BIOMOLECULES

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Chemicals or molecules present in the living organisms are known as **Biomolecules**

The sum total of different types of biomolecules, compounds and ions present in a cell is called as **cellular pool**

Biomolecules are compounds of **carbon**.
Hence the chemistry of living organisms is organized around carbon

Carbon is the most versatile and the most predominant element of life.

ELEMENT	Non living (Earth crust)	Living Matter
Hydrogen	0.14	0.5
Carbon	0.03	18.5
Oxygen	46.6	65.0
Nitrogen	Very less	3.3
Sulphur	0.03	0.3
Sodium	2.8	0.2
Calcium	3.6	1.5
Magnesium	2.1	0.1
Silicon	27.7	Very less

BIOMOLECULES

Micro molecules

Small sized, low mol wt
Between 18 and 800 daltons
Found in the acid soluble pool

- Minerals
- Gases
- Water
- Sugars
- Amino acids
- nucleotides

Macromolecules

Large sized, high mol wt
Above 10000 daltons
Found in the acid insoluble pool

- Carbohydrates
- Lipids
- Proteins
- Nucleic acids

The major complex biomolecules of cells

Biomolecule	Building block	Major functions
Protein	Amino acid	Basic structure and function of cell
DNA	Deoxyribonucleotide	Hereditary information
RNA	Ribonucleotide	Protein synthesis
Polysaccharide	Monosaccharide	Storage form of energy
Lipids	Fatty acids & glycerol	Storage form of energy to meet long term demands

CARBOHYDRATES

Carbohydrates are the most abundant organic molecules in nature.

The term carbohydrate is derived from the French term *hydrate de carbone* i.e. it is a hydrate of carbon or $C_n(H_2O)_n$

Carbohydrates are defined as organic substances having C, H & O Wherein H and O are in the ratio 2:1 as found in H_2O

FUNCTIONS OF CARBOHYDRATES

- Most abundant **source of energy** (4 cal/g)
- **Precursors** for many organic compounds **(fats, amino acids)**
- Present **as glycoproteins and glycolipids** in the **cell memebrane** and functions such as cell growth and fertilization
- Present as structural components like **cellulose in plants**, **exoskeleton** of some insects, **cell wall** of microorganisms
- **Storage form of energy** (glycogen) to meet the energy demands of the body.

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CARBOHYDRATES

MONOSACCHARIDES

Basic units of carbohydrates
Cannot be hydrolysed into smaller units

a. Based on the no. of C-atoms
a. Based on the type of functional group

OLIGOSACCHARIDES

They can be further hydrolysed

a. Disaccharides
b. Trisachharides
c. Tetrasachharides

POLYSACCHARIDES

Non crystalline, non soluble in water, tasteless, on hydrolysis gives mol of monosaccharides
e.g. starch , cellulose

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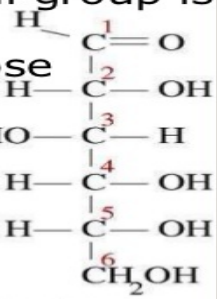
MONOSACCHARIDES

Based on the no of C-atoms

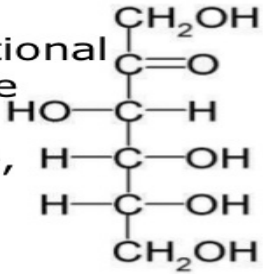
- **Trioses** ($C_3H_6O_3$)
  e.g. Glyceraldehyde, Dihydroxyacetone
- **Tetroses** ($C_4H_8O_4$)
  e.g. Erythrose, Threose
- **Pentoses** ($C_5H_{10}O_5$)
  e.g. Ribulose, Xylose Arabinose
  (*deoxyribose* – $C_5H_{10}O_4$)
- **Hexoses** ($C_6H_{12}O_6$)
  e.g. glucose, fructose galactose, mannose
- **Heptoses** ($C_7H_{14}O_7$)
  e.g. sedoheptulose glucoheptose

Based on the functional group

- **Aldoses** : the functional group is Aldehyde –CHO
  e.g. Glyceraldehyde, glucose



- **Ketoses** : the functional group is ketone (C = O)
  e.g. Dihydroxyacetone, fructose



