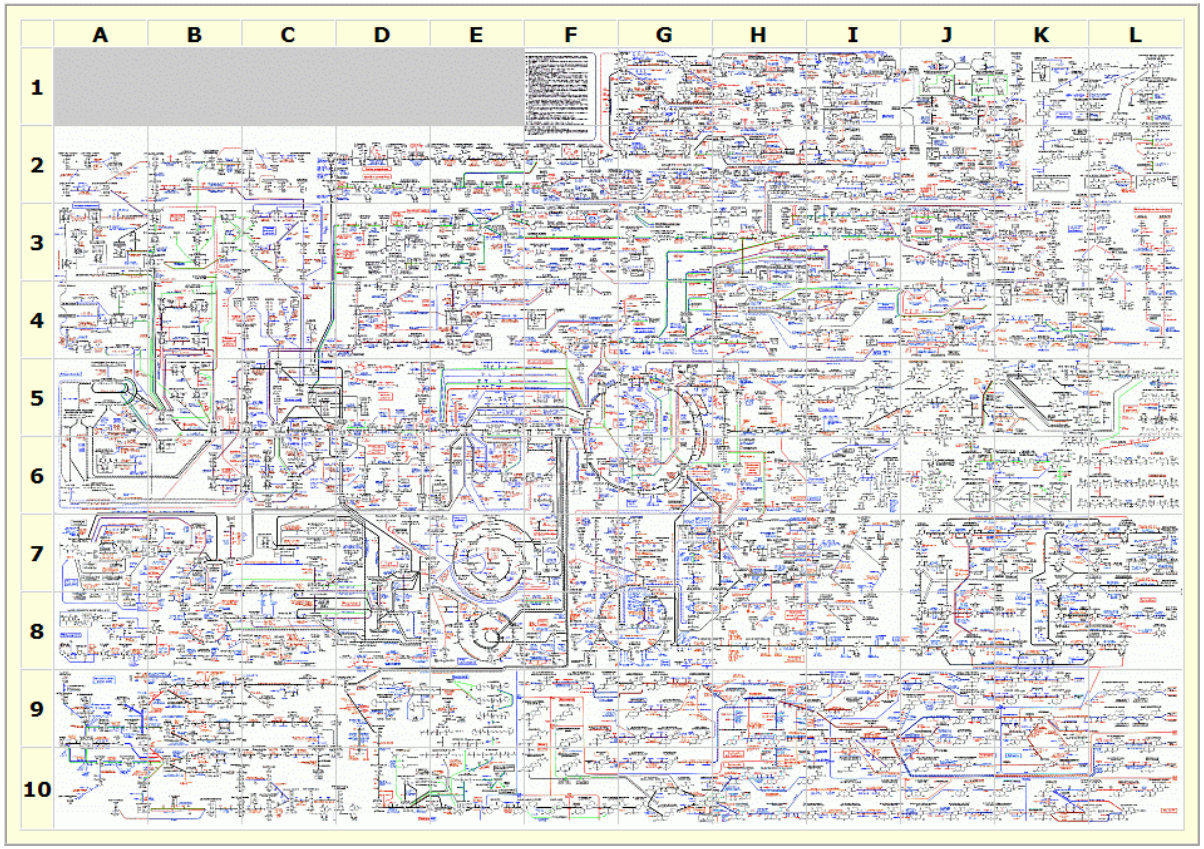
COMPONENTS OF OUR BIOLOGICAL GLOBE

OUR BIOLOGICAL GLOBE IS BASICALLY COMPOSED OF CERTAIN GROUPS (OF COURSE WITH A LARGE NUMBER OF SUB-TYPED DIVERSITIES) OF COMPOUNDS ONLY….. WHICH ARE CALLED

