

9. Biomolecules

Chemical composition

- All living organisms, from microbes to mammals, are composed of chemical substances.
- These chemical substances can be organic or inorganic. Chemical analysis is performed to find out chemical composition of a living cell.
- Water is the most abundant chemical compound in a living body.
- Most of the organic compounds are found in acid-soluble fraction.
- Inorganic compounds such as sulphate, phosphate, etc. are also found in acid-soluble fraction.

Organic compounds

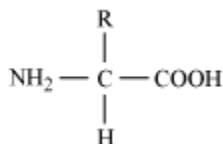
- All carbon compounds obtained from living tissues are known as organic biomolecules.
- These are of two types:
 - (a) Micromolecules (biomolecules)
 - (b) Macromolecules (bio-macromolecules)

A. Micromolecules (Biomolecules)

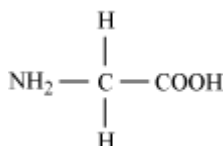
- These are organic compounds with molecular weights less than one thousand Dalton.
- Classified as amino acids, sugars, nucleotide bases, fatty acids, etc. These are also known as primary metabolites.
- Secondary metabolites on the other hand are compounds other than primary metabolites. These are commonly found in plants, fungi, and microbes. For example- Alkaloids, flavonoids, and essential oils etc. are secondary metabolites.

1. Amino acids

- These are organic compounds containing an amino group, carboxyl group, hydrogen, and a variable functional group (R).
- Common structure of an amino acid is



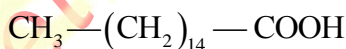
- Based on the nature of R group, there are many amino acids, but only 20 types of amino acids constitute proteins.
- Simplest amino acid is glycine that contains hydrogen as the R group.
- Structure of glycine is



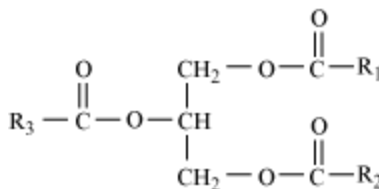
- Amino acids can be acidic (when carboxylic group is more, e.g. glutamic acid), basic (when amino group is more, e.g. lysine) or neutral (when both carboxylic and amino group are same in number, e.g. Valine).

2. Fatty acids

- Organic compounds containing a carboxyl group attached to an R group
- R group is variable and contains 1 to 19 carbons.
- Fatty acids can be saturated (without C=C double bond) or unsaturated (with one or more C=C double bonds).
- These are water insoluble compounds.
- Structure of fatty acid (palmitic acid)

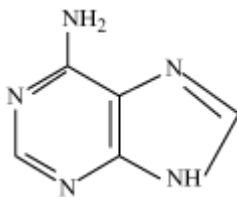


- Fatty acids are esterified with glycerol to form monoglycerides, diglycerides, and triglycerides.
- Structure of triglycerides is



3. Nitrogen bases

- These are organic compounds containing heterocyclic rings.
- Adenine, guanine, cytosine, uracil, and thymine are nitrogen bases.
- Structure of adenine is



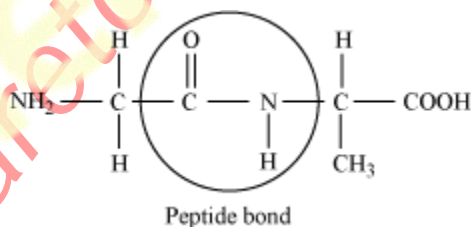
- When attached to sugar, these are known as nucleosides.
- When a phosphate group is also attached along with sugar, these are known as nucleotides.

B. Bio-macromolecules

- Organic compounds with molecular weights in the range of ten thousand Daltons and more are known as bio-macromolecules. Lipids are an exception.
- These are found in acid insoluble fraction.
- These are classified as proteins, polysaccharides, nucleic acids, etc.

1. Proteins

- Proteins are linear chains of amino acids linked by peptide bonds, hence also known as polypeptides.
- A peptide bond is formed between the carboxyl group of one amino acid and the amino group of next amino acid.
- Structure of peptide bond-