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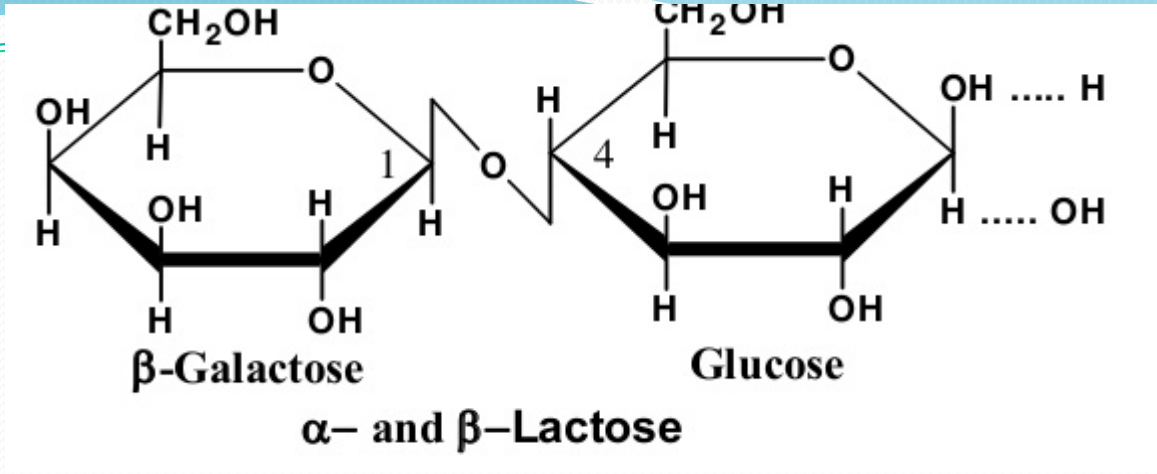
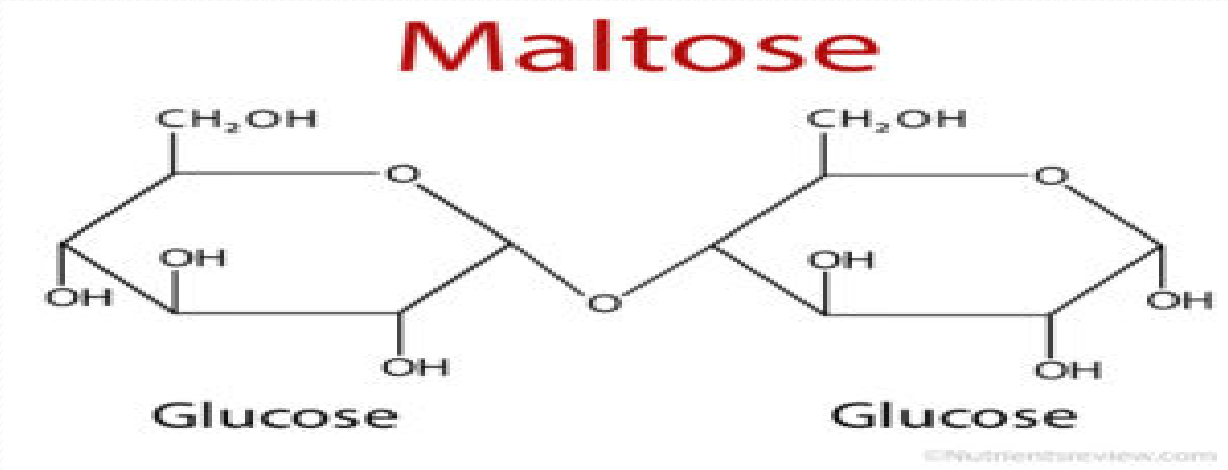


α– and β–Lactose



POLYSACCHARIDES

- Also called as GLYCANS
- Made up of repeating units of monsaccharides held by glycosidic bonds
- During its formation a water molecule is released at each condensation

This helps reduce the bulk making it almost insoluble decreasing its effect on the water potential or osmotic potential of the cell

- Unlike sugars they are not sweet.
- They are ideal as STORAGE AND AS STRUCTURAL COMPONENTS
- They are of 2 types **Homoglycans** and **Heteroglycans**.

HOMOGLYCANS

-Made up of only 1 type of monosaccharide monomers
-For eg **starch, glycogen, cellulose**
-Glucan (made up of glucose)
-Fructan(made up of fructose)
-Galactan (made up of galactose)

HETEROGLYCANS

-Made up condensation of2 or more types of monosaccharides
- For eg **Hyaluronic acid, agar, Chitin, peptidoglycans** etc

STORAGE POLYSACCHARIDES

STARCH

1. **Carbohydrate reserve of plants** and the most important dietary source for animals
2. High content of starch in cereals, roots, tubers, vegetables etc.
3. Homopolymer made up of **GLUCOSE** units. Also called as **GLUCAN**.
4. Starch = Amylose + Amylopectin (polysaccharide components)

GLYCOGEN

1. Carbohydrate reserve in animals. Hence referred as **animal starch**
2. High concentration in Liver, muscles and brain.
3. Also found in plants that do not have chlorophyll (yeast and fungi)
4. **GLUCOSE** is the repeating unit.

