9. Biomolecules

POINTS TO REMEMBER :

- **Biomolecules:** All the carbon compounds that we get from living tissues.
- **Macromolecules:** Molecules which have molecular weights less than one thousand dalton.
- **Amino acids:** Organic compounds containing an amino group and one carboxyl group (acid group) and both these groups are attached to the same carbon atom called α carbon.
- Twenty types of amino acids occur in proteins.
- Based on number of amino and carboxyl groups, amino acids can be:
    - **Acidic:** e.g. Glutamic acid
    - **Basic:** e.g. Arginine and lysine
    - **Neutral**: e.g. valine, alanine.

- **Aromatic amino acids** are tyrosine, phenylalanine, and tryptophan.
- Amino acids are ionizable into **zwitterionic** form.

Lipids :

- Water insoluble, containing C, H, O.
- They could be **simple fatty acids.**
- A fatty acid has a carboxyl group attached to an **R group.**
- The R group may be a methyl group ($-CH_3$) or ethyl ($-C_2H_5$) or higher number of-CH_2 group (1 carbon to 19 carbon). E.g**. palmitic acid** with 19 carbons, **arachidonic acid** has 20 carbons.
- Fatty acids could be **saturated** (without double bond) or **unsaturated** (with one more (c=c) double bond.
- Another example of lipid is **glycerol** which is **trihydroxy propane.**
- Many lipids may have both glycerol and fatty acids.
- Fatty acids esterified with glycerol to form **mono, di** or **triglycerides.**
- These are also called fats and oils based on the melting points.
- Oils have low melting points (e.g. **gingely oil).**
- **Phospholipids** are compound lipids with phosphorus and a phosphorylated organic compound. They are found in the cell membrane. e.g., **Lecithin.**

Nitrogen bases :

- Carbon compounds with heterocyclic rings.
- **Purine**: Adenine, Guanine.
- **Pyrimidine:** Cytosine, Uracil, Thymine.
- **Nucleoside:** Nitrogenous base + Sugar e.g., Adenosine, guanosine, thymidine Uridine and cytidine
- **Nucleotide:** Nitrogenous base + Sugar + Phosphate group. e.g., Adenylic acid, thymidylic acid, guanylic acid, uridylic acid and cytidylic acid.
- **Nucleic acid:** Polymer of nucleotides - DNA and RNA.

PRIMARY AND SECONDARY METABOLITES :

- **Primary metabolites :**
    - Have identified function.
    - Play known roles in physiological function.
    - Carbohydrates, amino acids, fats and oils, nitrogen bases are the example of primary metabolites.

- **Secondary metabolites :**
  - Have no definite function.
  - Have no direct role in normal physiology.
  - Alkaloid, favonoides, rubber, essential oils, antibiotics, coloured pigments. Scents, gums, spices are some example.

- **Biomacromolecules :** Biomolecules with molecular weights in the range of ten thousand daltons and above; found in acid insoluble fraction.
- Lipids are not strictly **macromolecules** as their molecular weights do not exceed 800 Da but form a part of the acid insoluble pool.

Proteins :

- Are polymers of amino acids linked by **peptide bond.**
- Is a **heteropolymer** not **homopolymer.**
- **Essential amino acids:** those can't be synthesized in our body, have to be supplied through our diet.
- **Non-essential amino acids:** our body can synthesize it from other sources.
- **Collagen** is the most abundant protein in animal.
- **Ribulose bisphosphate Carboxylase-Oxygenase (RUBISCO)** is most abundant protein in the whole biosphere.

POLYSACCHARIDES :

- Acid soluble pillet also has polysaccharides as another class of macromolecules.
- Polysaccharides are the long chain of sugars.
- **Cellulose** is homopolymer containing only glucose units.
- **Starch** is a variant of homopolymer of glucose which store energy.
- **Glycogen** is another homopolymer found in animal.
- **Inulin** is a polymer of **fructose.**
- In a polysaccharide chain the right end is called reducing end and left end is non-reducing end.
- Starch form helical secondary structure.
- Starch can hold Iodine (I_2) molecule in its helical portion hence gives blue colour.
- Cellulose dose not contain complex helices and hence cannot hold Iodine (I_2) and not give blue colour.
- Complex sugars have **amino-sugar** as building blocks. (Glucosamine, N-acetyl galactosamine.)
- Exoskeleton of arthropods made of complex sugar **called chitin.**
- Complex polysaccharides are heteropolymer.

