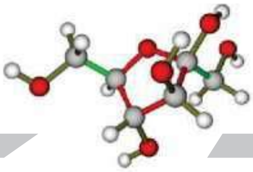


Chapter - 9

Biomolecules

Carbohydrates

They are long chains of sugars may be homopolymers or heteropolymers right end of chain is reducing end and left end of chain is non-reducing end

Lipids

Long chain fatty acids, may be saturated or unsaturated many fatty acids are found esterified with glycerol they may be mono bi or tri-glycrides

Proteins

Polypeptides, heteropolymers made of 20 types of amino acids, four levels of structures- primary, secondary, tertiary & quaternary

Nucleic Acids

Polynucleotides (DNA, RNA), consists of a mono saccharide, phosphate group and nitrogenes bases

Purines → A, G

Pyrimidines → C, T, U

Molecular Weight more than 10000 daltons found in acid insoluble pool

Biomacromolecules

Biomolecules

Biomicromolecules

Molecular Weight less than 10000 daltons eg inorganic sbstances, minerals, sugars, amino acids and nucleotides acid soluble pool

Enzymes Catalyse biochemical reactions

Bring down activation energy to enhance rate of biochemical reactions

Nucleic Acid behaving as enzymes - Ribozymes

Factors affecting enzyme action-PH, temperature, and concentration of substrate

Cofactors : non-proteinaceous constituents bound to the enzyme to make enzyme catalytically active eg prosthetic group, co-enzymes and metal ions

Inhibition of enzyme action
1. competitive inhibition
2. non-competitive

Classes of enzyme - (6) Dehydrogenases, transferases, hydrolases, lyases, isomerases and ligases

Points to Remember

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

Biomicromolecules : Molecules which have molecular weights less than one thousand dalton. They are also known as monomers. They are found in acid soluble fraction.

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

How to analyse chemical composition of living tissues?

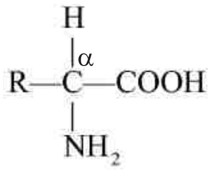
Living tissue + Trichloroacetic acid ⟶ Grinding ⟶ Thick Slurry

⟶ Filter through cheese cloth — Filterate (Acid soluble) / Retentate (Acid insoluble)

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 α carbon and so they are called α amino acids.



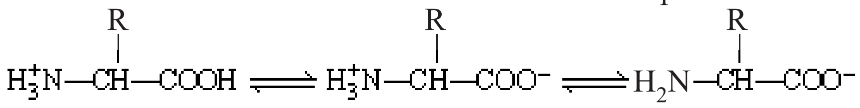
e.g. (1) In Glycine R = H

(2) In alanine R = CH_3

(3) In serine R = $CH_2 - OH$

- Twenty types of amino acids.

  Amino acid exists in Zwitterionic form at different pHs.



(A) (B) (C)

(Zwitterionic form)

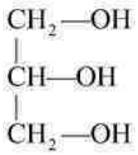
- Based on the type of side chains number of amino and carboxyl groups, amino acids can be :
  - (i) **Aromatic** – Tryptophan, phenylalanine and Tyrosine are aromatic (give smell) amino acids.
  - (ii) **Acidic Amino Acids** – (aspartic acid, glutamic acid).
  - (iii) **Basic amino acid** (Arginine).
  - (iv) **Neutral amino Acids** (valine, Proline).

Lipids :

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

- 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.

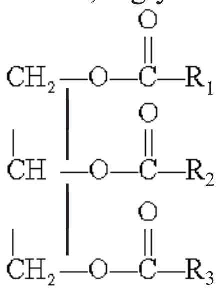
  Unsaturated : With one or more double bonds, *e.g.,* oleic acid, linoleic acid.
- **Glycerol :** A simple lipid, is trihydroxy propane.



- Some lipid have fatty acids esterified with glycerol.

  Example of fatty acid (Palmitic acid) (CH_3—$(CH_2)_{14}$—COOH)
- They can be monoglycerides, diglycerides and triglycerides.

