XI
9

BIOMOLECULES

SYLLABUS

Chemical constituents of living cells: Biomolecules-structure and function of proteins, carbodydrates, lipids, nucleic acids; Enzymes-types, properties, enzyme action.

KEY CONCEPTS

INTRODUCTION

* All the carbon compounds that we get from living tissues can be called **'biomolecules'.**
* Biomolecules are of two types. One, those which have molecular weights less than one thousand dalton and are usually referred to as micromolecules (Like amino acids, N_2 base, Monosaccharides) or simply biomolecules while those which are found in the acid insoluble fraction are called macromolecules or biomacromolecules (like, proteins, nucleic acids & polysaccharides).
* Biomacromolecules are polymers. They are made of building blocks which are different. Proteins are heteropolymers made of amino acids.
* Nucleic acids (RNA and DNA) are composed of nucleotides.
* Biomacromolecules have a hierarchy of structures – primary, secondary, tertiary and quaternary.
* Polysaccharides are components of cell wall in plants, fungi and also of the exoskeleton of arthropods. They also are storage forms of energy (e.g., starch and glycogen).
* Proteins serve a variety of cellular functions. Many of them are enzymes, some are antibodies, some are receptors, some are hormones and some others are structural proteins.

Primary metabolites :

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

Secondary metabolites :

* Have no definite function.
* Have no direct role in normal physiology.
* Alkaloid, flavonoides, rubber, essential oils, antibiotics, coloured pigments. Scents, gums, spices are some example.
* **Table : Some Secondary Metabolites**

Pigments	Carotenoids, Anthocyanins.
Alkaloids	Morphine, Codeine, etc.
Terpenoides	Monoterpenes, Diterpenes
Essential	Lemon grass oil, etc.
Toxins	Abrin, Ricin
Lectins	Concanavalin A
Drugs	Vinblastin, curcumin, etc.
Polymeric substances	Rubber, gums, cellulose

COMPOUNDS OF PROTOPLASM

* Fluid along with all the structures of cell bounded within the limits of cell membrane, is known as **protoplasm**.

* **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 :

* Liquid of life, major constituent of cell (about 70-90%) and exists in intracellular, intercellular and in vacuoles.
* It is a best solvent in nature, it forms the fluid matrix of protoplasm.
* Water in human body - 65-70% of total body weight.
* Human body ≈ 40 litre
  55% (22 litre) - intracellular fluid
  45% (18 litre) - extracellular fluid

Salts :

* Salts in protoplasm occur in ionised form.
* Some metallic and other ions such as Mg, Fe, Zn, Mo, Mn etc. act as cofactors in enzymatic activities.
* These regulates the osmotic pressure and chemical exchange of protoplasm from its environment.
* Some ions also act as co-factor:
  Zn^{+2} - Carbonic anhydrase
  Fe^{+2} - Aconitase, catalase
  Cu^{+2} - Tyrosinase
  Mo - Nitrogenase
  Mg^{+2} - Co-factor of many respiratory enzymes like Kinase, Enolase, Dehydrogenase.
  Ni - Urease enzyme.
* Some other functions of ions :
  Na^{+}, K^{+} ions - Nerve induction.
  Ca^{+2}, Mg^{+2} ions - Muscle contraction, Reduce more excitability of nerve and muscle.
  Ca^{+2} ion - Blood clotting, Bone formation.
  K^{+} ions - Helpful in seismonastic movement, stomatal opening and closing.

CARBOHYDRATES

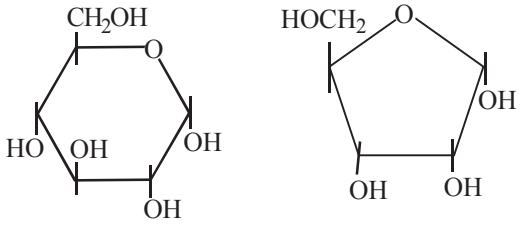
* It consists of carbon, hydrogen and oxygen in the ratio $C_nH_{2n}O_n$. It is also called saccharide and sugars are their basic components. *e.g.*, sugars, glycogen (animal starch), plant starch and cellulose.

Classification of carbohydrates

(i) Monosaccharides : These are single sugar units which can not be hydrolysed furthur into smaller carbohydrates. General formula is $C_nH_{2n}O_n$, e.g., Trioses-3C, (Glyceraldehyde, dihydroxyacetone), tetroses-4C, pentoses-5C, hexoses-6C.

Important Hexoses :

* **Glucose :** $C_6H_{12}O_6$. Grape sugar is dextrose. Grape is sour due to presence of tartaric acid. Fructose is called fruit sugar (sweetest among natural sugars) and glucose is called " sugar of body" (blood sugar). Normal level of blood glucose is 80-120mg/100ml. If it exceeds then condition is called "glucosuria".



$C_6H_{12}O_6$ (Glucose) $C_5H_{10}O_5$ (Ribose)

Sugars (Carbohydrates)

* **Fructose :** Occurs naturally in fruit juices and honey. Hydrolysis of cane sugar in body also yields fructose.
* **Galactose :** It is called as brain sugar. It's an important constituent of glycolipids and glycoproteins

Properties of monosaccharide

* Monosaccharides are colourless, sweet tasting, solids and show oxidation, esterification and fermentation.
* Due to asymmetric carbon, they exist in different isomeric forms. They can rotate polarized light hence they are dextrorotatory and laevorotatory.
* D-glucose after reduction gives rise to a mixture of polyhydroxy alcohol, sorbitol or mannitol.

Functions of monosaccharides

* Glucose is the ultimate source of ATP in the cell respiration.
* Polymerisation of these molecules forms macromolecules.
* Ribose and deoxyribose are constituent of nucleic acids and nucleotides.
* Sugars have free aldehyde or ketone group which can reduce Cu^{++} to Cu^{+} and are called reducing sugars. Benedicts or Fehling's test are used to confirm the presence of reducing sugars.

(ii) Oligosaccharides : Formed due to condensation of 2-10 monosaccharide units, the Oxygen bridge is known as "glycoside linkage" and water molecule is eliminated. The bond may be α and β.

(a) Disaccharides : Composed of two molecules of same or different monosaccharide units. Also called "double sugars". Molecular formula is $C_{12}H_{22}O_{11}$.

* **Maltose :** Also called "malt sugar" stored in germinating seeds of barley, oat, etc. It is formed by enzymatic (enzyme amylase) action on starch. It is a reducing sugar.
* **Sucrose :** "Cane sugar" or " table-sugar". Obtained from sugarcane and beet root and on hydrolysis splits into glucose and fructose.
* **Lactose :** Milk sugar or 5% in mammalian milk. On hydrolysis yields glucose and galactose. *Streptococcus lacti* converts lactose in to lactic acid and causes souring of milk.
* A disaccharide can be hydrolyzed, that is, split by the addition of water, into two monosaccharide units.

  During digestion, maltose is hydrolyzed to form two molecules of glucose:

  Maltose + Water $\rightarrow$ Glucose + Glucose

  Similarly, sucrose is hydrolyzed to form glucose and fructose:

  Sucrose + Water $\rightarrow$ Glucose + Fructose

(b) Trisaccharides : Composed of three molecules of sugars. Molecular formula is $C_{18}H_{32}O_{16}$.

* **Raffinose :** Found in sugar beet, cotton and in some fungi. It is made up of glucose, fructose and galactose.
* **Gentianose :** Found in rhizomes of gentian species, made up of glucose and fructose.

(c) Tetrasaccharides : Composed of four molecules of same or different sugars. Stachyose is found in *Stachys tubefera*. It is made up of two unit of galactose, one unit of glucose and one unit of fructose.

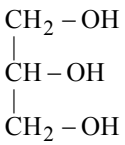
(iii) Polysaccharide :

* Polysaccharides are long chains of sugars.
* They are branched or unbranched polymers of monosaccharides jointed by glycosidic bond. Their general formula is $(C_6H_{10}O_5)_n$.
* Polysaccharides are amorphous, tasteless and insoluble or only slightly soluble in water and can be easily hydrolysed to monosaccharide units.
* In a polysaccharide chain (say glycogen), the right end is called the reducing end and the left end is called the non-reducing end.
* Starch forms helical secondary structures. In fact, starch can hold I_2 molecules in the helical portion. The starch-I_2 is blue in colour. Cellulose does not contain complex helices and hence cannot hold I_2.
* **Homopolysaccharides :** These are made by polymerisation of single kind of monosaccharides. *e.g.*, starch, cellulose, glycogen, etc.
* **Heteropolysaccharide :** These are made by condensation of two or more kinds of monosaccharides. *e.g.,* chitin, pectin, etc.
* **Food storage polysaccharides :** They serve as reserve food. *e.g.,* starch and glycogen.
* **Structural polysaccharides :** These take part in structural framework of cell wall *e.g.,* chitin and cellulose
* **Glycogen :** It is a branched polymer of glucose and contain 30,000 glucose units. It is also called animal starch. It is also found as storage product in blue green algae, slime moulds, fungi and bacteria. It is a non-reducing sugar and gives red colour with iodine. In glycogen, glucose molecule are linked by 1-4 glycosidic linkage in straight part and 1-6 linkage in the branching part glycogen has branch points about every 8-10 glucose units.

* **Starch :** Starch is formed in photosynthesis and function as energy storing substance. It is found abundantly in rice, wheat, legumes, potato (oval and ecentric shaped), banana, etc. Starch is of two types. Straight chain polysaccharides known as amylose and branched chain as amylopectin. Both composed of D-glucose units jointed by α-1-4 linkage and α-1-6 linkage. It is insoluble in water and gives blue colour when treated with iodine.
* **Inulin :** Also called "dahlia starch"(found in roots). It has unbranched chain of 30 – 35 fructose units linked by β-2-1 glycosidic linkage between 1 and 2 of carbon atom of D– fructose unit.
* **Cellulose :** Cellulose is a polymeric polysaccharide consisting of only one type of monosaccharide i.e., glucose. Cellulose is a homopolymer. Plant cell walls are made of cellulose. Paper made from plant pulp and cotton fibre is cellulosic. It is fibrous, rigid and insoluble in water. It doesn't give any colour when treated with iodine. It is a most abundant polysaccharide.
* **Chitin :** It is a polyglycol consisting of N-acetyl–D–glucosamine units connected with β-1,4 glycosidic linkage. Mostly it is found in hard exoskeleton of insects and crustaceans and some times in fungal cell wall. Second most abundant carbohydrate. It is a most abundant heteropolysaccharide.
* **Pectin :** It is a cell wall material in collenchyma tissue may also be found in fruit pulps, rind of citrus fruits etc. It is water soluble and can undergo sol gel transformation. It contain arabinose, galactose and galacturonic acid.
* **Neutral sugars :** It is found associated with cellulose in cell wall. The common sugars in hemicellulose are D-xylose, L–arabinose, D-galactose, D-mannose and D-glucusonic acid. *e.g.,* hemicellulose.
* **Gum :** It secreted by higher plants after injury or pathogenic attacks. It is viscous and seals the wound. It involves sugars like L-arabinose, D-galactose, D-glucusonic acid. *e.g.,* gum arabic.
* **Mucopolysaccharides :** These are gelatinous substance, containing amino sugars, uronic acid, etc. All slimy substances of plant are mucopolysaccharide. *e.g.,* hyaluronic acid, vitreous humour, chondridine sulphate, heparin, husk of isabgol and mucilage also.
* **Agar-Agar :** It is a galactan, consisting of both D and L galactose and it is used to prepare bacterial cultures. It is also used as luxative and obtained from cell wall of red algae *e.g.*, Gracilaria, Gelidium etc.

LIPIDS

* Fat and its derivatives are combinely known as lipid.
* A fatty acid has a carboxyl 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 carbon.
* Fatty acids could be saturated (without double bond) or unsaturated (with one or more C=C double bonds).
* Lipid glycerol is also known as **trihydroxy propane.**



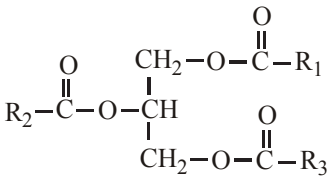
Glycerol

* Lipids are insoluble in water and soluble in organic solvents like acetones, chloroform, benzene, hot alcohol, ether etc.
* Lipids occur in protoplasm as minute globules
* Lipids do not form polymer.
* Lipids provide more than double energy as compare to carbohydrate.
* In animals, fat present in subcutaneous layer and working as food reservoir and shock-absorber.
* Lipid required less space for storage as compare to carbohydrate because lipid molecule is hydrophobic and condense.
* Animals store maximum amount of food in the form of lipid.
* Lipid provides maximum amount of metabolic water as compare to carbohydrate and protein on oxidation.
* Lipids are not strictly macromolecules.

Types of Lipids

(A) Simple Lipid or Neutral Fats :

* These are esters of long chain fatty acids and alcohol. In majority of simple lipids, the alcohol is a trihydroxy sugar alcohol i.e. glycerol.
* Three molecules of fatty acid linked with one molecule of glycerol. The linkage is called "**ester bond**", such type of lipids are called **Triglycerides**. Three molecules of water are released during formation of triglycerides (dehydration synthesis).



Triglyceride (R_1, R_2 and R_3 are fatty acids)

* Similar or different fatty acids participate in the composition of a fat molecule.
  Simple lipids contain two types of fatty acids:

(i) Saturated Fatty acids : Are those in which all the carbon atoms of hydro-carbon chain are saturated with hydrogen atoms
e.g. Palmitic acid $CH_3–(CH_2)_{14}–COOH$,
Stearic acid : $CH_3–(CH_2)_{16}–COOH$,

(ii) Unsaturated fatty acids : Acids are those in which some carbon atom are not fully occupied by hydrogen atoms e.g. Oleic acid, Linoleic acid

Polyunsaturated : Fatty acids with more than one double bonds e.g. Linoleic acid, Linolenic acid, Arachidonic acid, Prostaglandins (derived from arachidonic acid)

* Unsaturated fatty acid also called as essential fatty acids because no animal is able to synthesize them.
* Simple lipids with saturated fatty acid remain solid at normal room temperature e.g. fats.
* Simple lipids with unsaturated fatty acids remain liquid at room temperature e.g. oils.
* Saturated fatty acids are less reactive so they tend to store in body and cause obesity.
* Unsaturated fatty acids are more reactive so they tend to metabolise in body and provide energy.
* Oils with poly unsaturates are recommended by physicians for persons who suffer from high blood cholesterol or cardio-vascular diseases. This is because increasing the proportion of poly unsaturated fatty acids to saturated fatty acids, without raising the fats in the diet tend to lower the cholesterol level in blood.
* **Waxes :** Waxes are monoglycerides with only one molecule of fatty acid attached to a long chain monohydroxy alcohol. Waxes are more resistant to hydrolysis as compared to triglycerides. Waxes have an important role in protection. They form water insoluble coatings on hair and skin in animals and stem, leaves and fruits of plants.

