Biochemistry

UNIT-I

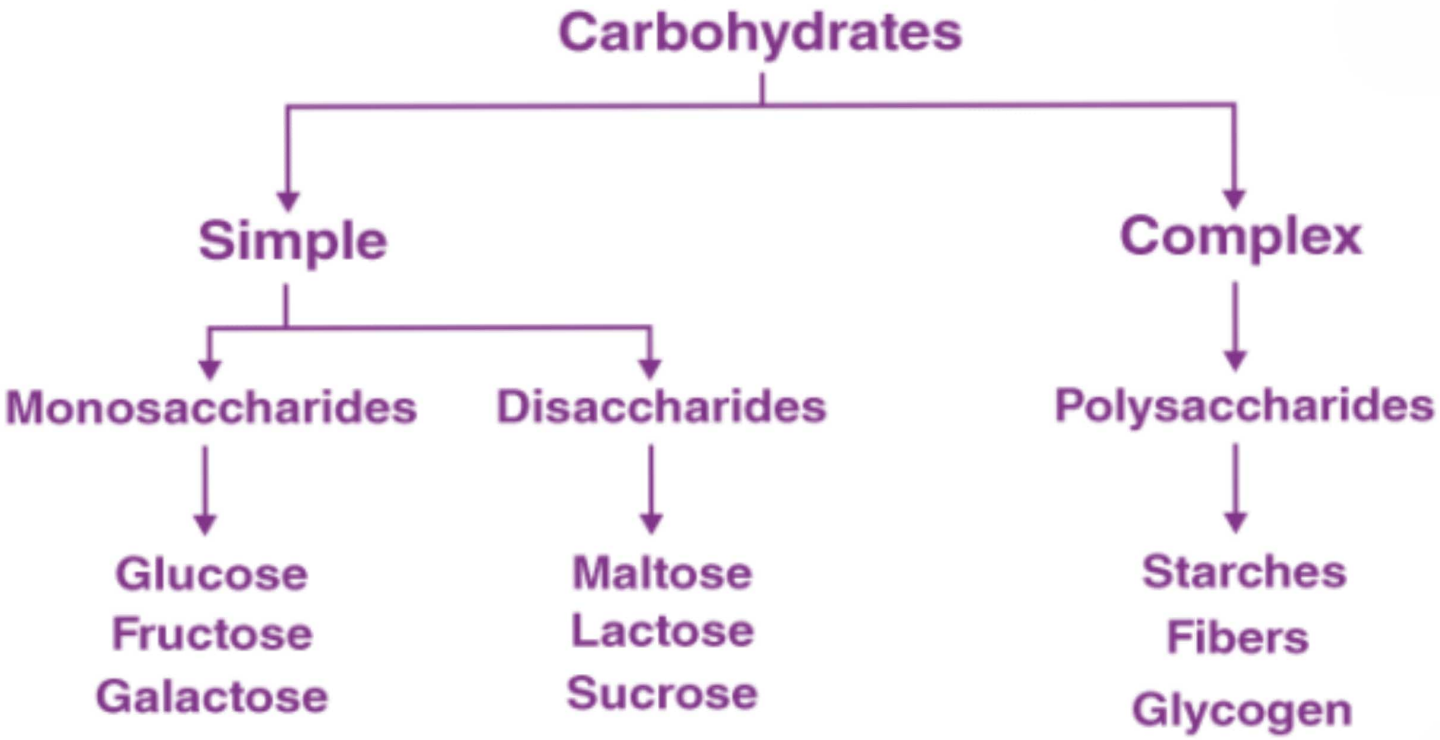
☆ Biomolecules :-

① CARBOHYDRATES :-

- Carbohydrate are most important organic molecule in nature.
- Carbohydrates are polyhydroxyaldehyde or ketone composed of Carbon, hydrogen and oxygen which produce them on hydrolysis.
- They are participating in cellular function and serve as the storage form of energy.
- Emperical formula is $(C_n(H_2O)_n$, where, n = number of Carbon atom

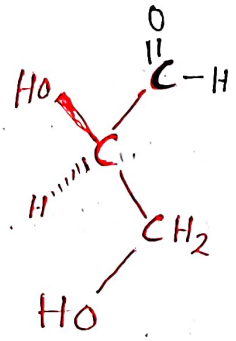
  Ex:- Glucose ($C_6H_{12}O_6$)

Classification of Carbohydrate :-

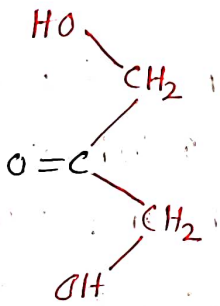


Chemical Nature of Carbohydrates :-

- Carbohydrates (Saccharide - Sugar) are polyhydroxy alcohol with a aldehyde or keto functional group.