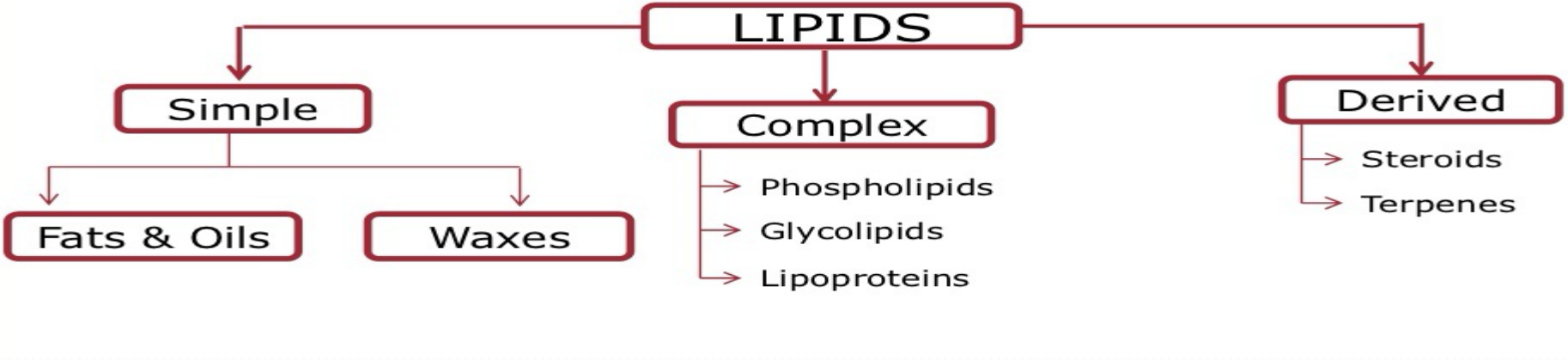
STRUCTURAL POLYSACCHARIDES

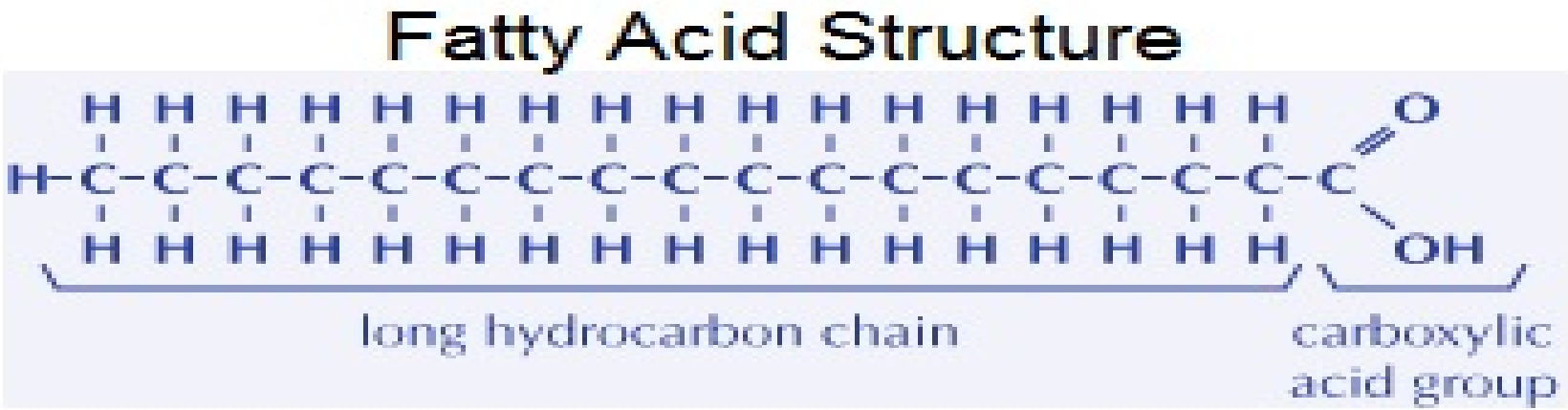
CELLULOSE

1. Occurs exclusively in plants and is the **most abundant organic substance** in plant kingdom.
2. Predominant constituent of plant cell wall.
3. **It is totally absent in animals.**

CHITIN

1. **Second most abundant** organic substance.
2. Complex carbohydrate of **Heteropolysaccharide** type.
3. Found in the exoskeletons of some invertebrates like insects and crustaceans. Provides both strength and elasticity.
4. Becomes hard when impregnated with calcium carbonate.


LIPIDS
Simple
Fats & Oils
Waxes
Complex
Phospholipids
Glycolipids
Lipoproteins
Derived
Steroids
Terpenes


Fatty Acid Structure
long hydrocarbon chain
carboxylic acid group

SIMPLE LIPIDS

They are esters of fatty acids with alcohol. They are of 2 types :

1. Neutral or true fats : Esters of fatty acids with glycerol
2. Waxes : Esters of fatty acids with alcohol other than glycerol.

Neutral / True fats

True fats are made up of C, H, & O but O is less
A fat molecule is made up of 2 components :
a) GLYCEROL
b) FATTY ACIDS (1-3 mol, of same or diff long chained)

WAXES

Lipids which are long chain saturated fatty acids and a long chain Saturated alcohol of high mol wt other than glycerol

Example :

1. **Bees wax :** secretion of abdominal glands of worker honey bees
2. **Lanolin or wool fat :** Secretion of cutaneous glands and obtained from the wool of sheep
3. **Sebum :** secretion of sebaceous glands of skin
4. **Cerumen :** soft and brownish waxy secretion of the glands in the external auditory canal. Also called as Earwax
5. **Plant wax :** Coating formed on the plant organs to prevent transpiration
6. **Paraffin wax :** A translucent waxy substance obtained from petroleum

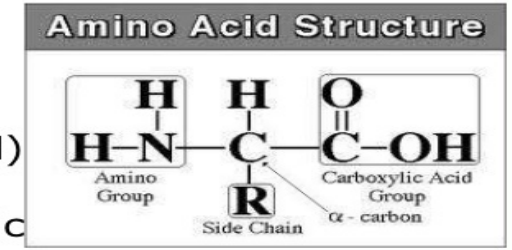
PROTEINS

- Most abundant organic molecules of the living system.
- They form about 50% of the dry weight of the cell.
- They are most important for the architecture and functioning of the cell.

Proteins are polymers of amino acids

- Proteins on complete hydrolysis yields Amino Acids
- There are 20 standard amino acids which are repeatedly found in the structure of proteins – animal, plant or microbial.
- Collagen is the most abundant animal protein and Rubisco is the most abundant plant protein
- Protein Synthesis is controlled by DNA.

