

## Chapter - 9

# Biomolecules

### Points to Remember

**Biomolecules :** All the carbon compounds that we get from living tissues.

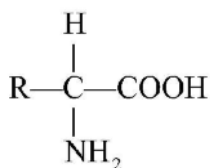
**Macromolecules :** Molecules which have molecular weights less than one thousand dalton. They are also known as monomers.

**Macro molecules :** Known as polymers.

### Primary and secondary metabolites :

- Primary metabolites have identifiable functions and play important roles in normal physiological process eg. Amino acids, nitrogenous bases, proteins and nucleic acid.
- Secondary metabolites are product of certain metabolic pathways from primary metabolites, eg. carotenoids, drugs, alkaloids, essential oils, rubber, gum, cellulose and resins etc.

**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  $\alpha$  carbon and so they are called  $\alpha$  amino acids.



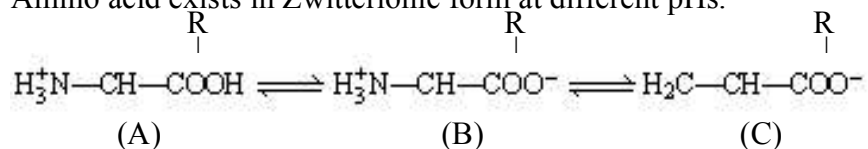
e.g. (1) In Glycine R = H

(2) In alanine R = CH<sub>3</sub>

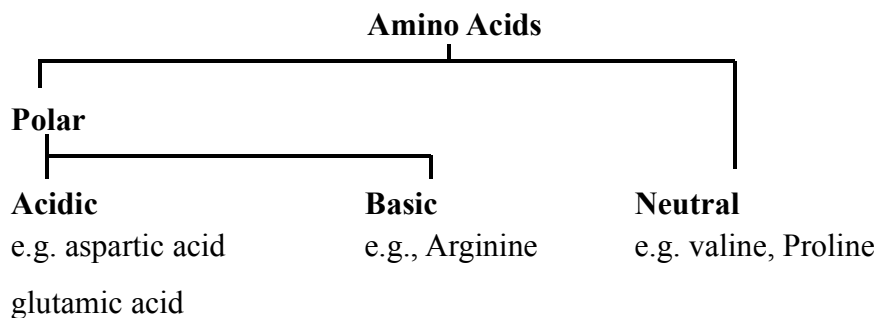
(3) In serine R = CH<sub>2</sub> – OH

- Twenty types of amino acids.

Amino acid exists in Zwitterionic form at different pHs.



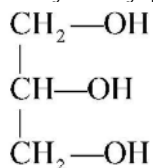
- Based on number of amino and carboxyl groups, amino acids can be :
  - (i) **Aromatic**—Tryptophan, phenylalanine and Tyrosine are aromatic (give smell) amino acids.



- (ii) **Non Polar**—Glutamine, tyrosine, serine

## Lipids :

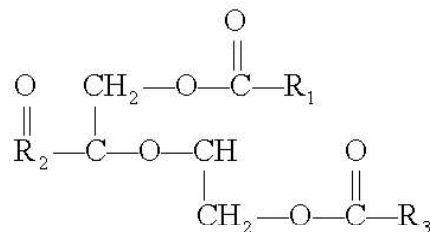
- Water insoluble, containing C, H, O.
- Fats on hydrolysis yield fatty acids.
- Fatty acid has a carboxyl group attached to an R group (contains 1 to 19 carbons).
- **Fatty Acids : Saturated :** With single bonds in carbon chain, *e.g.*, Palmitic acid, butyric acid.
- **Unsaturated :** With one or more double bonds, *e.g.*, oleic acid, linoleic acid.
- **Glycerol :** A simple lipid, is trihydroxy propane.



- Some lipid have fatty acids esterified with glycerol.  $\rightarrow \text{CH}_3 - (\text{CH}_2)_{14} - \text{COOH}$  fatty acid (Palmitic acid)



- They can be monoglycerides, diglycerides and triglycerides.