D-Glyceraldehyde
(an aldose)



Dihydroxyacetone
(a ketose)

- Empirical formula is $(CH_2O)n$; Some also contain nitrogen, phosphorus, or sulfur.

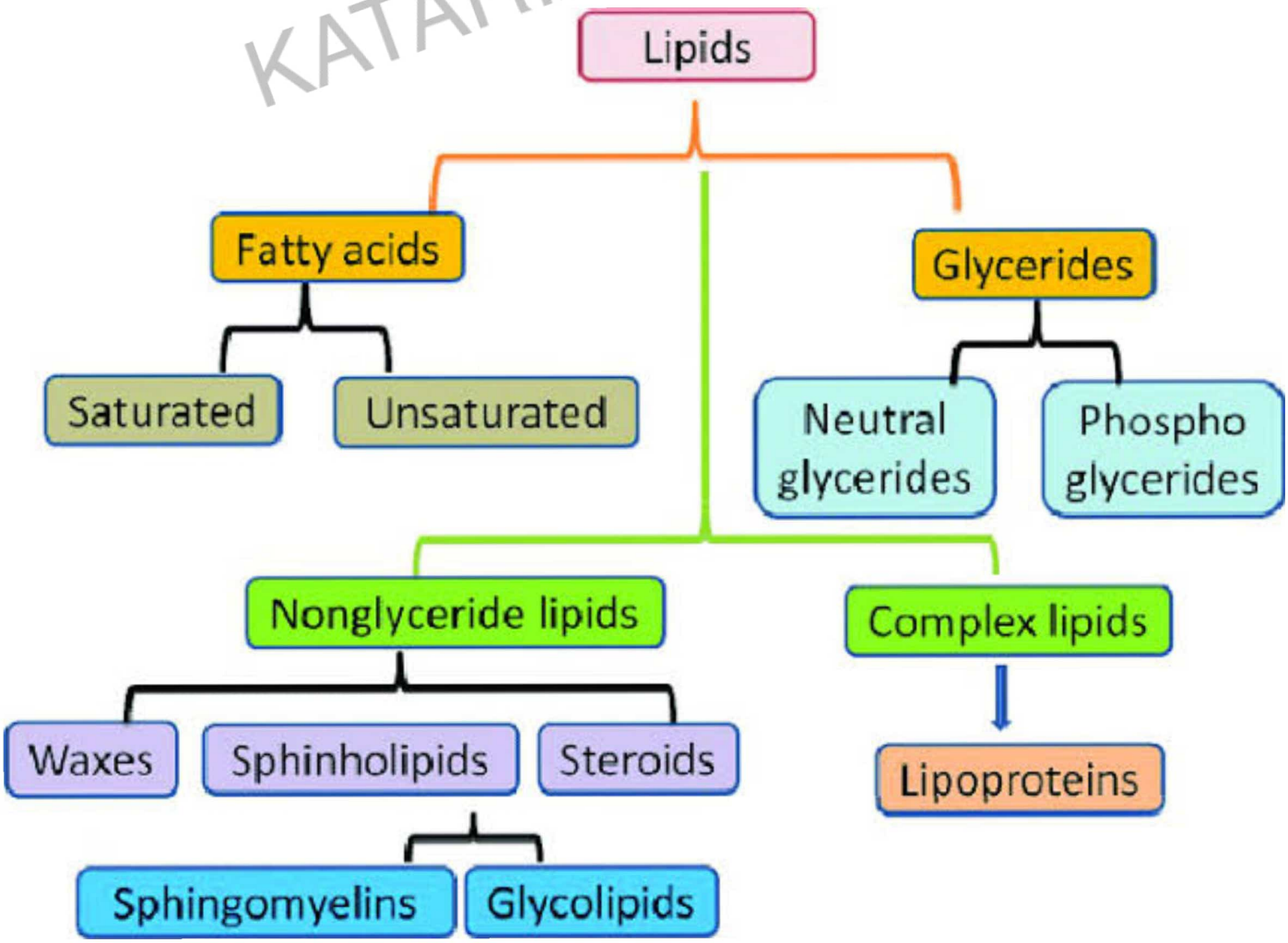
Biological Role of Carbohydrates :-

1. Carbohydrates Serve as an important Source as well as a Store of energy.
2. Carbohydrates are important starting Material for many organic Compounds like Aminoacids, nucleic acid and lipids.
3. Carbohydrates are the first Storage form of energy, in the form of glycogen to Compensate for immediate energy demand of body.
4. Carbohydrates are an important raw Material for the production of product like glucose, Maltose, enzymes, acids etc.
5. Carbohydrates are important Constituents of the Cell Structure in the form of glycolipid, glycoproteins, heparin, Cellulose, Starch etc.

② Lipids :-

- Lipids (hydrophobic or amphiphillic Small organic Molecule) relatively insoluble in water and Soluble in organic Solvent.
- Lipids include fat, wax, sterol, they are Source of energy.
- They are ester of fatty acid with alchol ester and utilize by living organism, they are Simplex form of lipid.