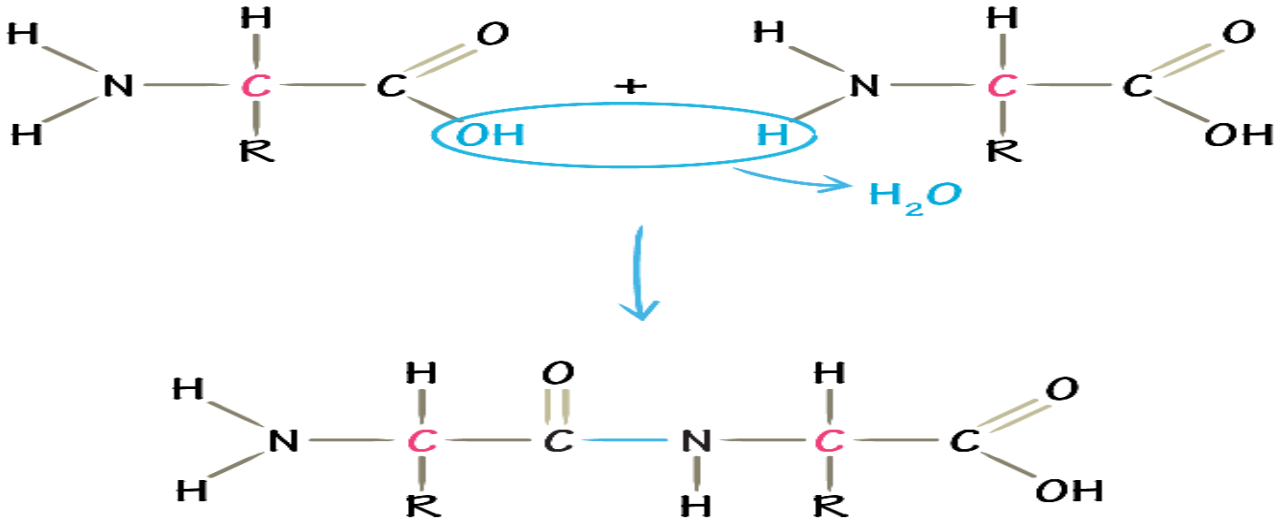
AMINO ACIDS

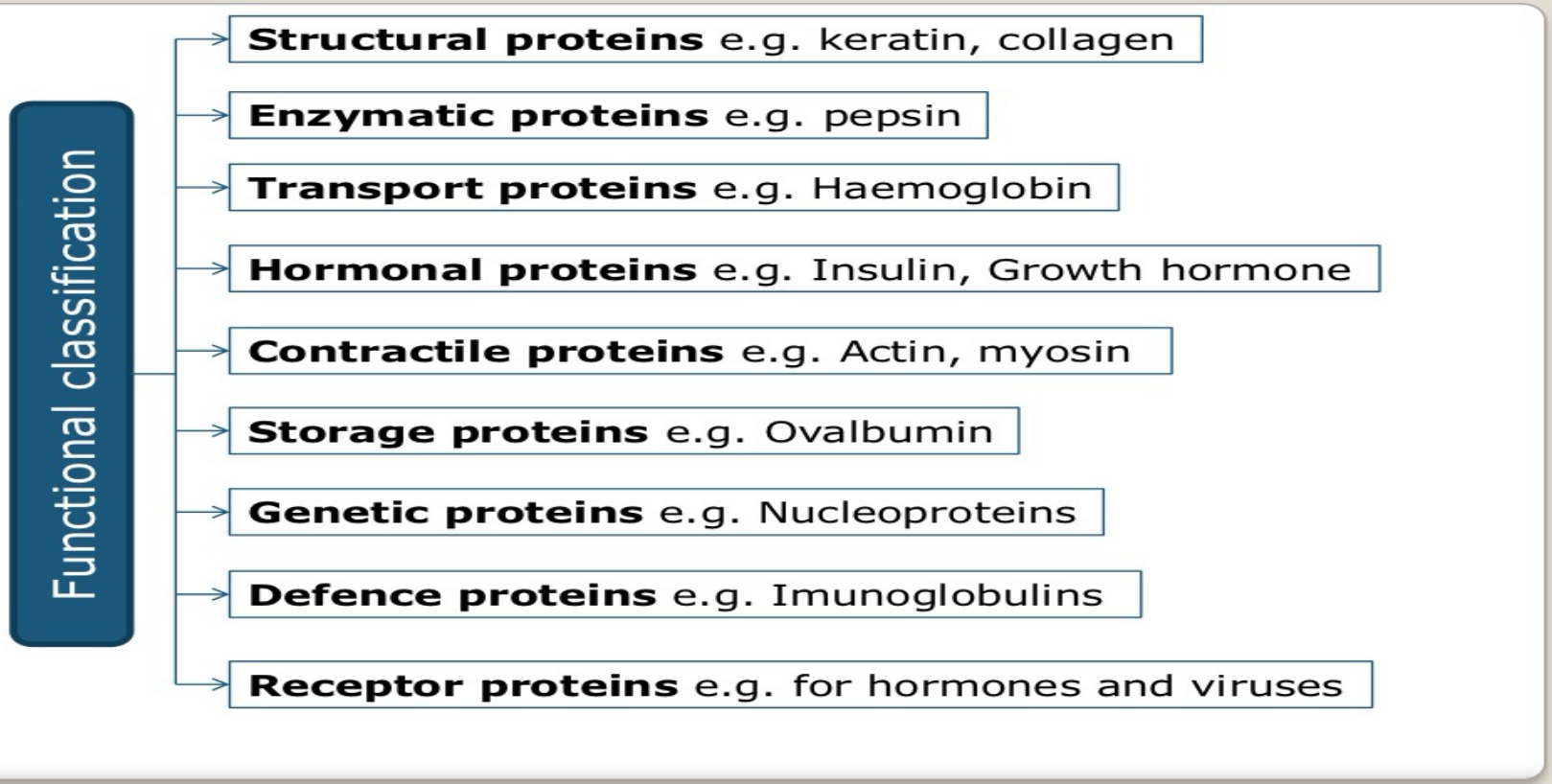


- Amino acids are group of organic compounds having 2 functional groups ($-NH_2$) and (-COOH)
- ($-NH_2$) group is basic whereas (-COOH) is acidic
- R- can be H in *glycine*, CH_3 in *alanine*, Hydroxymethyl in *serine* in others it can be hydrocarbon chain or a cyclic group
- All amino acids contain C, H, O and N but some of them additionally contain S
- Physical and chemical properties of amino acids are due to amino, carboxyl and R functional groups
- Amino acids are differentiated into 7 groups