Triglyceride ( $\text{R}_1$ ,  $\text{R}_2$ ,  $\text{R}_3$  are fatty acids.)

Phospholipids (Lecithin) found in cell membrane and lipids made complex structure in neural tissue.

- **Phospholipids** are compound lipids with phosphorus and a phosphorylated organic compound *e.g.*, Lecithin.

### Nitrogen bases

(Carbon compounds with heterocyclic rings)

**Purine** : Adenine, Guanine,      **Pyrimidine** : Cytosine, Uracil, Thymine.

Lipids are not strictly macromolecules as their molecular weight do not exceed 800 Da but form a part of the acid insoluble pool.

**Biomacromolecules** : Biomolecules with molecular weights in the range of ten thousand daltons and above; found in acid insoluble fraction. *e.g.* polysaccharides, nucleic acids, proteins and lipids.

**Nucleic acids** : Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

**Nucleoside** : Nitrogenous base + Sugar *e.g.* Adenosine, guanosine.

**Nucleotide** : Nitrogenous base + Sugar + Phosphate group. *e.g.* Adenylic acid, Guanylic acid. Thymidylic acid.

**DNA structure (Watson and Crick Model)** : DNA is a right handed, double helix of two polynucleotide chains, having a major and minor groove. The two chains are antiparallel, and held together by hydrogen bonds (two between A and T and three between C and G). The backbone is formed by sugar-phosphate-sugar chain. The nitrogen bases are projected more or less perpendicular to this, backbone and face inside. The pitch is  $34\text{\AA}$ . At each step of ascent, the strand turns  $36^\circ$ . The rise per base pair is  $3.4^\circ\text{\AA}$ , so one full turn involves ten base pairs.

**Protein** : proteins are polypeptides.

- They are polymers of amino acids linked by peptide bond.
- Is a heteropolymer (different monomers repeating 'n' number of times).
- For functions of proteins refer Table 9.5, Page no. 147 NCERT, Text Book of Biology for Class XI.

## Structure of Proteins

- (a) **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.
- (b) **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.
- (c) **Tertiary structure** : Long protein chain is folded upon itself like a hollow woollen ball. Gives a 3-dimensional view of protein, *e.g.*, myosin.
- (d) **Quaternary structure** : Two or more polypeptides with their foldings and coilings are arranged with respect to each other, *e.g.*, Human haemoglobin molecule has 4 peptide chains - 2  $\alpha$  and 2  $\beta$  submits.

**Monosaccharides** are joined by glycosidic acid bond, right end is reducing and left end is non reducing

**Polysaccharides** : Are long chain of polymers of monosaccharides.

- (a) **Starch** : Store house of energy in plant tissues. Forms helical secondary structures, made of only glucose monomers.
- (b) **Cellulose** : Homopolymer of glucose. It does not certain complex helices. Cotton fible is cellulose.
- (c) **Glycogen** : Is a branched homopolymer, found as storage polysaccharide in animals.
- (d) **Inulin** : Is a polymer of fructose.
- (e) **Chitin** : Chemically modified sugar (amino-sugars) N-acetyl galactosamine form exoskeleton of arthropods; heterpolymer.

## Metabolic Pathways :

- (a) **Anabolic pathways** : Lead to formation of more complex structure from a simpler structure with the consumption of energy, *e.g.*, Protein from amino acids., also known as biosynthetic pathways.
- (b) **Catabolic pathway** : Lead to formation of simpler structure from a complex structure, *e.g.*, Glucose  $\rightarrow$  Lactic Acid + energy

The most important energy currency in living systems is ATP (adenosine tri – phosphate).

**“There is no uncatalysed metabolic conversion in living system”**

The living state is a non-equilibrium steady state to be able to perform work. Without metabolism, there cannot be a living state.



## Bonds linking monomers in a polymer

**Peptide bond**—formed between the carboxyl ( $-\text{COOH}$ ) group of one amino acid, and the amino ( $-\text{NH}_2$ ) group of the next amino with the elimination of water moiety, (dehydration).