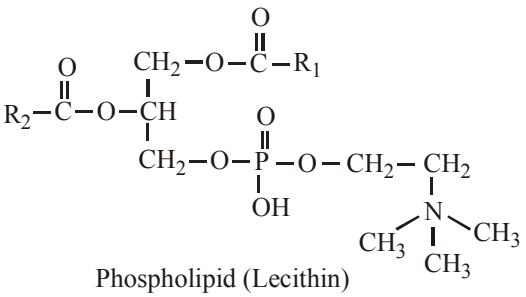
(B) Conjugated or Compound Lipids :

(i) Phospholipids or phosphatide or phospholipids :

2 Molecules of fatty acid + Glycerol + H_3PO_4 + Nitrogenous compound. Phospholipids are most abundant type of lipids in protoplasm.
Phospholipids have both hydrophilic polar end (H_3PO_4 and nitrogenous compound) and hydrophobic non polar end (fatty acids). Such molecules are called amphipathic. Due to this property, phospholipids form bimolecular layer in cell membrane.
Some biologically important phospholipids are :

(a) Lecithin or Phosphatidyl choline :

Nitrogenous compound in lecithin is choline.



Phospholipid (Lecithin)

Lecithin occurs in egg yolk, oil seeds and blood. In blood lecithin functions as carrier molecule. It helps in transportation of other lipid.

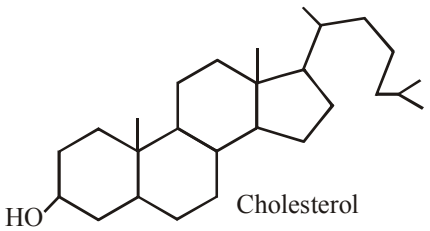
(b) Cephalin : Similar to lecithin but the nitrogenous compound is ethanolamine, cephalin occurs in nervous tissue, egg yolk and blood platelets.

(c) **Sphingolipids or sphingomylins** similar to lecithin but in place of glycerol it contains an amino alcohol sphingosine.
Sphingolipids occur in myelin - sheath of nerves, other examples of phospholipid are phosphatidyl serine, phosphatidyl inositol, plasmologens.

(ii) **Glycolipid:** 2 fatty acid + sphingosine + galactose
eg. Cerebroiside which occurs in white matter of brain
Gangliosides - These occur in nerve ganglia and spleen. These also contain N-acetyl neurominic acid and glucose beside other compounds.

(iii) **Derived Lipids** : Lipid derived from simple or conjugated lipid .Derived lipids are complex in structure. They are insoluble in water and soluble in organic solvents.
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.

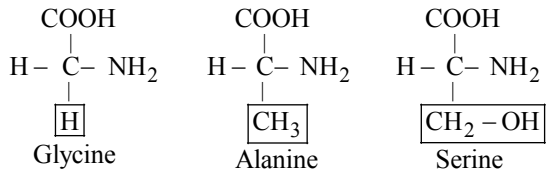


Cholesterol

Prostaglandins : It is a group of hormone like unsaturated fatty acids which function as messenger substance between cell. They are derived from arachidonic acid and related C_{20} fatty acid.
Another steroid compound, *diosgenin* produced by the yam plant (*Dioscorea*) is used in the manufacture of antifertility pills.

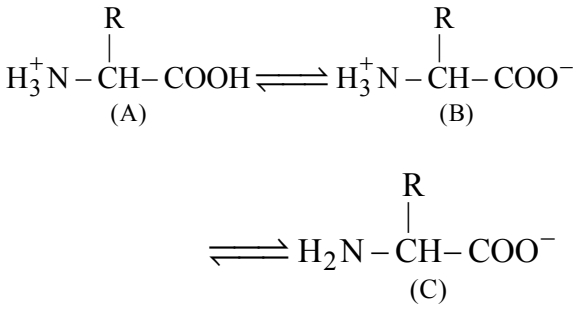
PROTEINS

* Protein name is derived from a greek word which means "holding first place" (Berzelius and mulder), Essential elements in protein are C, H, O, N.
* Most of the proteins contain sulphur. In some proteins iodine, iron and phosphorus are present.
* After water proteins are most abundant compounds in protoplasm. (7-14%) amount of proteins.
* Proteins are polymer of amino acid (Fisher and Hofmeister). There are approximately 300 amino acids known to exist but only 20 types of amino acids are used in formation of proteins.
* Proteins are heteropolymer of amino acid.
* Amino acids contains an amino group and an acidic group as substituents on the same carbon i.e., the α-carbon. Hence, they are called α-amino acids.
* They are substituted methanes. There are four substituent groups occupying the four valency positions. These are hydrogen, carboxyl group, amino group and a variable group designated as R group.
* Based on the nature of R group there are many amino acids. However, those which occur in proteins are only of twenty types. The R group in these proteinaceous amino acids could be a hydrogen (the amino acid is called glycine), a methyl group (alanine), hydroxy methyl (serine), etc.



Amino acids

* The chemical and physical properties of amino acids are essentially of the amino, carboxyl and the R functional groups.
* A particular property of amino acids is the ionizable nature of $–NH_2$ and –COOH groups. Hence in solutions of different pHs, the structure of amino acids changes.



B is called **Zwitterionic form**.

* Each amino acid is amphoteric compound because it contains one weak acidic – COOH and a weak alkaline group – NH_2.
* In protoplasm free amino acid occurs as ions (at isoelectric point)
* Iso electric point is that point of pH at which amino acids do not move in electric field.
* Out of 20 amino acids, 10 amino acids are not synthesized in body of animals so they are must in diet. These called Essential amino acid. e. g. Threonine, Valine, Leucine, Isoleucine, Lysine, Methionine, Phenylalanine Tryptophan, arginine, Histidine. Arginine and Histidine are semi essential.
* 10 amino acids are synthesized in animal body so these are called Non-essential amino adds. for e.g. Glycine, Alanine, Serine, Cysteine, Aspartic acid, Glutamic acid, Asparagine, Glutamine, Tyrosine and Proline.
* Amino acids join with peptide bond to form protein.
* Peptidyl transferase enzyme catalyses the synthesis of peptide bond.
* Property of protein depends on sequence of. amino acid and configuration of protein molecules.
* **Simple amino acids :** These have no functional group in the side chain. *e.g.*, glycine, alanine , leucine, valine etc. Glycine is a simplest amino acid.
* **Hydroxy amino acids :** They have alcohol group in side chain. *e.g.,* threonine, serine, etc.
* **Sulphur containing amino acids :** They have sulphur atom in side chain. *e.g.,* methionine, cystine.
* **Basic amino acids :** They have basic group ($-NH_2$) in side chain. *e.g.,* lysine, arginine.
* **Acidic amino acids :** They have carboxyl group in side chain. *e.g.,* aspartic acid, glutamic acid.
* **Aromatic amino acids :** They have aromatic group (benzene ring) in the side chain. *e.g.,* phenylalanine, tyrosine, etc.
* **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	Enables glucose transport into cells

Note :

* Glycine is the simplest and Tryptophan is complex Amino acid.
* Serine & Threonine are alcoholic amino acid.
* All the amino acids are laevo-rotatory, except Glycine which is non-rotatory.
* Proline, Hydroxy proline contain imino group ($-\ddot{N}H-$) instead of amino group so they are also called imino acid.

Configuration of Protein molecule

1. **Primary configuration or structure :** A straight chain of amino acids linked by peptide bonds form primary structure of proteins. This structure of proteins is most unstable. Newly formed proteins on ribosomes have primary structure.

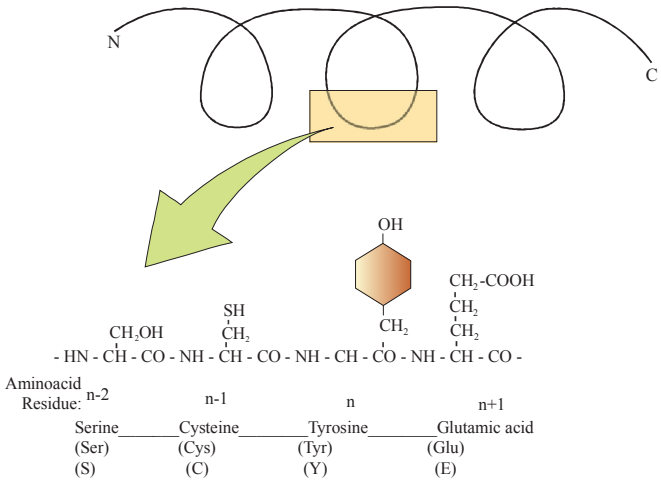


Figure : Primary structure of a portion of a hypothetical protein. N and C refer to the two termini of every protein. Single letter codes and three letter abbreviations for amino acids are also indicated.

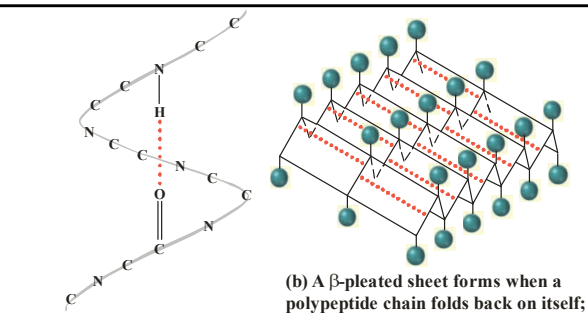
2. **Secondary configuration :** Protein molecules of sec. structure are spirally coiled. In addition to peptide bond, amino acids are linked by hydrogen bonds form between oxygen of one amide group and hydrogen of another amide group. This structure is of two types :

(i) **α-Helix :** Right handed rotation of spirally coiled chain with approximately 3½ amino acids in each turn. This structure has intramolecular hydrogen bonding i.e. between two amino acids of same chain e.g. Keratin , Myosin, Tropomyosin.

(ii) **β- Helix or pleated sheath structure :** Protein molecule has zig - zag structure. Two or more protein molecules are held together by intermolecular hydrogen bonding.e.g. Fibroin (silk).

* Proteins of sec. structure are insoluble in water and fibrous in appearance.

* Keratin is a fibrous, tough, resistant to digestion, sclero protein. Hard ness of keratin is due to abundance of cysteine amino acid in its structure.



(a) In an α-helix the R groups project out from the sides. (The R groups have been omitted in the simplified diagram)

(b) A β-pleated sheet forms when a polypeptide chain folds back on itself; half the R groups project above the sheet, and the other half project below it.

Figure : Secondary structure of a protein

3. **Tertiary Structure :** Proteins of tertiary structure are highly folded to give a globular appearance. They are soluble in water (colloid solution). Bonds in structure of protein :

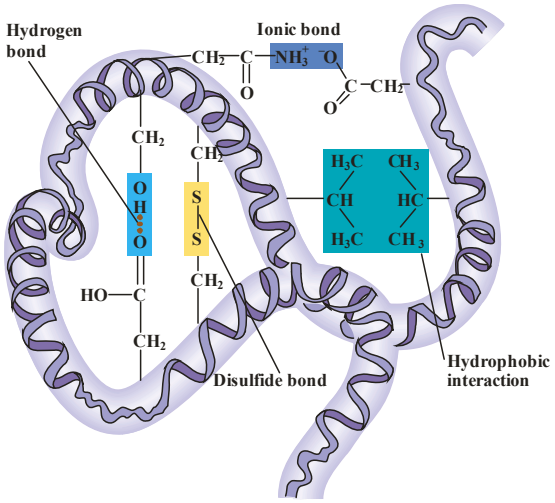
(i) Peptide bonds = strongest bond in proteins.

(ii) Hydrogen bonds

(iii) **Disulphide bond :** These bonds form between – SH group of amino acid (Mehionine, Cysteine). These bonds are second strongest bond and stabilise tertiary structure of protein.

(iv) **Hydrophobic bond :** Between amino acids which have hydrophobic side chains for e.g. Aromatic amino acid.

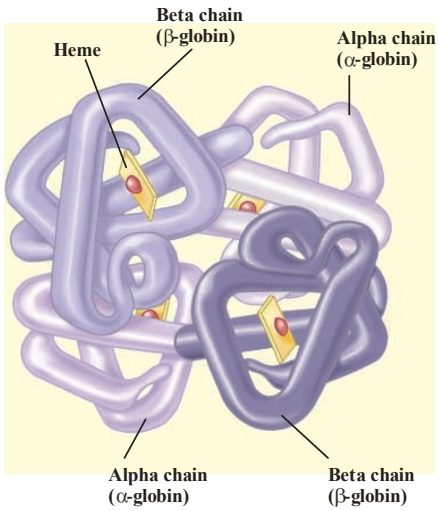
(v) **Ionic bond :** Formation of ionic bond occurs between two opposite ends of protein molecule due to electrostatic attraction. Majority of proteins and enzymes in protoplasm exhibit tertiary structure.



Hydrogen bonds, ionic bonds, hydrophobic interactions, and disulfide bridges between R groups hold the parts of the molecule in the designated shape.

Figure : Tertiary structure of a protein

4. **Quaternary Structure :** Two or more poly peptide chains of tertiary structure unite by different types of bond to form quaternary structure of protein. Different polypeptide chains may be similar (lactic-dehydrogenase) or dissimilar types (Haemoglobin, insulin). Quaternary structure is most stable structure of protein.



Hemoglobin, a globular protein, consists of four polypeptide chains, each joined to an iron-containing molecule, a heme.

Figure : Quaternary structure of a protein

Significance of structure of Protein

* The most important constituents of animals are protein and their derivatives.
* Proteins form approximately 15% of animal protoplasm.
* The physical and biological properties of proteins are dependant upon their secondary and tertiary configurations.
* Protein is electrically charged because it has $-NH_3^+$ and $-COO^-$ ionic components.
* In an acidic medium the $-COO^-$ group of protein converts to $-COOH$ and the protein itself becomes positively charged.
* In contrast, in an alkaline medium the $-NH_3^+$ group of protein changes to $-NH_2 + H_2O$ and as a result it becomes negatively charged. Therefore, at a specific pH a protein will possess an equal number of both negative and positive charges and it is at this specific pH a protein becomes soluble.
* If the pH changes towards either acidic or alkaline side, then the protein begins to precipitate.
* This property of protein has great biological significance.
* The cytoplasm of cells of organisms has an approximate pH of 7 but the pH of proteins present in it is about 6 and thus, the proteins are present in a relatively alkaline medium. Therefore, the proteins are negatively charged and also are not in a fully dissolved state.
* It is because of this insolubility, proteins form the structural skeleton of organismal cells.
* Similarly, the pH of nucleoplasm is about 7 but the pH of proteins, namely, histones and protamines, in it is relatively more. Therefore, as a result they are positively charged and do not remain fully dissolved in the nucleoplasm forming minute organelles, the most important being the chromosomes.
* Such compounds which exhibit both acidic and alkaline properties are called amphoteric compounds or zwitter ions.
* In the protoplasm, this dual property of proteins is utilized for neutralization of strong acids and alkalis since the protein acts as an ideal buffer in either of the situations.
* Besides changes in pH, salts, heavy metals, temperature, pressure, etc. also cause precipitation of proteins. Because of these changes, the secondary and tertiary configuration of proteins is destroyed and many times the tertiary structured globular proteins become converted to secondary configuration fibrous proteins.
* Such alternations in the physical state of proteins is called denaturation.
* If the change in the medium of protein is mild and for a short period, then denaturation of the protein is also temporary, however, if the change in medium is strong and prolonged then denaturation is permanent and the protein becomes coagulated.
* For example, the white or albumen of egg is a soluble globular protein but on heating it permanently coagulates into fibrous insoluble form.
* It is clear, that strong alternations result in the denaturation of proteins and they lose their biological properties and significance.
* It is this reason, that cells of organisms are unable to bear strong changes and they ultimately die.

Types of Proteins

1. **Simple Proteins :** Proteins which composed of only amino acid.