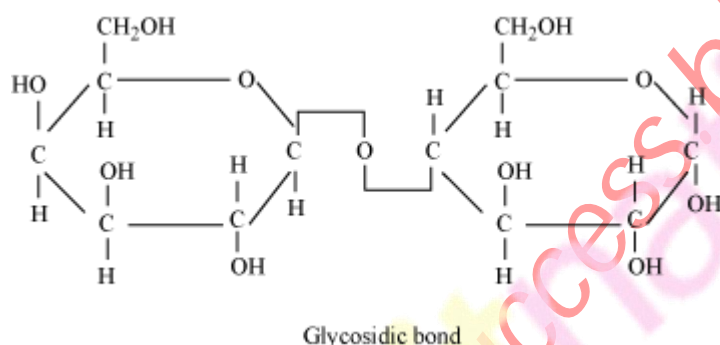


- Essential amino acids (obtained through diet or food) are part of dietary proteins.
- Functions of proteins:
 1. To transport nutrients
 2. Fighting infections
 3. Act as hormones and enzymes
- Collagen is the most abundant protein in the animals whereas RUBISCO (Ribulose biphosphate Carboxylase – Oxygenase) is the most abundant protein universally.
- Structures of proteins-

1. **Primary structure** is the linear chain of amino acids.
2. **Secondary structure** is the helical folded structure.
3. **Tertiary structure** is the three-dimensional view of protein.
4. **Quaternary structure** is the assembly of more than one polypeptide.

2. Polysaccharides

- Polysaccharides are long chains of sugars (monosaccharides).
- In a polysaccharide, the individual monosaccharides are joined by glycosidic bonds.
- Structure of glycosidic bond is



- Cellulose is a polysaccharide consisting of only one type of monosaccharide – glucose. Therefore, cellulose is a homopolymer or simple polysaccharides.
- Similarly, insulin is a polymer of fructose.
- Complex polysaccharides have building blocks, amino sugars, and chemically modified sugars such as glucosamine, N-acetyl galactosamines, etc. Hence, they are heteropolymers.
- Chitin is an example of complex polysaccharide. It forms the exoskeleton of arthropods and cell wall of fungi.

3. Nucleic acids

- Nucleic acids are polynucleotides.
- A nucleic acid containing deoxyribose sugar is DNA and that with ribose sugar is RNA.
- Bond formed between phosphate and hydroxyl group of sugar is known as phospho-diester bond.

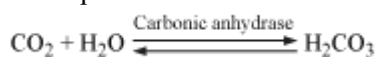
Metabolism

- All chemical reactions occurring in a living organism are together known as metabolism.
- Biosynthetic pathways where simple structures form complex structures are known as anabolic pathways.
- Degradation pathways where complex structures break to form simple structures are known as catabolic pathways.
- Energy is liberated in the form of ATP (Adenosine triphosphate).
- The rate of metabolic conversions (anabolism or catabolism) is affected by catalysts called enzymes.

Enzymes

- Enzymes are complex macromolecules with high molecular weight.
- Almost all enzymes are proteins. Those RNA which can catalyze their own biochemical reactions are called ribozymes.
- The site of an enzyme at which a substrate fits is called its active site.
- These can catalyze reactions at a high rate.

Example:



- Activation energy is the energy required to achieve the transition state.
- Enzymes are divided into 6 classes based on the type of reaction they catalyze - oxidoreductases, hydrolases, transferases, lyases, isomerases, and ligases.

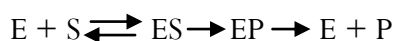
Properties of enzymes

- Enzymes do not start a reaction, but help in accelerating it.
- Enzymes affect the rate, but not the direction of a biochemical reaction.
- Most of the enzymes have high turnover number. **Turnover number** of an enzyme is the number of molecules of a substance that is acted upon by an enzyme per minute. High turnover number of enzymes increases the efficiency of reaction.
- Enzymes are specific in action.
- Enzymatic activity decreases with increase in temperature.
- The temperature and pH at which an enzyme shows the maximum activity is called the optimum temperature and optimum pH respectively.
- The activity of an enzyme declines both above and below the optimum value.
- Enzymes show maximum activity at an optimum pH of 6 – 8.

- The velocity of enzyme increases with increase in substrate concentration and then ultimately reaches a maximum velocity.
- A chemical that shuts the enzyme activity is called **inhibitor**.
- When an inhibitor binds to the active site and competes with the substrate for binding, it is called **competitive inhibitor**.

Nature of an enzyme action

- The enzyme (E) first unites with the substrate (S) and forms an intermediate enzyme substrate complex (ES).
- Then it returns to its original form with an intermediate formation of enzyme product complex (EP) after the reaction is concluded.



Cofactors

- The protein part of an enzyme is called **apoenzyme**.
- Cofactors are non-protein constituents bound to the enzyme. These make the enzyme catalytically active.
- Cofactors can be classified in three categories.
 - Prosthetic groups – These are organic compounds which tightly bind to the apoenzyme. Example: haem
 - Coenzymes – These are organic molecules which unite with the apoenzyme only during the course of reaction. Example: NAD
 - Metal ions – Example: Zn acts as cofactor for carboxypeptidase.

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