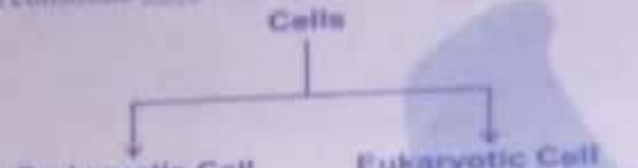
# CHAPTER NO. 2
# BIOLOGICAL MOLECULES
## KEY POINTS

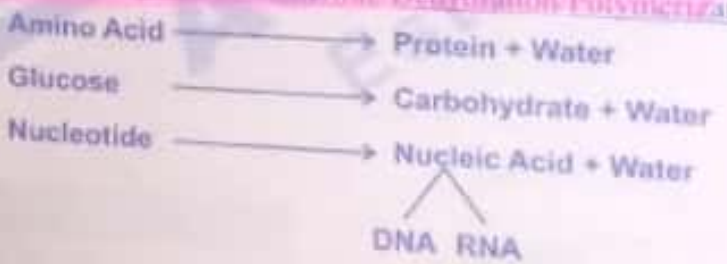
- The branch of chemistry in which we study about Bio-molecules or Biological molecules is called Bio-chem
- Those molecules which are present in the body of living organisms is called Bio-molecules or Biological molecules.
- Carbon, Hydrogen and Oxygen constitute 95% of body mass by biomass.




| Water | 70% | 70% | Same |
|---|---|---|---|
| Protein | 15% | 18% | High |
| Carbohydrate | 3% | 4% | High |
| Lipids | 2% | 3% | High |
| DNA | 1% | 0.25% | Less |
| RNA | 6% | 1.1% | Less |
| Enzyme + Hormone | 2% | 2% | Same |
| Salts + Minerals | 1% | 1% | Same |

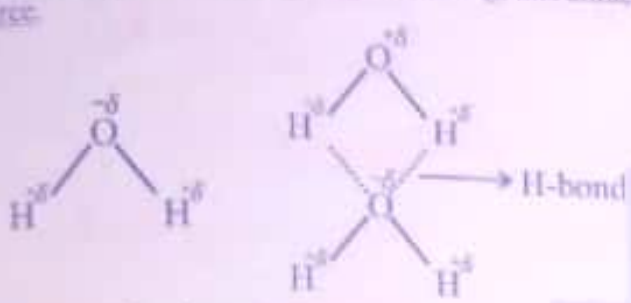
Tab 2.1: Cell Contents

- Water, enzyme + hormone and salts + minerals composition is same in both Prokaryotic and eukaryotic cell
- The concentration of protein lipids and carbohydrate in prokaryotic cells is less than eukaryotic cell.
- The concentration of DNA in prokaryotic cell is 1.
- The sum of all Bio-chemical reactions occurring in the body of living organisms is called Metabolism.
- Metabolism consists of two types; catabolism and anabolism.
- The process in which small and simple molecule combines together to form a large and complex molecule called Anabolism/Condensation/Endergonic/Endothermic/Dehydration/Polymerization.




- The bond between two Amino acid is called Peptide bond.
- The bond between two glucose molecules is called Glycosidic bond.
- The bond between fatty acid and glycerol is called Ester bond.
- The bond between nucleotides is called Phosphodiester.
- The process of formation of DNA from another DNA is called DNA replication.
- The process of formation of RNA (mRNA) from DNA is called Transcription.
- The process of formation of cDNA (complementary DNA) from mRNA (RNA) is called Reverse transcript

- The process of formation of both DNA and RNA is called Polymerization. The process in which large and complex molecule is converted into small and simple molecule is called Catabolism/Destructive process/Hydrolysis/Exothermic/Exergonic.
- Water is considered to be the universal solvent due to its Polarity.
- Polarity of water is due to difference in electronegativity.
- Water has high heat capacity due to hydrogen bond.
- Water molecules remain together due to hydrogen bonding, this attractive force between the molecules of water is called cohesive force.