(i) **Fibrous Protein :** Long, coiled and thread like. e.g. Collagen, Elastin, Keratin

(ii) **Globular Proteins:** e.g. Rubisco, Albumin, Histones, Globin, Protamine, Prolamines (Glaidin, Gluten, Zein),
Gluteline - slimy part of gluten of wheat.

2. **Compound Proteins :** Simple protein + non protein part (Prosthetic group)

(i) **Nucleoproteins -** Prosthetic group is nucleic acid.e.g. Chromatin, Ribosomes etc.

(ii) **Chromoprotein -** Prosthetic group is a porphyrin pigment e.g. Haemoglobin, Haemocyanin, Cytochromes.

(iii) **Lipoprotein -** Prosthetic group is lipid, eg. cell membrane, Lipovitelline of Yolk.

(iv) **Phospho proteins** - Prosthetic group is phosphoric acid. eg. Casienogen (milk), Pepsin, Ovovitelline, Phosvitin (egg).

(v) Lecitho protein - Fibrinogen (blood).

(vi) Metallo protein - Cu-Tyrosinase, Zn-Carbonic Anhydrase, Mn-Arginase, Mo-Zanthine Oxidase, Mg-Kinase

(vii) **Glycoproteins and Mucoproteins :** Glyco proteins have less than 4% Carbohydrates in their structure. They are most specific type of proteins. e.g. α, β, γ-globuline of blood, Mucin (Saliva) blood group proteins, Mucin, Erythroproetin etc. Muco proteins have more than 4% Carbohydrates e.g. Mucoids of synovial fluid, Osteomucoprotein of bones, Tendomuco protein of tendons, Chodro mucoprotein of cartilage.

3. **Derived Protein :** These form by denaturation or hydrolysis of protein.

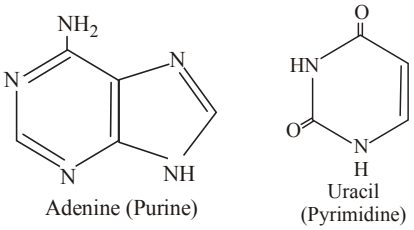
(i) Primary derived proteins are denaturation product of normal proteins e.g. Fibrin, Myosan

(ii) Secondary derived proteins are digestion products of proteins e.g. Proteoses, Peptones, Peutides.

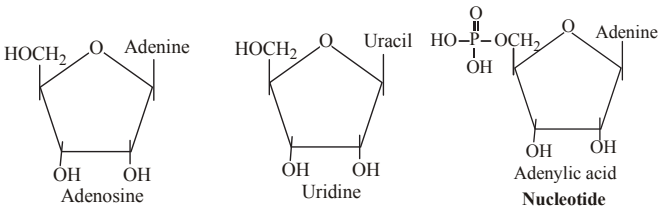
Note : Monomeric protein : Protein ,composed of one polypeptide chain.
Oligomeric/polymeric/Multimeric protein : Protein composed of more then one polypeptide chains.

NUCLEIC ACIDS

* Meischer discovered nucleic acids in nucleus of pus cell and called it nuclein. The name nucleic acid proposed by Altman.
* When nitrogen bases like – adenine, guanine, cytosine, uracil, and thymine are attached to a sugar, they are called **nucleosides**.
* If a phosphate group is also found esterified to the sugar they are called **nucleotides**. Adenosine, guanosine, thymidine, uridine and cytidine are nucleosides.



Nitrogen bases



Nucleosides **Nucleotide**

* Adenylic acid, thymidylic acid, guanylic acid, uridylic acid and cytidylic acid are **nucleotides**. Nucleic acids like DNA and RNA consist of nucleotides only.
* Nucleic acids are polymer **nucleotides.**
= Nitrogen base + pentose + phosphate
On the basis of structure nitrogen bases are broadly of two types :

(i) **Pyrimidines :** Consist of one pyrimidine ring. Skeleton of ring composed of two nitrogen and four Carbon atoms. e.g. Cytosine, Thymine & Uracil.

(ii) **Purines :** Consist of two rings i.e. one pyrimidine ring (2N+ 4C) and one imidazole ring (2N+ 3C) e.g Adenine and Guanine.

Pentose Sugar : Nitrogen base forms bond with first Carbon of pentose sugar to form a nucleoside, Nitrogen of third place (N_3) forms bond with sugar in case of Pyrimidines while in purines nitrogen of ninth place (N_9) forms bond with sugar. Phosphate forms ester bond (covalent bond with fifth carbon of sugar to form a complete nucleotide.

Types of Nucleosides and Nucleotides

(1) Adenine + Ribose = Adenosine
Adenosine + Phosphate = Adenylic acid (AMP)

(2) Adenine + Deoxyribose = Deoxy adenosine
Deoxy adenosine+ P=Deoxy adenylic acid (dAMP)

(3) Guanine + Ribose = Guanosine
Guanosine + P = Guanylic acid (GMP)

(4) Guanine + Deoxyribose = Deoxy guanosine
Deoxy guanosine+P=Deoxy guanylic acid (dGMP)

(5) Cytosine + Ribose = Cytidine
Cytidine + P = Cytidylic acid (CMP)

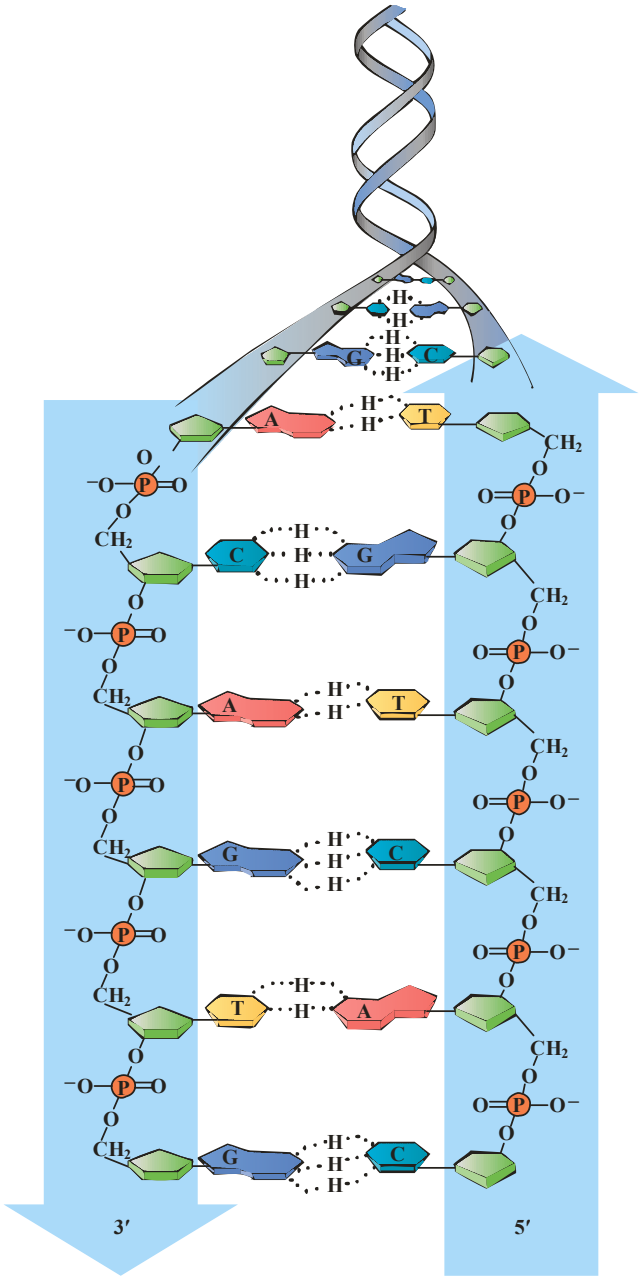
(6) Cytosine + Deoxyribose = Deoxycytidine
Deoxycytidine + P= Deoxycytidylic acid (dCMP)

(7) Uracil + Ribose = Uridine
Uridine + P = Uridylic acid (UMP)

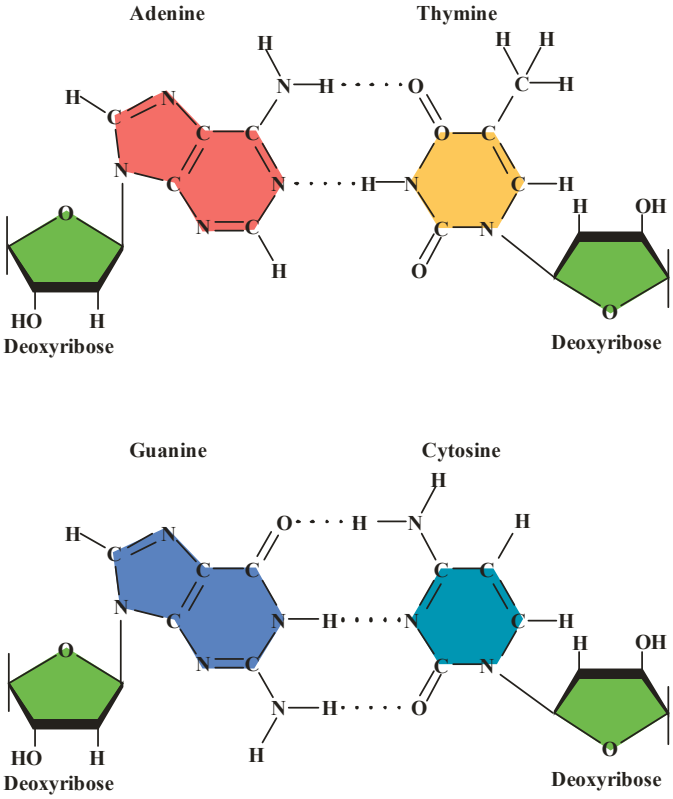
(8) Thymine + Deoxyribose = Deoxy thymidine
Deoxythymidine + P = Deoxythymidylic acid (dTMP)

DNA

* Discovered by - Meischer
* DNA term given by - Zacharis
* In DNA pentose sugar is deoxyribose sugar and four types of nitrogen bases A,T,G , C.



(a) The two sugar–phosphate chains run in opposite directions. This orientation permits the complementary bases to pair.



(b) Hydrogen bonding between base pairs adenine (A) and thymine (T) (top) and guanine (G) and cytosine (C) (bottom). The AT pair has two hydrogen bonds; the GC pair has three.

Figure : Base pairing and hydrogen bonding

* Wilkins and Franklin studied DNA molecule with the help of X-Ray crystallography.
* With the help of this study, Watson and Crick (1953) proposed a double helix model for DNA. For this model Watson, Crick and Wilkins were awarded noble prize in 1962.
* According to this model, DNA is composed of two polynucleotide chains.
* Both polynucleotide chains are complementary and anti parallel to each other.
* In both strand of DNA direction of phosphodiester bond is opposite. i.e. if direction of phosphodiester bond in one strand is 3'-5' then it is 5'-3' in another strand.
* Both strand of DNA held together by Hydrogen bonds. These hydrogen bonds are present between Nitrogen bases of both strand.
* Adenine binds to Thymine by two hydrogen bonds and cytosine binds to Guanine by three hydrogen bonds.
* **Chargaff's equivalency rule :** In a double stranded DNA, amount of purine nucleotides is equal to amount of pyrimidine nucleotides.
Purine = Pyrimidine

$$[A] + [G] = [T] + [C] \quad ; \quad \frac{[A]+[G]}{[T]+[C]} = 1$$

$$\text{Base ratio} = \frac{A+T}{G+C} = \text{constant for a given species.}$$

* In a DNA , $A + T > G + C \Rightarrow A - T$ type DNA. Base ratio of A – T type of DNA is more than one. eg. Eukaryotic DNA
* In a DNA, $G + C > A + T \Rightarrow G - C$ type DNA. Base ratio of G-C type of DNA is less than one. eg. Prokaryotic DNA.
Melting point of DNA depends on G–C contents. More G – C contents then more melting point.
T_m = Temperature of melting.
T_m of prokaryotic DNA > T_m of Eukaryotic DNA
* DNA absorbs U.V. rays means 2600Å wavelength.
* Out of two strand of DNA only one strand participates in transcription, it is called Antisense strand/Noncoding strand/Template strand.
* Other strand of DNA which does not participate in transcription is called sense strand/Coding strand.
* **Denaturation and renaturation of DNA :** If a normal DNA molecule is placed at high temperature (80-90°C) then both strand of DNA will separate to each other due to breaking of hydrogen bonds. It is called DNA-denaturation. When denatured DNA molecule is placed at normal temperature then both strand of DNA attached and recoiled to each other. It is called renaturation of DNA.
* **Hyperchromicity :** When a double stranded DNA is denatured by heating then denatured DNA molecule absorbs more amount of light, this phenomenon is called hyperchromicity.
* **Hypochromicity :** When denatured DNA molecule cool slowly then it becomes double stranded and it absorb less amount of light. This phenomenon is called hypochromicity.

Configuration of DNA molecule

* Two strands of DNA are helically coiled like a revolving ladder. Back bone of this ladder (Reiling) is composed of phosphates and sugars while steps (bars) composed of pairs of nitrogen bases.
* Two chains have anti-parallel polarity. It means if one chain has the polarity 5' $\rightarrow$ 3' the other than 3' $\rightarrow$ 5'.
* Distance between two successive steps is 3.4Å, In one complete turn of DNA molecule there are such 10 steps (10 pairs of nitrogen bases). So the length of one complete turn is 34 Å. This is called **helix length.**
Diameter of DNA molecule i.e. distance between phosphates of two strands is 20Å.
* Distance between sugar of two strands is 11.1Å.
* Length of hydrogen bonds between nitrogen bases is 2.8-3.0Å. Angle between nitrogen base and C_1 carbon of pentose is 51°.
* Molecular weight of DNA is 10^6 to 10^9 dalton.
* In nucleus of eucaryotes the DNA is associated with histone protein to form nucleoprotein. Histone occupies major groove of DNA at 30° angle.
* Bond between DNA and Histone is salt linkage (Mg^{+2}).
* DNA in chromosomes is linear while in progaryotes, mitochondria and chloroplast it is circular.

* In $\phi \times 174$ bacteriophage the DNA is single stranded and circular isolated by Sinsheimer. G-4, S-13, M-13, F_1 and Fd - Bacteriophages also contain ss-circular DNA.

Ribo Nucleic Acid (RNA)

Structure of RNA is fundamentally the same as DNA, but there are some differences. The differences are :

* In place De-oxyribose sugar of DNA, there is present Ribose sugar in RNA.
* In place of nitrogen base Thymine present in DNA, there is present nitrogen base uracil in RNA.
* DNA molecule is Dextrorotatory while RNA molecule is Laevorotatory.
* RNA is made up of only one polynucleotide chain i.e. R.N.A. is single stranded.

Exception : RNA found in Reo-virus is double stranded. i.e. it has two polynucleotide chains.