No.	Nature	Amino acids
1.	**NEUTRAL** : Amino acids with 1 amino and 1 carboxyl group	Glycine (Gly), Alanine (Ala), Valine (Val), Leucine (Leu), Isoleucine (Ile)
2.	**ACIDIC** : 1 extra carboxyl group	Aspartic acid (Asp), Asparagine (Asn), Glutamic acid (Glu), Glutamine (Gln)
3.	**BASIC :** 1 extra amino group	Arginine (Arg), Lysine (Lys)
4.	**S – CONTAINING :** Amino acids have sulphur	Cysteine (Cys), Methionine (Met)
5.	**ALCOHOLIC** : Amino acids having –OH group	Serine (Ser), Threonine (Thr), Tyrosine (Tyr)
6.	**AROMATIC** : Amino acids having cyclic structure	Phenylalanine (Phe), Tryptophan (try)
7.	**HETEROCYCLIC** : amino acids having N in ring structure	Histidine (His), Proline (Pro)

Peptide Bond Formation




Functional classification
Structural proteins e.g. keratin, collagen
Enzymatic proteins e.g. pepsin
Transport proteins e.g. Haemoglobin
Hormonal proteins e.g. Insulin, Growth hormone
Contractile proteins e.g. Actin, myosin
Storage proteins e.g. Ovalbumin
Genetic proteins e.g. Nucleoproteins
Defence proteins e.g. Imunoglobulins
Receptor proteins e.g. for hormones and viruses

Enzymes are a group of catalysts functioning in a biological system

They are usually proteinaceous substances produced by the living cell Without themselves getting affected.

Enzymes enhance the rate of reaction and are formed in the cell under the instructions of genes

ENZYMOLOGY is the branch of science that deals with the study of Enzymes in all the aspects like nomenclature, reactions and functions

Enzymes occur in colloidal state and are often produced in inactive form called **proenzymes (zymogen),** which are converted to their active forms by specific factors like pH, substrate etc.

The enzymes that are produced **within** a cell for metabolic activities are known as **endoenzymes** and those which act **away** from the site of synthesis are called **exo-enzymes**

GENERAL PROPERTIES OF ENZYME AND FACTORS AFFECTING THEIR ACTIVITY

1) Enzymes **accelerate** the reaction but do not initiate it.

2) Enzymes themselves do not participate in the reaction and remain **unchanged** at the end of the reaction. Enzymes, are therefore, needed in **small amounts**.

3) The molecule of an enzyme is **larger** than that of substrate molecule and hence during reaction a specific **part** of enzyme molecule comes in contact with the substrate molecule. That part is called **active site** of enzyme.

4) **Amphoteric nature:** Chemically most of the enzymes are proteins and, therefore, show amphoteric nature. The enzymes can react with **acidic** substances as well as **alkaline** substances.

5) **Specificity:** Most of the enzymes are specific in their action. A single enzyme acts upon a **single** substrate or a group of closely related substrates.

For example, the enzyme urease can act only upon urea invertase can act upon sucrose only

A slight change in the configuration of the substrate molecule requires action by a different enzyme.

6) **Colloidal nature:** All enzymes are colloidal in nature and thus provide **large surface area** for reaction to take place. Colloids (colloids- gel like) are mixtures of two components i.e. dispersed particles and dispersion medium. The size of the dispersed particles is larger than dispersion medium.

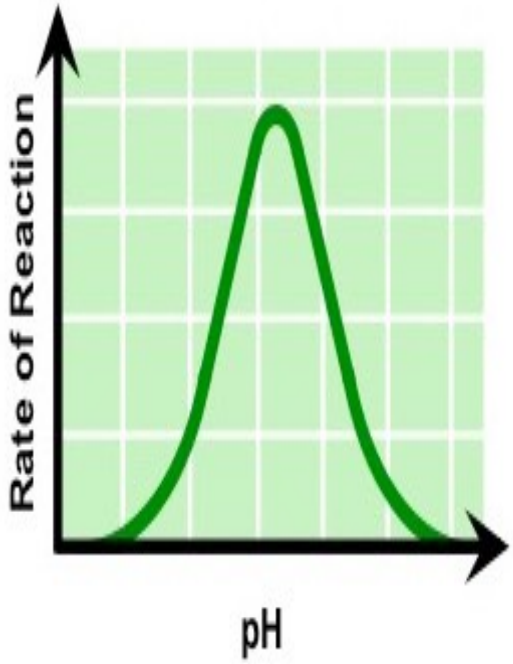
7) **Enzyme optima :** Enzymes generally work best under certain **narrowly defined conditions** referred to as optima. These include appropriate temperature and PH.

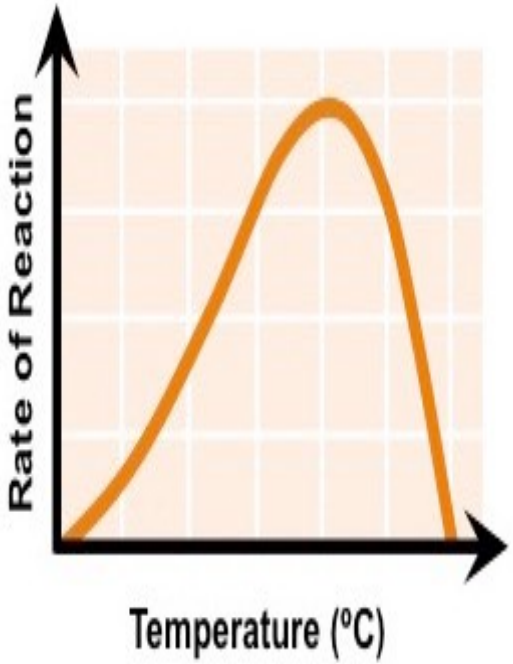
a) **Temperature sensitivity :** Since the enzymes are proteins, they are affected by change in temperature. With increase in temperature, **increase** in enzyme activity takes place (up to 40 C). However, when temperature increases **above 60 C** the proteins undergo **denaturation** or even complete **breakdown**. When the temperature is reduced to **freezing point** or below freezing point the enzymes become **inactivated** but they are not destroyed. The rate of reaction is more at optimum temperature.