*******BIOMOLECULES*******

- NUCLEIC ACIDS
- PROTEINS
- LIPIDS
- CARBOHYDRATES
- HORMONES
- VITAMINS
- OTHERS……

OUR METABOLIC GLOBE



A brief recap of Enzymology

➢**Life is an intricate meshwork involving a perfect coordination of a vast majority of chemical reactions. Some of these reactions result in synthesizing large molecules; others in cleaving large molecules and still others either utilize energy or liberate energy. All these reactions occur very slowly at the low temperatures and the atmospheric pressures – the conditions under which living cells carry on their life processes. Yet in the living cells these reactions proceed at extremely high rates. This is due to the presence of some catalysts produced and synthesized inside the cells. The term " Enzyme" was first used by Frederick W. Kuhne (1878) to designate these biological catalysts.**

➢**The name 'enzyme' [*en*^{G} = in ; *zyme*^{G} = yeast] initially means 'in yeast'. This was referred to denote one of the most noteworthy reactions wherein the production of ethanol and CO_2 through the agency of an enzyme *Zymase*, present in yeast takes place.**

- In the year **1926**, **James Summer** first isolated and crystallized *Urease*, which provided a breakthrough in early enzyme studies, and he found that *Urease* crystals consisted entirely of protein.

- In **1930s**, **J.B.S. Haldane** wrote a treatise entitled "Enzymes". Haldane suggested that weak-bonding interactions between an enzyme and its substrate(s) might be used to distort the substrate and catalyze a reaction. This insight lies at the heart of our current understanding of enzymology.

- In the latter part of the **20th Century**, research on the enzymes of cellular metabolism has been intensive. It was led to purification and characterization of thousands of enzymes, elucidation of the structure and chemical mechanism of many of these, and a general understanding of how enzymes work.
- Virtually all enzymes are **proteins**, although some catalytically active **RNAs** (Ribozymes) have been identified.

Basic Features

- Enzymes are bio-catalysts
- Enzymes are bio-macro molecules
- The molecular weight of enzymes ranges from 12 kDa to 500 kDa or even more
- Metabolic Enzymes are principally made up of proteins
- The primary, secondary, tertiary and quaternary structures of proteins are essential to their catalytic activity
- Enzymes are synthesized within the cell and they are operative at the site of their synthesis
- Enzymes change the rate or velocity of a biochemical reaction without being used up themselves
- Enzymes are highly specific and their activity can be regulated
- For a biochemical reaction to proceed, the energy barrier needed to transform the substrate molecules into the transition state has to be overcome
- The transition state has the highest free energy in the reaction pathway. The difference in free energy between the substrate and the transition state is termed the Gibbs free energy of activation ($\Delta G^{\ddagger}$).
- An enzyme stabilizes the transition state and lowers $\Delta G^{\ddagger}$, thus increasing the rate at which the reaction occurs

The concept of ACTIVE SITE

- The active site is the region of the enzyme that binds the substrate, to form an enzyme-substrate complex, and forms it into product.

- The active site is a three-dimensional entity, often a cleft or crevice on the surface of the protein, in which the substrate is bound by multiple weak interactions

- The substrate specificity of an enzyme is determined by the properties and spatial arrangement of the amino acid residues forming the active site

