Biomolecules

Introduction

Bio: Life Molecules: Combination of atoms

In our biosphere there is a wide diversity in living organisms. All living organisms are made up of the same chemicals i.e., elements and compounds. If we analyses a plant tissue, animal tissue or a microbial paste, we obtain elements like carbon, hydrogen, oxygen etc. A similar analysis on a non-living matter say a piece of rock gives a list of similar chemicals. But when examined closely it is observed that in living organisms the relative abundance of carbon and hydrogen with respect to other elements is higher than in earth's crust.

How to Analyse Chemical Composition

- By performing a chemical analysis, the various biomolecules that are found in living tissues (a vegetable or a piece of liver etc.) can be studied. When a living tissue is grinded in trichloroacetic acid (Cl3CCOOH) using a mortar and pestle, a thick slurry is formed. This slurry when strained through cheese cloth or cotton gives two fractions, one is the filtrate which is called acid-soluble pool where thousands of organic compounds are found. The other fraction is called the retentate or the acid-insoluble pool where compounds like proteins, nucleic acids, polysaccharides etc. are found.
- All the carbon compounds that we get from living tissues can be called 'biomolecules'.
- However, inorganic elements and compounds are also present in the living organisms, which can be known with help of a technique called 'ash' analysis. A small amount of a living tissue (say a leaf or liver and this is called wet weight) is weighed and dried. All the water evaporates. The remaining material gives dry weight.
- When this tissue is fully burnt, the carbon compounds are oxidised to gaseous forms like CO2, water vapour and are removed and the remnant is called 'ash'. This ash contains many inorganic elements like calcium, magnesium etc.

  Therefore elemental analysis gives elemental composition of living tissues in the form of hydrogen, oxygen, chlorine, carbon etc. while analysis for compounds gives an idea of the kind of organic and inorganic constituents present in living tissues.

Table : A comparison of elements present in non-living and living matter

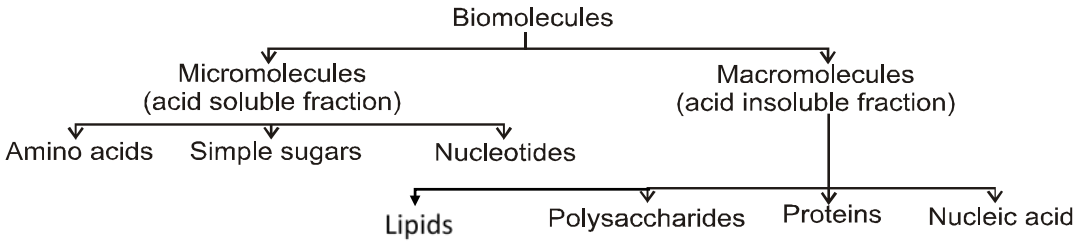
Elements	% Weight of	
	Earth's crust	Human body
Hydrogen (H)	0.14	0.5
Carbon (C)	0.03	18.5
Oxygen (O)	46.6	65
Nitrogen (N)	Very little	3.3
Sulphur (S)	0.03	0.3
Sodium (Na)	2.8	0.2
Calcium (Ca)	3.6	1.5
Magnesium (Mg)	2.1	0.1
Silicon (Si)	27.7	Negligible
Adapted from CNR Rao, Understanding Chemistry, Universities Press, Hyderabad.		

- In the acid-soluble fraction, inorganic compounds like sulphate, phosphate etc. are also present.
- From a chemistry point of view functional groups like aldehydes, ketones, aromatic compounds etc. can be identified.

Table: A list of inorganic constituents of living tissues

Component	Formula
Sodium	Na^+
Potassium	K^+
Calcium	Ca^{++}
Magnesium	Mg^{++}
Water	H_2O
Compounds	NaCl, $CaCO_3$, PO_4^{3-}, SO_4^{2-}

- From a biological point of view we can classify the biomolecules into micromolecules and macromolecules and further into amino acid, nucleotide bases, fatty acids etc.



Primary and Secondary Metabolites

Living organisms produce thousands of organic compounds (biomolecules) including amino acids, sugars, chlorophylls, haems etc. These are required for their basic or primary metabolic processes like photosynthesis, respiration, protein and lipid metabolism etc. These organic compounds are called primary metabolites.

Many plants, fungi and microbes of certain genera and families synthesize a number of organic compounds (biomolecules) which are not involved in primary metabolism and seem to have no direct function in growth and development of organisms. Such compounds are called secondary metabolites.

Thus, primary metabolites have identifiable functions and play known roles in normal physiological processes. The functions or role of secondary metabolites in host organisms are not understood. However many of them are useful to human welfare (e.g., rubber, drugs, spices, scents and pigments).

Table : Some secondary metabolism

Pigments	Carotenoids, Anthocyanins, etc.
Alkaloids	Morphine, Codeine, etc
Terpenoids	Monoterpenes, Diterpenes etc.
Essential oils	Lemon grass oil, etc.
Toxins	Abrin, Ricin
Lectins	Concanavalin A
Drugs	Vinblastin, Curcumin, etc.
Polymeric substances	Rubber, Gums, Cellulose

Biomacromolecules

- The acid insoluble fraction, has only four types of organic compounds, i.e., proteins, nucleic acids, polysaccharides and lipids. These classes of compounds with the exception of lipids, have molecular weights in the range of ten thousand Daltons and above. For this very reason, biomolecules, i.e., chemical compounds found in living organisms are of two types. One, those which have molecular weights less than one thousand Dalton and are usually referred to as macromolecules or simply biomolecules while those which are found in the acid insoluble fraction are called macromolecules or biomacromolecules.
- Lipids are not strictly macromolecules. Their molecular weight does not exceed 800 Da, but they come under the acid insoluble fraction because when we grind a tissue, cell membrane and other membranes are broken into pieces and form vesicles which are not water soluble (lipids are also present in structures like cell membrane and other membranes). Therefore, these membrane fragments in the form of vesicles get separated along with the acid insoluble pool.
- The acid-soluble fraction represents roughly the cytoplasmic composition (without organelles), while the acid insoluble fraction represents the macromolecules of the cytoplasm and cell organelles. The two fractions together represent the entire chemical composition of living tissues or organisms.

Table: Average composition of cells

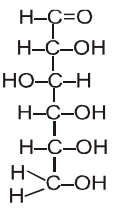
Component	% of the total cellular mass
Water	70-90
Proteins	10-15
Carbohydrates	3
Lipids	2
Nucleic acids	5-7
Ions	1

- Water is most abundant chemical in living organisms.

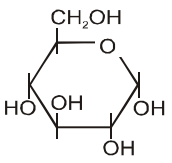
Carbohydrates (Poly Hydroxy Aldehydes or ketones)

- Carbohydrates are mainly compounds of carbon, hydrogen and oxygen. These are also known as saccharides because their basic components are sugars. They are of two types, small and large (complex). Small carbohydrates (biomicromolecules) are further divided into monosaccharides, derived monosaccharides and oligosaccharides. Large carbohydrates (biomacromolecules) are called polysaccharides.

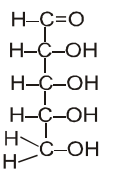
1. **Monosaccharides :** They are those sugars or simple carbohydrates which cannot be hydrolysed further into smaller components. These are composed of 3-7 carbon atoms and are biomicromolecules.



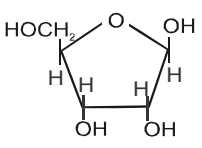
Open chain of Glucose



$C_6H_{12}O_6$(Glucose)

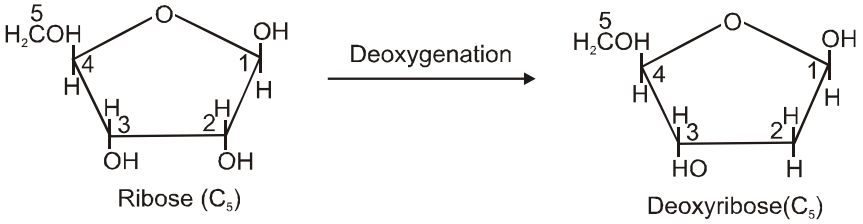


Open chain of Ribose



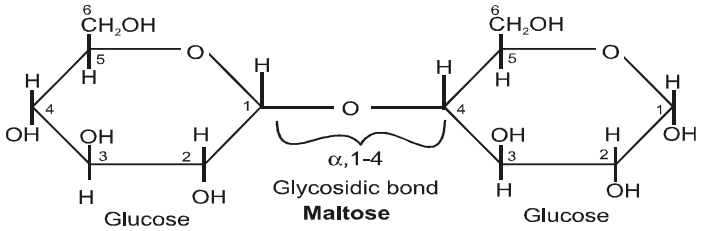
$C_5H_{10}OH_5$(Ribose)

2. **Derived Monosaccharides :** Monosaccharides are modified variously to form a number of different substances.
   - Deoxy sugar: e.g. Deoxygenation (removal of oxygen at 2nd carbon) of ribose produces deoxyribose.



   - Amino sugar: e.g. glucosamine
   - Sugar acid : e.g. glucuronic acid, ascorbic acid
   - Sugar alcohol: e.g. mannitol (present in brown algae)

3. **Oligosaccharides :** They are small carbohydrates which are formed by condensation (a chemical reaction in which two molecules combine to form one molecule with loss of a small molecule usually water) of 2-9 monosaccharides and are biomicromolecules. The monosaccharide units are joined together by glycosidic bond. It is formed between the aldehyde or ketone group of one monosaccharide and the alcohol group of another. This bond is also formed by dehydration. It is normally formed between carbon 1 of one monosaccharide unit and carbon 4 of second monosaccharide unit. Depending upon the number of monosaccharide molecules condensed to form oligosaccharides, they can be disaccharides (e.g., sucrose, maltose, lactose, trehalose (present in haemolymph of insects), trisaccharides (e.g., raffinose - made up of glucose, fructose and galactose), tetrasaccharides (e.g., stachyose) etc.



4. **Polysaccharides :** The acid insoluble pellet also has polysaccharides (carbohydrates) as another class of macromolecules. Polysaccharides are polymers or chains of monosaccharides and are macromolecules. They are threads (literally a cotton thread) containing different monosaccharides as building blocks and are branched or unbranched. In a polysaccharide the individual monosaccharides are linked by a glycosidic bond. The right end of a polysaccharide is reducing end while the left end is non-reducing end. Depending upon the composition, polysaccharides are of two types, homopolysaccharides and heteropolysaccharides.