- The force between water molecules and cell surface or container is called adhesion.
- The amount of heat to change the temperature of water by 1°C is called Heat capacity.
- The melting and boiling point of water is high due to Hydrogen bond
- The boiling point of water is 100°C and freezing point of water is 0°C.
- The boiling point of water is −80°C and freezing point is −100°C without hydrogen bond.
- Water is slightly ionizable due to hydrogen bond
- Water is most heavy at 4°C. Above and below 4°C water is light, such behavior of water is called Anomalous behavior or unusual behavior.
- Water show Capillary action in which it moves in xylem tissue due to cohesive and adhesive force.
- The force of attraction between two water molecules with walls of its container is called Adhesive force.
- Most abundant and common protein in nature is Rubisco.
- Most abundant chlorophyll in nature is Chlorophyll a.
- Most abundant organic compound in nature is cellulose (Carbohydrate).
- Most abundant organic compound in cell is protein.
- Most abundant compound in cell or in nature is water.
- Protoplasm cannot survive if its water content is reduced to low as 10%.
- Only polar and ionic compounds are soluble in water.
- The amount of heat added or subtracted from water to occur 1% change in its temperature is called Specific heat capacity.
- 1 out of 550 million molecules change into ions spontaneously.
- The organic compound consists of polyhydroxy aldehyde or polyhydroxy ketonic compound or yield such molecule is called Carbohydrate.
- Carbohydrate is also called hydrated carbon because it contains same ratio of hydrogen and oxygen as in Water.
- The formula of carbohydrate is $(CH_2O)_n$ where n is the number of Carbon. $C_6H_{12}O_6 \rightarrow n = 6$
- Carbohydrates provide energy to the body.
- Carbohydrate consists of monosaccharide, oligosaccharide and polysaccharides.
- Monosaccharide consists of 3 — 7 carbon atoms.
- Glucose and fructose are isomers with different structural formula.
- Glucose, Galactose and Mannose are considered to be isomers having same molecular formula but different arrangement of H and OH on asymmetric carbon.
- Glucose and Galactose have aldehyde as a functional group while Fructose have Ketone as a functional group, so these are isomers too.
- Oligo saccharide consists of 2-10 monosaccharide units.
- Most abundant oligo saccharide is Disaccharide.
- Fructose is the sweetest monosaccharide.

pes of Oligosaccharides:

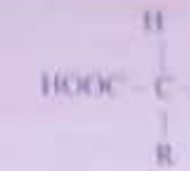
- 3- Carbon Atom ⟶ Triose
  - Glycer Aldehyde 3-Phosphate (Aldehyde)
  - Dihydroxy Acetone Phosphate (Ketone)
- 4- Carbon Atom ⟶ Tetrose ⟶ Erythrose
- 5- Carbon Atom ⟶ Pentose
  - Ribulose Biphosphate (Rubp) (Ketonic)
  - Ribose Sugar (RNA) (ALdehyde)
  - Deoxy Ribose Sugar (DNA) (Aldehyde)
- 6- Carbon Atom ⟶ Hexose
  - Glucose (Aldehyde)
  - Glactose (ALdehyde)
  - Fructose (Ketone)
- 7- Carbon Atom ⟶ Heptose
  - Monoheptolose
  - Pseudoheptolose

| | |
|---|---|
| Monosaccharide → Disaccharide | 6 Monosaccharide → Hexa Disaccharide |
| Monosaccharide → Tri Disaccharide | 7 Monosaccharide → Hepta Disaccharide |
| Monosaccharide → Tetra Disaccharide | 8 Monosaccharide → Octa Disaccharide |
| Monosaccharide → Penta Disaccharide | 9 Monosaccharide → Nona Disaccharide |
| 10 Monosaccharide → | Deca Disaccharide |

Tab 2.2: Types of Disaccharide

Glucose + Glucose → Maltose
Glucose + Galactose → Lactose
Glucose + Fructose → Sucrose
Grapes contain 25% of glucose.
100ml of blood contains 100 mg of glucose.
Cellulose, Chitin, Starch and Glycogen are the examples of polysaccharide.
Cellulose is present in the cell wall of plant cell.
Chitin is present in the cell wall of fungi and is present in the exoskeleton of Arthropods.
Plant stores food in the form of starch.
Animal stores food in the form of glycogen.
Glycogen always exists in branched form while starch exists in branched (Amylopectin) and unbranched (Amylose) form.
Monosaccharide is soluble in water and sweet in taste.
Polysaccharide is tasteless and is insoluble in water.
Polysaccharide when linked with Amino group is called Chitin.