- They are structural Component of cell Membrane.

Classification of lipids :-



Chemical nature of lipids :-

- Lipids are the Complex Compounds.
- These are made up of C, H and O_2 but poor in O_2 Content.
- Lipids are fatty esters of glycerols.
- Lipids = Fatty acid + glycerols.

Biological Role of lipids :-

1. Lipids function as the Medium and Source of fat Soluble Vit.
2. Phospholipids and Sterols Make up about half the mass of the biological membrane and regulate membrane permeability.
3. other lipids, although in Small amounts, play an important role as enzyme Cofactors light absorbing pigment, electron Centers emulsifying agent and hydrophobic anchors.
4. Lipids play an important role of Cellular Messenger as well as that of Cellular Metabolite regulator.
5. Lipid function as the Insulators of internal organs of the body.

(3) Nucleic Acid :-

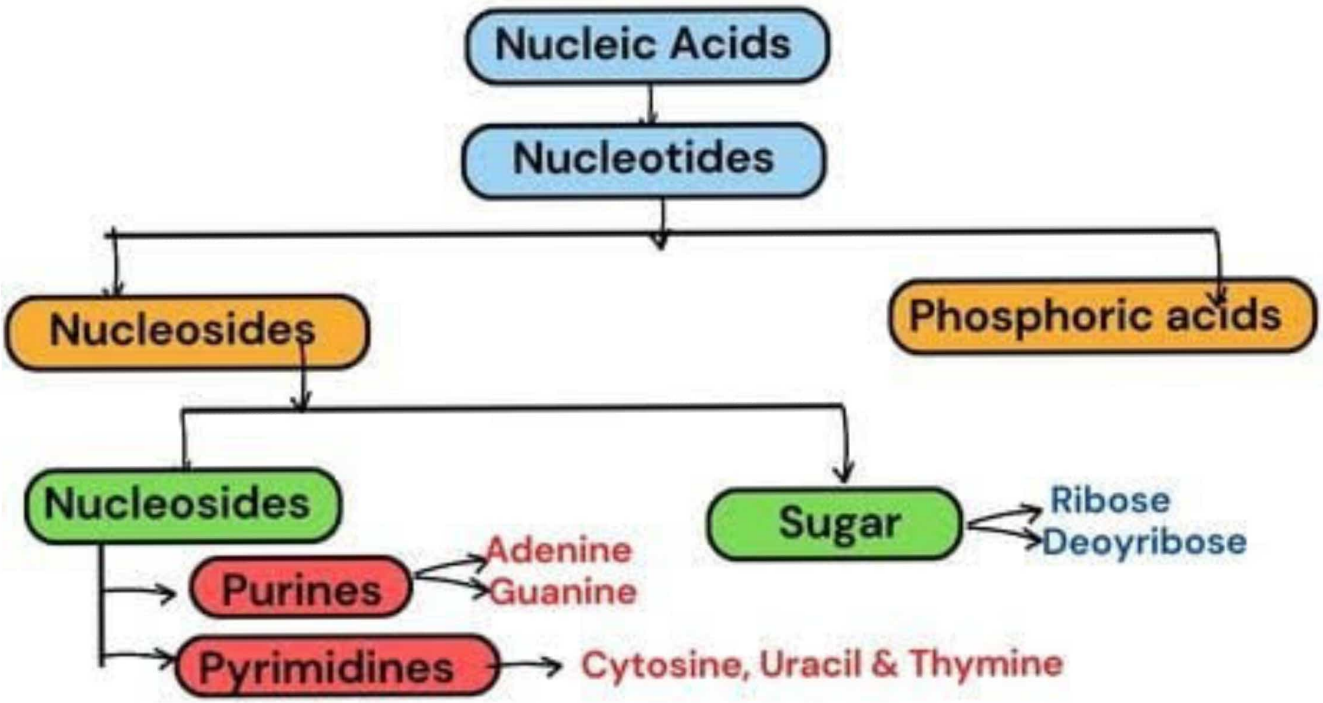
- Nucleic acid Serves as a transmitters of genetic information.
- Two type of nucleic acid :
  1. DNA (Deoxyribonucleic acid)
  2. RNA (Ribonucleic acid)
- Nucleic acid are the polymer of necleotide held by 3' and 5' Phosphodiester bond.