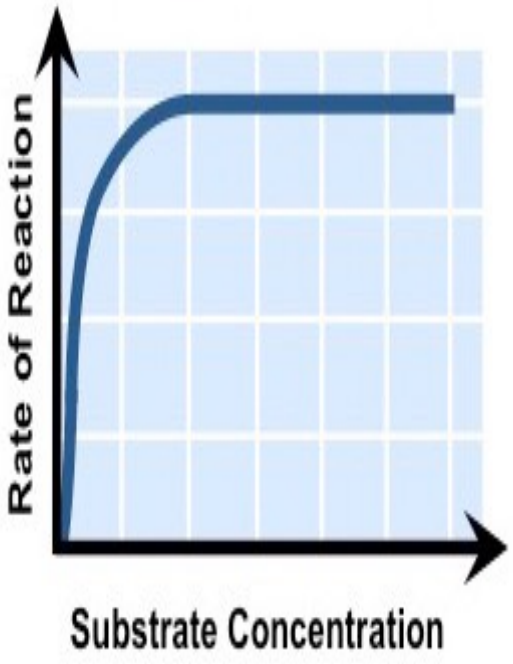
b) **pH sensitivity :** Most of the enzymes are **specific** to **pH** and remain active within particular range of pH. The strong acid or strong base denatures enzymes. Most of the intracellular enzymes function best around **neutral pH**

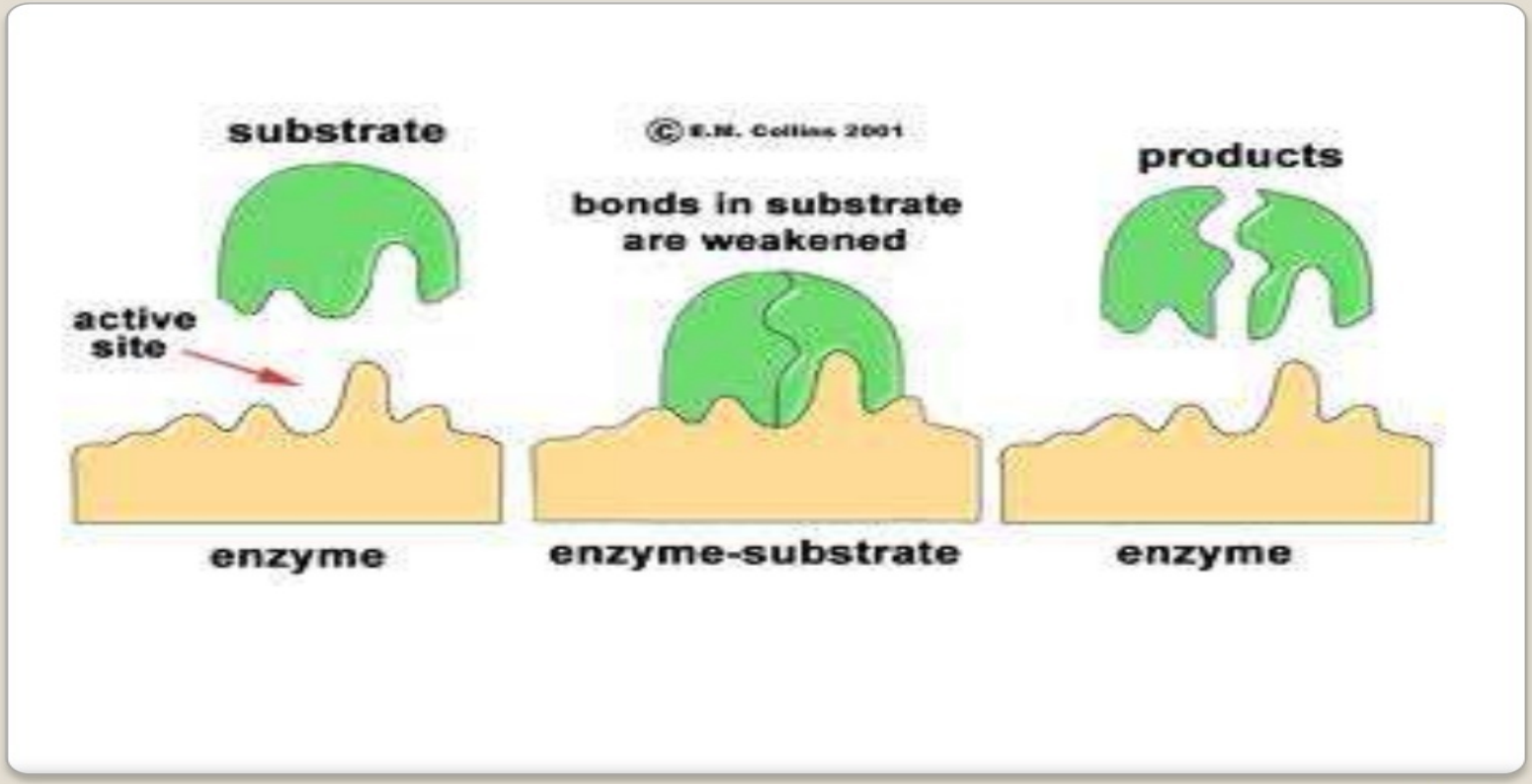
8) Concentration of enzyme and substrate : The rate of reaction is proportionate to the concentration of the reacting molecules. If the **substrate concentration** is increased the rate of **enzyme action** also increases up to certain limit. Beyond a certain concentration, the enzyme molecules remain saturated with substrate molecules and the activity becomes steady.

