CHAPTER 2
BIOLOGICAL MOLECULES

→ Water: Most abundant of all compounds of protoplasm
→ Proteins: Most abundant organic compounds in cell
→ Carbohydrates: Most abundant biomolecules in nature
→ Collagen: Most abundant protein in higher vertebrates.
→ Cellulose: Most abundant carbohydrate in nature
→ Glysine: simplest amino acid
→ RuBis Co: Most common protein in nature.

→ Two monomers join together when a hydroxyl group (OH) is removed from one monomer and a hydrogen (H) is removed from another. This is called condensation Reaction (dehydration). In this process water molecule is removed.

→ Both condensation and hydrolysis need specific enzymes.

→ Protoplasm cannot survive if its water content is reduced to as low as 10 percent.

→ Water has high specific heat means water absorbs or releases large quantities of heat energy with little change in temperature. This property helps the organisms to maintain body internal temperature and protect them from rapid temp changes.

→ Water has high heat of vaporization which helps animals and plants get rid of excess body heat during sweating and transpiration.

→ Without hydrogen bonds, water would boil at −80°C and would freeze at −100°C.

→ Water is most dense at 4°C

→ Carbohydrates are polyhydroxy aldehydes or ketones or substances which yield such compounds on hydrolysis.

Glyceraldehyde → Aldehyde Group
Ribose → Aldehyde Group
Ribulose → Ketose Group
Glucose → Aldehyde
Fructose → Ketone

* Names of monosaccharides end in 'ose'.

TRIOSES : Glyceraldehyde , Dihydroxyacetone
PENTOSES : Ribose , Deoxyribose , Ribulose
HEXOSES : Glucose , Galactose , Fructose

→ Ribose and Glucose when put in water form ring structures
→ The covalent bond that is formed b.w two monosaccharid units is called glycosidic bond.
→ Maltose = Glucose + Glucose
Lactose = Glucose + Galactose
Sucrose = Glucose + Fructose

* Glycogen → Branched chains of glucose monomers
Cellulose → unbranched chain of glucose
Starch → may be branched (Amylopectin) or unbranched (Amylose)

→ Chitin : polymer of glucose with amino ($-NH_2$) group
→ Human blood contains 100 mg of glucose per 100 mℓ of blood

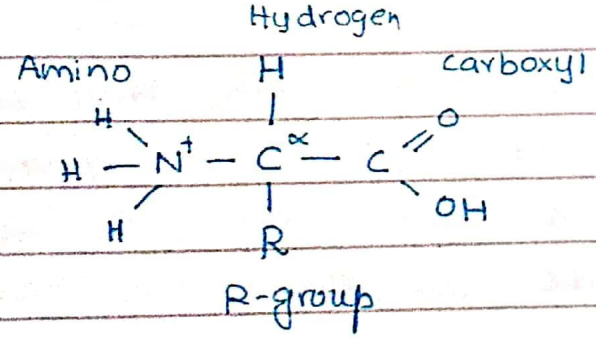
→ Our bodies can only use right-handed sugar ; left-handed sugar is indigestible

→ Amino acids are almost all left-handed.
Our body can't manufacture right-handed protein.
However, cell walls of bacteria contain right-handed amino acids.

→ Grapes contain 27% glucose.

PROTEINS

* COMPOSITION : C, H, O, N and sometimes Sulphur.
* Amino Acids : Carboxylic Acids having amino group



Total Amino Acids : 20-22

Negative → 2
Positive → 3
Polar → 6
Aromatic → 3
Non-Polar → 6
Sulphur → 2

* Negative → Glutamate + Aspartate
* Positive → Histidine + Arginine + Lysine
* Polar → Serine + Threonine + Cystene + Glutamine + Aspargine + Proline

* Aromatic : Tyrosine + Tryptophan + Phenyl alarine
* Non-Polar : Glysine + Valine + Methionine + Alanine + Lasine + Isoleucine
* Sulphur : Methionine + Cysteine

* Dipeptide chain → 3 Amino Acids , 2 peptide bonds
  Tripeptide chain → 4 Amino Acids , 3 peptide bonds

* Insulin → 2 polypeptide chains
* Haemoglobin → 4 Polypeptide chains (2 alpha, 2 beta)
  Alpha chain → 141 amino acid
  Beta chain → 146 amino acid
  Total Amino Acids → 574
  Total peptide Bonds → 570

* Insulin consist of 51 amino acids and 49 peptide bonds.

* In sickle cell haemoglobin molecule, glutamic acid is replaced by valine.

FIBROUS PROTEINS

→ one or more polypeptide chains → water-insoluble
→ linearly arranged in form of fibers
→ e.g keratin, myosin, collagen

GLOBULAR PROTEINS

→ globular or spherical due to folding of polypeptide chains.
→ water-soluble.
→ haemoglobin, albumin of egg white, enzymes, antibodies, proteins of cell membrane

→ Sanger in 1951 was the first person who determined sequence of amino acids in insulin molecule.