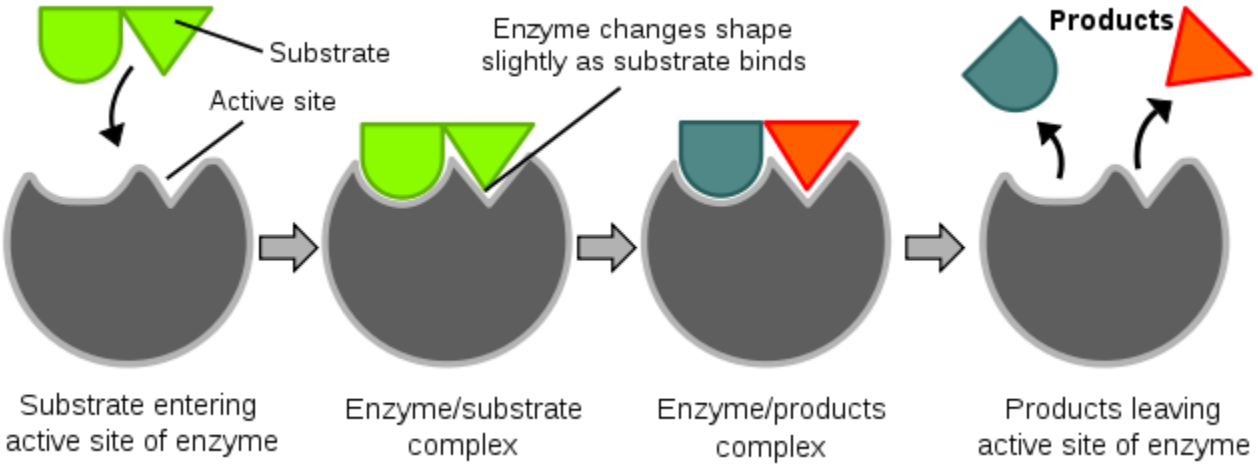
- The active centre is like a recess or pocket. The active centre of a conjugated enzyme includes cofactors. The number of active centers in oligomeric enzymes (those possessing a quaternary structure) may be equal to the number of subunits, i.e., one centre per subunit. Occasionally, two enzyme subunits can participate in the buildup of a functionally active centre.

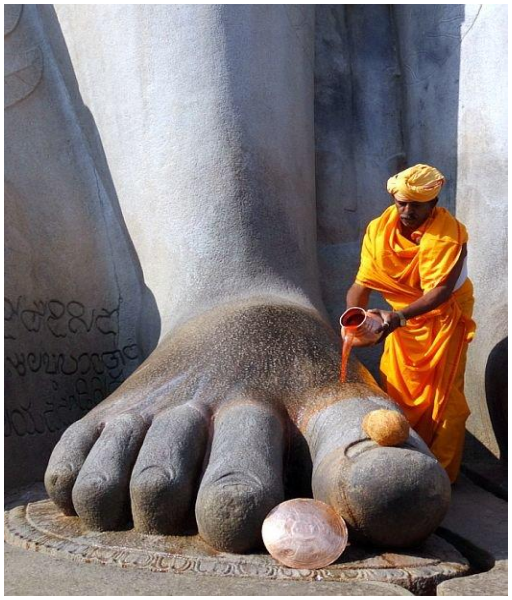
Structure of the Active centre:

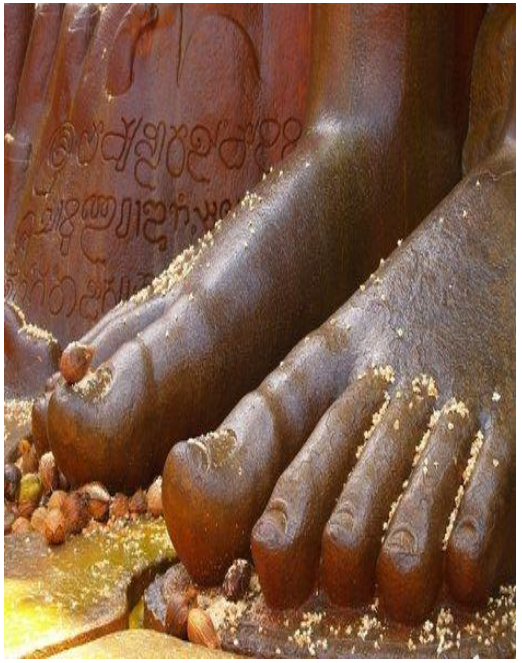
There are distinguished, in the active centre, a contact site (anchor site) for binding a substrate, and a catalytic site at which the conversion of the bound substrate takes place. However, this functional differentiation is somewhat arbitrary, since the binding of a substrate at the contact site does not leave unaffected the specificity and the rate of substrate conversion at the catalytic site.