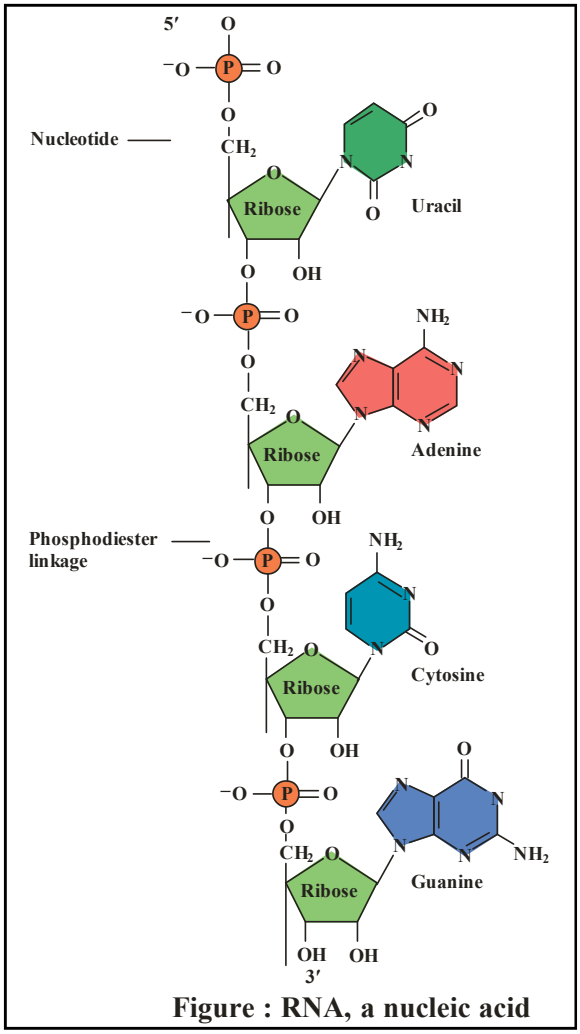


Figure : RNA, a nucleic acid

Types of RNA

I. Genetic RNA or Genomic RNA :

In the absence of DNA, sometime RNA working as genetic material and genomic RNA transfer informations from one generation to next generation.

eg. Reo virus, TMV, QB bacteriophage.

II. Non-genetic RNA - 3 types

(1) r - RNA (2) t - RNA (3) m - RNA

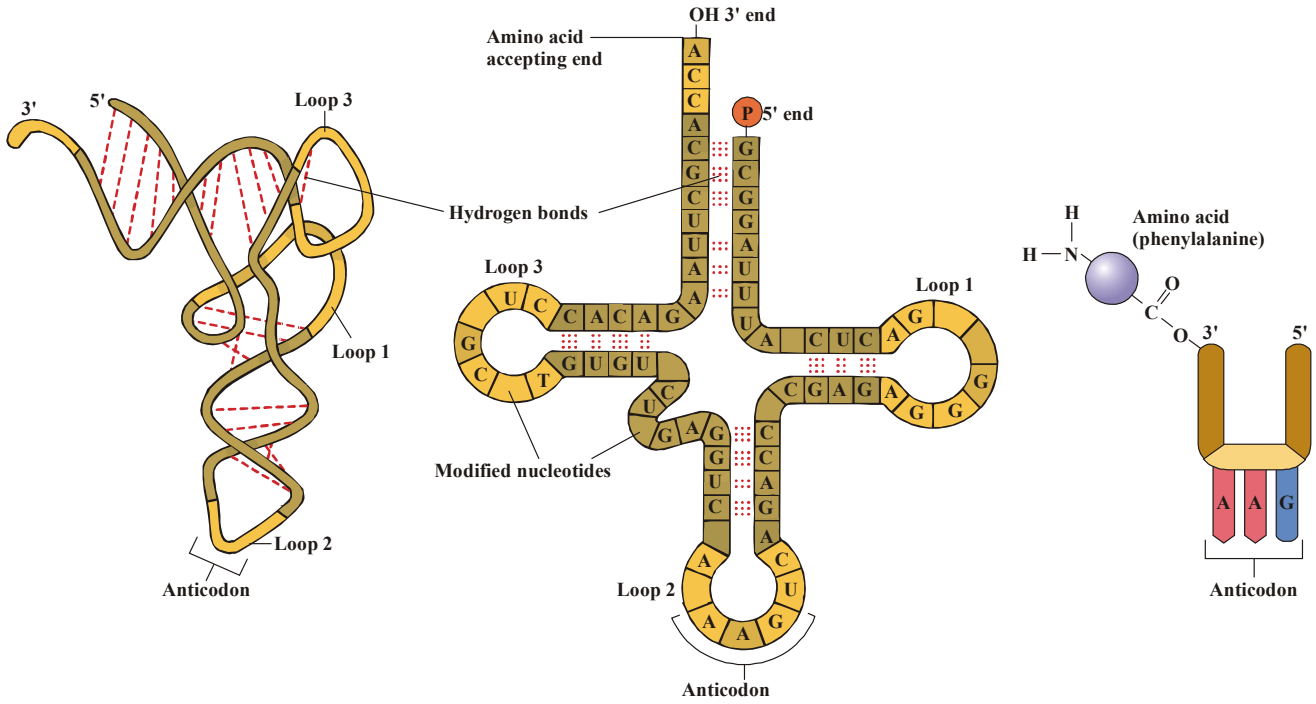
(1) Ribosomal RNA (r - RNA)

* This RNA is 80% of the cells total RNA
* It is found in ribosomes and it is produced in nucleolus.
* It is the most stable form of RNA.
* There are present 80s type of ribosomes in Eukaryotic cell. Their subunits are 60s and 40s. In 60s sub unit of ribosome three types of r-RNA are found 5s, 5.8s, 28s.
* In the same way 40s sub unit of ribosome has only one type of r-RNA = 18s.
* 80s ribosome has total 4 molecules of r-RNA.
* Prokaryotic cells have 70s type of ribosomes and its subunits are 50s and 30s.
* 50s sub unit of ribosome contains 2 molecules of r-RNA = 5s and 23s.
* 30s sub unit of ribosome has 16s type of r-RNA.
* 70s RNA has total 3 molecules of r-RNA.

Function : At the time of protein synthesis r-RNA provides attachment site to t-RNA and m-RNA and attaches them on the Ribosome. The bonds formed between them are known as Salt linkages. It attaches t - RNAto the larger subunit of ribosome and m-RNA to smaller subunit of ribosome.

(2) Transfer : - RNA (t-RNA)

* It is 10-15% of total RNA.
* It is synthesized in the nucleus by DNA.
* It is also known as soluble RNA (sRNA)
* It is also known as Adapter RNA.
* It is the smallest RNA (4s).



(a) The 3-D shape of a tRNA molecule is determined by hydrogen bonds formed between complementary bases.

(b) One loop contains the anticodon; these unpaired bases pair with a complementary mRNA codon. The amino acid attaches to the terminal nucleotide at the hydroxyl (OH) 3' end.

(c) This stylized diagram of an aminoacyl-tRNA shows that the amino acid attaches to tRNA by its carboxyl group, leaving its amino group exposed for peptide bond formation.

Figure : Three representations of a tRNA molecule

Function : At the time of protein synthesis it acts as a carrier of amino-acids.

Discovery : t-RNA was discovered by Hogland, Zemecknike and Stephenson.

Structure : The structure of t-RNA is most complicated.

A scientist named Holley presented Clover leaf mood of its structure. In two dimensional structure the t-RNA appears clover leaf like but in three dimensional structure (by Kim) it appears L-shaped.

* tRNA is a compact molecule look like inverted L.
* The molecule of t - RNA is of single strand.
* There are present three nucleotides in a particular sequence at 3' end of t - RNA and that sequence is = CCA.
* All the 5 ' ends i.e. last ends are having G (guanine).
* 3' end is known as Acceptor end.
* t-RNA accepts amino acids at acceptor points. Amino acid binds to 3' end by its – COOH group.
* The molecule of t-RNA is folded and due to folding some complementary nitrogenous bases come across with each other and form hydrogen bonds.
* There are some places where hydrogen bonds are not formed, these places are known as loop.

Loops : There are some abnormal nitrogenous bases in the loops, that is why hydrogen bonds are not formed. e.g. Inosine (I), Pseudouracil (Ψ), Dihydrouridine (DHU)

(3) Messenger RNA (m -RNA) :

* The m - RNA is 1-5% of the cell's total RNA
* Discovery:- Messenger RNA was discovered by Huxley, Volkin and Astrachan. The name m-RNA was given by Jacob and Monad..
* The m - RNA is produced by genetic DNA in the nucleus. This process is known as Transcription.
* It is least stable RNA.

METABOLIC BASIS FOR LIVING

* **Anabolic pathways**: Lead to formation of more complex molecules from a simpler molecules with the consumption of energy. e.g., Protein from amino acids.
* **Catabolic pathway**: Lead to formation of simpler molecule from a complex molecule. e.g., Glucose → Lactic Acid.
* The most important form of energy currency in living systems is the bond energy in a chemical called **adenosine triphosphate (ATP).**

ENZYME

* Term enzyme was given by Kuhne.
* Zymase (from yeast) was the first discovered enzyme by Buchner.
* Enzymes are biocatalysts made up of proteins (except ribozyme), which increases the rate of biochemical reactions by lowering down the activation energy.
* The first purified and crystalized enzyme was urease (by J.B.Sumner) from Canavalia/Jack Bean (Lobia plant).
* Proteinaceous nature of enzyme was suggested by Northrop and Sumner.
* First discovered ribozyme was L_{19} RNAase by T.Cech from rRNA of a protozoan Tetrahymena thermophila and RNAase P or Ribonuclease P by Altman in prokaryotic cell.
* **Table : Differences between enzymes and inorganic catalysts**

S.N.	Enzymes	Inorganic catalysts
1.	Almost all enzymes are proteins and have a complex molecular organisation.	They are usually small and simple molecules like nickel, platinum etc.
2.	They occur in living cells.	They do not occur in living cells.
3.	An enzyme catalyses only a specific reactions.	They are not specific for any one reaction and can catalyse a number of reactions.
4.	They get damaged at high temperatures (above 40°C).	They work efficiently at high temperatures and pressures.
5.	They are highly efficient.	They are less efficient.

Characteristics of enzymes

1. All enzymes are proteins, but all proteins are not enzymes.
2. All enzymes are tertiary & globular proteins (Isoenzymes quarternary protein)
3. Enzymes accelerate the rate of reaction, without undergoing any change in themselves. Enzymes lower down the activation energy of substrate or reactions.
4. Enzymes are macromolecules of amino acids, which are synthesized on ribosomes under the control of genes.
5. M.wt. of enzymes are high and they are colloidal substances.
6. Enzymes are very sensitive to pH & temperature. Optimum temp. for enzymes is 20-35°C. Most of enzymes are active at neutral pH, hydrolytic enzymes of lysosomes are active on acidic pH (5).
7. Enzymes are required in very minute amount for bio-chemical reactions.
8. Their catalytic power is represented by Michaelis Menten constant or Km constant and turn over number. "The number of substrate molecules converted into products per unit time by one molecule of the enzyme in favourable conditions is called turn over number." The maximum turn over number is of Carbonic anhydrase is 360 lakh, for Catalase is 50 lakh, for favoprotein is 50 & for lysozyme is 30 per minute.
9. Enzymes are very specific to their substrate or reactions.

Structure of enzyme

1. **Simple enzymes :** They are made up of only proteins. eg. pepsin, trypsin. papain.
2. **Conjugated enzymes :** They are made up of a protein part & non protein part.

(i) **Co-enzymes :** Co-enzymes are non-protein organic groups, which are loosely attached to apoenzymes. They are generally made up of vitamins.

(ii) **Prosthetic group :** When non-protein part is tightly or firmly attached to apoenzyme.

(iii) **Metal activators/co-factors /metallic factor:** Loosely attached inorganic co-factor.
eg. Mn, Fe, Co, Zn, Ca, Mg, Cu

* **Active site :** Specific part of amino acid chain in enzyme structure at which specific substrate is to be binded and catalysed, known as active site. Active site of enzyme is made up of very specific sequence of amino acids, determined by genetic codes.
* **Allosteric site :** Besides the active site's, some enzymes possess additional sites, at which chemicals other than substrate (allosteric modulators) are bind. These sites are known as allosteric sites and enzyme with allosteric sites are called as allosteric enzymes. e.g. hexokinase, phosphofructokinase.

Terminology

* **Endoenzymes :** Enzymes which are functional only inside the cells.
* **Exoenzymes :** Enzymes catalysed the reactions outside the cell Eg:- enzymes of digestion, some enzymes of insectivorous plants, Zymase complex of fermentation.
* **Proenzyme/Zymogen :** These are precursors of enzymes or inactive forms of enzymes.
eg. Pepsinogen, Trypsinogen etc.
* **Iso-enzymes :** Enzymes having similar action, but little difference in their molecular configuration are called isoenzymes. 16 forms of α-amylase of wheat & 5 forms of LDH (Lactate dehydrogenase) are known. These all forms are synthesised by different genes.
* **Inducible enzymes :** When formation of enzyme is induced by substrate availability.
eg. Lactase, Nitrogenase, β-galactosidase.
* **Extremozymes :** Enzymes, which may also function at extremely adverse conditions e.g Taq polymerase.
* **Abzymes :** When the monoclonal antibodies are used as enzymes or reagents.
* **Biodetergents :** Enzymes used in washing powders are known as bio-detergents eg. amylase, lipase, proteolytic enzymes.
* **House keeping / constitutive enzymes :** Which are always present in constant amount & are also essential to cell.

Nomenclature and classification

Enzymes are divided into six classes:

(i) **Oxidoreductases / dehydrogenases**
Enzymes which catalyse oxidation-reduction reactions involving transfer of electrons / H^+ from one molecule to another. In these reactions one compound is oxidised and other is reduced.
Example - Dehydrogenase, oxidases, reductases, catalase, peroxidase.

$$S_{reduced} + S'_{oxidised} \rightarrow S_{oxidised} + S'_{reduced}$$

$$\text{Alcohol} + \text{NAD} \xrightarrow{\text{alcohol dehydrogenase}} \text{Aldehyde} + NADH_2$$

(ii) **Transferases :** These enzymes catalyse the transfer of specific groups other than hydrogen from one substrate to another.
Example - Transaminase (transfers amino group), Kinase (catalyse the phosphorylation of substrate by transferring phosphate group usually from ATP).

$$S - G + S' \rightarrow S + S' - G$$

$$\text{Glucose} + \text{ATP} \xrightarrow{\text{Glucohexokinase}} \text{Glucose 6 phosphate} + \text{ADP}$$

(iii) **Hydrolases :** These enzymes catalyse the breakdown of larger molecules into smaller molecules with the addition of water. They catalyse hydrolysis of ester, ether, peptide, glycosidic,
C–C, C-halide or P–N bonds.
Example - Proteases, amylases, lipases, maltase, nucleases and other digestive enzymes.

$$\text{Sucrose} + H_2O \xrightarrow{\text{sucrase/invertase}} \text{Glucose} + \text{fructose}$$

(iv) **Lyases :** These enzymes catalyse the cleavage of substrate into two parts, without the use of water or removal of groups without hydrolysis. A double bond is formed at the place of removal of group.
Example - Aldolase, decarboxylase, carbonic anhydrase etc.

$$\begin{array}{cc} X & Y \\ | & | \\ C & - C \end{array} \rightarrow X - Y + C = C$$

Fructose 1, 6, diphosphate $\xrightarrow{\text{aldolase}}$ Dihydroxy acetone phosphate + glyceraldehyde phosphate

(v) Isomerases : These enzymes catalyse the rearrangement of molecular structure to form isomers. Isomers are molecules or molecular compounds that are similar in that they have the same molecular formula however have different arrangements of the atoms or group of atoms involved. They catalyse inter-conversion of optical, geometric or positional isomers.
Example - Isomerase

Glucose-6-phosphate $\xrightleftharpoons{\text{isomerase}}$ fructose 6-phosphate

(vi) Ligases : These enzymes catalyse covalent bonding of two substrates to form a large molecule. They catalyse joining of C–C, C–S, C–N, P–O etc. bonds by using energy of ATP.
Example - RUBP carboxylase, ligase, Phosphoenol pyruvate (PEP carboxylase) etc.
Phosphoenol pyruvic acid + CO_2 $\xrightarrow[\text{PEP carboxylase}]{\text{ATP}}$ oxaloacetic acid

* International Union of Biochemistry (IUB) appointed an Enzyme Commission (EC) in 1961 which devised some basic principles for classification and nomenclature of enzymes. IUB system has divided enzymes into six major classes. Each class in turn is subdivided into many subclasses which are further divided. A four digit enzyme commission (EC) number (e.g., 5.2.1.7) is assigned to each enzyme represents:
  (i) I^{st} digit – Class
  (ii) II^{nd} digit – Subclass
  (iii) III^{rd} digit – Sub-subclass
  (iv) IV^{th} digit – Individual enzyme

Co-factors

* Non-protein constituents called cofactors are bound to the the enzyme to make the enzyme catalytically active. In these instances, the protein portion of the enzymes is called the apoenzyme.
* Three kinds of cofactors may be identified: prosthetic groups, co-enzymes and metal ions.
* Prosthetic groups are organic compounds and are distinguished from other cofactors in that they are tightly bound to the apoenzyme. For example, in peroxidase and catalase, which catalyze the breakdown of hydrogen peroxide to water and oxygen, haem is the prosthetic group and it is a part of the active site of the enzyme.
* Co-enzymes are also organic compounds but their association with the apoenzyme is only transient, usually occurring during the course of catalysis.
* The essential chemical components of many coenzymes are vitamins, e.g., coenzyme nicotinamide adenine dinucleotide (NAD) and NADP contain the vitamin niacin.
* A number of enzymes require metal ions for their activity which form coordination bonds with side chains at the active site and at the same time form one or more cordination bonds with the substrate, e.g., zinc is a cofactor for the proteolytic enzyme carboxypeptidase.
* Catalytic activity is lost when the co-factor is removed from the enzyme which testifies that they play a crucial role in the catalytic activity of the enzyme.