*Nucleotides are Composed of

- Nitrogenous base (purine / pyrimidine)
- pentose Sugar (ribose / deoxyribose)
- phosphate group

Nucleotide ⟶ Base + Sugar + phosphate
(Base + Sugar = Nucleoside)

Classification of neucleic acid :-

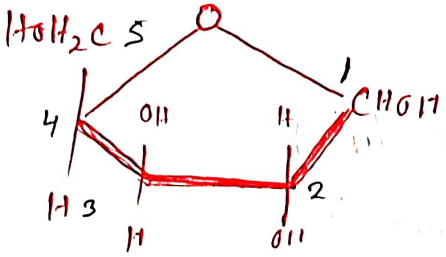


Chemical nature of Nucleic acid :-

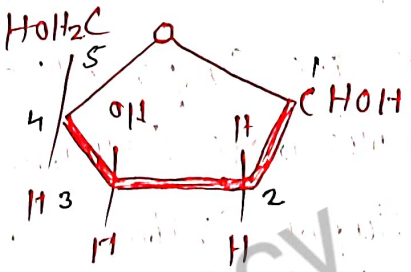
A nucleic acid Consists of three parts, namely pentose Sugar, phosphate group and hetero cyclic nitrogenous bases.

(i) pentose Sugar :-

Two Sugars, namely D-ribose and D-2-deoxyribose are Commonly associated with nucleic acids.



D-ribose

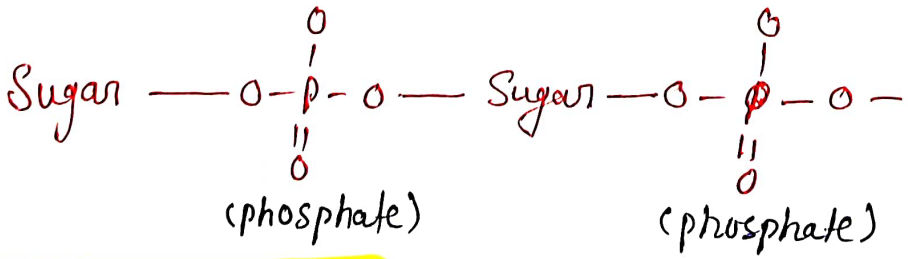


D-2-Deoxyribose

(ii) Phosphate Group :-

The backbone of a nucleic acid is made up of alternating Sugar and phosphate Molecule.

- The Sugar and phosphate Molecule are bonded together to form a long chain, as represented below.



(iii) Heterocyclic Nucleobase :-

- These are nitrogenous heterocyclic Compounds. Cytosin (C), Guanine (G), adenine (A) and Thymine (T) are present in DNA molecule. Whereas thymine is replaced by Uracil (U) in RNA Molecule.

Biological Role of DNA :-

1. In living beings it serves as a genetic Material and is responsible for the Characteristic features of living organism. Ex. Colour of the skin and eye, height, intelligence etc.
2. It Carries information Specific to an individual.