   (i) Homopolysaccharides : Homopolysaccharides consist of only one type of monosaccharide monomer. Starch and glycogen both are polymers of glucose and serve as a storage form in plants and animals respectively.

   (a) Glycogen : Glycogen is made up of about 30,000 glucose residues. It is a branched structure having α1, 4 linkage at unbranched part and the branching points have α1, 6 linkage. It gives red colour with iodine

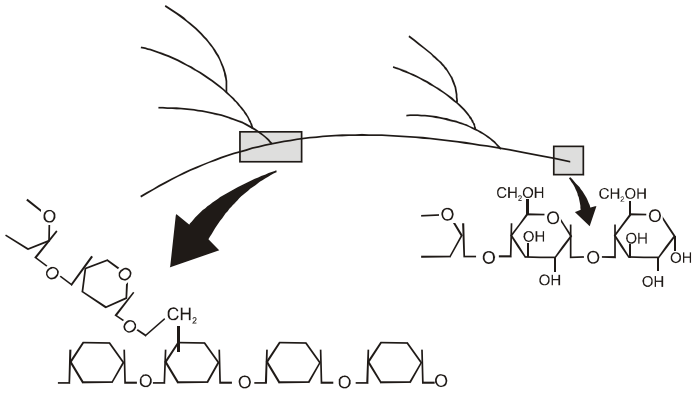


Fig. : Diagrammatic representation of a portion of glycogen

(b) Starch : Starch is a polymer of α-glucose.

Starch has two components - amylose (an unbranched polymer) and amylopectin (a branched polymer).

Amylopectin : Consists of 2000 - 200,000 glucose molecules forming straight chain by α-1, 4-glycosidic linkage and branching points have α, 1, 6-glycosidic linkage (branching after 25 glucose units).

Amylose : Consists of α, 1-4 glycosidic linkage between α-D glucose molecules. It is straight chain of 200-1000 glucose units. It is helical each turn consists of 6 glucose units.

Starch forms helical secondary structure i.e., the chain of glucose molecules folds in the form of a helix. Starch gives a characteristic blue colour with iodine (I_2) molecules due to the ability of the latter to occupy a position in the interior of a helical coil of glucose unit.

(c) Cellulose : Cellulose (Hexosan polysaccharide) : Cellulose is the main structural unbranched homopolysaccharide of plants. One molecule of cellulose has about 6000 β-glucose residues. Cotton fibres contain the largest amount (90 percent) of cellulose among natural materials. Wood contains between 25 to 50 percent cellulose, the rest being hemicellulose or lignin fibres of cotton, linen and jute are used for textile and ropes. Cellulose can be hydrolysed or digested by cellulase enzyme. Cellulose is unbranched homopolysacchande of β-glucose. Cellulose is the most abundant carbohydrate in biosphere. Cellulose is produced by plants and is used for building cell walls. Cellulose is the most abundant organic compound in the biosphere.

In plants cellulose serves as structural component in plant cell wall. Paper made from plant pulp is cellulose. Cellulose does not contain complex helices and hence cannot hold I_2.

(d) Inulin : is a polymer of fructose. It is a storage polysaccharide of roots and tubers of dahlia and related plants. Inulin is not metabolised in human body and is readily filtered through the kidney. It is therefore used in testing of kidney function.

(e) Chitin : It is the second most abundant organic substance. In chitin the basic unit is a nitrogen containing glucose derivative known as N-acetyl glucosamine. The exoskeletons of arthropods have chitin.

(ii) Heteropolysaccharides : Heteropolysaccharides consists of more than one type of monosaccharide monomer i.e., they are heteropolymers and are more complex polysaccharides. Some of the heteropolysaccharides are:

(a) Peptidoglycan : In peptidoglycan, the heteropolysaccharide chains are made up of two alternate amino-sugar molecules i.e., N-acetyl glucosamine and N-acetyl muramic acid.

(b) Hyaluronic acid : It is a heteropolymer composed of D-glucuronic acid (a carboxylic acid) and D-N-acetyl glucosamine (a monosaccharide derivative of glucose). Hyaluronic acid accounts for the toughness and flexibility of cartilage and tendon.

(c) Heparin **(d) Pectin** **(e) Hemicellulose** **(f) Chondroitin**

Note : Agar is a type of mucopolysaccharide and is obtained from red algae. It is used as culture medium in laboratory.

Concept Builder

1. With respect to earth crust abundancy of which element are always greter in any living organism :
(1) Phosphorous & Sulphur (2) Nitrogen and potassium
(3) Carbon and hydrogen (4) Carbon and oxygen

2. The basic criteria for differentiating bio micro molecules and bio macromolecules is :
(1) Molecular weight (2) Mode of action
(3) Amount in the organism (4) Evolutionary finding

3. Which of the following is the most abundant chemical in living organism:
(1) Carbohydrates (2) Nitrogen gas (N_2) (3) Water (4) RUBISCO

4. How many statements regarding chitin is/are true :
I. It is a simple polysaccharide II. It is a homopolymer
III. It forms endoskeleton of arthropods IV. Cell membrane of fungi are made of it.
(1) 3 (2) 2 (3) 1 (4) 0

5. Decreasing order of organic compound in protoplasm is:-
(1) Protein, lipid, Nucleic acid, Vitamin
(2) Protein, Nucleic acid, carbohydrate, lipid
(3) Carbohydrate, Lipid, Nucleic acid and vitamin
(4) None of these

6. Which is odd -
(1) Chitin – Carbohydrate (2) Pectin - Protein
(3) Steroid - Lipid (4) Wax - Lipid

7. Glycogen is stored in -
(1) Liver and muscles (2) Liver only
(3) Muscles only (4) Pancreas

8. Which one is a disaccharide ?
(1) Galactose (2) Fructose (3) Maltose (4) Dextrin

9. Which substance is not a carbohydrate ?
(1) Starch (2) Glycogen (3) Wax (4) Glucose

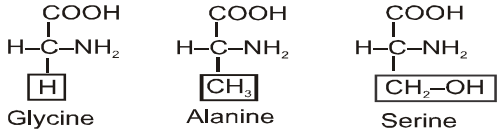
10. Which is not polysaccharide ?
(1) Sucrose (2) starch (3) Glycogen (4) cellulose

Concept Builder (Answer-Key)										
Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ans.	3	1	3	3	2	2	1	3	3	1

Amino Acids

Amino acids are organic compounds, having amino group ($-NH_2$) and carboxylic group (–COOH) attached to the same carbon i.e., the α-carbon (α-carbon is the carbon to which functional groups are attached). The α-carbon also bears hydrogen and a variable R group. They are substituted methane as there are four substituent groups occupying the four valency positions of carbon. Since both the functional groups are attached to the α-carbon so they are called α-amino acids.

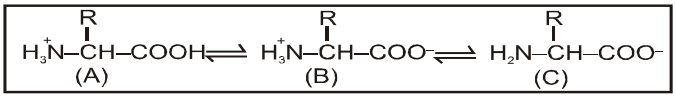
- Based on the nature of R groups there are many amino acids.
- Amino acids which occur in proteins are only of twenty types. The R group in these proteinaceous amino acids could be a hydrogen (glycine), a methyl group (alanine), hydroxy methyl (serine), etc.
- Humans are incapable of synthesizing half of the 20 standard amino acids and these are known as essential amino acids.
  They must be obtained from food. e.g., Lysine, methionine, phenylalanine, tryptophan, valine, isoleucine, leucine, threonine.
- Semi essential amino acids: They can be synthesised very slowly by human beings. e.g., Arginine and histidine.
- The amino acids that are synthesized in our body are called non-essential amino acids to denote the fact that they are not needed in the diet.
  e.g., Alanine, cysteine, glutamate, glycine, proline etc.



Amino acids

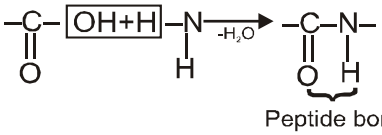
- Physical and chemical properties of amino acids are mainly due to the amino, carboxyl and R functional groups. Based on comparative number of amino and carboxyl groups, amino acids can be acidic, basic and neutral.
  (i) Acidic amino acids: The amino acids have an extra carboxylic group.
  Example: Glutamic acid (glutamate), aspartic acid (aspartate).
  (ii) Basic amino acids: They have an additional amino group.
  Example - Lysine, arginine etc.
  (iii) Neutral amino acids: Amino acids have one amino group and one carboxylic group.
  Example - Valine, alanine, glycine, leucine, isoleucine.
  (iv) Sulphur containing amino acid: Have sulphur.
  Example - Cysteine, cystine and methionine.
  (v) Alcoholic amino acid: Have –OH group.
  Example - Serine, threonine.
  (vi) Heterocyclic amino acid: N is present in ring.
  Example - Proline, histidine.
  (vii) Aromatic amino acids possess cyclic structure with a straight side chain bearing carboxylic and amino group.
  Example - Tyrosine, phenylalanine, tryptophan etc.

- A particular property of amino acids is the ionizable nature of NH_2 and COOH groups. These fully ionized species known as Zwitter ions have both a positive and a negative charge.



B is called zwitterionic form.

- Two amino acids can join through amino group of one and carboxylic group of the other forming peptide bond by loss of water molecule. When a few amino acids are joined in this fashion, the structure is called an oligopeptide. When many amino acids are joined, the product is called a polypeptide.



Functions of Amino Acids :

(i) Besides their principal function as building blocks for proteins, specific amino acids are also converted into different types of biologically active compounds. For example, tyrosine is converted into the hormones thyroxine and adrenaline, as well as the skin pigment melanin, glycine is involved in the formation of haem and tryptophan in the formation of the vitamin nicotinamide as well as the plant hormone indole-3-acetic acid.

(ii) After the removal of the amino group the carbon chain of many amino acids is converted into glucose.

(iii) On losing the carboxyl groups as carbon dioxide, amino acids form biologically active amines such as histamine. Histamine is required for the functioning of muscles, blood capillaries and gastric juices and glutamate and cysteine for glutathione.

(iv) Ornithine and citrulline are components of urea cycle.

(v) Antibiotics have non-protein amino acids.

(vi) Amino acids form organic acids which form glucose by gluconeogenesis.

Proteins

Proteins are large-sized macromolecules having one or more polypeptides (linear chains or polymers of amino acids linked by peptide bond). The term polypeptide is often used interchangeably with protein. However, a single polypeptide must be at least 50 amino acid long in order to qualify for the term.