Mode of action of enzyme

1. Lock & Key theory or template theory :
* Given by Emil Fischer
* According to this theory active sites of enzymes serve as a lock into, which the reactant substrate fits like a key.
Supported by competitive inhibition.

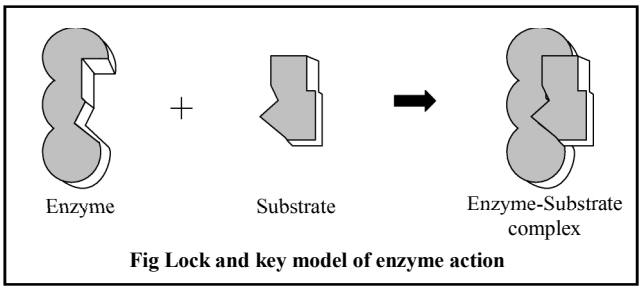


Fig Lock and key model of enzyme action

2. Enzyme - Substrate complex theory :
* Given by Henry explained by Michaelis & Menten

* Each enzyme (E) has a substrate (S) binding site in its molecule so that a highly reactive enzyme-substrate complex (ES) is produced.
* This complex is short-lived and dissociates into its product(s) P and the unchanged enzyme with an intermediate formation of the enzyme-product complex (EP).
* The formation of the ES complex is essential for catalysis.

  Enzyme + Substrate $\rightleftharpoons$ ES $\rightarrow$ EP $\rightarrow$ Product + Enzyme
* The catalytic cycle of an enzyme action :

(i) First, the substrate binds to the active site of the enzyme, fitting into the active site.

(ii) The binding of the substrate induces the enzyme to alter its shape, fitting more tightly around the substrate.

(iii) The active site of the enzyme, now in close proximity of the substrate breaks the chemical bonds of the substrate and the new enzyme-product complex is formed.

(iv) The enzyme releases the products of the reaction and the free enzyme is ready to bind to another molecule of the substrate and run through the catalytic cycle once again.

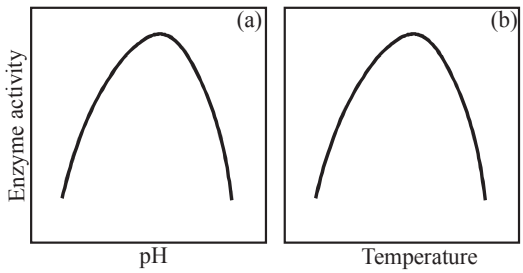
Factors

1. **pH :** Enzymes very sensitive to pH.

2. **Temperature :** High temp inactivates enzyme causing their denaturation. They also get inactive at lower temp. Generally all enzymes better perform at body temp. of organism.

3. **Enzyme concentration :** Increase in concentration of enzymes will increase the rate of enzymatic reaction.

4. **Substrate concentration :** Increase in substrate conc^{n} increases the activity of enzymes until all the active sites of enzyme are saturated.



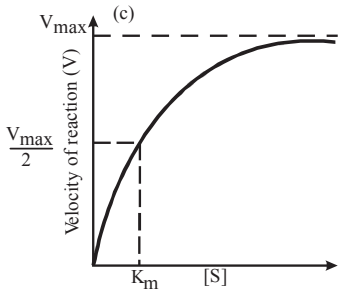


Figure: Effect of change in : (a) pH (b) Temperature and (c) Concentration of substrate on enzyme activity.

5. **Inhibitors/Enzyme inhibition :**

(i) **Competitive inhibitors or competitive inhibition and reversible type :**

* These are substrate analogues, which bind to the active site of enzymes & enzymes get inhibited, such inhibition is called as competitive inhibition. Eg. Succinic dehydrogenase is inhibited by its competitor malonate.
* This is reversible inhibition. Malonate is known as substrate analogue of succinate.
* Similarly sulpha drugs are substrate analogue of p-amino benzoic acid (PABA) used in folic acid synthesis in bacterical cells. Hence these drugs are used to kill bacterial cells.

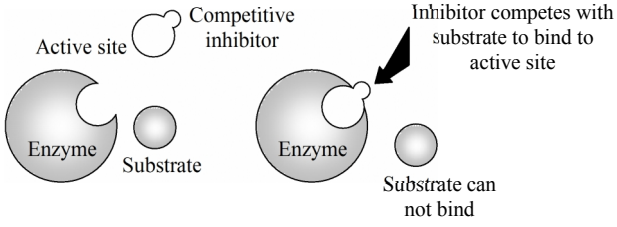


Fig Competitive inhibition

(ii) **Non-competitive inhibitors or non competitive inhibition and irreversible type:** In this type of inhibition, inhibitor substance can bind simultaneously to an enzyme, other than it's active site and destroy the sulfhydril (S–H) group of enzyme.

Example : Toxic metals, CO, CN poisoning of cytochrome oxidase.

* Such inhibition are irreversible inhibition.

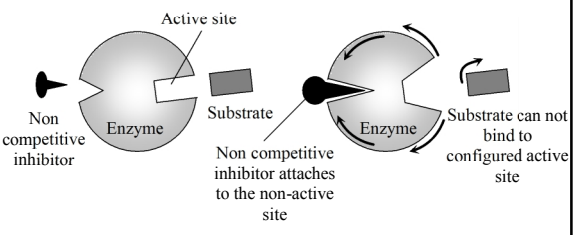


Fig : Non-competitive inhibition

(iii) Non competitive & reversible type : When inhibitor binds at allosteric site reversibly.

* When product of biochemical reaction inhibits the enzyme action, it is known as product inhibition or retro inhibition or feed back inhibition.
* The product may binds at allosteric site of allosteric enzyme then it is non-competitive reversible allosteric inhibition. Example : inhibition of hexokinase by glucose 6P. So, product inhibition is always reversible inhibition.

K_m Constant (Miehalies & Menten Constant)

* $_m$ constant of an enzyme, is the concentration of substrate at which rate of reaction of that enzyme attains half of its maximum velocity." It is given by Michaelis & Menten. The value of Km should be lower for an enzyme.
* K_m exhibits catalytic activity of an enzyme.
* Ki constant (Enzyme inhibitor complex dissociation constant) indicates the dissociation of enzyme inhibitor complex (EIC) of reversible inhibitors.
  K_m and K_i constant of an enzyme should be low.
* If competitive inhibitor is present, then km ↑ and V_{max} - No change
* If Non-competitive (reversible) inhibitor is present, then,
  K_m - No change, V_{max} - Decrease.
* Competitive inhibiton is overcome by increase in concentration of substrate.
* $K_m = \frac{1}{2} V_{max}$
  K_m value differs from substrate to substrate because different enzymes differ in their affinity towards different substrates. A high K_m indicates low affinity while a low K_m shows strong affinity. Protease acts on different proteins. So it's K_m value will differ from protein to protein.

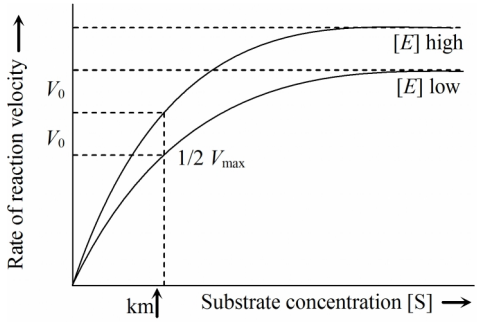


Fig : Reaction velocity '*V*' and substance concentration (*S*) for a typical enzyme catalysed reaction

CONCEPT REVIEW

* Polysaccharides are the long chain of sugars.
* **Cellulose** is homopolymer containing only glucose units.
* **Starch** is a variant of homopolymer of glucose.
* **Inulin** is a polymer of **fructose.**
* In a polysaccharide chain the right end is called reducing end and left end is non-reducing end.
* Starch form helical secondary structure.
* Starch can hold Iodine (I_2) molecule in its helical portion hence gives blue colour.
* Cellulose dose not contain complex helices and hence cannot hold Iodine (I_2) and not give blue colour.
* Complex sugars have **amino-sugar** as building blocks. (Glucosamine, N-acetyl galactosamine.)
* Exoskeleton of arthropods made of sugar **called chitin.**
* Complex polysaccharides are heteropolymer.
* **Peptide bond :** Formed between the carboxyl (-COOH) group of one amino acid and the amino ($-NH_2$) group of the next amino acid with the elimination of water moiety.
* **Glycosidic bond :** Individual monosaccharides linked with each other to form polysaccharides. This bond is also formed by dehydration. Formed between two carbon atoms of two adjacent monosaccharides.
* **Phosphodiester bond :** In a nucleic acid a phosphate moiety links the 3'-carbon of one sugar one nucleotide to the 5'-carbon of the sugar of the succeeding nucleotide. The bond between the phosphate and hydroxyl group of sugar is an ester bond.

There is one such ester bond on either side, it is called Phosphodiester bond.

* **Oxidoreductases/dehydrogenases :** Enzymes which catalyse oxidoreduction between two substrates Sand S' , e.g.,
  S reduced + S' oxidised → S oxidised + S' reduced
* **Transferases :** Enzymes catalysing a transfer of a group, G (other than hydrogen) between a pair of substrate S and S',
  e.g., S-G + S' → S + S' - G
* **Hydrolases :** Enzymes catalysing hydrolysis of ester, ether, peptide, glycosidic, C–C, C–halide or P – N bonds.
* **Lyases :** Enzymes that catalyse removal of groups from substrates by mechanisms other than hydrolysis leaving double bonds.
* **Isomerases:** Includes all enzymes catalysing interconversion of optical, geometric or positional isomers.
* **Ligases :** Enzymes catalysing the linking together of two compounds.

IMPORTANT POINTS

* Sucrose is a carbohydrate.
* In RNA, thymine is replaced by uracil.
* Starch is a polymer of glucose.
* Cellulose is polysaccharide.
* Glycogen is a polymer of glucose.
* DNA does not occur in ribosomes.
* The enzyme purified and crystallised for the first time was urease.
* Enzyme complex involved in alcoholic fermentation is Zymase.
* Key and lock hypothesis of enzyme action was given by Fishcher.
* Enzyme amylase belongs to hydrolases.
* Most common monosaccharides found in nucleus are pentoses.
* An amino acid without asymmetrical carbon atom is glycine.
* Lactose is made of Glucose + Galactose.
* RNA contains ribose sugar.
* Enzyme involved in hydrolysis of starch to maltose is amylase.
* Maltose is a disaccharide.
* Steroid is cholesterol.
* K_m value is related to ES complex.
* Sweetest sugar is fructose.
* Sugar present in DNA is pentose.
* Gluconic acid is a reducing sugar.
* Simple polyhydroxy ketone molecule containing 3-7 carbons is polysaccharide.
* Triglycerides = Uracil
  Lactose = Galactose
  RNA = Secondary structure
  β-pleats = Glycerol
  Bee wax = Palmitic acid
* Quaternary structure is present in haemoglobin.
* Molecules having charged groups of opposite polarity are Zwitter ions.

QUESTION BANK

EXERCISE - 1 (LEVEL-1) [NCERT EXTRACT]

SECTION - 1 (VOCABULARY BUILDER)

Choose one correct response for each question.
For Q.1-Q.4
Match the column I with column II.

Q.1

	Column I	Column II
a.	Fructose	i. Protein
b.	Galactose	ii. Phospholipid
c.	Lecithin	iii. Brain Sugar
d.	Anticoagulant	iv. Heparin
e.	Insulin	v. Fruit Sugar

(A) (a) - ii, (b)-i, (c)-iv, (d)-iii, (e)-v
(B) (a) - iv, (b)-ii, (c)-i, (d)-v, (e)-iii
(C) (a) - v, (b)-iii, (c)-ii, (d)-iv, (e)-i
(D) (a) - iv, (b)-iii, (c)-ii, (d)-v, (e)-i

Q.2

	Column I	Column II
a.	Dehydrogenases	i. Interconversion of optical, geometrical positional isomers.
b.	Ligases	ii. Group transfer.
c.	Isomerases	iii. Oxidoreduction between two substrates.
d.	Hydrolases	iv. Linking together of two bond.
e.	Transferases	v. Hydrolysis of bonds.

Codes
(A) a-v, b-iv, c-i, d-ii, e-iii
(B) a-iv, b-iii, c-v, d-ii, e-i
(C) a-v, b-iv, c-ii, d-iii, e-i
(D) a-iii, b-iv, c-i, d-v, e-ii

Q.3 Match the following columns.

	Column I	Column II
a.	Triglycerides	i. Galactose
b.	Lactose	ii. Glycerol
c.	RNA	iii. Palmitic acid
d.	β-pleated	iv. Uracil
e.	Bee wax	v. Secondary structure

Codes
(A) a-iv, b-i, c-v, d-ii, e-iii
(B) a-v, b-i, c-iv, d-ii, e-iii
(C) a-iii, b-i, c-iv, d-v, e-ii
(D) a-ii, b-i, c-iv, d-v, e-iii

Q.4

a.	Enzymatic	i.	Provide regulatory signals between cells; insulin is an example.
b.	Structural	ii.	Initiates cellular responses by binding molecules to cell surface or the internal environment.
c.	Receptor	iii.	Provides support to cells.
d.	Hormones	iv.	Involved in cellular movements; actin and myosin are examples.
e.	Motile	v.	Increases movement across the cell membrane, typically ions.
f.	Transport	vi.	Increases the rate of biological reactions.