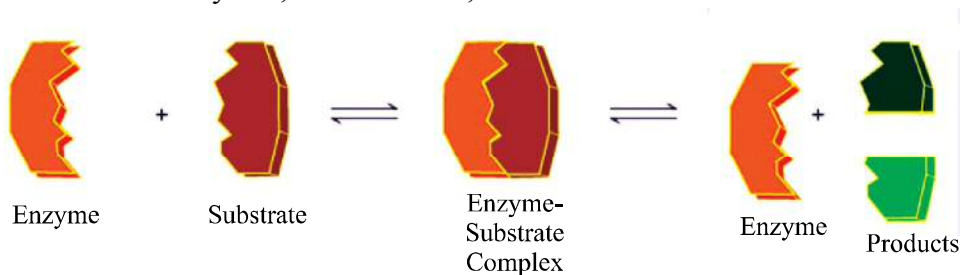
**Glycosidic bond**—bond formed between two carbon atoms of two adjacent monosaccharides., by dehydration.

**Phosphodiester bond**—bond formed in nucleic acids where in a phosphate moiety links the 3-carbon of one sugar of one nucleotide to the 5-carbon of the sugar of the succeeding nucleotide. (The bond between phosphate group and hydroxyl group of sugar)

**Ezymes :** Are biocatalyst.

- Almost all enzymes are proteins.
- Ribozymes—Nucleic acid 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. (Fig. 9.6, Page no. 156, NCERT Text Book of Biology for Class XI).
- $\text{E} + \text{S} \rightleftharpoons \text{ES} \rightarrow \text{EP} \rightarrow \text{E} + \text{P}$

where E = Ezymes, S = Substrate, P = Product



Steps of Enzyme Action

## 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. (Fig. 9.7, Page no. 157, NCERT, Text Book of Biology for Class XI).

(c) **Concentration of substrate** : The velocity of enzymatic reaction rises with increases 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 bind 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. (Actual is succinic acid).

### Classification of enzymes :

1. **Oxidoreductase/dehydrogenases** : Catalyse oxidation-reduction between 2 substrates.  $S_{reduced} + S'_{oxidised} \rightarrow S'_{oxidised} + S_{reduced}$ .
2. **Transferases** : Catalyse transfer of a group between a pair of substrates.  
 $S - G + S' \rightarrow S + S' - G$
3. **Hydrolases** : Catalyse hydrolysis of ester, ether, peptide, glycosidic, C-C, P-N bonds.
4. **Lyases** : Catalyse removal of groups from substrates by mechanisms other than hydrolysis. Leave double bonds.
5. **Isomerases** : Catalyse inter-conversion of optical, geometrical or positional isomers.
6. **Ligases** : Catalyse linking together of 2 compounds.  
C-O, C-S, C-N, P-O

**Co-factors** : Enzymes become catalytically active when they bind to non protein constituent called co-factors. Protein portion of enzyme is called apoenzyme.

- **Prosthetic group** : These are organic compounds which are tightly bound to the apoenzyme.  
e.g., Haem is prosthetic group in peroxidase and catalase.
- **Coenzyme** : These are organic compounds whose association with the apoenzyme is only transient, usually occurring during the course of catalysis.  
e.g., Coenzyme Nicotinamide adenine dinucleotide (NAD) and NADP contain vitamin niacin.
- **Metal ions** : Metal ions form coordination bond with side chains at the active site and at the same time form one or more coordination bonds with substrate.  
e.g. zinc in enzyme carboxy peptidase.



## Questions

### Very Short Answer Questions

(1 mark each)

1. Why do oils generally remain in liquid state even in winters ?
2. Name an element found in proteins but not in lipids and carbohydrates.
3. What is the difference between RNA and DNA in terms of nitrogenous base ?
4. What does an enzyme do in terms of energy requirement of a reaction ?
5. What is the function of ATP in cell metabolism ?
6. Name the protein which form the intercellular ground substance.
7. What are biomacromolecules ?
8. Why enzymes are called bio-catalysts ?