9) Enzyme inhibitors : Enzyme inhibitors are certain products which inhibit enzyme activity. During the reaction, if the **active site** of enzyme is occupied by these **inhibitors** instead of substrate molecules and the **activity** of enzyme is **lost**. These substances are like substrate molecules in their **structure** and are called **competitive inhibitors**.


Rate of Reaction
pH


Rate of Reaction
Temperature (°C)


Rate of Reaction
Substrate Concentration


substrate
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products
bonds in substrate
are weakened
active
site
enzyme
enzyme-substrate
enzyme

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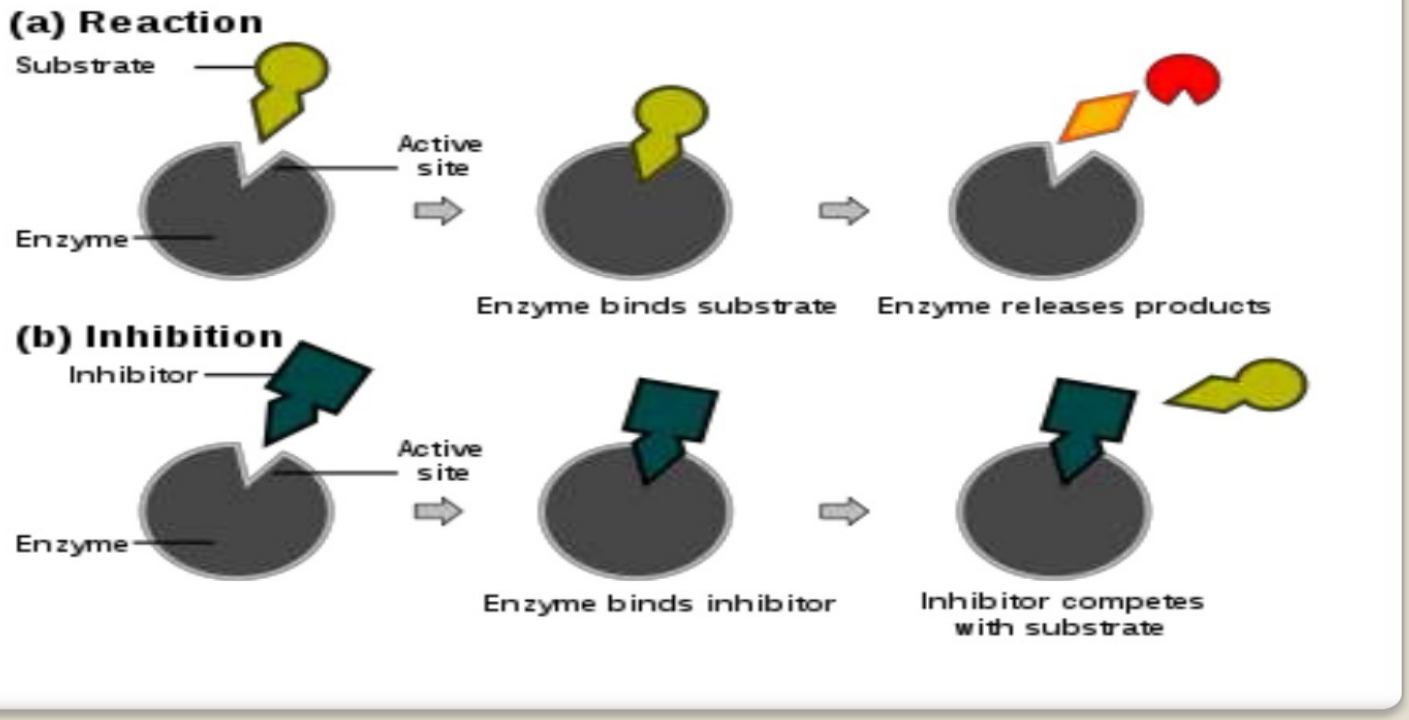
(a) Reaction
Substrate
Active site
Enzyme
Enzyme binds substrate
Enzyme releases products
(b) Inhibition
Inhibitor
Active site
Enzyme
Enzyme binds inhibitor
Inhibitor competes with substrate

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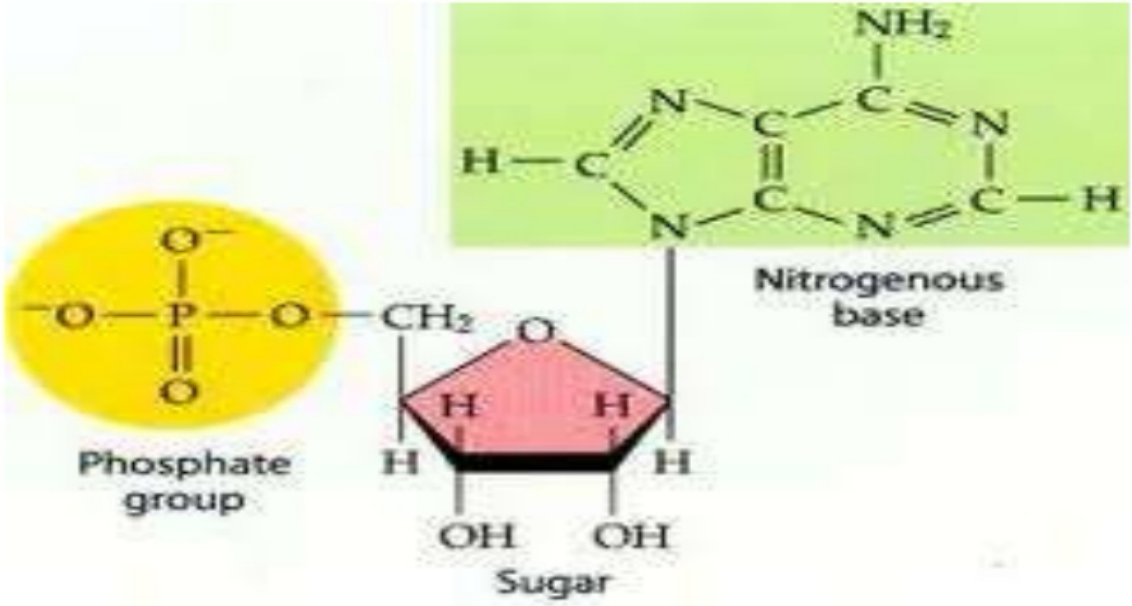
NUCLEOTIDES