Codes
(A) a-vi, b-iii, c-ii, d-i, e-iv, f-v
(B) a-vi, b-i, c-iv, d-ii, e-iii, f-v
(C) a-iii, b-i, c-vi, d-v, e-ii, f-iv
(D) a-iii, b-i, c-iv, d-vi, e-ii, f-v

SECTION - 2 (BASIC CONCEPTS BUILDER)

For Q.5 to Q.21 :

Choose one word for the given statement from the list.

DNA, RNA, Secondary, 16, 17, RUBISCO, Lowering, Palindromic DNA, Adenosine Triphosphate (ATP), Fructose, Nucleotides, Enzymes, Glucose, Apoenzyme, Competitive Inhibitor, Peptide bond.

Q.5 Palmitic acid has ____ carbons including the carboxyl group.

Q.6 A nucleic acid containing deoxyribose is called __ while that which contains ribose is called ___

Q.7 The DNA in which the base sequence of one strand is opposite to that of other strand when read from opposite direction is called _____.

Q.8 ____ is the most abundant protein in whole of the biosphere.

Q.9 An α-helix is the example of __protein structure.

Q.10 The proteinaceous molecule that joins a non-proteinaceous prosthetic group to form a functional enzyme is called _____.

Q.11 The 'repeating unit' of glycogen is _____.

Q.12 Enzymes catalyses the biochemical reactions by _____ the activation energy.

Q.13 Proteins with catalytic power are called _____.

Q.14 Primary structure of proteins is due to the presence of _____.

Q.15 Fructan is a polymer of _____.

Q.16 The inhibitor which inhibits the enzyme activity by binding to the active site of the enzyme, due to the close resemblance to the substrate in its molecular structure is called _____.

Q.17 The most important form of energy currency in living organisms is the bond energy in the chemical called _____.

Q.18 If a phosphate group is esterified to the sugar, they are called ____.

Q.19 All enzymes are active only at 37°C. **[True / False]**

Q.20 Enzymatic inhibitors bind at the active site. **[True / False]**

Q.21 Ribozymes are RNA molecules that catalyze chemical reactions. **[True / False]**

SECTION - 3 (ENHANCE PROBLEM SOLVING SKILLS)

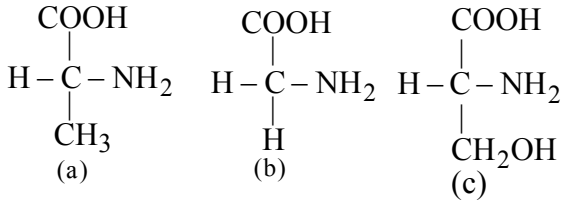
Choose one correct response for each question.

PART - 1 : CHEMICAL COMPOSITION

Q.22 Variety of amino acids are formed on the basis of
(A) position of hydroxyl group.
(B) position of carboxyl group.
(C) position of hydrogen.
(D) nature of R group.

Q.23 Which of the following statements is incorrect?
(A) Lipids are strictly macromolecules.
(B) Palmitic acid has 16 carbons including carboxyl carbon.
(C) Oils have low melting point and hence remain as oil in winters.
(D) Arachidonic acid is an unsaturated fatty acid.

Q.24 Name the amino acids a-c correctly.



(A) a-Glycine, b-Serine, c-Alanine
(B) a-Alanine, b-Glycine, c-Serine
(C) a-Serine, b-Glycine, c-Alanine
(D) a-Serine, b-Alanine, c-Glycine

Q.25 Molecule X contains a sugar and a phosphate group. What is the molecule X?
(A) A carbohydrate (B) A fatty acid
(C) A nucleotide (D) An amino acid

Q.26 98% of living organism is formed of six elements -carbon, hydrogen, nitrogen, oxygen and
(A) S & Mg (B) Mg & Na
(C) Ca & P (D) P & S

Q.27 The amino acids are acidic, basic and neutral based on the number of –
(A) amino groups and hydrogen.
(B) amino and carboxyl groups.
(C) hydrogen and carboxyl groups.
(D) carboxyl groups.

Q.28 Which of the following is the most abundant element present in human body?
(A) Carbon (B) Hydrogen
(C) Oxygen (D) Nitrogen

Q.29 Lecithin is –
(A) Simple lipid (B) Derived lipid
(C) Phospholipid (D) Steroids

PART - 2 : PRIMARY AND SECONDARY METABOLITES

Q.30 Which of the following secondary metabolites an used as drugs?
(A) Vinblastin and curcumin (B) Anthocyanin
(C) Gums and cellulose (D) Abrin and ricin

Q.31 Which of the following secondary metabolites is a polymeric substance?
(A) Ricin (B) Monoterpenes
(C) Curcumin (D) Rubber

Q.32 In animal tissues, the categories of compounds present are called
(A) molecules
(B) primary metabolites
(C) secondary metabolites
(D) biomolecules

Q.33 A high fever is dangerous to humans because –
(A) proteins are used up quickly
(B) fats are oxidised
(C) enzymes are denatured
(D) BMR is lowered

Q.34 Which of the following is a secondary metabolite as well as a drug?
(A) Concanavalin A (B) Vinblastine
(C) Diterpenes (D) Ricin

Q.35 Select the correct constituents of protein.
(A) Carbon, hydrogen, oxygen and nitrogen.
(B) Carbon, hydrogen, nitrogen and sulphur.
(C) Carbon, hydrogen, nitrogen, oxygen & sulphur
(D) Carbon, hydrogen and oxygen

Q.36 Allosteric modulation occurs due to the inhibition action of enzymes by –
(A) competitive inhibition
(B) substrate concentrations
(C) products of reaction
(D) enzyme concentrations

Q.37 Which of the following is a primary metabolite?
(A) Carotenoid (B) Glucose
(C) Morphine (D) Cellulose

Q.38 Primary metabolites play known roles in
(A) ecology
(B) chemical process
(C) human welfare
(D) physiological process

PART - 3 : BIOMACROMOLECULES

Q.39 Chemical compounds that have molecular weights less than one thousand dalton are usually referred to as –
(A) biomolecules (B) micromolecules
(C) macromolecules (D) Both (A) and (B)

Q.40 Which of the following is the simplest amino acid'
(A) Tyrosine (B) Asparagine
(C) Glycine (D) Alanine

Q.41 The acid soluble pool, roughly represents
(A) chemical composition of cell.
(B) cytoplasmic composition of cell.
(C) Both (A) and (B)
(D) None of the above

Q.42 Chemical compounds which are found in the acid insoluble fraction are called –
(A) biomolecules (B) macromolecules
(C) micromolecules (D) Both (A) and (B)

Q.43 The most abundant chemical in living organisms is
(A) protein (B) water
(C) lipids (D) nucleic acids

PART - 4 : PROTEINS

Q.44 Which of the following is an essential amino acids?
(A) Valine (B) Leucine
(C) Tryptophan (D) All of these

Q.45 Among the following, richest source of protein is
(A) rice (B) gram
(C) wheat (D) soyabean

Q.46 Name the most abundant protein in animal world.
(A) RUBISCO
(B) Carboxylase-oxygenase
(C) Collagen
(D) Cellulose

PART - 5 : POLYSACCHARIDES

Q.47 Sucrose, a common table sugar is composed of
(A) glucose and fructose
(B) glucose and galactose
(C) fructose and galactose
(D) None of the above

Q.48 Inulin is a polymer of
(A) Fructose (B) Glucose
(C) Mannose (D) Ribose

Q.49 Which of the following polysaccharide is present as a store house of energy in plant tissues?
(A) Glycogen (B) Cellulose
(C) Insulin (D) Starch

Q.50 Cotton fibre is made up of
(A) Cellulose (B) Glycogen
(C) Chitin (D) Starch

Q.51 Maltose gives rise to two molecules of –
(A) fructose (B) lactose
(C) glucose (D) sucrose

Q.52 Chitin is a –
(A) polysaccharide
(B) nitrogenous polysaccharide
(C) lipoprotein
(D) protein

Q.53 Plant cell walls are made of
(A) Homopolymer of fructose.
(B) Heteropolymer of glycogen.
(C) Homopolymer of glucose.
(D) Homopolymer of glycogen.

Q.54 Raffinose is a –
(A) monosaccharides (B) disaccharides
(C) trisaccharides (D) polysaccharides

Q.55 As starch is related to plant body, which of the following polysaccharides is related to animal body?
(A) Cellulose (B) Chitin
(C) Glycogen (D) Inutin

PART - 6 : NUCLEIC ACIDS

Q.56 For nucleic acids, the building block is a
(A) nucleotide (B) nucleoside
(C) polynucleotide (D) sugar

Q.57 Nucleotides are formed by
(A) purine, sugar and phosphate
(B) purine, pyrimidine and phosphate
(C) purine or pyrimidine, sugar and phosphate
(D) pyrimidine, sugar and phosphate

Q.58 Select the correct pair of substituted purines.
(A) Cytosine and thymine
(B) Adenine and guanine
(C) Uracil and cytosine
(D) Guanine and uracil

PART - 7 : STRUCTURE OF PROTEINS

Q.59 The β-pleated sheet structure found in proteins is due to –
(A) linking together of two or more polypeptides
(B) coiling of polypeptide chains
(C) formation of peptide bonds
(D) folding of the coiled polypeptide chains

Q.60 Tick mark the incorrect statement about adult human haemoglobin
(A) It is made up of four sub-units.
(B) Two sub-units are of α-type and two sub-units of beta-type.
(C) It has quarternary structure of protein.
(D) It is a simple protein.

Q.61 Which type of protein is present in human skin?
(A) Primary proteins (B) Secondary proteins
(C) Tertiary proteins (D) Quarternary proteins

Q.62 The tertiary structure of proteins can be destroyed by
(A) High energy radiations (B) High temperature
(C) Drastic changes in pH (D) All of these

Q.63 In a polypeptide chain, a β-pleated sheet is an example of –
(A) 20 structure (B) 10 structure
(C) 40 structure (D) 30 structure

Q.64 Which of the following structure of protein is absolutely necessary for the many biological activities of proteins?
(A) Primary (B) Secondary
(C) Tertiary (D) Quaternary

Q.65 Which form of keratin is present in human hair ?
(A) Parallel β-sheet (B) α-helix
(C) Antiparallel β-sheet (D) None of these

Q.66 Antibodies that help to fight infectious agents are
(A) Polysaccharides (B) Amino acids
(C) Proteins (D) Glucose

PART - 8 : NATURE OF BOND

Q.67 In a protein molecule, the amino acid units are linked together by bonds formed between the amino acid units and the carboxyl group of successive amino acids.
(A) peptide (B) hydrogen
(C) covalent (D) ionic

Q.68 The left handed DNA is called –
(A) A-DNA (B) B-DNA
(C) Z-DNA (D) C-DNA

Q.69 One of the secondary structures exhibited by DNA is –
(A) Stehenson's model
(B) Watson-Crick model
(C) Bohr's model
(D) Wilkenson model

Q.70 In a polysaccharide, the individual mono-saccharides are linked by a –
(A) glycosidic bond (B) peptide bond
(C) ester bond (D) phosphodiester bond

Q.71 The pyrimidine base, which confers additional stability to DNA over RNA, is
(A) adenine (B) guanine
(C) cytosine (D) thymine

PART - 9 : METABOLISM

Q.72 Every chemical (metabolic) reaction is a __ reaction.
(A) induced (B) reversible
(C) catalysed (D) spontaneous

Q.73 The metabolite flow is called –
(A) dynamic state of body constituents
(B) flow of traffic junctions
(C) turn over flow
(D) adiabatic flow of reactions

Q.74 Biomolecules are constantly being changed into some other biomolecules and are made from –
(A) amino acids (B) biomolecules only
(C) monosaccharides (D) enzymes

Q.75 Which of the following statement{s) is/are correct?
(A) Living steady state has a self regulatory mechanism called homeostasis.
(B) Energy flow and energy transformation of living system follows law of thermodynamics.
(C) Metabolism is the release and gain of energy.
(D) All of the above

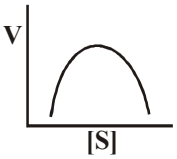
PART - 10 : ENZYMES

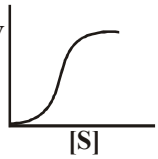
Q.76 Proteins with catalytic power are known as
(A) metabolites (B) essential protiens
(C) enzymes (D) receptors

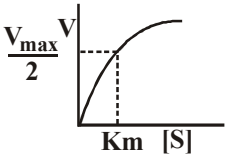
Q.77 Which of the following statements about enzymes are correct?
I. Enzymes do not alter the overall change in free energy for a reaction.
II. Enzymes are highly specific for reactions.
III. The energy input needed to start a chemical reaction is called activation energy.
IV. Enzymes are proteins whose three dimensional shape is key to their functions.
(A) I and V (B) I, II and V
(C) II and V (D) All of these

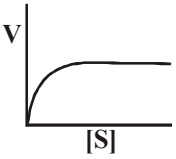
Q.78 Which of the following is not an example of competitive inhibition?
(A) Inhibition of succinic dehydrogenase by malonate.
(B) Sulphur drugs used to control bacterial pathogens.
(C) Inhibition of alcohol dehydrogenase by ethanol in methanol poisoning.
(D) Inhibition of hexokinase by glucose-6-phosphate

Q.79 Select the correct graph which shows relationship between the rate of an enzyme activity and substrate concentration.

(A) 

(B) 

(C) 

(D) 

Q.80 What are proenzymes?
(A) Inactive form of enzymes
(B) Active form of enzymes
(C) Neutral form of enzymes
(D) None of these

Q.81 Which of the following, factors can influence enzyme activity?
(A) High temperature (B) pH
(C) Substrate concentration (D) All of these

Q.82 The effectiveness of an enzyme is affected least by –
(A) temperature
(B) concentration of the substrate
(C) original activation energy of the system
(D) concentration of the enzyme

Q.83 Those nucleic acids which behave like enzymes are known as
(A) ribozymes (B) pepzymes
(C) Both (A) and (B) (D) ribose

Q.84 Which of the following is a cofactor for the proteolytic enzyme carboxypeptidase?
(A) Zinc (B) Copper
(C) Calcium (D) Magnesium

Q.85 Malonate inhibits succinate dehydrogenase, is an example of
(A) allosteric inhibition
(B) negative feedback
(C) competitive inhibition
(D) non-competitive inhibition

Q.86 What would happen to V(max) in presence of a competitive inhibitor?
(A) Decreases
(B) Increases
(C) Remains the same
(D) First increases then decreases

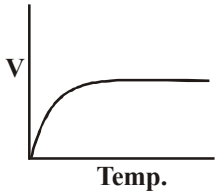
Q.87 The following reaction is catalysed by which of enzyme?

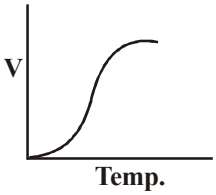
$$NADH + H^+ + \frac{1}{2}O_2 \rightarrow NAD^+ + H_2O$$

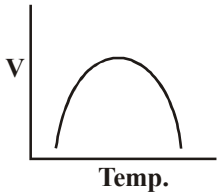
(A) Hydrolases (B) Cytochrome oxidases
(C) Transferases (D) Lyases

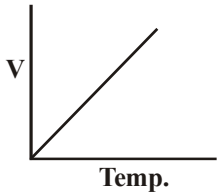
Q.88 Which of the following group of enzymes helps in catalysing a transfer of a group (other than hydrogen) between a pair of substrates?
(A) Oxidoreductases (B) Transferases
(C) Lyases (D) Isomerases

Q.89 Select the correct graph, which shows the effect of temperature on the velocity of a typical enzymatic reaction.