- Human body cannot digest left handed (L-handed) sugar, while can digest and absorb right handed sugar and L-handed amino acid but in nature most of the sugar and amino acid is left handed except Bacterial cell wall where right handed amino acid and sugar is present.
- Total number of amino acids in nature is 20.
- Amino acids are variable from one another due to Alkyl group (R).



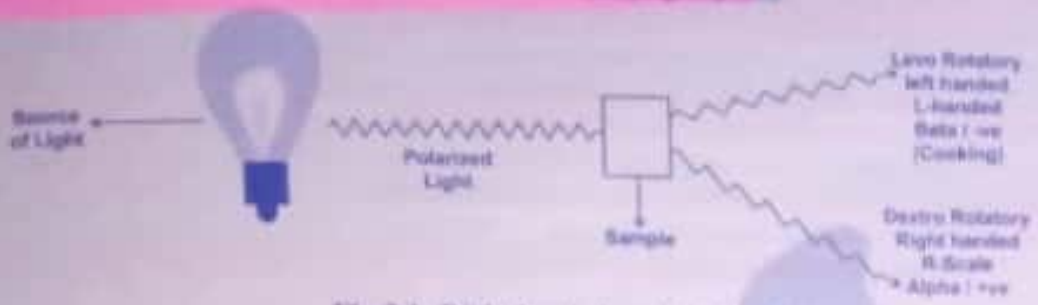




**Fig 2.1:** Right-handed and Left-handed sugar

- Amino acid, having negative charge is called
  ***N_ve GA = Glutamate + Aspartate***
- Amino acids having positive charge
  ***HAL P +ve = Histidine + Arginine + Lysine***
- Amino acids which are polar in nature
  ***STC + GAP = Serine + Threonine cysteine + Glutamine Asparagine + Proline***
- Amino acids which are aromatic in nature
  ***TTP = Tyrosine + Tryptophan + Phenyl alanine***
- Amino acids which are non-polar in nature
  ***GI'MALI = Glycine + Valine methionine + Alanine lucine + Isoleucine***
- Amino acids having sulphur (S)
  ***CM = Methionine + Cysteine***
- Fibrous protein are Keratin, Myosin, Collagen, and Actin.
- Antibodies, Enzyme and Hemoglobin are the examples of globular protein.
- Insulin is the example of primary structure of protein.
- Insulin consists of two polypeptide chains.
- Insulin consists of 51 amino acid and 49 peptide bonds.
- Insulin structure was determined by Singer in 1951.
  ***1 − 21 Amino Acid = 20 (Peptic bond)***
  ***1 − 30 Amino Acid = 29 (Peptic bond)***
- A polypeptide chain consists of 21 amino acid having 20 peptide bonds.

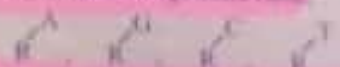


**Fig 2.3:** Structure of Insuline

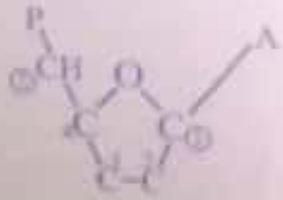
- Hemoglobin is an example of Quaternary structure of protein.
- Hemoglobin consists of 4 polypeptide chains; 2 alpha and 2 betas.
- Alpha chains contain 141 amino acid and beta chain contains 146 amino acid.
- Hemoglobin consists of 574 amino acid and 570 peptide bonds.
- When glutamic acid is replaced by Valine sickle cell, anemia is formed.
- Proteins like keratin is present in nails and hair.
- Enzymes are globular protein.
- Amino acids are carboxylic acid having amino group.