Usually, the enzyme active centre is made up of 12 to 16 amino acid residues of a polypeptide chain; occasionally their number may be larger. The amino acids that constitute the active centre are located at various sites of the polypeptide chain, often at its opposite ends. When folded in space, they approach one another and form the active centre. The remaining amino acid residues of the enzyme polypeptide chain provide for an appropriate spatial configuration of the active centre and exert influence on the reactivity of its constituent groups.

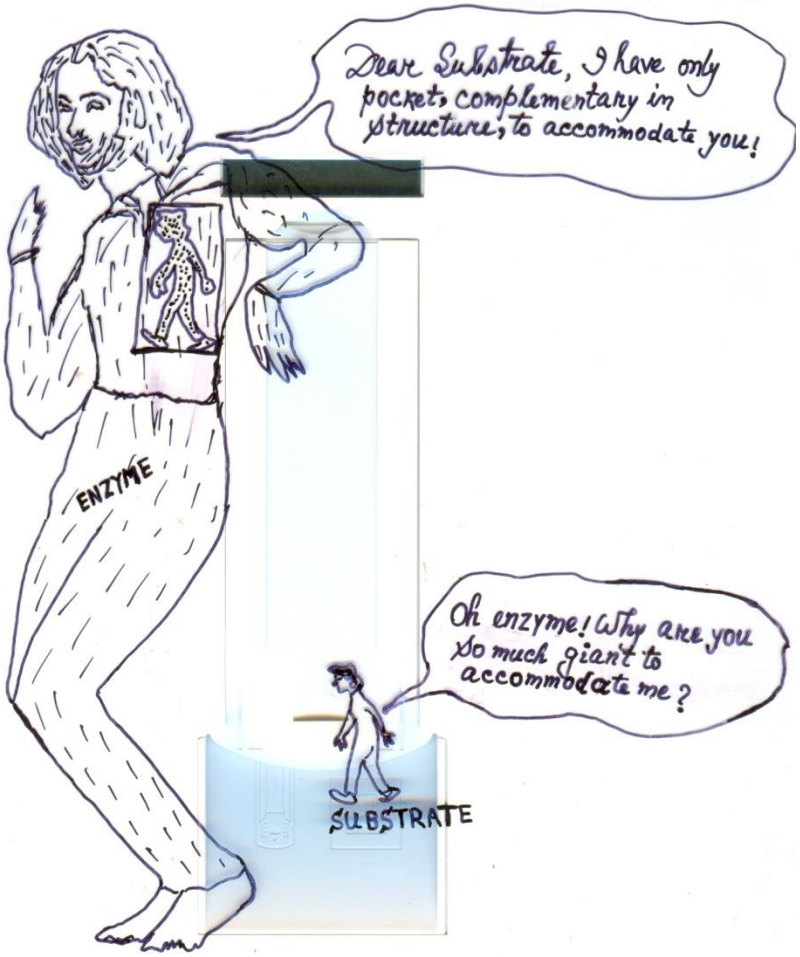
The amino groups found in a close proximity of the active centre and capable of influencing the reactivity of its functional groups are sometimes called accessory groups. Remote amino acid residues that exert a conformational influence on the enzyme molecule are called facilitating groups. About 1/2 to 2/3 of the total number of enzyme protein amino acids are engaged, directly or indirectly, in the functioning of the active centre.


Substrate
Active site
Enzyme changes shape slightly as substrate binds
Products
Substrate entering active site of enzyme
Enzyme/substrate complex
Enzyme/products complex
Products leaving active site of enzyme





CARTOON



[courtesy : Prof. A.G. Dutta]

Hence, the definition of enzyme can be coined:

A biomolecule, either protein or RNA, that catalyzes a specific biochemical reaction. It does not affect the equilibrium of the catalyzed reaction; it enhances the rate of a reaction by providing a reaction path with lower activation energy.

INTERNATIONAL UNION OF BIOCHEMISTRY AND MOLECULAR BIOLOGY

Recommendations on Biochemical & Organic Nomenclature, Symbols & Terminology etc.

http://www.chem.qmul.ac.uk/iubmb/

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If the table below is unusable check this button for an alternative presentation

To search the database click here .