As there are 20 types of amino acids, a protein is a heteropolymer and not a homopolymer. A homopolymer has only one type of monomer repeating 'n' number of times. Collagen is the most abundant protein in animal world. It is the main component of connective tissue of animals. Ribulose bisphosphate carboxylase-oxygenase (RuBisCo) is the most abundant protein in the whole biosphere. RuBisCo is an enzyme involved in carbon fixation (photosynthesis), a process by which atmospheric CO_2 is converted by plants to energy rich molecules i.e., glucose.

Most abundant protein in nature is RuBisCO, in our body is collagen.

Structure of Proteins:

Biologists describe the protein structure at four levels - primary, secondary, tertiary and quaternary.

1. **Primary Structure:**

- The sequence in which amino acids are arranged in a polypeptide chain of a protein is called its primary structure. It gives the positional information of amino acids in a protein i.e., which is the first amino acid, which is the second, and so on.

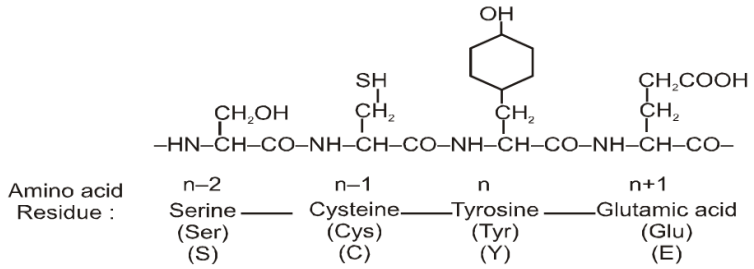


Fig.: Primary structure of a portion of a hypothetical protein. N and C refer to the two termini of every protein. Single letter codes and three letter abbreviations for amino acids are also indicated

- In these chains of amino acids which constitute protein, the amino acid present at the left end is the first amino acid, whereas the one at the right end is the last amino acid of the protein.
- The first amino acid is known as N-terminal amino acid and the last is known as C-terminal amino acid.

2. **Secondary Structure:**

- Some portions of the protein thread are folded either in the form of a helix (similar to a revolving staircase) or β-pleated sheet.
  The α-helix and β-pleated sheet are two types of secondary structures. In α-helix, there is interaction between every fourth amino acid by the formation of intramolecular hydrogen bond. The polypeptide gets a helical shape (α-helix). The intramolecular hydrogen bond is a bond formed between the hydrogen atom and the highly electronegative atom such as nitrogen, oxygen and fluorine of the same molecule.

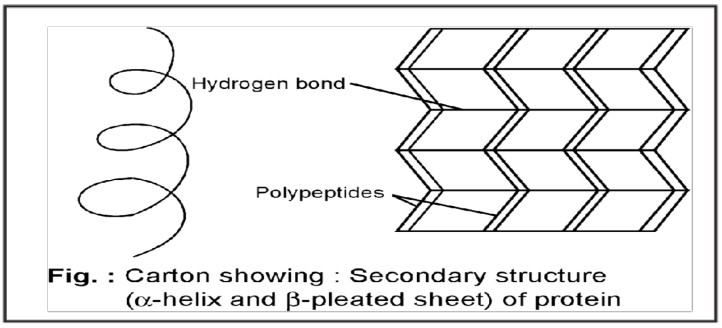


Fig. : Carton showing : Secondary structure (α-helix and β-pleated sheet) of protein

- In proteins, only right-handed helices are observed.

  Example - Keratin protein present in hair.
- When two or more β-strand chains are held together by intermolecular hydrogen bonds, the structure is described as β-pleated sheet.

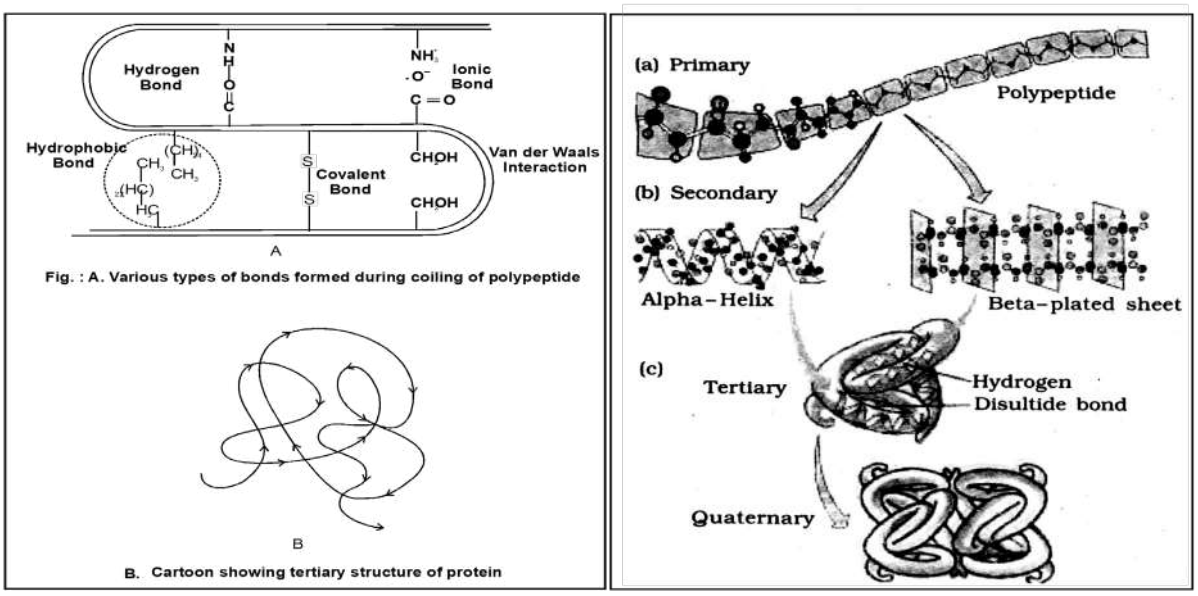
  Example - Fibroin protein of silk

3. **Tertiary Structure:**

- The long protein chain or the polypeptide chain usually folds upon itself like a hollow wollen ball. This is termed as tertiary structure. This structure gives a 3-dimensional view of a protein.

- Tertiary structure is absolutely necessary for the many biological activities of proteins for example, this structure brings distant amino acid side chains closer forming the active site (the site to which a substrate gets attached) of proteins i.e., enzymes.

  Example - Myoglobin (protein found in muscle cell)



4. Quaternary Structure:

- Quaternary structure is formed when a protein has more than one subunits (individual polypeptide chains of a quaternary protein are called subunits) or polypeptide chains and each polypeptide has a primary, secondary or tertiary structure of its own. The way in which these individual folded polypeptides are arranged with respect to each other (e.g., linear string of spheres, spheres arranged one upon each other in the form of a cube or plate etc.) gives the architecture of the quaternary structure of a protein.

  For example, haemoglobin has such structure. Haemoglobin has four helical polypeptide chains, two α-chains and two β-chains.

Table : Some proteins and their functions

Protein	Functions
Collagen	Intercellular ground substance
Trypsin	Enzyme
Insulin	Hormone
Antibody	Fights infectious agents
Receptor	Sensory reception (smell,taste, hormone, etc.)
GLUT-4	Enable glucose transport into cells

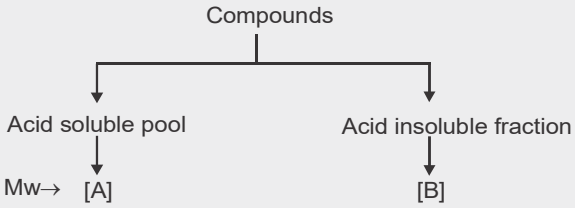
- All enzymes are protein accept Ribozyme

Concept Builder

1. When a living tissue is grinded in trichloroacetic acid (Cl_3COOH) a thick slurry is obtained which can be stained through a cotton giving out two fractions respectively:
(1) Filtrate acid soluble and retentate acid insoluble
(2) Filtrate and insoluble and retentate acid soluble
(3) Filtrate and retentate both acid insoluble
(4) Filtrate and retentate both acid soluble

2. On what basis the acidic, basic and neutral nature of amino acid is determined:
(1) Number of amino group (2) Number of carboxyl group
(3) Both (1) and (2) (4) Number of hydrogen atoms

3.



(1) 80 to 800 Da, 10^2 Da or above (2) 180 to 1800 Da, 10^2 Da or above
(3) 18 to 800 Da, 10^3 Da or above (4) 80 to 1600 Da, 10^3 Da or above

4. Which of the following statements are true?
(i) Each protein is a polymer of amino acid
(ii) A protein is a heteropolymer
(iii) Amino acids which can be found in our body are essential amino acids.
(iv) There are 20 types of amino acids for protein synthesis.
(1) (i), (ii) only (2) (iii), (iv) (3) (i), (iv) only (4) (i), (ii) and (iv)

5. Units of proteins which unite in long chains to form proteins, are called-
(1) Sugar (2) Purines (3) Pyrimidines (4) Amino acids

6. Milk protein is-
(1) Lactogen (2) Myosin (3) Casein (4) Pepsin

7. Most simple amino acid is-
(1) Tyrosine (2) Lysine (3) Glycine (4) Aspartic acids

8. Which of the following amino acid is essential -
(1) Alanine (2) Glycine (3) Tryptophan (4) Tyrosine

9. Variations in proteins are due to -
(1) Sequence of amino acids (2) Number of amino acids
(3) R - group (4) None

10. Histone is a basic protein due to -
(1) Alanine & glycine (2) Methionine & serine
(3) Tryptophan & tyrosine (4) Lysine & Arginine

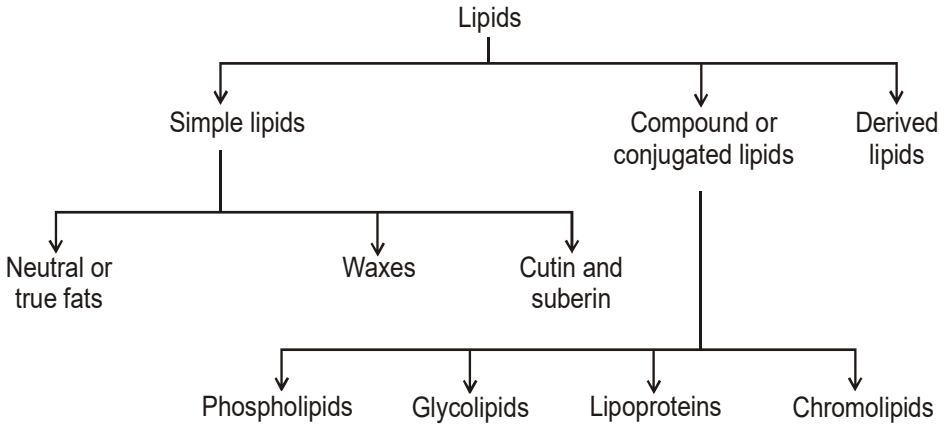
Concept Builder (Answer-Key)										
Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Ans.	1	3	3	4	4	6	3	3	1	4

Lipids

- Lipids are all made of carbon, hydrogen and little oxygen and are water insoluble but get dissolved in organic solvents like ether, benzene, acetone etc. The lipids are not polymers but they are assembled from smaller molecules by dehydration.
- Lipids could be simple fatty acids or glycerol (which is trihydroxy propane). Many lipids have both glycerol and fatty acids. Some lipids have phosphorus and a phosphorylated organic compound in them. Some lipids have more complex structures.