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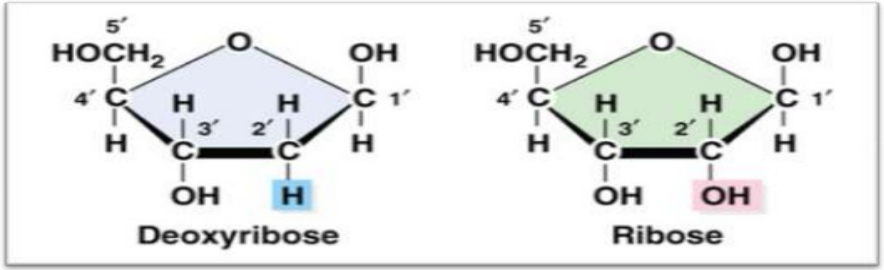
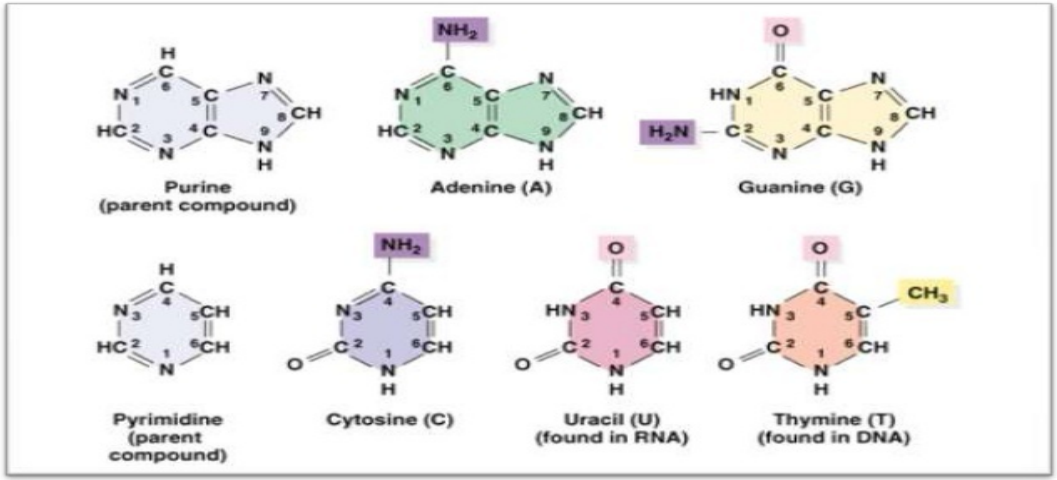


SUGAR

N2 BASES



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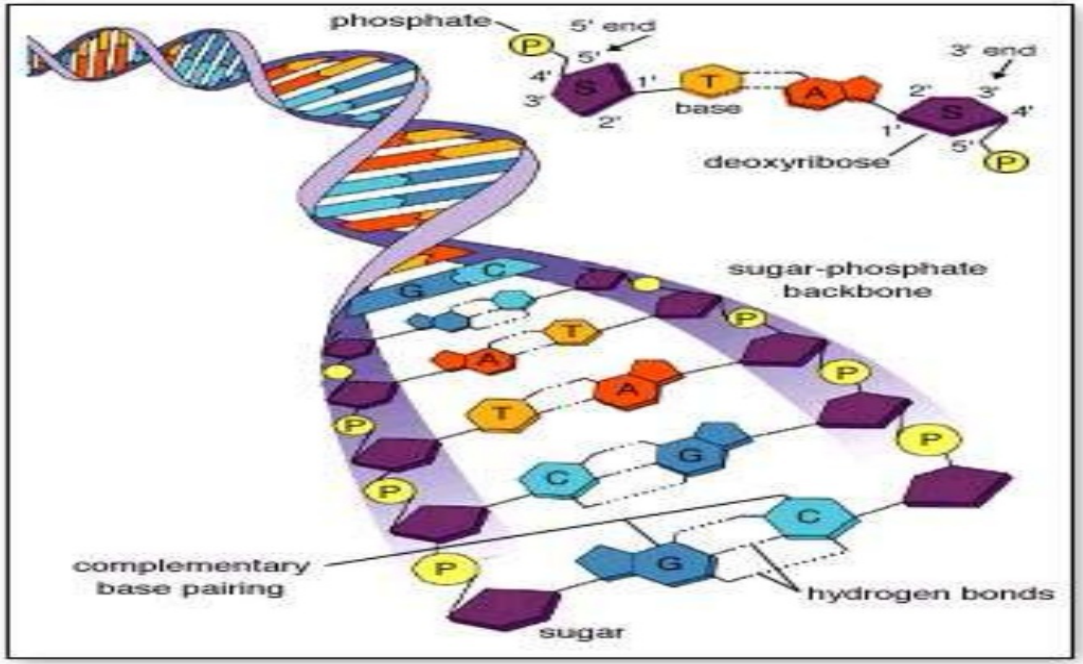
phosphate
5' end
3' end
base
deoxyribose
sugar-phosphate backbone
complementary base pairing
hydrogen bonds
sugar

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References:-

Google Images

NCERT Text Book

KVS, NVS

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