Triglyceride,



R_1, R_2, R_3 are alkyl groups in fatty acids

- **Phospholipids** are compound lipids with phosphorus and a phosphorylated organic compound *e.g.,* Lecithin.
  Phospholipids (Lecithin) found in cell membrane and lipids made complex structure in neural tissue.

Nitrogen bases

(Carbon compounds with heterocyclic rings)

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

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

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

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

DNA structure (Watson and Crick Model) :

1. DNA is a right handed, double helix of two polynucleotide chains, having a major and minor groove.

2. The two chains are antiparallel, and held together by hydrogen bonds (two between A and T and three between C and G).

3. The backbone is formed by sugar-phosphate-sugar chain.

4. The nitrogen bases are projected more or less perpendicular to this, backbone and face inside.

5. The pitch is 34A°. At each step of ascent, the strand turns 36°. The rise per base pair is 3.4°A, so one full turn involves ten base pairs.

Protein : proteins are polypeptides.

- They are polymers of aminoacids linked by peptide bond.
- Is a heteropolymer (different monomers repeating 'n' number of times).
- Functions : Intercellular ground substance (collagen), as enzyme (Trypsin) as hormone (Insulin), to fight infections (Antibodies), as sensery receptors, and to enable glucose transport in cells (GLUT-4)

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 α and 2 β Subunits.

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

Polysaccharides : Are long chain 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 contain complex helices. Cotton fibre 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 glucosamine form exoskeleton of arthropods; homopolymer.

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

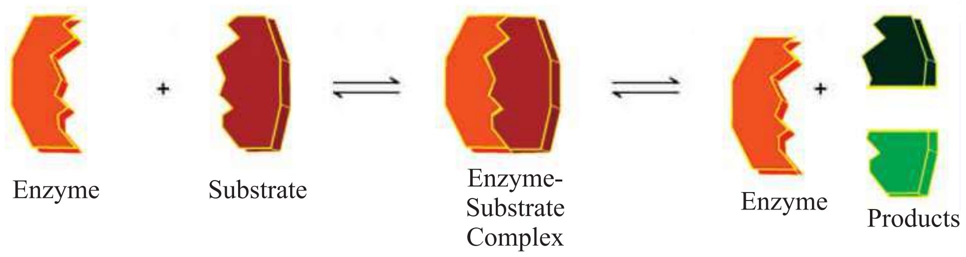
Peptide bond—formed between the carboxyl (–COOH) group of one amino acid, and the amino (– NH_2) group of the next amino with the elimination of water moiety, (dehydration).

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)

Enzymes : 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 rate of reactions many folds.
- Enzymes lower the activation energy of reactions. (Fig. 9.6, Page no. 156, NCERT Text Book of Biology for Class XI).
- $E + S \rightleftharpoons ES \rightarrow EP \rightarrow E + P$
  where E = Enzymes, S = Substrate, P = Product



Steps of Enzyme Action

Factors affecting enzyme activity :

(a) Temperature : Show highest activity at optimum temperature. Activity declines above and below the optimum value.

(b) pH : Enzymes function in a narrow range of pH. Highest activity at optimum pH. (Fig. 9.7, 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 substrate is succinic acid).

Classification of enzymes :

1. **Oxidoreductase/dehydrogenases :** Catalyse oxidoreduction between 2 substrates. S reduced + S′ oxidised → 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. leaving 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 becomes catalytically active when it binds to non protein constituent called co-factors. Protein portion of enzyme is called apoenzyme.

- **Prosthetic group :** These are organic compound which 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 bond with substrate.

  e.g. zinc in enzyme carboxy peptidase.

Questions

(SRT) Select Response Type Question (1 mark each)

1. Purine bases are...
   (a) Adenosine & Guanosine (b) Adenine only
   (c) Guanine only (d) Adenine & Guanine
2. Bond between two monosaccharides is...
   (a) Glycosidic bond (d) Phosphodiester linkage
   (c) Peptide bond (d) Coordinate bond
3. Name an element found in protein but not in lipids & carbohydrates.
   (a) Hydrogen (b) Carbon
   (c) Nitrogen (d) Chlorine

CONSTRUCTED RESPONSE TYPE (CRT)

Very Short Answer Questions (1 mark each)