Classification

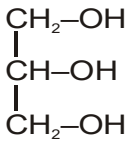
The lipids are classified into sub-groups as follows:



A. Simple Lipids: These are esters (organic acids and alcohols react to form esters) of fatty acid with various alcohols. They are of two types:

I. Neutral or True Fats: These are esters of fatty acid with glycerol. They are also called glycerides. A fat molecule consists of one molecule of glycerol and one to three molecules of the same or different long-chain fatty acids.

(a) Glycerol: A glycerol molecule has 3 carbons, each bearing a hydroxyl (–OH) group.



Glycerol (tryhydroxy propane)

(b) Fatty: A fatty acid molecule is an unbranched chain of carbon atoms having a carboxylic group attached to an R group. The R group could be a methyl ($-CH_3$) or ethyl ($-C_2H_5$) or higher number of $-CH_2$ groups (1 carbon to 19 carbons). For example, palmitic acid has 16 carbons including carboxyl carbon. Arachidonic acid has 20 carbon atoms including the carboxyl atom

Fatty acids are of two types :

1. Saturated Fatty Acids: Fatty acids without double bond.

Example - Palmitic acid, stearic acid

$CH_3–(CH_2)_{14}–COOH$	$CH_3–(CH_2)_{16}–COOH$
Fatty acid	Fatty acid
(Palmitic acid)	(Stearic acid)

2. **Unsaturated Fatty Acids :** Fatty acids with one or more double bonds.

Example - Oleic acid, linoleic acid, linolenic acid, arachidonic acid

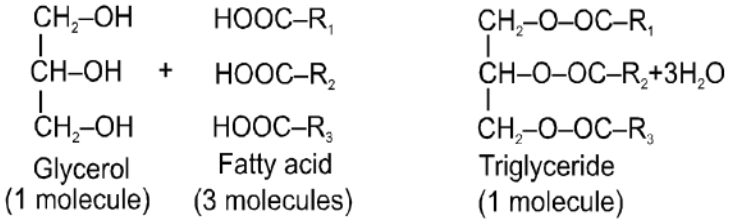
$CH_3(CH_2)_7\ CH = CH\ (CH_2)_7\ COOH$

Oleic acid

$CH_3(CH_2)_4\ CH = CH\ CH_2\ CH = CH(CH_2)_7\ COOH$

Linoleic acid

- Neutral or true fats may be monoglyceride if there is only one molecule of fatty acid attached to a glycerol molecule. If the number of fatty acids attached to a glycerol happens to be two, it is called diglyceride, or triglyceride if the number of fatty acids is three.



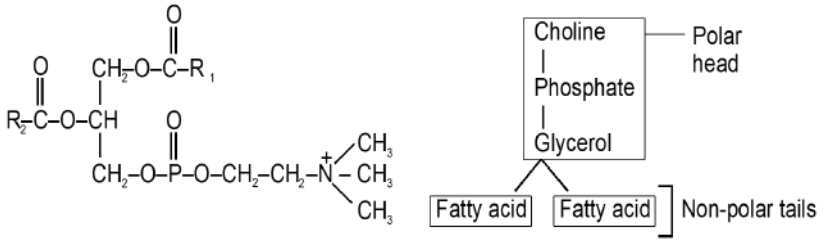
- Based on the melting point triglycerides can be called as fats or oils. Fats have high melting point and remain as solids at room temperature. e.g., butter, ghee while oils have low melting point and remain as liquids/oil at room temperature. e.g., gingely oil, sunflower oil, etc.

II. Waxes : These are esters of fatty acids with alcohol of high molecular weight instead of glycerol. e.g., bee wax, lanolin etc. They have an important role to play in protection. They form waterinsoluble coatings on hair and skin in animals and stems, leaves and fruits of plants.

Bee wax is formed from palmitic acid ($C_{16}H_{32}O_2$) and myricyl alcohol ($C_{30}H_{61}OH$). Bee wax is also called as Hexacosyl palmitate, secreted by worker bees. Lanolin (wool fat), forms a water proof coating around the animal fur.

B. Compound or Conjugated Lipids : These are esters of fatty acids with alcohol, but contain some other substances also. They are :

(i) Phospholipids : The phospholipids are composed of a molecule of glycerol or other alcohol having (i) a phosphate group joined to one of its outer –OH groups, (ii) two fatty acid molecules linked to the other two –OH groups, and (iii) a nitrogen-containing choline molecule, bound to the phosphate group. Phospholipids are found in cell membranes. Lecithin is one example of phospholipid.



Phospholipid (lecithin)

(ii) Glycolipids : Glycolipids contain fatty acids, alcohol sphingosine and sugar (galactose). The sugar replaces one fatty acid molecule. The glycolipids are present in myelin sheath of nerve fibres and in the outer surface of cell membrane of chloroplast.

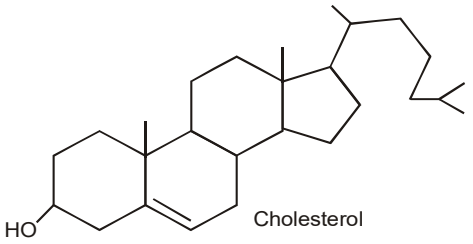
(iii) Lipoproteins : Lipoproteins contain lipids (mainly phospholipids) and proteins in their molecules. Membranes are composed of lipoproteins.

(iv) Chromolipids : These contain pigments such as carotenoids e.g. Carotene, vitamin A.

C. Derived Lipid :

Steroids : The steroids do not contain fatty acids, but are included in the lipids because they have fat-like properties. Instead of straight chain they are composed of four fused carbon rings. The various steroids differ in the number and position of double bonds between carbon atoms and in the side groups linked to the ring. The most common steroids are sterols. A common sterol is cholesterol.

- Cholesterol is the most abundant steroid in the animal tissues. Food rich in animal fats contain cholesterol. It is also synthesised in the liver.
- Cholesterol is an essential component of animal plasma membrane.



Cholesterol

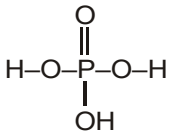
Nature of Bond Linking Monomers in A Polymer

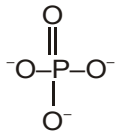
- In a polypeptide or a protein, amino acids are linked by a **peptide bond** which is formed when the carboxyl (-COOH) group of one amino acid reacts with the amino ($-NH_2$) group of the next amino acid with the elimination of a water moiety (the process is called dehydration. In a polysaccharide the individual monosaccharides are linked by a **glycosidic bond.** This bond is also formed by dehydration. This bond is formed between two carbon atoms of two adjacent monosaccharides.

Nucleic Acids

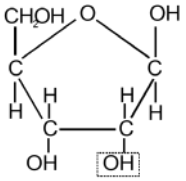
- Nucleic acids are polymers of nucleotides and are macromolecules. There are two types of nucleic acids namely - deoxyribonucleic acid (DNA) or ribonucleic acid (RNA). Nucleotide serves as the building block of nucleic acid. A nucleotide is composed of:

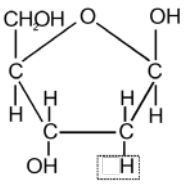
(i) A Phosphate Group :


Phosphoric Acid

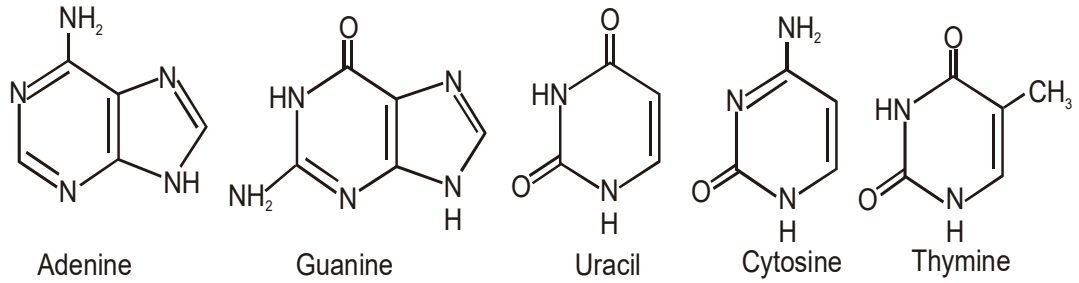

Phosphate ion

(ii) A five-carbon sugar or pentose sugar (monosaccharide) : In RNA the sugar is ribose (thus the name ribonucleic acid) and in DNA the sugar is deoxyribose (thus deoxyribonucleic acid).