What's Here and What's New	Changes to Published Documents for World Wide Web Presentation	Home page for IUBMB

Full text of IUBMB Nomenclature Committee Recommendations

Enzyme Nomenclature	**EC 1 Oxidoreductases**	**EC 2 Transferases**
EC 3 Hydrolases	**EC 4 Lyases**	**EC 5 Isomerases**
EC 6 Ligases	**Supplements**	**Proposed New Enzymes** New September 2012
Enzymes Kinetics	**Multiple Forms of Enzymes (Isoenzymes)**	**Multienzymes**
Nomenclature Nucleic Acid Sequences (incompletely specified bases)	**Junctions and Branchpoints in Nucleic Acids**	**Translation factors**
Membrane Transport Proteins	**Electron Transport Proteins Nomenclature**	**Peptide Hormone Nomenclature**
***myo*-Inositol**	**Biochemical Thermodynamics** revised version	Watch this space !

Full text of IUPAC IUBMB Joint Commission on Biochemical Nomenclature recommendations

Polymerised Amino Acids Nomenclature	**Nucleic Acid & Constituents Abbreviations and Symbols**	**Carbohydrate Nomenclature**
Nomenclature of Amino Acids and Peptides	**Conformations of Polynucleotide Chains**	**Conformation of Polysaccharide Chains**
Conformation of Polypeptide Chains	**Glycolipid Nomenclature**	**Cyclitol Nomenclature**

Glycopeptide, Glycoprotein & Peptidoglycan Nomenclature	**Lipid Nomenclature**	**Carotenoid Nomenclature**
Steroid Nomenclature	**Prenol Nomenclature** Terpenoid precursors	**Retinoid Nomenclature (Vitamin A)**
Vitamin D Nomenclature	**Corrinoid Nomenclature (Vitamin B-12)**	**Tocopherol Nomenclature (Vitamin E)**
Vitamin B-6 Nomenclature (Pyridoxal)	**Tetrapyrrole Nomenclature**	**Lignan Nomenclature**
Folic Acid Nomenclature	**Biochemical Phosphorus Compounds**	**Newsletter (1996, 1999, 2004 & 2009)**
Nomenclature of Quinones with Isoprenoid Chains	Watch this space !	

Bibliographic Data on Biochemical and other Nomenclature Recommendations		
IUPAC-IUBMB Biochemical Nomenclature	"Biochemical Nomenclature and Related Documents" 1992	Other IUPAC nomenclature recommendations
Glossary of Organic Class Names	**Basic Terminology of Stereochemistry**	**Glossary of Medicinal Chemistry Terms**
Bioinorganic glossary	**Gold Book - chemical glossary**	**Isotopic modification**
Natural product nomenclature	**Physical organic chemistry glossary**	**IUPAC Atomic Weights (2009 table)** **New element names December 2011**
Full Text of Other IUPAC Nomenclature Recommendations	Map of Usage Statistics (to January 2009)	Provisional IUPAC nomenclature recommendations