- Carbohydrate is stored in the body in the form of Glycogen. lipids is stored in the body in Adipose tissue (under the skin) in the form of animal fats while protein cannot be stored in the body but can be used in the structural component of body.
- Both functional groups (Amino + Carboxylic group) are attached with the same carbon called Alpha carbon.
- Sickle cell anemia is due to the Recessive autosomal gene received from parent.
- Fibrous protein is insoluble in water while globular protein is soluble in water.
- Lipids are insoluble in water but are soluble in other organic compound e.g. ether.
- Lipid consists of plant oil, animal fats, phospholipid, waxes, steroid and Terpenoid.
- Animal fats and plant oil are collectively called Triglyceride or Acyl glycerol.
- Triglyceride consists of three fatty acids and one Glycerol.
- Steroid and terpenoids are considered to be fats on the basis of their Characteristics.
- Glycerol consists of three carbon atoms which is soluble in water while fatty acid consists of hydrogen atom (not soluble in water) not on the basis of their composition.
- Fatty acids consist of Saturated and Unsaturated hydrocarbons.
- Saturated fatty acid has no double bond between carbon atom and cannot accommodate further hydrogen e.g. palmitic acid.
- Unsaturated fatty acid has double bond and can accommodate further hydrogen e.g. oleic acid.
- Palmitic acid consists of 16 carbon atoms is the example of saturated fatty acid.
- Oleic acid and linoleic acid consist of 18 carbon atoms and is the example of Unsaturated fatty acid.
- Fats produce double amount of energy as compared to the carbohydrates and proteins because it contains more carbon to hydrogen bond as compared to carbon to oxygen.
- In triglyceride 3rd number of fatty acid is replaced by phosphate it is called Phospholipid.
- Waxes consists of long chains of fatty acid and long chains of alcohol.
- Steroid contain Cholesterol as a basic unit.
- Each steroid is different from other by the functional group attached.
- Testosterone, Androgen, Estrogen, Progesterone, Aldosterone, Vitamin D are steroids in nature.
- Cholesterol consists of four rings and having 27 carbon atoms.
- The basic unit of terpenoid is Isoprenoid.
- Isoprene combine together to form carotenoid, rubber etc.
- Carotenoid is the accessory pigment which absorbs sunlight and protects chlorophyll from intense sunlight.
- Carotenoid consists of Carotene and Xanthophyll.
- Xanthophyll absorbs yellow color light.
- Carotene absorbs red and orange color light.
- Carotenoid absorbs yellow, orange, red or brown color light (YOR).
- When glycerol reacts with saturated fatty acid, animal fats are formed.
- $Ca^{2+}$ is absorbed and is regulated by thyrocalcitonin.
- Beta carotene is present in Carrot which is converted into two molecules of Vitamin A by human body and is Retina (Helps in vision).
- Auxin, Gibberellin and cytokinin are the plant hormones which are Lipids in nature.
- Nucleic acid consists of two types: DNA and RNA.
- DNA contains Deoxyribonucleotides while RNA contains ribonucleotides.
- DNA and RNA are made up of Nucleotides.
- Single Nucleotide consists of pentose sugar, phosphate group and nitrogenous base.

- Nucleoside consists of pentose sugar and nitrogenous base.



- Mono nucleotide consists of one nucleoside e.g. ATP, GTP, CTP, UTP.
- ATP is considered to be the currency of energy in the body of living organism.
- ATP changes into ADP and releases -7 kcal energy.



- In nucleotide nitrogenous bases (A + G + C + T + U) is attached to carbon number 1 of pentose sugar while phosphate group is attached to carbon number 5 of Pentose sugar.
- Nitrogenous bases consist of double ring structure called Purine and single ringed structure called Pyrimidine.
- Purine consists of Adenine (A) and Guanine (G) → AG.
- Pyrimidine consists of Cytosine (C), Thymine (T) and Uracil (U) → CUT.
- Nucleotide consists of three types: mono nucleotide, dinucleotide and poly nucleotide.
- Adenine reacts with Ribose sugar called Adenosine. Adenosine = Ribose sugar + adenine base.
- In ATP the curve bond indicates that it is unstable and high energy bond.
- Co-enzyme is made up of dinucleotide, minerals and vitamins.
- NAD stand for Nicotinamide Adenine Dinucleotide.
- NADP stand for Nicotinamide Adenine Dinucleotide Phosphate.
- FAD stand for Flavin Adenine Dinucleotide.
- Nicotinamide is a vitamin called Nicotinic acid or Niacin.
- Flavin is a vitamin called Riboflavin (Vitamin $B_{12}$).
- In 1962 James Watson, Francis Crick and Maurice Wilkins received Nobel Prize.
- DNA structure was determined by James Watson, Francis Crick and Maurice Wilkins in 1953.
- The diameter between two nucleotides is 2nm.
- The base pair are flat with a distance of 0.34nm between them.
- The bond between Adenine and Thymine is double hydrogen bond. $A = T$
- The bond between Cytosine and Guanine is triple hydrogen bond. $C \equiv G$