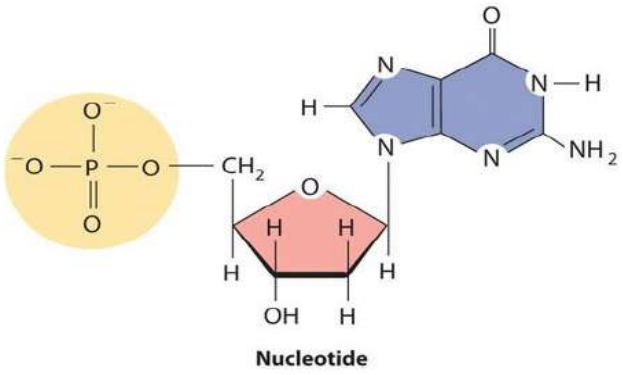

β-ribose


β-deoxyribose

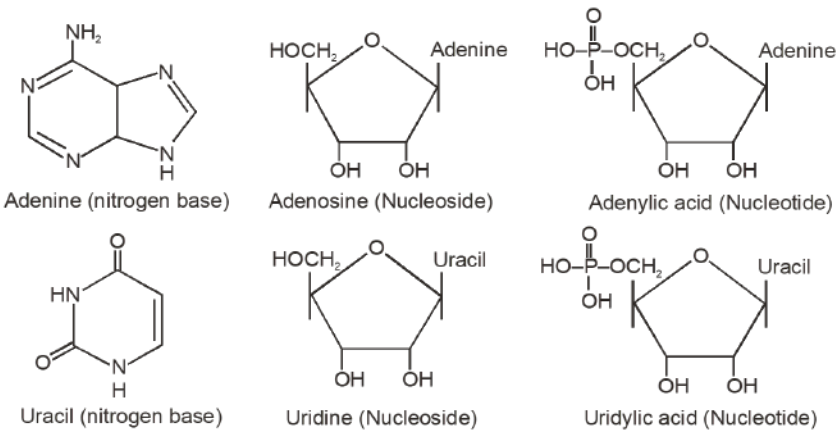
(iii) A heterocyclic nitrogen-containing compound called base: There are four different bases commonly found in DNA : adenine (A), guanine (G), thymine (T) and cytosine (C). RNA also contains adenine, guanine, and cytosine but instead of thymine it has uracil (U). Adenine and guanine are double-ring bases called purines. Cytosine, thymine and uracil are single-ring bases called pyrimidines.



- The nitrogenous base molecule is joined to the sugar molecule by a glycosidic bond and forms a structure called nucleoside. The nucleoside combines with a phosphate group by an ester bond to form a nucleotide.



	Nitrogenous Base	Nucleoside	Nucleotide
1	Adenine	Adenosine	Adenylic acid
2	Guanine	Guanosine	Guanylic acid
3	Cytosine	Cytidine	Cytidylic acid
4	Thymine	Thymidine	Thymidylic acid
5	Uracil	Uridine	Uridylic acid



- In a nucleic acid a phosphate moiety (moiety is a part of a larger molecule or structure) links the 3' carbon of one sugar of one nucleotide to the 5' carbon of the sugar of the succeeding nucleotide. The bond formed between the phosphate and hydroxyl group of sugar is an ester bond. As there is one such ester bond on either side, it is called phosphodiester bond.
- DNA is the genetic material and forms molecular basis of heredity (the transmission of genetic characters from parents to offspring) in all organisms. In certain viruses, such as tobacco mosaic virus (TMV), RNA is the genetic material.
- Nucleic acids exhibit a wide variety of secondary structures for example, one of the secondary structure exhibited by DNA is the famous Watson-Crick model.

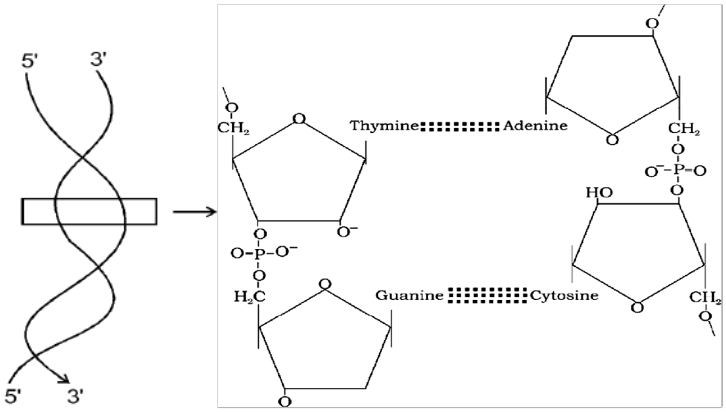


Fig. : Diagram indicating secondary structure of DNA

Watson-Crick Model of DNA :

- This model says that DNA exists as a double helix. A DNA molecule has two unbranched polynucleotide strands. Each polynucleotide strand or chain consists of a sequence of nucleotides linked together by phosphodiester bonds. The polynucleotide strands are antiparallel, i.e., run in the opposite direction.
- The two strands are not coiled upon each other but the double strand is coiled upon itself around a common axis like spiral staircase with base pairs forming steps while the backbones of the two strands form railings. The backbone is formed of sugar and phosphate.
- The nitrogen bases are projected more or less perpendicular to the sugar phosphate backbone but face inside.
- The base-pairing is specific. Adenine is always paired with thymine and guanine is always paired with cytosine. Thus, all base-pairs consist of one purine and one pyrimidine. Once the sequences of bases in one strand of a DNA double helix is known, the sequence of bases in the other strand is also known because of the specific base pairing. The two strands of a DNA double helix are thus said to be complementary (not identical). This is known as complementary base pairing.
- The two polynucleotide strands are held together in their helical structure by hydrogen bonding between bases in opposing strands. Adenine and thymine form two hydrogen bonds. Guanine and cytosine form three hydrogen bonds.
- One end of the strand is called 5' end where the fifth carbon of the pentose sugar is free and the other end is called 3' end where the third carbon of pentose sugar is free.
- At each base pair the strand turns 36°. One full turn of the helical strand (360°) would involve ten base pairs i.e., one turn of 360° of the helical strand has about 10 nucleotide on each strand of DNA. The base-pairs in DNA are stacked 3.4 Å apart. Thus, pitch of the DNA is 34 Å as ten base pairs occupy a distance of about 34 Å.
- This form of DNA with the above mentioned salient features is known as B-DNA.

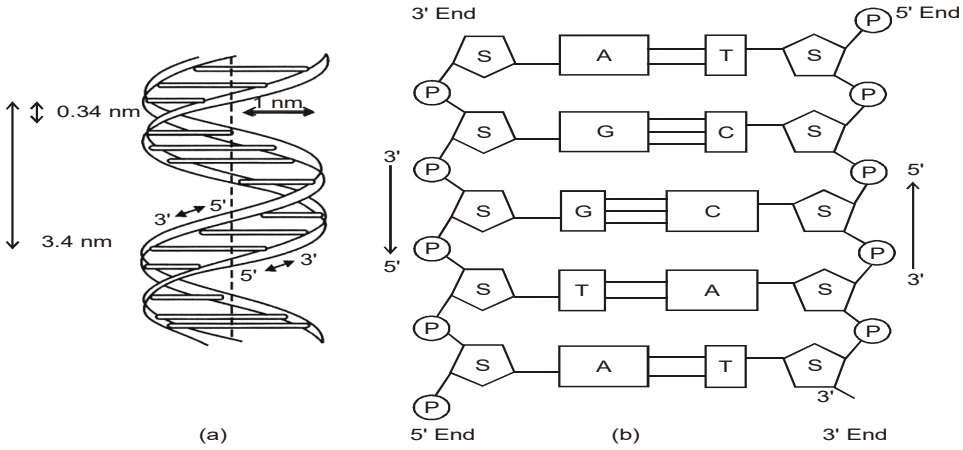


Fig. : DNA double helix

Chargaff' Rule :

(i) The amount of adenine is always equal to that of thymine; and the amount of guanine is always equal to that of cytosine (i.e., A = T and G = C).

(ii) The base ratio (A + T)/(G + C) may vary from one species to another, but is constant for a given species.

RNA : (Ribonucleic Acid) :

- There are three types of non-genetic RNA.

(i) Messenger RNA (m-RNA) : It is produced in the nucleus and carries the information for the synthesis of proteins; it was discovered by Jacob and Monod (1961).

(ii) Ribosomal RNA (r-RNA) : It is the largest RNA and constitutes about 80% of total cellular RNA. Found in the ribosomes where protein synthesis takes place.

(iii) Transfer RNA : It is the smallest type of RNA and constitutes about 10-15% of total cellular RNA. These are found in the cytoplasm and are different types. Their function is to collect amino acids from the cytoplasm for protein synthesis.

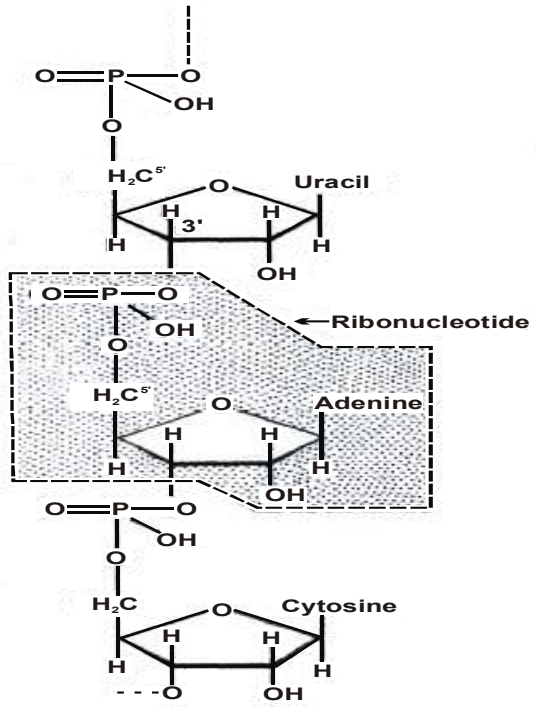


Fig. : A polynucleotide strand of RNA

Concept Builder

1. Which of the structure of protein is absolutely necessary for many biological activities:
(1) Primary (2) Secondary (3) Tertiary (4) Quaternary

2. Which type of structure of nucleic acid is exhibited by DNA in watson and crick model:
(1) Primary (2) Secondary (3) Ribosome (4) Any of the above

3. Ribozyme is a type of:
(1) Protein (2) Nucleic acid (3) Ribosome (4) Fatty acid

4. A nucleotide has three chemically distinct components:
(i) Homocyclic compound
(ii) Heterocyclic compound
(iii) Monosaccharide
(iv) Disaccharide
(v) Phosphoric acid
(1) (i), (iii) and (v) (2) (i), (iv) and (v) (3) (ii), (iv) and (v) (4) (ii), (iii) and (v)

5. Which of the following may be true to for RNA-
(1) A = U G = C (2) A ≠ U G≠ C (3) A = U = G = C (4) Purines = Pyrimidines

6. Nucleic acids are made up of -
(1) Amino acids (2) Pentose sugars (3) Nucleosides (4) Nucleotide

7. Double helix model of DNA which was proposed by Watson and crick was of –
(1) C-DNA (2) B-DNA (3) D-DNA (4) Z-DNA

8. DNA differs from RNA in –
(1) Only Sugar (2) Nitrogen base only
(3) Nitrogen base and sugar (4) None

9. Back bone of structure of DNA molecule is made up of -
(1) Pentose Sugar and phosphate (2) Hexose sugar and phosphate
(3) Purine and pyrimidine (4) Sugar and phosphate