### Short Answer Questions-I

(2 marks each)

9. Differentiate between prosthetic group and coenzyme ?
10. What are glycosidic bonds and peptide bonds ?
11. Why are amino acids also known as substituted methane?
12. Amino acids exist as zwitter ions. Give its structure. Why is it formed ?
13. Why do starch give blue black colour with iodine ?
14. Why are starch and glycogen more suitable than glucose as a storage product ?
15. What would happen when salivary amylase which acts on starch in mouth enter in stomach ?
16. Differentiate between homo polysaccharides saccharides and hetero polysaccharides.
17. Why do physicians recommend vegetable oils rich in polyunsaturated fat for persons suffering from cardiovascular diseases ?
18. Why does the shelf life of fruits and vegetables increase in a refrigerator ?

### Short Answer Questions-II

(1 mark each)

19. Differentiate between primary and secondary metabolites with examples ?
20. List out some major proteins and their function ?
21. Explain the structure of proteins.
22. Explain Watson-Crick model on DNA structure.
23. Explain peptide bond, glycosidic bond and phosphodiester bond.
24. Explain competitive inhibition along with an example.

### Long Answer Questions

(5 marks each)

25. List the 6 classes of enzymes along with their functions.

## Answers

### Very Short Answer

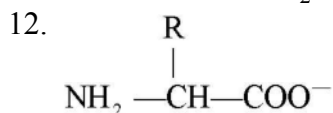
(1 marks each)

1. Oils are unsaturated lipids, hence have lower melting points.
2. Nitrogen.
3. RNA has uracil instead of thymine.
4. Lowers the activation energy of reaction.
5. Are the energy currency of cell.
6. Collagen.
7. Refer point to remember.
8. Enzymes are proteins that catalyze metabolic/chemical reactions inside the living being. That's why they are called biocatalysts.

### Short Answer-I

(2 marks each)

9. Refer 'Points to remember'.
10. Refer, 'Points to remembers'.
11. The  $\alpha$ -carbon has 4 substituted groups occupying the 4 valency positions :  
H,  $\text{—COOH}$ ,  $\text{—NH}_2$  and  $\text{—R}$  group.



Due to ionizable nature of  $\text{—NH}_2$  and  $\text{—COOH}$  groups.

13. Starch form helical secondary structure which can hold  $\text{I}_2$ .
14. Occupy lesser space as less bulky and can hydrolysed to glucose when required.
15. In mouth, salivary amylase changes starch into maltose. Action of amylase stops in stomach as it cannot act in an acidic medium.
16. Homopolysaccharides                      Heteropolysaccharides
 

(a) Constituted of single type of monosaccharide units	Constituted by two or more type of monosaccharide unit and their derivatives
(b) e.g., starch, glycogen, cellulose	e.g., Peptidoglycans, chitin
17. Polyunsaturated oils contain fatty acids having one or more double bonds which does not clog arteries due to high proportion of polyunsaturated fatty acids.



18. Low temperature prevents growth of food spoiling micro organisms and also inhibits the action of enzymes present in the food, because, enzymes are inactivated at low temperature.
19. **Secondary metabolites**—The metabolites like alkaloids lectins Drugs, Pigments, Spices and scents etc. which are useful to human welfare and have ecological importance.
- Primary metabolites**—The metabolites having identifiable functions and play important role in normal physiological processes, *e.g.*, sugars, amino acids, fats and oils and nucleotides, etc.
20. Refer Page No. 147, Table 9, 5, NCERT, text book of biology class XI.

### Short Answers-I

(3 marks each)

21. Refer 'Points to remember'.
22. Refer 'Points to remember'.
23. Refer Page No. 151. NCERT, Text Book of Biology for Class XI.
24. Refer 'Points to remember'.

### Long Answers

(5 marks each)

25. Refer Page No. 158., NCERT, Text Book of Biology for Class XI.