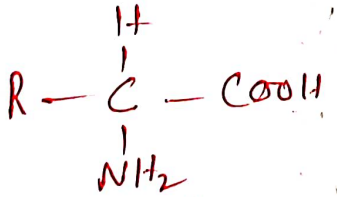
Biological Role of RNA :-

1. The mRNA is a direct Carrier of genetic information from the nucleus to the Cytoplasm.
2. The tRNA is a Carrier of amino acid to the Site of protein Synthesis.
3. The rRNA is required for the formation of Ribosomes.

(4) Amino acid :-

Amino acids are a group of organic Compounds Containing two functional groups. Carboxy (-COOH) and amino ($-NH_2$)

- In a amino acid, both groups are attached to the same Carbon atoms.



Classification of Amino acid :-

(A) Based on the chemical structure
(B) Based on the nutritional requirement
(C) Based on the metabolic fate

(A) Based on Chemical Structure:-

(i) Side Chain Containing Aliphatic Group:-

1. Glycine
2. Alanine
3. Valine
4. Leucine
5. Isoleucine

(ii) Side chain Containing Acidic group:-

1. Asparagine
2. Aspartic acid
3. Glutamine
4. Glutamic acid

(iii) Side Chain Containing basic group:-

1. Arginine
2. Lysine
3. Cystein
4. Methionine.

(B) Based on the Nutritional requirement:-

Essential AA	Non-Essential AA	Semi-Essential A.A
- Tryptophan	- Alanine	- Arginine
- Threonine	- Asparagine	- Histidine
- Histidine	- Aspartic	
- Arginine	- Glutamic	
- Lysine	- Cysteine	
- Leucine	- prolin	
- methionine	- Glutamine	
- Valine	- Glycine	
- isoLeusine	- serine	
	- Tyrosine	

(C) Based on Metabolic fate:-

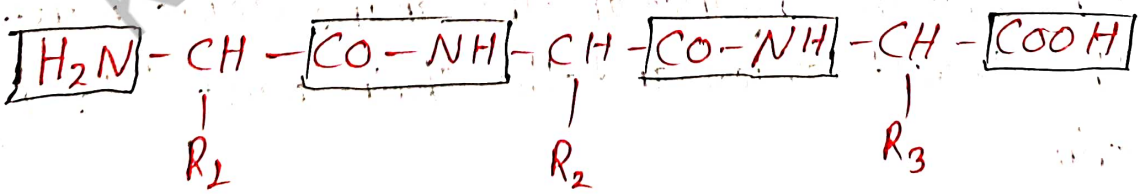
Ketogenic A.A
- Leucine
- Lysine

Glycogenic A.A
- Arginine
- Glutamate
- Histidine
- proline
- valine

Glycogenic & ketogenic AA
- Isoleucine
- Phenylalanine
- Tyrosine
- Tryptophan.