STRUCTURE OF PROTEINS :

- **Primary structure**: Is found in the form of linear sequence of amino acids. First amino acid is called N-terminal amino acid and last amino acid is called C-terminal amino acid.
- **Secondary structure**: Polypeptide chain undergoes folding or coiling which is stabilized by hydrogen bonding. Right handed helices are observed. e.g., fibrous protein in hair nails.
- **Tertiary structure**: Long protein chain is folded upon itself like a hollow woolen ball. Gives a 3-dimensional view of protein, e.g., myosin.
- **Quaternary structure**: Two or more polypeptides with their folding and coiling are arranged with respect to each other. e.g., Human haemoglobin molecule has 4 peptide chains - 2α and 2β subunits.

NATURE OF BOND LINKING MONOMERS IN A POLYMER :

- **Peptide bondb :** Formed between the carboxyl (-COOH) group of one amino acid and the amino ($-NH_2$) group of the next amino acid with the elimination of water moiety.
- **Glycosidic bondb :**
    - Individual monosaccharides linked with each other to form polysaccharides.
    - This bond is also formed by dehydration.
    - Formed between two carbon atoms of two adjacent monosaccharides.

- **Phosphodiester bondbb :**
    - In a nucleic acid a phosphate moiety links the 3'-carbon of one sugar one nucleotide to the 5'-carbon of the sugar of the succeeding nucleotide.
    - The bond between the phosphate and hydroxyl group of sugar is an ester bond.
    - There is one such ester bond on either side, it is called Phosphodiester bond.

- **Anabolic pathways**: Lead to formation of more complex molecules from a simpler molecules with the consumption of energy. e.g., Protein from amino acids.
- **Catabolic pathway**: Lead to formation of simpler molecule from a complex molecule. e.g., Glucose → Lactic Acid.

ENZYMES :

- Are biocatalysts.
- Almost all enzymes are proteins.
- Ribozyme - Nucleic acids that behave like enzymes.
- Has primary, secondary and tertiary structure.
- Active site of an enzyme is a crevice or pocket into which substrate fits.
- Enzymes get damaged at high temperatures.
- Enzymes isolated from thermophilic organisms (live under high temperatures) are thermostable.
- Enzymes accelerate the reactions many folds.
- Enzymes lower the activation energy of reactions.
- The chemicals on which the enzyme acts called substrates.
- Enzyme converts substrates into products.

Nature of enzyme action :

- The substrate binds to the active site of the enzyme, fitting into the active site.
- The binding of the substrate induces the enzymes to alter its shape, fitting more tightly around the substrate.
- Active site now breaks the chemical bond of the substrate and enzyme-product complex is formed.
- The enzyme releases the product.

Factors affecting enzyme activity :

- **Temperature :**
    - Show highest activity at optimum temperature.
    - Activity declines above and below the optimum value.

- **pH :**
  - Enzymes function in a narrow range of pH.
  - Highest activity at optimum pH.

- **Concentration of substrate :**
  - The velocity of enzymatic reaction rises with increase in substrate concentration till it reaches maximum velocity (V max). Further increase of substrate does not increase the rate of reaction as no free enzyme molecules are available to find with additional substrate.

- **Enzyme inhibition**: When the binding of a chemical shuts off enzyme activity, the process is called inhibition and chemical is called inhibitor.
- **Competitive inhibition**: Inhibitor closely resembles the substrate in its molecular structure and inhibits the enzyme activity. E.g., inhibition of succinic dehydrogenase by malonate.

Classification of enzymes :

- **Oxidoreductase/dehydrogenases**: Catalyse oxidoreduction between 2 substrates.
- **Transferases**: Catalyse transfer of a group between a pair of substrates.
- **Hydrolases**: Catalyse hydrolysis of ester, ether, peptide, glycosidic, C-C, P-N bonds.
- **Lyases**: Catalyse removal of groups from substrates by mechanisms other than hydrolysis leaving a double bond in the product.
- **Isomerases**: Catalyse inter-conversion of optical, geometric or positional isomers.
- **Ligases**: Catalyse linking together of 2 compounds.

Cofactors :

- Non-protein constituents found to the enzyme to make it catalytically active.
- Protein portion of enzyme is called apoenzyme.
- **Prosthetic groups:** Are organic compounds tightly bound to apoenzyme. E.g., haem in peroxydase and catalase.
- **Co-enzymes**: Organic compounds which loosely bind with enzyme. E.g., NAD, NADP.
- **Metal ions**: Required for enzyme activity. Form coordination bond with side chains at active site and with substrate. E.g., zinc is a co-factor for enzyme enters stomach?