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 aminoacids 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 and hetero poly saccharides.
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 (3 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 phospodiester fond.
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

(SRT) Select Resonse Type Question (1 mark each)

1. (d) Adenine & Guanine
2. (a) Glycosidic bond
3. (c) Nitrogen

CONSTRUCTED RESPONSE TYPE (CRT)

Very Short Answer (1 marks each)

4. Lowers the activation energy of reaction.
5. ATP is 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 α-carbon has 4 substituted groups occupying the 4 valency positions : H, — COOH, — NH_2 and — R group.
12. $$\begin{array}{l} \qquad\quad R \\ \qquad\quad | \\ NH_3^+ - CH - COO^- \end{array}$$

    Due to ionizable nature of — NH_2 and — COOH groups.
13. Starch form helical secondary structure which can hold I_2.
14. Occupy lesser space as less bulky and can be 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.

Short Answers-I (3 marks each)

19. **Secondary metabolites**—The metabolites like alkaloids lectins drugs, pigments, spices and scents etc. which are useful to human welfare and have ecological importance, are products of certain metabolic pathways.

    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 Table 9.5, NCERT, text book of biology class XI.

21. Refer ‘Points to remember’.

22. Refer ‘Points to remember’.

23. Refer ‘Points to remember’.

24. Refer ‘Points to remember’.

Long Answers (5 marks each)

25. Refer ‘Points to remember’.

Case study based question (4 marks each)

26. Read the following and answer the question given below:

Enzymes are proteins that act as biological catalysts (biocatalyst). Almost all enzymes are proteins. Some Nucleic acid behaves like enzymes. They are called ribozymes. Enzymes have tertiary structure and many crevices called ‘active sites’. Enzymes act upon substrate and change them into products. Substrate binds to the active sites of enzymes.

26. (i) Which enzyme is used by the biscuit manufactures to lower the protein level of flour?

(a) Amylases (b) Proteases

(c) Cellulases (d) Xylases

26. (ii) Which of the following statement is/are correct about enzymes?

(a) An enzyme is a protein which acts as a biocatalyst to accelerate the rate of reaction.

(b) Life would not exist without the presence of enzymes in cells

(c) Enzymes participate in various cellular metabolic processes

(d) All the above

26. (iii) A protein having both structural and enzymatic properties is :

(a) Collagen (b) Trypsin

(c) Myosin (d) Actin

26. (iv) The diagram shows a metabolic pathway :

$$A \xrightarrow{\text{Enzyme -1}} B \xrightarrow{\text{Enzyme -2}} C \xrightarrow{\text{Enzyme -3}} D$$

What would happen to the rate of production of 'D', if enzyme 1 was not present?

(a) It would stop

(b) It would be increased

(c) It would be decreased

(d) No effect

Assertion and Reason Type Questions (1 mark each)

In each of the following questions, two statements are given, one is Assertion and other is Reason. Mark the correct answer as :

(a) Both assertion and reason are true, and the reason is the correct explanation of the assertion.

(b) Both assertion and reason are true but the reason is not the correct explanation of the assertion.

(c) Assertion is true but reason is false.

(d) Both the assertion and reason are false.

27. **Assertion :** A coenzyme or metal ion tightly bound to enzyme protein is called prosthetic group.

Reason : A complete catalytically active enzyme together with its bound prosthetic group is called apoenzyme.

28. **Assertion :** Secondary metabolites are produced in small quantities and their extraction from the plant is difficult and expensive.

Reason : Secondary metabolites can be commercially produced by using tissue culture technique.

29. **Assertion :** All enzymes are not proteins.

Reason : RNA molecules that possess catalytic activity are called ribozymes.

Answers :

Ans. 26 (i) (b) Proteases

Ans. 26 (ii) (d) All the above

Ans. 26 (iii) (c) Myosin

Ans. 26 (iv) (a) It would stop

Ans. 27 (c) Assertion is true but reason is false.

Ans. 28 (b) Both assertion and reason are true, but the reason is not the correct explanation of the assertion.

Ans. 29. (a) Both assertion and reason are true, but the reason is the correct explanation of the assertion.