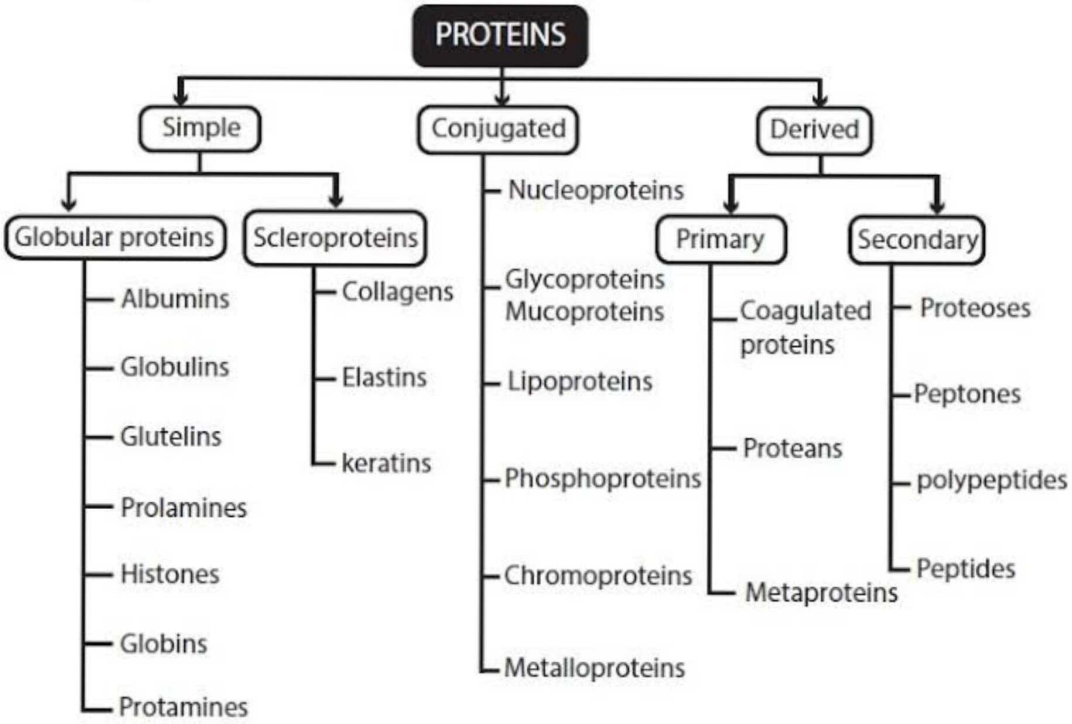
✡ Protein :-

- Proteins may be defined as high Molecular weight Mixed polymer of α-amino acid join by peptide bond.
- Protein are the most abundand organic Molecules of living System.
- Protein are essential Nutrients for Guiding block of body tissue.
- protein are acting as enzymes, hormones, blood Clotting factor etc.



Amino terminal Carboxy terminal

Classification of proteins :-



: Classification of Proteins based on chemical composition

Chemical nature of protein :-

- proteins are chains of amino acid joined by peptide bonds.
- Order of the A.A is determined by your DNA
- The sequence of amino acids in ~~ae~~ each protein determines its unique shape and function.
- For the protein to function the amino acids must be in the correct order and the chain must fold up properly.

Biological Role of protein :-

- Enzymes - biological Catalysts
- Antibodies - - defense proteins
- Transport proteins
- movement protein
- Nutrient protein etc.

☆ Bioenergetics :-

Bioenergetics is a part of biochemistry, dealing with the energy involved in Making and breaking of chemical bonds in the biological Molecule found in the living world.

- It is an active branch of biological research and includes study of different biological processes at cellular Level within a living organism

e.g. Cellular respiration, Metabolism processes etc.

☆ Concept of free Energy :-

- The Concept of free energy (G) is very useful in biochemistry.
- The practical measurement of free energy Content of a substance is not possible.
- If a chemical reaction Converts Substance A to B, then Change in free energy (ΔG) is observed.

Note :- The energy actually available to do work (utilizable) is known as free energy.

$$A \rightleftharpoons B \qquad \text{---------- (1)}$$

$$\Delta G = G_B - G_A \quad \text{or} \quad -\Delta G = G_B - G_A \qquad \text{---- (2)}$$

- If the free energy Change (ΔG) in the reaction is positive, the reaction involves an increase in free energy and occur spontaneously.

- The reactions which have negative ΔG are called as exergonic reactions and those that have positive ΔG are called as endergonic reactions.
- The free energy change in the following reaction can be studied using thermodynamic properties of reactant A and product B and can be expressed as:

$$\text{Reactant (A)} \rightleftharpoons \text{product (B)}$$

$$\Delta G = \Delta H - T\Delta S$$

where - ΔG = Free energy change
ΔH = Enthalpy change (change in heat content)
T = Absolute temperature at which reaction takes place
ΔS = Entropy change (

- In the standard state, when pH is 7, temperature is 25°C and the concentration of solute is 1 molar at 1 atmospheric pressure, the actual free ~~eng~~ energy change in the reaction can be calculated by the following equation.

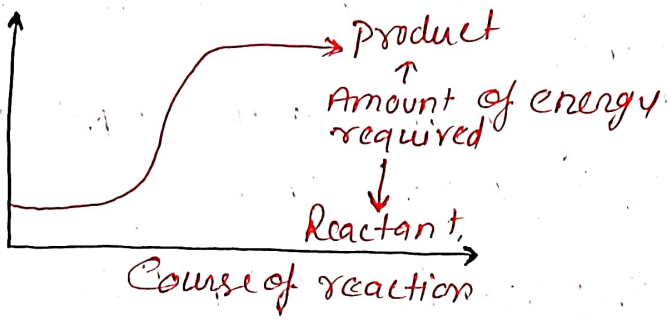
$$\Delta G = \Delta G^\circ + 'RT' \ln \frac{[\text{product}]}{[\text{Reactant}]}$$