LEVELS OF STRUCTURE OF PROTEINS

1. Primary Structure → Linear sequence
2. Secondary Structure → spirally coiled
3. Tertiary structure → Three dimentional structure
4. Quaternary structure → Two or more polypeptide chains arranged into large sized molecule

LIPIDS

→ contain C, H, O

→ Nitrogen and Phosphorus may also be present

→ They usually contain more carbon-hydrogen bonds and less oxygen as compared to carbohydrates

* Acylglycerol → Glycerol + Fatty Acid

Phospholipids → 1 Glycerol + 2 Fatty Acids + 1 Phosphoric Acid usually linked to some nitrogen group

Waxes → Long chain fatty acid bonded to long chain alcoh

Steroids → No Fatty acid. Four fused carbon rings containing 17 carbon atoms

Carbon Rings (3 Hexagonal, 1 Pentagonal)

Terpenoids → No fatty acids. formed of isoprenoid units

* Triglycerides → 1 Glycerol + 3 Fatty Acids

→ A fatty acid consists of a long hydrocarbon chain with a carboxyl group at one end.

→ Most fatty acids in cell contain 16- 18 carbon atoms per molecule.

* Oleic Acids → Unsaturated fatty acids (atleast 1 double bond)
* Palmatic Acid → Saturated fatty acid (no double bond)

* Glycerol :→ 3 carbon compound
  → To each carbon hydroxyl group is attached
  → OH groups are polar and therefore glycerol is soluble in water.

→ Acylglycerol with saturated fatty acids are called fats.

→ Acylglycerol with unsaturated fatty acids are usually liquid at room temperature. (oils)

→ A triglyceride molecule is converted into phospholipid when a fatty acid is replaced by one phosphate.

→ Phospholipids have:
  Phosphate head → polar and hydrophilic
  Two Hydrocarbon Tails → Non-polar and hydrophobic

Waxes:

→ solid at room temperature

→ high melting point

→ hydrophobic

→ stable compound and resistant to degradation.

STEROIDS:

→ backbone of four fused carbon rings containing 17 carbon atoms
→ differ from one another by type of functional group attached
→ Cholestrol is a steroid which is a precursor of all steroid hormones such as aldosterone, sex hormones and Vitamin D.
→ Aldosterone: helps to regulate sodium content of blood

TERPENOIDS:

→ Isoprenoid units join by the process of condensation and gives rise to terpenes, rubber, carotenoids etc.
→ Carotenoids are lipids that are yellow, orange, red or brown pigments. They are of two types:
    1. Carotene (orange, red)
    2. Xanthophylls (Yellow)

Beta-Carotene:

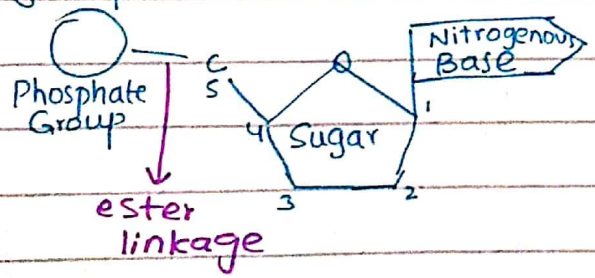
→ most widespread and important carotene
→ It is the orange pigment of carrots
→ Human body breaks β-carotene to form two molecules of vitamin A.

* Lipids store greater amount of energy than carbohydrate bcz they contain less oxygen and more C-H bonds than carbohydrates.

NUCLEIC ACIDS

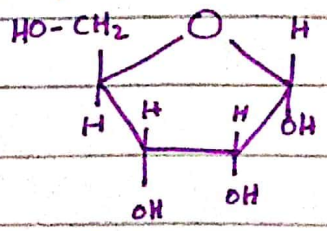
→ polynucleotide chain (polymers)
→ Units : Nucleotides
→ Two Types : DNA and RNA
→ Nucleoside : Base + Sugar
→ Nucleotide : Base + Sugar + Phosphate
(Pentose Sugar) (Phosphoric Acid)

→ In a typical nucleotide, the nitrogenous base is attached to carbon no.1 of pentose sugar while phosphate group is attached to carbon no. 5.

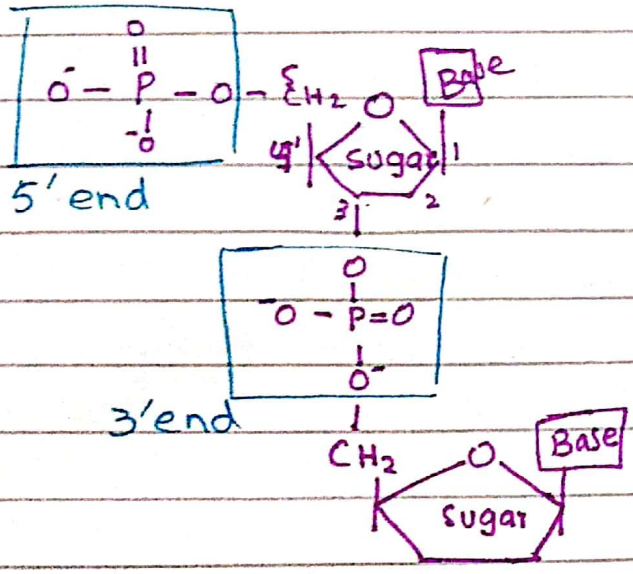


→ The bond formed b.w phosphoric acid (H_3PO_4) and hydroxyl group of pentose sugar is called ester linkage

Ribose Structure :



→ In a polynucleotide chain one phosphoric acid is attached to the OH group of carbon no. 3 of pentose sugar while another phosphoric acid is attached to OH group of carbon no. 5 of pentose sugar. This is called phosphodiester linkage.