(A) 

(B) 

(C) 

(D) 

EXERCISE - 2 (LEVEL-2)

Choose one correct response for each question.

Q.1 Glycogen is stored in –
(A) Liver and muscles (B) Liver only
(C) Muscles only (D) Pancreas

Q.2 Cholesterol is synthesized in –
(A) Pancreas (B) Brunners gland
(C) Spleen (D) Liver

Q.3 Which is a disaccharide –
(A) Galactose (B) Fructose
(C) Maltose (D) Dextrin

Q.4 Which element is normally absent in proteins –
(A) C (B) N
(C) S (D) P

Q.5 Which substance is not carbohydrate –
(A) Starch (B) Glycogen
(C) Wax (D) Glucose

Q.6 To get quick energy one should use –
(A) Carbohydrate (B) Fats
(C) Vitamins (D) Proteins

Q.7 Protein most abundant in human body is –
(A) Collagen (B) Myosin
(C) Actin (D) Albumin

Q.8 Which is not polysaccharide –
(A) Sucrose (B) starch
(C) Glycogen (D) cellulose

Q.9 Decreasing order of amount of organic compound in animal
(A) Carbohydrate, Protein, fat, and nucleic acid
(B) Protein, fats, nucleic acid and carbohydrate
(C) Protein, fats, carbohydrates and nucleic acid.
(D) Carbohydrate, fats, Proteins and nucleic acid

Q.10 Characteristic feature of haemoglobin –
(A) Reversible union with oxygen
(B) Red Colour
(C) Presence of Cu
(D) Presence of Globulin protein

Q.11 Units of proteins which unite in long chains to form proteins, are called –
(A) Sugar (B) Purines
(C) Pyrimidines (D) Amino acids

Q.12 Milk protein is –
(A) Lactogen (B) Myosin
(C) Casein (D) Pepsin

Q.13 Chemically enzymes are –
(A) Fats (B) Carbohydrates
(C) Hydrocarbons (D) Proteins

Q.14 Long chain molecules of fatty acids are formed by –
(A) Polymerisation of 2 carbon compounds
(B) Decomposition of fats
(C) Polymerisation of glycogen
(D) Conversion of glycogen

Q.15 Most simple amino acid is –
(A) Tyrosine (B) Lysine
(C) Glycine (D) Aspartic acids

Q.16 Amino acids which are not synthesized in the body
(A) Non-essential (B) Essential
(C) Deaminated (D) All of them

Q.17 Which of the following will be different in different animals
(A) Fats (B) Carbohydrates
(C) Proteins (D) Vitamins

Q.18 Fats in the body are formed when –
(A) Glycogen is formed from glucose
(B) Sugar level becomes stable in blood
(C) Extra glycogen storage in liver and muscles is stopped
(D) All of them

Q.19 Gauchers disease is concerned with which of the following
(A) Abnormal fat metabolism
(B) Abnormal protein metabolism
(C) Abnormal carbohydrate metabolism
(D) None of them

Q.20 For body growth and repair one needs –
(A) Carbohydrates (B) Fats
(C) Proteins (D) Vitamins

Q.21 In India the best source for proteins in herbivorous persons
(A) Pulses (B) Potato
(C) Egg (D) Meat

Q.22 Proteins are conducted in the body in the form of –
(A) Amino acids (B) Natural proteins
(C) Enzymes (D) nucleic acids

Q.23 Which is sweet in taste, but is not sugar –
(A) Starch (B) Saccharine
(C) Lactose (D) Protein

Q.24 The formation of protein can be considered as –
(A) Dehydration synthesis
(B) Dehydration analysis
(C) Hydration synthesis
(D) Hydration analysis

Q.25 Translocation of sugars in flowering plants occurs in
(A) Glucose (B) Sucrose
(C) Fructose (D) Maltose

Q.26 Sucrose is composed of –
(A) Glucose & Fructose
(B) Glucose & Glycogen
(C) Two molecules of Glucose
(D) Glycogen & Fructose

Q.27 Allosteric enzymes have allosteric sites for –
(A) Inhibition only
(B) Activation only
(C) Reduction in activation energy
(D) Both activation and inhibition

Q.28 Substrate concentration at which an enzyme attains half of its max. velocity is –
(A) Half life of enzyme
(B) Km-constant of enzyme
(C) Concentration ratio
(D) None of these

Q.29 Energy required for start of biochemical reaction is
(A) Potential energy (B) Entropy
(C) Activation energy (D) Kinetic energy

Q.30 Part of active site of enzyme, where substrate is supported
(A) Catalytic group (B) Buttressing group
(C) Activation chamber (D) Ki - constant

Q.31 Enzymes, vitamins and hormones can be classified into a single category of biological chemicals, because all of
(A) enhance oxidative metabolism.
(B) are conjugated proteins.
(C) are exclusively synthesized in the body of a living organism.
(D) help in regulating metabolism.

Q.32 An organic substance bound to an enzyme and essential for its activity is called –
(A) Apoenzyme (B) Isoenzyme
(C) Coenzyme (D) Holoenzyme

Q.33 An enzymes of TCA cycle are located in the mitochondrial matrix except one which is located in inner mitochondrial membrane in eukaryotes and in cytosol in prokaryotes. This enzyme is –
(A) Succinate dehydrogenase
(B) Lactate dehydrogenase
(C) Isocitrate dehydrogenase
(D) Malate dehydrogenase

Q.34 DNA polymerase enzyme is required for the synthesis
(A) DNA From DNA
(B) DNA from RNA
(C) Both the above
(D) DNA from nucleosides

Q.35 Ligase enzyme is used for –
(A) Denaturation of DNA
(B) Splitting DNA into small bits
(C) Joining bits of DNA
(D) Digestion of lipids

Q.36 The component present in both nucleotides & nucleosides
(A) sugar (B) phosphate
(C) nitrogenous base (D) both (A) and (C)

Q.37 Which of the following is a triglyceride?
(A) Wax (B) Phospholipid
(C) Oil (D) Steroid

Q.38 The sum total composition of acid soluble and acid insoluble fraction represents the entire composition of
(A) dead cells (B) gene pool
(C) cellular pool (D) gene library

Q.39 Michaelis Menten Constant (K_m) is equal to
(A) the rate of reaction
(B) the rate of enzymatic activity
(C) substrate concentration at which the reaction attains half of its maximum velocity
(D) substrate concentration at which the rate of reaction is maximum.

Q.40 Select the option that correctly identifies the chemical bond: present in the given biomolecules. Polysaccharides - a, Proteins - b, Fats - c, Water- d.
(A) a-Ester, b-Peptide, c-Glycosidic, d-Hydrogen
(B) a-Glycosidic, b-Peptide, c-Ester, d-Hydrogen
(C) a-Glycosidic, b-Peptide, c-Hydrogen, d-Ester
(D) a-Hydrogen, b-Ester, c-Peptide, d-Glycosidic

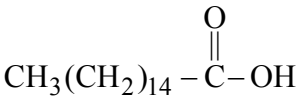
Q.41 Feed back inhibition of an enzyme is influenced by
(A) enzyme itself (B) external factors
(C) end product (D) substrate

Q.42 The form of DNA with 34Å pitch with a rise per base pair of 3.4 Å is called –
(A) A-DNA (B) B-DNA
(C) Z-DNA (D) C-DNA

Q.43 Select the correct option that identifies the nature of apoenzyme and co-factor correctly.

	Apoenzyme	**Co-factor**
(A)	Protein	Non-protein
(B)	Non-protein	Protein
(C)	Protein	Protein
(D)	Non-protein	Non-protein

Q.44 Given below is the chemical formula of



(A) palmitic acid (B) stearic acid
(C) glycerol (D) galactose

Q.45 Which of the following is an isozyme?
(A) α-amylase (B) Glucokinase
(C) Lactic dehydrogenase (D) All of these

Q.46 In which one of the following sets of three items, each belongs to the category mentioned against them?
(A) Lysine, glycine, thiamine- Amino acids.
(B) Myosine, oxytocin and gastric juices- Hormones.
(C) Rennin, helicase and hyaluronidase - Enzymes.
(D) Optic nerve, oculomotor,vagus- Sensory nerves.

Q.47 Identify whether the given conditions are anabolic or catabolic.
I. Glucose → Lactic acid
II. Amino acids → Proteins
(A) I-catabolic; II-catabolic
(B) I-anabolic; II-catabolic
(C) I-catabolic; II-anabolic
(D) I-anabolic; II-anabolic

Q.48 Which one is diaminodicarboxylic amino acid?
(A) Cystine (B) Lysine
(C) Cysteine (D) Aspartic acid

EXERCISE - 3 (LEVEL-3)

Choose one correct response for each question.

Q.1 If base order in one chain of DNA is "ATCGA" then how many no. of H-bond found in DNA duplex –
(A) 20 (B) 12
(C) 10 (D) 11

Q.2 Nucleotides are building blocks of nucleic acids. Each nucleotide is a composite molecule formed by –
(A) Base-sugar-OH
(B) Base-sugar-phosphate
(C) Sugar-phosphate
(D) $(\text{Base-sugar-phosphate})_n$

Q.3 Which one of the following hydrolyses internal phosphodiester bonds in a polynucleotide chain
(A) Lipase (B) Protease
(C) Exonuclease (D) Endonuclease

Q.4 Carbohydrates, the most abundant biomolecules on earth, are produced by –
(A) Some bacteria, algae and green plant cells.
(B) All bacteria, fungi and algae.
(C) Fungi, algae and green plants cells.
(D) Viruses, fungi and bacteria.

Q.5 Which functional group participates in disulphide bond formation in proteins –
(A) Thioether (B) Thiol
(C) Thioester (D) Thiolactone

Q.6 Physical basis of life is –
(A) Cytoplasm (B) Protoplasm
(C) Nucleoplasm (D) Endoplasm

Q.7 In DNA purine nitrogen bases are –
(A) Uracil and Guanine (B) Guanine & Adenine
(C) Adenine & cytosine (D) None

Q.8 Which of the following diasaccharide gives two molecules of glucose on hydrolysis –
(A) Maltose (B) Lactose
(C) (A) and (B) both (D) Sucrose

Q.9 Which of the following is the example of acidic amino acid–
(A) Lysine (B) Glutamic acid
(C) Aspartic acid (D) (B) and (C) both

Q.10 Specificity of protein is due to –
(A) Types of amino acid
(B) Sequence of amino acid
(C) Number of amino acid
(D) Quantity of amino acid

Q.11 Bond between phosphate and sugar in a nucleotide is –
(A) H-bond (B) Covalent bond
(C) Phosphodiester bond (D) Sulphide bond

Note (Q.12-Q.13) :
(A) Statement- 1 is True, Statement-2 is True, Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True ; Statement-2 is NOT a correct explanation for Statement-1.
(C) Statement - 1 is True, Statement- 2 is False.
(D) Statement -1 is False, Statement -2 is False.

Q.12 **Statement 1 :** Enzymes have active sites and substrates reactive sites, on their surfaces respectively.
Statement 2 : Active and reactive sites push the enzyme and substrate molecules away from each other.

Q.13 **Statement 1 :** Enzymes are defined as biological proteins.
Statement 2 : Chemically all enzymes are globular proteins.

Q.14 Which of the following statements about amino acids is incorrect?
(A) Essential amino acids are not synthesized in the body, therefore have to be provided in the diet.
(B) Leucine, isoleucine, lysine, valine are essential amino acids.

(C) Cysteine and methionine are sulphur containing amino acids.
(D) Lysine and arginine are acidic amino acids.

Q.15 The regulation by an organism of chemical composition of its blood and body fluids and other aspects of its internal environment so that physiological processes can proceed at optimum rates is called
(A) metabolism (B) enthalpy
(C) entropy (D) homeostasis

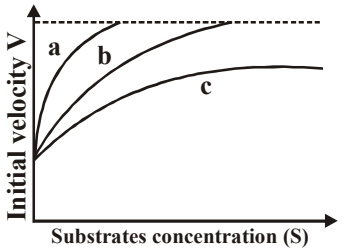
Q.16 Inhibition of succinate dehydrogenase by malonate is an example of
(A) non-competitive inhibition
(B) competitive inhibition
(C) allosteric inhibition
(D) negative feed back.

Q.17 An example of aromatic amino acid is
(A) tyrosine (B) phenylalanine
(C) tryptophan (D) all of these.

Q.18 Which of the following is an example of isozyme?
(A) α-Amylase
(B) Glucokinase
(C) Lactate dehydrogenase
(D) All of these

Q.19 In a DNA molecule, the phosphate group is attached to __ carbon of the sugar residue of its own nucleotide and carbon of the sugar residue of the next nucleotide by bonds.
(A) 5', 3', phosphodiester
(B) 5', 3', glycosidic
(C) 3', 5', phosphodiester
(D) 3', 5', glycosidic

Q.20 The figure given below shows three velocity substrate concentration curves for an enzyme reaction. What do the curves a, b and c depict respectively?



(A) a-normal enzyme reaction, b-competitive inhibition, c-non-competitive inhibition
(B) a-enzyme with an allosteric modulator added, b-normal enzyme activity, c-competitive inhibition
(C) a-enzyme with an allosteric stimulator, b-competitive inhibitor added, c-normal enzyme reaction
(D) a-normal enzyme reaction, b-non- competitive inhibitor added, c-allosteric inhibitor added

EXERCISE - 4 (PREVIOUS YEARS AIPMT/NEET EXAM QUESTIONS)

Choose one correct response for each question.

Q.1 A phosphoglyceride is always made up of – **[NEET 2013]**

(A) a saturated or unsaturated fatty acid esterified to a phosphate group which is also attached to a glycerol molecule.
(B) only a saturated fatty acid esterified to a glycerol molecule to which a phosphate group is also attached.
(C) only a unsaturated fatty acid esterified to a glycerol molecule to which a phosphate group is also attached.
(D) a saturated or unsaturated fatty acid esterified to a glycerol molecule to which a phosphate group is also attached.

Q.2 Transition state structure of the substrate formed during an enzymatic reaction is –**[NEET 2013]**

(A) permanent and stable
(B) transient but stable
(C) permanent but unstable
(D) transient and unstable

Q.3 The essential chemical components of many coenzymes are : **[NEET 2013]**

(A) Vitamins (B) Proteins
(C) Nucleic acids (D) Carbohydrates

Q.4 Macro molecule chitin is : **[NEET 2013]**

(A) Simple polysaccharide
(B) Nitrogen containing polysacchairde
(C) Phosphorus containing polysaccharide
(D) Sulphur containing polysaccharide

Q.5 Which is not correct with respect to enzyme action – **[AIPMT 2014]**

(A) Substrate binds with enzyme at its active site.
(B) Addition of lot of succinate does not reverse the inhibition of succinic dehydrogenase by malonate.
(C) A non-competitive inhibitor binds the enzyme at a site distinct from that which binds the substrate.
(D) Malonate is a competitive inhibitor of succinic dehydrogenase.