10. One of the characteristics of DNA is –
(1) Uracil (2) Deoxyribose sugar
(3) Single strandedness (4) Ability of protein synthesis

11. Number of H-bonds between guanine and cytosine are -
(1) One (2) Two (3) Three (4) Four

Concept Builder (Answer-Key)											
Que.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Ans.	3	2	2	4	2	4	2	3	1	2	3

Dynamic State of Body Constituents – Concept of Metabolism

- Living organisms contain thousands of organic compounds or biomolecules (also known as metabolites) that are present in certain concentrations (expressed as mols/cells or moles/litre etc.) All these biomolecules have a turn over which means they are constantly being changed into some other biomolecules and also made from some other biomolecules. Through chemical reactions, this breaking and making occurs constantly in living organisms. Together all these chemicals reactions are called metabolism.
- Biomolecules get transformed due to metabolic reactions that occur in a living cell/organism.
- A few examples of metabolic transformations are : removal of CO_2 from amino acids making an amino acid (contain –COOH and $–NH_2$) into an amine (contain NH_2 only as functional group), removal of amino group in a nucleotide base; hydrolysis (cleavage of a bond by the addition of element of water, yielding two or more products) of a glycosidic bond in a disaccharide such as lactose, yields two monosaccharide molecules namely glucose and galactose.
- Metabolites are converted into each other in series of linked reaction called metabolic pathways. These pathways resemble the automobile traffic in a city. They are either linear or circular and criss-cross each other i.e., there are traffic junctions.
- Flow of metabolites through metabolic pathway has a definite rate and direction like automobile traffic. This metabolic flow is called the dynamic state of body constituents.
- In healthy conditions, this interlinked metabolic traffic is very smooth and without a single reported mishap.
- In metabolic reactions, every chemical reactions that occurs is a catalysed reaction (reactions that occur in the presence of a catalyst). Catalyst which accelerates the rate of a given metabolic conversions (reactions) are known as enzymes. Almost all enzymes are proteins with catalytic power. Thus, enzymes are biocatalyst which accelerates the rate of a given metabolic reactions.
- There is no uncatalysed metabolic reaction. Even CO2 dissolving in water is a catalysed reaction in living systems.

$$\underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O} \xrightarrow[(\text{Enzyme})]{\text{Carbonic anhydrase}} \underset{\text{Carbonic acid}}{H_2CO_3}$$

- All chemical reactions occurring in the living systems are mediated through the biocatalyst called enzymes.

Metabolic Basis of Living

- Metabolic pathways can lead to a more complex structure from a simpler structure for example, acetic acid becomes cholesterol. Acetic acid is the primary precursor in the production of body cholesterol. The acetic acid is converted to cholesterol in the liver through a series of biochemical reactions. Such metabolic pathways are called biosynthetic pathways or anabolic pathways. Another example is formation of proteins from amino acids. Anabolic pathways consume energy.

- Metabolic pathways can also lead to a simpler structure from a complex structure for example glucose (6 carbon compound) becomes lactic acid (3 carbon compound). In every living cell glucose is converted into pyruvate through 10 metabolic steps called glycolysis. In vigorously contracting muscles, due to lack of oxygen, the pyruvate gets converted into lactic acid (converted acetyl CoA which further breaks down into CO_2 and H_2O). This constitute degradation and are called catabolic pathways. Catabolic pathways leads to release of energy.
- Living organisms trap the energy liberated during degradation and store it in the form of chemical bonds of molecules like ATP (adenosine triphosphate). When needed, the chemical bonds breakdown and energy is liberated. This liberated energy is utilised for biosynthetic, osmotic (related to osmosis i.e., movement of solvent from a region of diluted solution to a region of concentrated solution through a semipermeable membrane) and mechanical work that we perform.
- Adenosine triphosphate (ATP) a nucleotide, is called universal energy carrier as well as energy currency of the cell. ATP is formed of an adenine (a purine), a ribose (pentose sugar) and a row of three phosphate attached to ribose.
- ATP molecules are produced during cellular respiration. The second and third phosphates of ATP are attached by high energy bonds. Breakdown of these bonds liberate energy to perform the various cellular activities. ATP is found in all living cells.

The Living State

- In a living organism tens and thousands of metabolites or biomolecules are present at concentrations characteristic of each of them for example, glucose is 4.5-5.0 mM in blood, hormones in nanograms/ml.
- The most important fact of biological systems is that all living organisms exist in a steady state. Steady state is a non-equilibrium state in which all the biomolecules remain at constant concentration. These biomolecules are in a metabolic flux.
- Metabolic flux is the rate of turn over of molecules through a metabolic pathway. Flux (the act of flowing is regulated by the enzymes involved in a pathway within cells. Regulation of flux is vital for all metabolic pathways to regulate the metabolic pathways activity under different conditions.
- Any chemical or physical process moves spontaneously to equilibrium but at equilibrium no work can be done. Living organisms cannot afford to reach equilibrium as they work continuously. Therefore, the living state is a non-equilibrium steady-state to be able to perform work.
- Living process is a constant effort to prevent attaining equilibrium. This is done by energy input (absorption of energy). Metabolism provides a mechanism for the production of energy. Hence the living state and metabolism are synonymous. Without metabolism there cannot be a living state.

Exercise - I

1. Which element is present negligible in human body ?

(1) O (2) C

(3) H (4) Si

2. Pentoses and hexoses are common:

(1) Oligosaccharides (2) Disaccharides

(3) Monosaccharides (4) Polysaccharides

3. Fehling's solution can detect presence of :

(1) Sucrose (2) Glucose

(3) Amino acids (4) Lipids

4. Which of the following is present in acid insoluble fraction?

(1) Glucose (2) Fructose

(3) Alanine (4) Lipid

5. Which of the following secondary metabolites is a polymeric substance?

(1) Ricin (2) Monoterpenes

(3) Curcumin (4) Rubber

6. Which of the following is the most abundant element present in human body?

(1) Carbon (2) Hydrogen

(3) Oxygen (4) Nitrogen

7. Which of the following is a primary metabolite?

(1) Carotenoid (2) Glucose

(3) Morphine (4) Cellulose

8. Which of the following is not a macromolecule?

(1) Amino acid (2) Nucleotide

(3) Monosaccharide (4) All the above

9. Inulin is a polymer of:

(1) Fructose (2) Glucose

(3) Mannose (4) Ribose

10. Plant cell walls are made of:

(1) Homopolymer of fructose

(2) Heteropolymer of glycogen

(3) Homopolymer of glucose

(4) Homopolymer of glycogen

11. As starch is related to plant body, which of the following polysaccharides is related to animal body?

(1) Cellulose (2) Chitin

(3) Glycogen (4) Inulin

12. Which of the following is not a chemically modified sugar?

(1) Glucosamine

(2) N-acetyl galactosamine

(3) Galacturonic acid

(4) Dihydroxy acetone

13. Cotton fiber is made up of :

(1) Cellulose (2) Glycogen

(3) Chitin (4) Starch

14. Iodine test can detect the presence of:

(1) Starch (2) Cellulose

(3) Both (1) & (2) (4) Chitin

15. Which of the following is a structural polysaccharide?

(1) Glycogen (2) Starch

(3) Inulin (4) Cellulose

16. Which of the following is mismatched?

(1) Chitin – Polymer of glucosamine

(2) Glycogen – Polymer of glucose

(3) Cellulose – Heteropolysaccharide

(4) Inulin – Homopolysaccharide

17. Unbranched polymer of glucose is:

(1) Starch (2) Glycogen

(3) Cellulose (4) Chitin

18. Which of the following is the most abundant carbohydrate in biosphere?

(1) Starch (2) Glycogen

(3) Cellulose (4) Hemicellulose

19. Based on the nature of R group there are many amino acids. If the R group in a portentous amino acid is a methyl group, then the amino acids is :