Where - ΔG = free energy change
ΔG° = Standard free energy change
R = Gas constant (1.987×10^{-3} kcal $\times$ deg^{-1} $\times$ mol^{-1})
T = Temeperature (298°k)
In = Natural Logarithm (Can be converted to $\log_{10}$ multiply by 2.303)

ENDERGONIC REACTION :-

- An endergonic reaction is a chemical reaction in which the Standard Change in Free energy is positive, and energy is absorbed and it is thermodynamically non-favarable.

$$\Delta G^\circ > 0$$

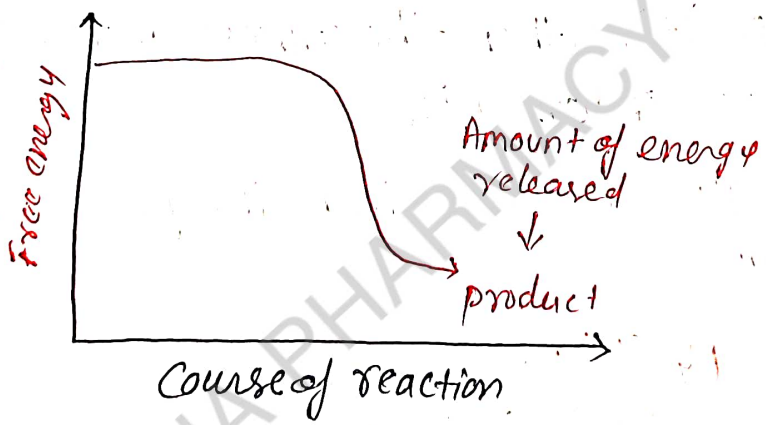


EXERGONIC REACTION :-

A exergonic reaction is a chemical reaction where the Change in the Gibbs free energy is negative, indicating a Spontaneous reaction. It means it is thermodynamically favarable.

$$\Delta G = G_{product} - G_{reactant} < 0$$

- Energy releasing



✱ Relationship blw free energy, enthalpy and entropy :-

→ Every living cell and organism must perform work to stay alive, to grow and to reproduce

→ 1st Law of Thermodynamics: The energy of the universe remains constant.

→ 2nd Law of Thermodynamics: All spontaneous processes increase the entropy of the universe.

— The important state functions for the study of biological system are:

① The Gibbs free Energy (G) –

Which is equal to the total amount of energy capable of doing work during a process at constant temperature and pressure.

- If ΔG is negative, then the process is spontaneous and termed exergonic.
- If ΔG is positive, then the process is nonspontaneous and termed endergonic.
- If ΔG is equal to zero, then the process has reached equilibrium.

② The Enthalpy (H) :-

Which is the heat content of the system. Enthalpy is the amount of heat energy transferred (heat absorbed or emitted) in a chemical process under constant pressure.

- When ΔH is negative the process produces heat and it termed exothermic.
- When ΔH is positive the process absorbs heat and it termed endothermic.

③ The Entropy (S) :-

- It is a quantitative expression of the degree of randomness or disorder of the system.
- Entropy measure the amount of heat dispersed or transferred during a chemical process.

- When ΔS is positive then the disorder of the system has increased.
- When ΔS is negative then the disorder of the System has decreased.

$$\Delta G = \Delta H - T\Delta S$$

[ΔG = Gibbs Free Energy ; ΔH = change in Enthalpy ; T = Temperature in k
ΔS = Change in Entropy]

★ Energy Rich Compounds :-

- High energy phosphates act as energy Currency of Cell.
- Three major Sources of high energy phosphates taking part in energy Capture.

1. Oxidative phosphorylation :-

- In Metabolic pathway, Cells ~~are~~ use enzymes to oxidize nutrients, thereby releasing energy which is used to produce
- A biological System obtains energy by the hydrolysis of Certain Compounds. The Compounds which possess sufficient free energy to release approximately 7 Cal/mol of energy at pH 7.0 are known as Energy Rich Compound.

- The hydrolysis of energy-rich Compounds (e.g. phosphoenol Pyruvate, 1,3-bisphosphoglycerate, phosphocreatine etc) release more energy than that of ATP.
- Often the high energy Compounds have a phosphate group (except acetyl CoA) and are termed as High-energy Phosphate Compound.