$$\begin{vmatrix} R-A=T-R \\ R-C\equiv G-R \end{vmatrix}$$

- DNA is double stranded present in Nucleus and acts as a hereditary material.
- DNA contains deoxy ribose sugar and adenine, guanine, cytosine and thymine as a nitrogenous base.
- RNA is single stranded, present mostly in cytoplasm and helps in protein synthesis.
- RNA consists of Ribose sugar and Adenine, Guanine, Cytosine and Uracil.
- In RNA Thymine is replaced by Uracil.
- Both DNA and RNA have three nucleotides in common (A + G + C).
- Messenger RNA is synthesized from DNA which carry information of protein synthesis called Transcription.
- Ribosomal RNA (rRNA) produce ribosome which helps in Protein synthesis.
- Transfer RNA (tRNA) pack amino acid and placed on Genetic code of mRNA to produce protein.
- RNA consists of three types: rRNA, tRNA and mRNA.
- In 1928 Fredrick Griffith performed experiment of transformation in which he observed that the non-pathogenic bacteria have absorbed DNA from pathogenic bacteria, as a result they have been transformed to pathogenic form.
- The transduction in which donor bacteria is received by recipient bacteria through third party called Bacteriophage.
- If we had to write down all the information in the DNA, it would make 900 volumes each of 500 pages.
- A Conjugate molecule is defined as a molecule that is formed by the combination of two different molecules belonging to different categories.
- Lipoproteins, Glycolipid and Glycoprotein are present in plasma membrane.
- Glycolipid is present in Brain.
- Nucleoprotein is present in Chromosome.
- Lipoprotein consists of lipids and proteins.
- Nucleoprotein consists of DNA and proteins.
- Glycolipid consists of carbohydrates and lipids.
- Glycoprotein consists of carbohydrate and protein.
- Glycoprotein is present in egg albumin.

## GENETIC CODES:

- Genetic code was proposed by Marshall Nirenberg and Heinrichs Mathai in 1961.
- If each nucleotide acts as a Genetic code then total number of Genetic codes are 4:

$$A + G + C + U = (4) = 4 \times 1 = 4 = 4 \ (A + G + C + U)$$

- If two nucleotides act as a Genetic code then total number of Genetic codes are 16:

$$A + G + C + U = (4)^2 = 4 \times 4 = 16$$

(AA + AG + AC + AU)
(GG + GC + GU + GA)
(CC + CU + CA + CG)
(UU + UA + UG + UC)

- If three nucleotides act as a Genetic code so total no of Genetic code are 64:

$$A + G + C + U = (4)^3 = 4 \times 4 \times 4 = 64$$

→ 1 start codon = AUG
64 Genetic codes → 3 stop codon = UAA + UAG + UGA
→ 60 Genetic codes for 20 amino acids

- Genetic code or codon are present on messenger RNA (mRNA).
- Anti-code are present on transfer RNA (tRNA).
- Amino acids having six genetic codes:
  LAS = Leucine + Arginine + Serine
- Amino acids having three genetic codes:
  I = Isoleucine
- Amino acids having single genetic codes:
  MT → Methionine, Threonine
- Amino acids having four genetic codes:
  G-P TV-A → Glycine, Tyrosine, Valine, Alanine
- Amino acids having each 2 genetic code (GPGC – TALHA):
  Histidine, Glutamine, Asparagine, Tryptophan, Phenylalanine, Cysteine, Glutamine, Aspartate, Lysine