(1) Glycine (2) Alanine

(3) Serine (4) Phenylalanine

20. Which of the following amino acid is basic in nature?

(1) Glutamic acid (2) Lysine

(3) Valine (4) Tyrosine

21. Valine amino acids is :

(1) α-AA

(2) β-AA

(3) γ-AA

(4) All the three types

22. Tick mark the incorrect statement about adult human hemoglobin :

(1) It is made up of four sub-units

(2) Two sub-units are of α-type and two sub-units of β-type

(3) It has quintenary structure of protein

(4) It is a simple protein

23. Which of the following structure of protein is absolutely necessary for the many biological activities of proteins?

(1) Primary (2) Secondary

(3) Tertiary (4) Quaternary

24. What is the R group in Glycine?

(1) $-CH_2-OH$ (2) $-H$

(3) $-CH_3$ (4) None of them

25. Antibodies that help to fight infectious agents are:

(1) Polysaccharides (2) Amino acids

(3) Proteins (4) Glucose

26. The tertiary structure of proteins can be destroyed by:

(1) High energy radiations

(2) High temperature

(3) Drastic changes in pH

(4) All of these

27. Which of the following is acidic amino acid?

(1) Valine (2) Glutamic acid

(3) Arginine (4) Lysine

28. Unsaturated fats are made saturated by :

(1) Polymerisation

(2) Dehydrogenation

(3) Hybridisation

(4) Hydrogenation

29. Arachidonic acid has :

(1) 20 carbons excluding carboxyl carbon

(2) 20 carbons including carboxyl carbon

(3) 16 carbons excluding carboxyl carbon

(4) 16 carbons including carboxyl carbon

30. Lecithin is:

(1) Simple lipid (2) Derived lipid

(3) Phospholipid (4) Steroids

31. N-Acetyl glucosamine is:

(1) An amino acid

(2) A modified lipid

(3) A modified sugar

(4) None of the above

32. Which of the following statements is incorrect?

(1) Lipids are strictly macromolecules

(2) Palmitic acid has 16 carbons including carboxyl carbon

(3) Oils have low melting point and hence remain as oil in winters

(4) Arachidonic acid is an unsaturated fatty acid

33. How many total carbons are present in palmitic acid?

(1) 15 (2) 16

(3) 17 (4) 20

34. Which of the following is component of simple lipid?

(1) Glycerol (2) Glycol

(3) Fatty acid (4) both 1 & 3

35. Lipids may be:

(1) Monoglyceride (2) Diglyceride

(3) Triglyceride (4) All the above

36. In a normal adult, descending order of concentration of following molecules is:

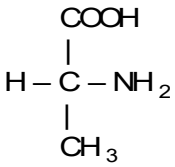
(1) K > Na > Fe > Cu

(2) Na > K > Cu > Fe

(3) Fe > Na > K > Cu

(4) Na > Fe > K > Cu

37. Following structure is related to which AA?



(1) Glycine (2) Alanine

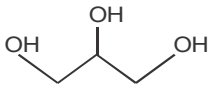
(3) Serine (4) Tyrosine

38. Which of the following is a homopoly-saccharide?

(1) Heparin (2) Inulin

(3) Pectin (4) Hyaluronic acid

39. Observe the structure and identify the compound:



(1) Glycine (2) Glycerol

(3) Glycolipid (4) Glucose

40. Which one is the most abundant protein in the animal world?

(1) Trypsin (2) Haemoglobin

(3) Collagen (4) Insulin

41. Which of the following sugar is not found in plants?

(1) Sucrose (2) Glucose

(3) Lactose (4) Fructose

42. Jute fibers deteriorate quickly because:

(1) Cellulose content is high

(2) Lignin content is high

(3) Cellulose content is low

(4) Lignin content is low

43. Which of the following contains β-1,4 linkage?

(1) Maltose

(2) Sucrose

(3) Lactose

(4) Fructose

44. An indispensable role in energy metabolism is played by -

(1) Phosphorus

(2) Lithium

(3) Sodium

(4) Calcium

45. Basic unit of a nucleic acid is :

(1) Pentose sugar

(2) Phosphoric acid

(3) Nucleotide

(4) All of these

46. Which of the following statements is incorrect ?

(1) Lipids are strictly macromolecules

(2) Palmitic acid has 16 carbons including carboxyl carbon

(3) Oils have low melting point and hence remain as oil in winters

(4) Arachiodonic acid is an unsaturated fatty acid

47. Which one is correct base pairing for DNA molecules ?

(1) Cytosine – Uracil

(2) Thymine – Guanine

(3) Thiamine – Cytosine

(4) Cytosine – Guanine

48. DNA resembles RNA as both have :

(1) Ability to replicate

(2) Similar sugars

(3) Similar pyrimidine bases

(4) Polymer of nucleotides

49. On hydrolysis, a nucleoside would not yield:

(1) Purines

(2) Pyrimidine

(3) Pentose sugar

(4) Phosphoric acid

50. Which of the following statement is incorrect?

(1) Backbone of DNA is formed by sugar-phosphate-sugar chain

(2) Nucleic acid are present in acid soluble fraction of any living tissue

(3) DNA and RNA function as genetic material

(4) There are three hydrogen bonds between G and C in DNA molecule

51. Which of the following is not a salient feature of B-DNA ?

(1) One full turn of helical strand involve 10 base pairs

(2) Pitch of helix would be 34 Å

(3) Diameter of double helix would be 20 Å

(4) DNA with left handed coiling

52. Select the odd one :

(1) When glucose is degraded to lactic acid in our skeletal muscle energy is liberated.

(2) Energy currency in living system is the bond energy in ATP.

(3) There is no uncatalysed metabolic conversion in living system.

(4) None of the above

53. Match the following according to composition of cells :

	A Component		B % of the total cellular mass
i	Carbohydrates	(a)	15
ii	Water	(b)	3
iii	Nucleic acid	(c)	75
iv	Protein	(d)	7

(1) (i–c) (ii–a) (iii=d) (iv–b)

(2) (i–d) (ii–c) (iii=b) (iv–a)

(3) (i–b) (ii–c) (iii=d) (iv–a)

(4) (i–d) (ii–c) (iii=a) (iv–b)

54. Which of the following is wrongly matched :

(1) GLUT–4 (a) Enables glucose transport into cells

(2) Receptor (b) Hormone

(3) Trypsin (c) Hormone

(4) Insulin (d) Hormone

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Ans.	4	3	2	4	4	3	2	4	1	3	3	4	1	1	4	3	3	3	2	2	1	4	3	2	3
Que.	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Ans.	4	2	4	2	3	3	1	2	4	4	1	2	2	2	3	3	1	3	1	3	1	4	4	4	2
Que.	51	52	53	54																					
Ans.	4	4	2	3																					

Exercise - II

1. 98% of living organisms is formed of six elements - carbon, hydrogen, nitrogen, oxygen and :

(1) S & Mg (2) Mg & Na

(3) Ca & P (4) P & S

2. Which of the following compounds is found in acid soluble pool during analysis of a living tissue ?

(1) Protein (2) Lipid

(3) Polysaccharide (4) Monosaccharide

3. Which of the following is a secondary metabolite as well as a drug ?

(1) Concanavalin A (2) Vinblastine

(3) Diterpenes (4) Ricin

4. Which of the following statement is false regarding proteins ?

(1) A protein is heteropolymer and not a homopolymer

(2) Collagen is the most abundant protein in the animal world

(3) RUBISCO is the most abundant protein in the whole biosphere

(4) The first amino acid in the polypeptide chain is called as C-terminal amino acid and the last amino acid is called as N-terminal amino acid

5. α-amino acids :

(1) Participate in protein synthesis

(2) have –COOH group and $-NH_2$ group attached on same carbon

(3) are substituted methane compounds

(4) All the above are correct

6. Which of the following is correct statement?

(1) Amino acids may be considered as substituted methane

(2) α-AA have difference only in R group

(3) In serine, R-group is hydroxy methyl

(4) All the above

7. Match the following :

(w) GLUT 4	(i) Hormone
(x) Insulin	(ii) Intercellular ground substance
(y) Collagen	(iii) Enables glucose transport
(z) Receptor	(iv) Sensory reception

(1) w-i, x-ii, y-iii, z-iv

(2) w-ii, x-iii, y-iv, z-i

(3) w-iii, x-i, y-ii, z-iv

(4) w-ii, x-iv, y-i, z-iii

8. Match the following :

Column-I		Column-II	
a	Alkaloid	I	Vinblastin, curcumin
b	Essential oils	II	Morphine, Codeine
c	Toxins	III	Lemon grass oil
d	Drugs	IV	Abrin, Ricin

(1) a-II, b-III, c-IV, d-I

(2) a-III, b-II, c-IV, d-I

(3) a-II, b-III, c-I, d-IV

(4) a-III, b-II, c-I, d-IV

9. Which of the following options consist of nonessential amino acids only ?

(1) Valine, leucine, glycine, alanine

(2) Glycine, serine, proline, glutamic acid

(3) Proline, aspartic acid, glutamic acid, methionine

(4) Cysteine, tyrosine, alanine, isoleucine

10. From the following groups, select the one which has only secondary metabolites ?

(1) Arbrin, cellulose, arginine, tyrosine

(2) Glycine, gums, serine, diterpenes

(3) Carotenoids, phenylalanine, curcumin, rubber

(4) Conclavin-A, morphine, codeine, vinblastin

11. The lipid which is found in cell membrane is :

(1) Phospholipid

(2) Lecithin

(3) 1 & 2 both

(4) Palmitic acid

12. Heterocyclic ring is found in which compound :

(1) N-bases

(2) Ring structure of monosaccharides

(3) Protein

(4) 1 & 2 both

13. Select the option having all correctly matched pairs :

A. Alkaloids (i) Carotenoid; Anthocyanin

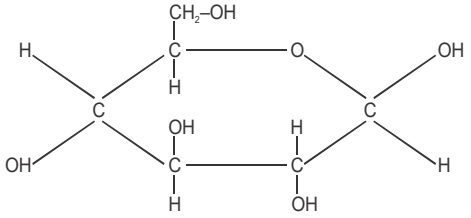
B. Pigments (ii) Vinblastin; curcumin

C. Drugs (iii) Morphine; Codeine

(1) A-i, B-ii, C-iii (2) A-ii, B-iii, C-i

(3) A-iii, B-i, C-ii (4) A-i, B-iii, C-ii

14. Following structure is :



(1) α-Glucose (2) β-Glucose

(3) Ribose (4) Deoxyribose

15. Which of the following is secondary metabolites?

(1) Rubber (2) Alkaloids

(3) Terpenoids (4) All the above

16. Which of the following statement is correct?

(1) Lipids are micromolecules

(2) Lipids has <1000 Daltons molecular weight

(3) Proteins are heteropolymer

(4) All the above are correct

17. Steroid hormones are almost similar in structure to:

(1) Triglyceride (2) Tyrosine

(3) Coenzyme-A (4) Cholesterol

18. Which statement is a false statement?

(1) Glycerol is trihydroxy propane

(2) Cellulose does now show iodine test

(3) The concentration of glucose in blood in an adult man is 4.5-5.0 mM

(4) Lipids are macromolecule

19. All the following statements about the structure of glycogen are true, except :

(1) Branched chains occur, after every ten residues

(2) It is a copolymer of glucose and mannose

(3) It contains α-1, 4-glycosidic linkages

(4) It contains α-1, 6-glycosidic linkages

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Ans.	4	4	2	4	4	4	3	1	2	4	3	4	3	2	4	4	4	4	2

Exercise – III (Previous Year Questions)

[AIPMT 2007]

1. Which monosaccharide does not show optical isomerism ?

(1) Dihydroxy acetone

(2) Glyceraldehyde

(3) Erythrose

(4) Ribose

2. About 98 percent of the mass of every living organism is composed of just six elements including carbon, hydrogen, nitrogen, oxygen and :

(1) Calcium and phosphorus

(2) Phosphorus and sulphur

(3) Sulphur and magnesium

(4) Magnesium and sodium

3. Which one of the following is not a constituent of cell membrane ?

(1) Phospholipids

(2) Cholesterol

(3) Glycolipids

(4) Proline

[AIIMS 2010]

4. Lactose is made up of :

(1) β-glucose & α-glucose

(2) Glucose & Mannose

(3) β-glucose & β-galactose

(4) Glucose & Fructose

5. Correct order of abundance of oxygen, Sulphur, magnesium and calcium in the earth crust ?

(1) O > Ca > Mg > S

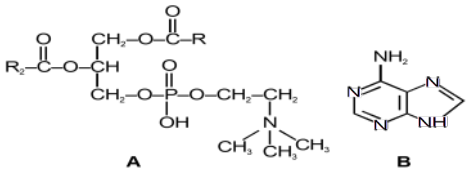
(2) S > O > Mg > Ca

(3) Ca > O > S > Mg

(4) Mg > Ca > S > O

[AIPMT (Pre.) 2011]

6. Which one of the following structural formula of two organic compounds is correctly identified along with its related function ?