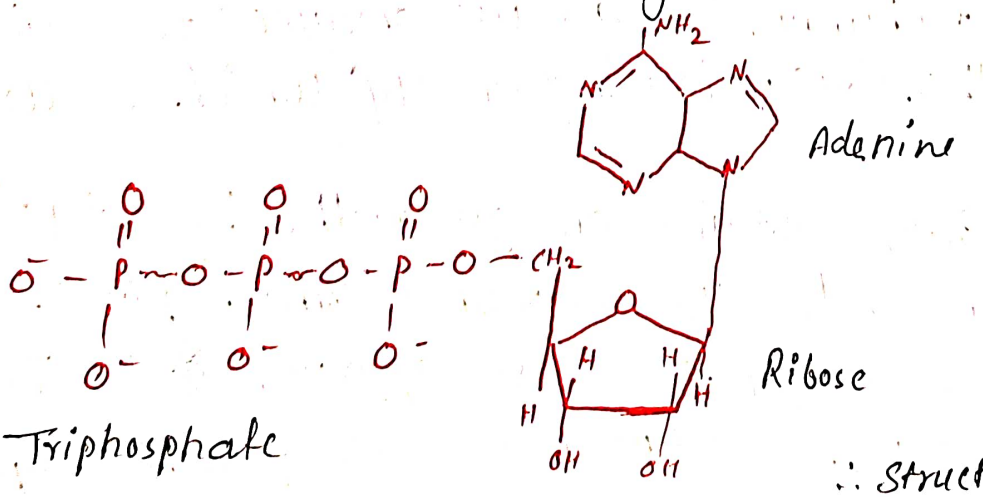
Classification :-

There are at least five groups of high-energy Compounds

1] Pyrophosphates, e.g. ATP
2] Acyl phosphates e.g. 1,3-bisphosphoglycerate
3] Enol Phosphates e.g. phosphoenolpyruvate
4] Thioesters e.g. acetyl CoA
5] Phosphagens e.g. phosphocreatine.

☆ Adenosine Triphosphate (ATP) :-

ATP is the most Common energy Source utilised for various biochemical reaction. It is a large Molecule and thus Cannot be Stored in cells in huge amount



∴ Structure of ATP

- ATP is a high-energy Compound as it has ~~two~~ two Phosphoanhydride bonds in the triphosphate unit. ATP functions as energy Currency for the Cell as Seen from the ATP-ADP Cycle.

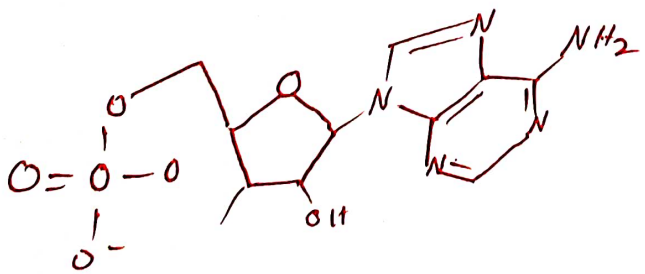
- Therefore, its Synthesis and Consumption occurs Simltaneosly. In the Cells energy is stored in form of Smallar Molecules (e.g glucose). These Molecules are Metabolised by various enzymes within a Cell and energy is liberated in the form of ATP along with Co_2 and H_2O as a by-product.

Biological Significance of ATP :-

① Metabolism, Synthesis and active transport
② Cell Structure and locomotion.
③ Cell Signalling — (i) Extracellular
(ii) Intracellular
④ Nucleic Acid Synthesis

✱ Cyclic Adenosine Monophosphate (cAMP) :-

- Cyclic Adenosine Monophosphate is an important Second messenger and is formed by activating adenylyl Cyclase (a membrane enzyme)



- Then the so formed Cyclic Amp activates Specific protein.
- Some ion channel are gated by Cyclic AMP, but an important protein activated by Cyclic AMP protein kinase A which Phosphorylated Some of the Cellular proteins.

Biological Significance :-

① Hormonal System - There are various hormones which alter the level of Cyclic Amp

② Lipolysis

③ Steroidogenesis

④ Cardiovascular System

⑤ Clinical implication.