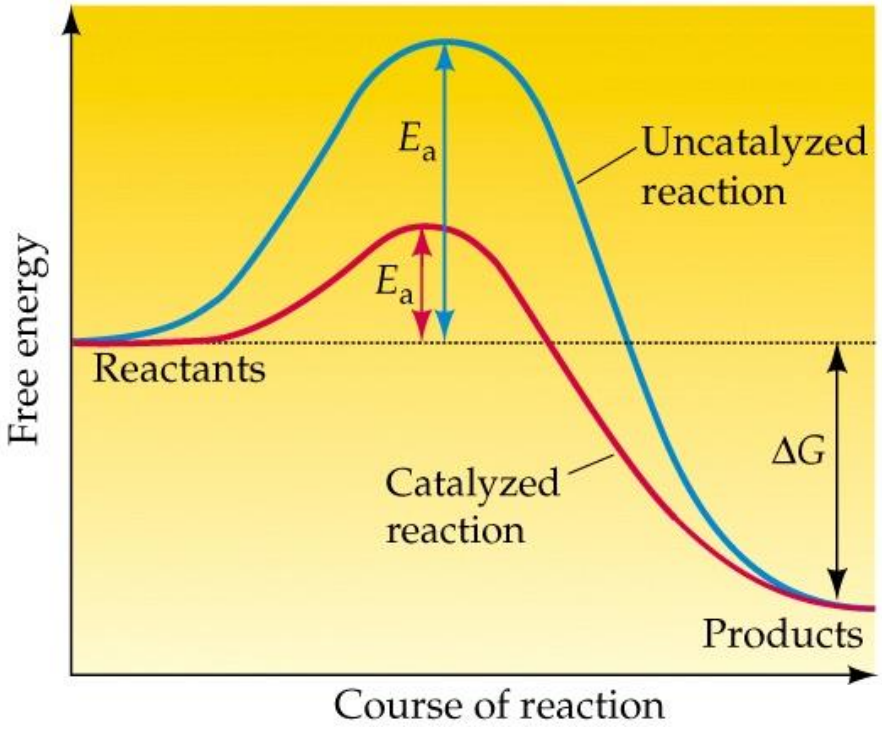
Most entries in the above table are hypertext linked to the full details. If these links are not active please consult the non-table form.

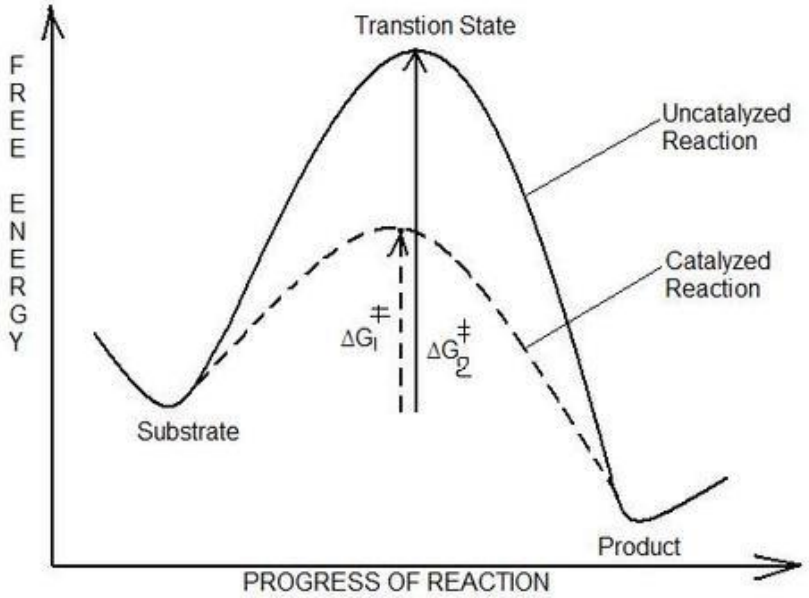
Last update 5 September 2012.

Change to IUPAC Nomenclature Home Page for chemical nomenclature.

Mechanism of enzyme reaction: The key concepts

- Enzymes affect reaction rates, not equilibria
- Reaction rates and equilibria have precise thermodynamic definitions
- A few principles explain the catalytic power and specificity of enzymes
- Weak interactions between enzyme and substrate are optimized in the transition state
- Enzymes use binding energy to provide reaction specificity and catalysis
- Specific catalytic groups contribute to catalysis
- Enzyme kinetics as an approach to understanding mechanism


Free energy
E_a
E_a
Uncatalyzed reaction
Reactants
ΔG
Catalyzed reaction
Products
Course of reaction


Transtion State
FREE ENERGY
Uncatalyzed Reaction
Catalyzed Reaction
$\Delta G_1^{\ddagger}$
$\Delta G_2^{\ddagger}$
Substrate
Product
PROGRESS OF REACTION