A B

(1) B : adenine - a nucleotide that makes up nucleic acids

(2) A : Triglyceride - major source of energy

(3) B : Uracil - a component of DNA

(4) A : Lecithin - a component of cell membrane

[AIPMT (Pre.) 2012]

7. For its activity, carboxypeptidase requires :

(1) Niacin (2) Copper

(3) Zinc (4) Iron

8. Which one of the following sets of monosaccharides forms sucrose ?

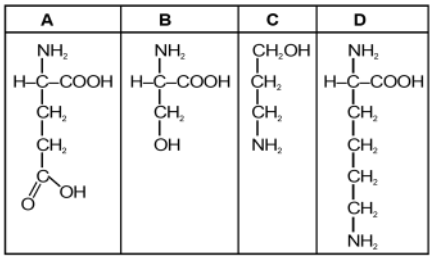
(1) β-D-Glucopyranose and α-D-fructofuranose

(2) α-D-Glucopyranose and β-D-fructofuranose

(3) α-D-Glucopyranose and α-D-fructofuranose

(4) β-D-Glucopyranose and β-D-fructofuranose

9. Which one out of A - D given below correctly represents the structure formula of the basic amino acid ?



Options :

(1) A (2) B (3) C (4) D

10. Which one is the most abundant protein in the animal world ?

(1) Collagen (2) Insulin

(3) Trypsin (4) Haemoglobin

[NEET-UG 2013]

11. The most abundant intracellular cation is :

(1) K^+ (2) Na^+

(3) Ca^{++} (4) H^+

12. Macro molecule chitin is :

(1) Simple polysaccharide

(2) Nitrogen containing polysaccharide

(3) Phosphorus containing polysaccharide

(4) Sulphur containing polysaccharide

13. Which one of the following is a non-reducing carbohydrate ?

(1) Maltose

(2) Sucrose

(3) Lactose

(4) Ribose

[Re-AIPMT 2015]

14. The chitinous exoskeleton of arthropods is formed by the polymerisation of :

(1) lipoglycans

(2) keratin sulphate and chondroitin sulphate

(3) D-glucosamine

(4) N-acetyl glucosamine

[AIIMS 2015]

15. Which of the following pair of amino acid have positive charge at pH = 7 :

(1) Asp - glu (2) Lys - Arg

(3) Gly - Ala (4) Asp - gly

16. Which one of the following statements is **wrong** ?

(1) Sucrose is a disaccharide

(2) Cellulose is a polysaccharide

(3) Uracil is a pyrimidine

(4) Glycine is a Sulphur containing amino acid

17. A typical fat molecule is made up of :

(1) Three glycerol molecules and one fatty acid molecule.

(2) One glycerol and three fatty acid molecules

(3) One glycerol and one fatty acid molecule.

(4) Three glycerol and three fatty acid molecules

18. Which of the following are not polymeric ?

(1) Nucleic acids (2) Proteins

(3) Polysaccharides (4) Lipids

[AIIMS-2015 (Evening)]

19. Match the following :

Column-I		Column-II	
(A)	Alkaloid	(i)	Abrin, ricin
(B)	Toxin	(ii)	Morphine, codeine
(C)	Pigment	(iii)	Concanavalin-A
(D)	Lectins	(iv)	Carotenoid

(1) A-ii, B-i, C-iv, D-iii

(2) A-i, B-ii, C-iii, D-iv

(3) A-iv, B-iii, C-ii, D-i

(4) A-ii, B-iii, C-iv, D-i

20. Select odd one :

(1) Aspartic acid and glutamic acid

(2) Thymine, cytosine and uracil

(3) Adenine and guanine

(4) Adenine and Lysine

[AIIMS-2016 (Morning)]

21. Match the column-I with column-II and choose correct option :

	Column-I		Column-II
A.	Insulin	i.	Fights infectious agents
B.	Antibody	ii.	Enables glucose transport into cells
C.	Receptor	iii.	Hormone
D.	GLUT-4	iv.	Sensory reception

(1) A-iii, B-ii, C-iv, D-i

(2) A-iii, B-i, C-iv, D-ii

(3) A-i, B-ii, C-iii, D-iv

(4) A-ii, B-iii, C-iv, D-i

[NEET-2017]

22. Which one of the following statement is correct, with reference to enzymes?

(1) Apoenzyem = Holoenzyme+ Coenzyme

(2) Holoenzyme = Aopenzyme + Coenzyme

(3) Coenzyme = Apoenzyme + Holoenzyme

(4) Holoenzyme = Coenzyme + Co-factor

[NEET-2018]

23. Match the items given in Column-I with those in Column-II and select the **correct** option given below :

Column-I	**Column-II**
a. Fibrinogen	i. Osmotic balance
b. Globulin	ii. Blood clotting
c. Albumin	iii. Defence mechanism

	a	**b**	**c**
(1)	ii	iii	i
(2)	iii	ii	i
(3)	i	iii	ii
(4)	i	ii	iii

24. The two functional groups characteristic of sugars are :

(1) Carbonyl and hydroxyl

(2) Hydroxyl and methyl

(3) Carbonyl and phosphate

(4) Carbonyl and methyl

[AIIMS-2018 [Morning-(B)]

25. Examples of essential amino acids are –

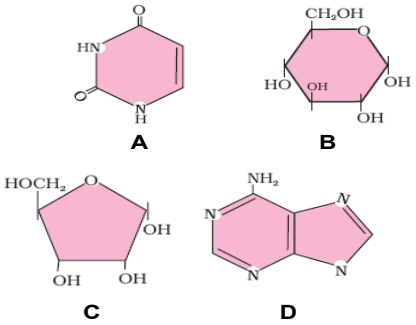
(1) Lys, Gly, Trp, Val

(2) His, Val, Lys, Trp

(3) Phe, Glu, Met, Ala

(4) Ala, Arg, Asn, Pro

26. Select the option having correct matching of structure and sequence of the molecules given below –



(1) A - Uracil, B - Glucose, C - Ribose, D - Adenine

(2) A - Adenine, B - Glucose, C - Uracil, D - Ribose

(3) A - Uracil, B - Ribose, C - Glucose, D - Adenine

(4) A - Adenine, B - Uracil, C - Ribose, D - Glucose

[NEET-2019]

27. Which of the following glucose transporters is insulin-dependent ?

(1) GLUT III (2) GLUT IV

(3) GLUT I (4) GLUT II

28. Concanavalin A is :

(1) a lectin (2) a pigment

(3) an alkaloid (4) an essential oil

[NEET-2019 (Odisha)]

29. Which of the following organic compounds is the main constituent of lecithin?

(1) Arachidonic acid (2) Phospholipid

(3) Cholesterol (4) Phosphoprotein

30. "Ramachandran plot" is used to confirm the structure of:-

(1) RNA (2) Proteins

(3) Triacylglycerides (4) DNA

[NEET-2020]

31. Match the following:

(a) Inhibitor of catalytic activity — (i) Ricin

(b) Possess peptide bonds — (ii) Malonate

(c) Cell wall material in fungi — (iii) Chitin

(d) Secondary metabolite — (iv) Collagen

Choose the correct option from the following:

	(a)	(b)	(c)	(d)
(1)	(ii)	(iii)	(i)	(iv)
(2)	(ii)	(iv)	(iii)	(i)
(3)	(iii)	(i)	(iv)	(ii)
(4)	(iii)	(iv)	(i)	(ii)

32. Identify the basic amino acid from the following.

(1) Valine (2) Tyrosine

(3) Glutamic Acid (4) Lysine

33. Which of the following is the most abundant protein in the animals?

(1) Insulin (2) Haemoglobin

(3) Collagen (4) Lectin

34. Identify the substances having glycosidic bond and peptide bond, respectively in their structure:

(1) Inulin, insulin

(2) Chitin, Cholesterol

(3) Glycerol, trypsin

(4) Cellulose, lecithin

[NEET-2020 (Covid-19)]

35. Identify the statement which is incorrect.

(1) Sulphur is an integral part of cysteine.

(2) Glycine is an example of lipids.

(3) Lecithin contains phosphorus atom in its structure.

(4) Tyrosine possesses aromatic ring in its structure.

[NEET-2021]

36. Which of the following are not secondary metabolites in plants?

(1) Morphine, codeine

(2) Amino acids, glucose

(3) Vinblastin, curcumin

(4) Rubber, gums

37. Match List-I with List-II.

List-I		List-II	
(a)	Protein	(i)	C = C Double bonds
(b)	Unsaturated fatty acid	(ii)	Phos-phodiester bonds
(c)	Nucleic acid	(iii)	Glycosidic bonds
(d)	Polysaccharide	(iv)	Peptide bonds

Choose the correct answer from the options given below.

	(a)	(b)	(c)	(d)
(1)	(iv)	(i)	(ii)	(iii)
(2)	(i)	(iv)	(iii)	(ii)
(3)	(ii)	(i)	(iv)	(iii)
(4)	(iv)	(iii)	(i)	(ii)

38. Identify the incorrect pair.

(1) Alkaloids - Codeine

(2) Toxin - Abrin

(3) Lectins - Concanavalin A

(4) Drugs - Ricin

39. Following are the statements with reference to 'lipids'.

(a) Lipids having only single bonds are called unsaturated fatty acids.

(b) Lecithin is a phospholipid.

(c) Trihydroxy propane is glycerol.

(d) Palmitic acid has 20 carbon atoms including carboxyl carbon.

(e) Arachidonic acid has 16 carbon atoms.

Choose the correct answer from the options given below.

(1) (a) and (b) only (2) (c) and (d) only

(3) (b) and (c) only (4) (b) and (e) only

[NEET-2022]

40. Read following statements on lipids and find out correct set of statements:

(a) Lecithin found in the plasma membrane is a glycolipid

(b) Saturated fatty acids possess one or more c=c bonds

(c) Gingely oil has lower melting point, hence remains as oil in winter

(d) Lipids are generally insoluble in water but soluble in some organic solvents

(e) When fatty acid is esterified with glycerol, monoglycerides are formed

Choose the **correct answer** from the options given below:

(1) (a), (b) and (c) only

(2) (a), (d) and (e) only

(3) (c), (d) and (e) only

(4) (a), (b) and (d) only

ANSWER KEY

Que.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Ans.	1	1	4	3	1	4	3	2	4	1	1	2	2	4	2	4	2	4	1	4	2	2	1	1	2
Que.	26	27	28	29	30	31	32	33	34	35	36	37	38	39	39	40									
Ans.	1	2	1	2	2	2	4	3	1	2	2	1	4	3	3	3									