* Nitrogenous Bases are:
  1. Pyramidines (single ring)
  2. Purines (Double Ring)

* Pyramidines → Thymine, Cytosine, Uracil
* Purines → Adenine, Guanine

* Examples of:
  Mononucleotide → Adenosine Triphosphate (ATP)
  Dinucleotide → Adenine Dinucleotide
  Polynucleotides → DNA + RNA

* Adenosine → Adenine base linked to pentose sugar (Ribose)

* An ATP molecule is hydrolyzed into ADP and P and 7kcal energy is produced.

* The adenine dinucleotide in combination with different vitamins form important compounds called co-enzymes.
* Important co-Enzymes are:
  1. NAD (Nicotinamide Adenine Dinucleotide)
  2. NADP (Nicotinamide Adenine Dinucleotide Phosphate)
  3. FAD (Flavin Adenine Dinucleotide)

* DNA
  → base pairs always consist of purines pointing towards pyramidines
  → Molecule diameter = 2nm
  → Distance b·w base pairs = 0·34nm
  → DNA contain pentose sugar as deoxyribose
  → The two strands are held together by hydrogen bonds b·w purine and pyramidine bases.
  T = A G ≡ C

* RNA
  → Pentose sugar as Ribose
  → mRNA: carries msgs from DNA to ribosome for protein synthesis
  → tRNA: transfers specific Amino acid from cytoplasm to ribosome
  → rRNA: in combination with protein form body of ribosome

DNA $\xrightarrow{\text{transcription}}$ mRNA $\xrightarrow{\text{translation}}$ Protein

CONJUGATED MOLECULES

→ molecules that are formed by the combination of two different molecules belonging to different categories.

e.g

1. Glycoprotein → Carbohydrate + Protein
2. Lipoprotein → Lipids + Protein
3. Nucleoproteins → Nucleic Acids + Protein
4. Glycolipid → Carbohydrates + Lipids
5. Glycoproteins → Carbohydrates + Proteins

→ Nucleic Acids are slightly acidic and soluble in water

→ Glycolipids are important component of brain and plasma membrane

→ Glycoproteins are present in egg albumin and plasma membrane.

→ Bond between sugar and nitrogenous base in a nucleoside is glycosidic bond

→ The most abundant type of RNA in eukaryotic cell is rRNA

→ Ring form of fructose forms 5 cornered ring

→ The total number of sense codon in genetic code is 61

→ The starting codon is AUG

→ Non-sense codons → UAA, UAG, UGA

→ Mature ovum in humans is surrounded by plasma membran Ovum is the smallest cell of body

→ The centre of porphyrin in the head region of haemoglobin is occupied by Fe^{+2} ion while in chlorophy it is Mg^{+2} ion

→ If each nucleotide acts as a Genetic code then tota number of genetic codes are 4

→ If two nucleotides act as genetic code than total number of genetic codes are 16 i-e $4^2 = 16$

→ If three nucleotides act as genetic code then total number of genetic codes are 64. i-e $4^3 = 64$

→ Genetic code or codon present on mRNA

→ Anti-code are present on tRNA

→ Amino Acids having six genetic codes:

LAS = Leucine + Arginine + Serine

→ Amino Acids having three genetic codes:

Isoleucine

→ Amino acides having four genetic code:

G-ATV ⇒ Glycine, Tyrosine, Valine, Alanine

→ Proteins, carbohydrates and fats are collectively called Triumvirates.

→ No. of chromosomes:

Pigeon = 80 (40 pairs)
Potato = 48 (24 pairs)
Chimpanzee = 48 (24 pairs)
Man = 46 (23 pairs)
Frog = 26 (13 pairs)
Onion = 16 (8 pairs)
Garden pea = 14 (7 pairs)
Drosophila = 8 (4 pairs)

→ The secondary structure of protein is found in keratin.

→ If solute particles are entering into cell by using protein, it implies that they are hydrophilic.

→ An active site of enzyme is normally hydrophobic in nature

→ Prosthetic Group and irreversible inhibitor can be permanently bound to protein

→ In chlorophyll head an atom of magnesium is coordinated with the nitrogen of each pyrrole ring.

→ The polar region of phospholipid molecule is hydrophobic head

* PERCENTAGE COMPOSITION OF A BACTERIAL CELL & MAMMALIAN CELL

	Bacterial Cell	Mammalian Cell
Water	70 %	70 %
Proteins	15 %	18 %
Carbohydrates	3 %	4 %
Lipids	2 %	3 %
DNA	1 %	0.25 %
RNA	6 %	1.1 %
Enzymes, Hormones	2 %	2 %
Inorganic Ions	1 %	1 %