Q.6 Which of the following is a non-reducing carbohydrate? **[AIPMT 2014]**

(A) Maltose (B) Sucrose
(C) Lactose (D) Ribose 5-phosphate

Q.7 Which one of the following statements is incorrect **[AIPMT 2015]**

(A) In competitive inhibition, the inhibitor molecule is not chemically changed by the enzyme.
(B) The competitive inhibitor does not affect the rate of breakdown of the enzyme-substrate complex.
(C) The presence of the competitive inhibitor decreases the K_m of the enzyme for the substrate.
(D) A competitive inhibitor reacts reversibly with the enzyme to form an enzyme-inhibitor complex.

Q.8 The chitinous exoskeleton of arthropods is formed by the polymerisation of: **[RE-AIPMT 2015]**

(A) D- glucosamine
(B) N- acetyl glucosamine
(C) lipoglycans
(D) keratin sulphate and chondroitin sulphate

Q.9 Which of the following biomolecules does have phosphodiester bond ? **[RE-AIPMT 2015]**

(A) Monosaccharides in a polysaccharide.
(B) Amino acids in a polypeptide.
(C) Nucleic acids in a nucleotide.
(D) Fatty acids in a diglyceride.

Q.10 The amino acid Tryptophan is the precursor for the synthesis of **[NEET 2016 PHASE 1]**

(A) Melatonin and Serotonin
(B) Thyroxine and Triiodothyronine
(C) Estrogen and Progesterone
(D) Cortisol and Cortisone

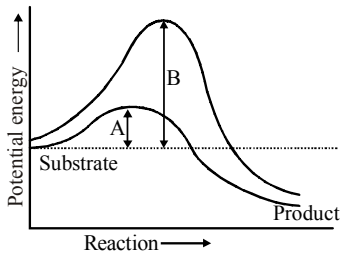
Q.11 A typical fat molecule is made up of **[NEET 2016 PHASE 1]**
(A) Three glycerol molecules and one fatty acid molecule.
(B) One glycerol and three fatty acid molecules
(C) One glycerol and one fatty acid molecule
(D) Three glycerol and three fatty acid molecules

Q.12 Which one of the following statements is wrong? **[NEET 2016 PHASE 1]**
(A) Sucrose is a disaccharide
(B) Cellulose is a polysaccharide
(C) Uracil is a pyrimidine
(D) Glycine is a sulphur containing amino acid

Q.13 A non-proteinaceous enzyme is **[NEET 2016 PHASE 2]**
(A) Lysozyme (B) Ribozyme
(C) Ligase (D) Deoxyribonuclease

Q.14 Which of the following is the least likely to be involved in stabilizing the three-dimensional folding of most proteins? **[NEET 2016 PHASE 2]**
(A) Hydrogen bonds
(B) Electrostatic interaction
(C) Hydrophobic interaction
(D) Ester bonds

Q.15 Which of the following describes the given graph correctly? **[NEET 2016 PHASE 2]**



(A) Endothermic reaction with energy A in presence of enzyme and B in absence of enzyme.
(B) Exothermic reaction with energy A in presence of enzyme and B in absence of enzyme.
(C) Endothermic reaction with energy A in absence of enzyme and B in presence of enzyme.
(D) Exothermic reaction with energy A in absence of enzyme and B in presence of enzyme.

Q.16 Which of the following are not polymeric? **[NEET 2017]**
(A) Nucleic acids (B) Proteins
(C) Polysaccharides (D) Lipids

Q.17 Which one of the following statements is correct, with reference to enzymes? **[NEET 2017]**
(A) Apoenzyme = Holoenzyme + Coenzyme
(B) Holoenzyme = Apoenzyme + Coenzyme
(C) Coenzyme = Apoenzyme + Holoenzyme
(D) Holoenzyme = Coenzyme + Co-factor

Q.18 The two functional groups characteristic of sugars are **[NEET 2018]**
(A) Carbonyl and phosphate
(B) Carbonyl and methyl
(C) Hydroxyl and methyl
(D) Carbonyl and hydroxyl

Q.19 Concanavalin A is **[NEET 2019]**
(A) an alkaloid (B) an essential oil
(C) a lectin (D) a pigment

Q.20 Consider the following statement **[NEET 2019]**
(a) Coenzyme or metal ion that is tightly bound to enzyme protein is called prosthetic group.
(b) A complete catalytic active enzyme with its bound prosthetic group is called apoenzyme.
Select the correct option.
(A) Both (a) and (b) are true.
(B) (a) is true but (b) is false.
(C) Both (a) and (b) are false
(D) (a) is false but (b) is true.

Q.21 Purines found both in DNA and RNA are **[NEET 2019]**
(A) Adenine and thymine
(B) Adenine and guanine
(C) Guanine and cytosine
(D) Cytosine and thymine

ANSWER KEY

EXERCISE-1 (SECTION-1&2)

(1) (C) **(2)** (D) **(3)** (D)
(4) (A) **(5)** 16
(6) DNA, RNA
(7) Palindromic DNA, Non-coding DNA
(8) RUBISCO **(9)** Secondary
(10) Apoenzyme **(11)** Glucose
(12) Lowering **(13)** Enzymes
(14) Peptide bond **(15)** Fructose
(16) Competitive inhibitor
(17) Adenosine Triphosphate (ATP)
(18) Nucleotides **(19)** False
(20) False **(21)** True

EXERCISE - 1 [SECTION-3]

Q	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
A	D	A	B	C	D	B	C	C	A	D	B	C	B	C	C	B	D	D	C	B	B	B	D	D	C
Q	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
A	A	A	D	A	C	B	C	C	C	A	C	B	A	D	B	D	A	C	B	C	A	C	B	A	D
Q	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89							
A	C	A	B	D	C	D	D	C	A	D	C	A	A	C	C	B	B	C							

EXERCISE - 2

Q	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
A	A	D	C	D	C	A	A	A	C	A	D	C	D	A	C	B	C	C	A	C	A	A	B	A	B
Q	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48		
A	A	D	B	C	B	D	C	A	C	C	D	C	C	C	B	C	B	A	A	C	C	C	A		

EXERCISE - 3

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	B	B	D	A	B	B	B	A	D	B	B	C	A	D	D	B	D	D	A	A

EXERCISE - 4

Q	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
A	D	D	A	B	B	B	C	B	C	A	B	D	B	D	B	D	B	D	C	B	B

SOLUTIONS

EXERCISE-1

(1) (C)

(2) **(D). Oxidoreductases/dehydrogenases** Enzymes which catalyse oxidoreduction between two substrates S and S' e.g.,
S reduced + S' oxidised → S oxidised + S' reduced

Transferases : Enzymes catalysing a transfer of a group, G (other than hydrogen) between a pair of substrate S and S', e.g.,
$S - G + S' \rightarrow S + S' - G$

Hydrolases : Enzymes catalysing hydrolysis of ester, ether, peptide, glycosidic, C-C, C-halide or P-N bonds.

Lyases : Enzymes that catalyse removal of groups from substrates by mechanisms other than hydrolysis leaving double bonds.

$$\begin{array}{cc} X & Y \\ | & | \\ C & - C \end{array} \rightarrow X - Y + C = C$$

Isomerases : Includes all enzymes catalysing interconversion of optical, geometric or positional isomers.

Ligases : Enzymes catalysing the linking together of two compounds, e.g., enzymes which catalyse joining of C-O, C-S, C-N, P-O etc. bonds.

(3) (D) **(4)** (A)

(5) **16.**

(6) **DNA, RNA.**

(7) **Palindromic DNA** reads the same basic sequence in opposite direction.
Satellite DNA part of DNA having long stretches of repetitive base pairs.
Non-coding DNA Greater part of DNA in eukaryotic cells does not code for RNAs. This 'extra' DNA seems to have no function. It has two special forms (i) Repetitions DNA. (ii) Jumping genes.

(8) **RUBISCO** is the most abundant protein in whole of the biosphere.

(9) **Secondary.** An α-helix is an example of secondary protein structure.

(10) **Apoenzyme.** The enzymes which work only in the presence of cofactors are known as apoenzymes.
A working combination of an apoenzyme and cotade (mineral ion, prosthetic group or coenzyme) is called enzyme system or holoenzyme.
Apoenzyme + Mineral ion / Prosthetic/Coenzyme group → Enzyme system or holoenzyme.

(11) **Glucose.** Starch, glycogen, cellulose, chitin, etc., are homoglycan (glucose) containing only glucose units. Homoglycans are the polysaccharides having only one type of monosaccharides units in them.

(12) **Lowering.** Enzymes catalyses the biochemical reactions by lowering the activation energy.

(13) **Enzymes.** The catalysts which hasten the rate of a given metabolic conversation are also proteins. These proteins with catalytic power are named enzymes.

(14) **Peptide bond.** Primary structure of proteins is due to the presence of peptide bond.

(15) **Fructose.** Fructan is a polymer of fructose.

(16) **Competitive inhibitor.** When the inhibitor closely resembles the substrate in its molecular structure and inhibits the activity of the enzyme, it is known as competitive inhibitor.

(17) **Adenosine Triphosphate (ATP).** The most important form of energy currency in living organism is the bond energy in the chemical called ATP.

(18) **Nucleotides.** Nitrogen bases when found attached to a sugar, they are called nucleoside. If a phosphate group is esterified to the sugar, they are called nucleotide.

(19) **False.** Each enzyme has its optimal range.

(20) **False.** Competitive inhibitor binds to the active site while noncompetitive inhibitor works by binding to site other than the active site.

(21) True

(22) **(D).** Based on the nature of R group, there are many amino acids.

(23) (A) **(24)** (B) **(25)** (C) **(26)** (D)

(27) **(B).** Based on number of amino and carboxyl groups, amino acids are acidic (e.g., glutamic acid), basic (lysine) and neutral (valine).

(28) (C) **(29)** (C)

(30) **(A).** Vinblastin and curcumin are used as drugs.

(31) (D)

(32) **(B).** In animal tissues, the categories of compounds present are called primary metabolites.

(33) **(C).** At high temperature, enzymes present in the body gets destroyed/denatured.

(34) (B)

(35) **(C).** The proteins are composed of carbon, hydrogen, oxygen, nitrogen and sulphur. Certain proteins may contain phosphorous, iron or other elements also.

(36) **(C).** Enzyme inhibition caused by a product of enzyme catalysed reaction is allosteric modulation or feedback inhibition. Thus, products of reaction inhibits the enzyme action, e.g., glucose-6-phosphate, the end product of glycolysis, can inhibit hexokinase activity.

(37) (B)

(38) **(D).** Primary metabolities includes amino acids, sugars, etc. They play a major role in physiological processes.

(39) **(D).** Chemical compounds that have molecular weight less than one thousand dalton are usually referred to as biomolecules or micromolecules.

(40) **(C).** Among these, glycine is the simplest amino acid.

(41) **(B).** The acid soluble pool represents the cytoplasmic composition of cell. The macromolecules from cytoplasm and organelles becomes acid insoluble fraction. Together, they represent the entire chemical composition of living tissues or organisms.

(42) **(B).** Chemical compounds, which are found in the acid insoluble fraction are called biomacromolecules or macromolecules.

(43) **(B).** The most abundant chemical in living organisms is water. Water content is 70-90% of the total cellular mass.

(44) **(D).** Seven amino acids are the essential amino acids for man. They include leucine, isoleucine, lysine, methionine, phenylalanine, tryptophan and valine.

(45) **(D).** Soyabean is the richest source of protein (36-44%). From its seeds, edible oil and a milk-like substance is obtained, which is used as a substitute of milk.

(46) **(C).** Collagen is the most abundant protein in animal world.

(47) **(A).** Sucrose is a non-reducing sugar. It consists of one glucose and one fructose moiety and it is the main transporting sugar in plants.

(48) (A)

(49) **(D).** Starch is present as a store house of energy in plant tissues.

(50) (A)

(51) **(C).** Maltose is a disaccharide that gives two molecules of glucose on hydrolysis. It is found during germination of starchy seeds. It is produced commercially from starch by a starch hydrolysing enzyme, diastase.

(52) **(B).** Chitin is a nitrogeneous polysaccharide.

(53) (C)

(54) **(C).** Raffinose is a trisaccharides.

(55) (C)

(56) **(A).** For nucleic acids, the building block is a nucleotide. A nucleotide has three chemically distinct components. One is a heterocyclic compound, second is a monosaccharide and the third a phosphoric acid or phosphate.

(57) **(C).** The nucleotides are formed by the union of a phosphate group with a nucleoside. A nucleoside contains a sugar molecule along with an organic nitrogeneous base. Thus, a nucleotide contains an organic nitrogeneous base (purine or pyrimidine) along with a sugar molecule and a phosphate group, i.e.,
Nucleoside = Sugar molecule + Organic nitrogenous base
Nucleotide = Nucleoside + Phosphate group

(58) **(B).** Adenine and guanine are substituted purines, while the rest (uracil, cytosine and thymine) are substituted pyrimidines.

(59) **(A).** Two or more polypeptide chains may join together by intermolecular hydrogen bonds and may bend into parallel folds to form β-pleated sheet.

(60) (D)

(61) **(B).** Human skin contains α-keratin, which is a secondary form of proteins.

(62) (D)

(63) **(A).** The α-helix, random coil and β-pleated sheets are termed the secondary structure of proteins.

(64) (C)

(65) **(B).** Keratin of hair and myosin of muscle have α-helical structure. Fibroin, the protein in silk fibres produced by insects and spiders, has pleated structure.

(66) (C)

(67) **(A).** In a protein molecule, the amino acid units are linked together by peptide bonds formed between the amino acid units and the carboxyl groups of successive amino acids.

(68) **(C).** Five forms of DNA have been reported. A, B, C and D forms are right handed, while the Z-DNA is left handed.

(69) **(B).** Nucleic acids exhibit a wide variety of secondary structures. For example, one of the secondary structures exhibited by DNA is the famous Watson-Crick model. This model says that DNA exists as a double helix. The two strands of polynucleotides are anti parallel i.e., run in the opposite direction. The backbone is formed by the sugar-phosphate-sugar chain. The nitrogen bases are projected more or less perpendicular to this backbone but face inside

(70) **(A).** Polysaccharides are large sized carbohydrates $(C_6H_{10}O_5)_n$ which are formed by the condensation of a number of monosaccharides. There are also called glycans because of their formation from sugars. Linkage between adjacent monosaccharides is through glycosidic bonds at each point of condensation.

(71) **(D).** In DNA, thymine (5-methyl uracil) in present, which provides extra stability to DNA as it do not contain 2'-OH group like uracil. Uracil is present in the place of thymine in in RNA.

(72) **(C).** There is no uncatalysed metabolic conversion in living systems. Even CO_2 dissolving in water, a physical process, is a catalysed reaction in living systems.

(73) **(A).**

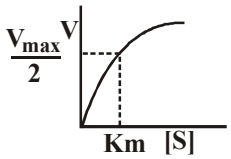
(74) (B) **(75)** (D)

(76) **(C).** Proteins with catalytic power are called enzymes. Their basic function is their involvment in the change of rate of reaction either increase or decrease.

(77) **(D).**

(78) (D)

(79) **(C).** When enzyme molecules are more than substrate molecules, a progressive increase in the substrate molecules (s), increases the velocity (v) of their conversion to products.



However, eventually the rate of reaction reaches a maximum. At this stage, the active sites of all the available enzyme molecules are occupied by the substrate molecules. Therefore, the substrate molecules occupy the active sites vacated by the products and cannot increase the rate of reaction further.

(80) **(A).** Inactive form of enzymes is called proenzymes.

(81) (D)

(82) **(C).** The enzymes lower the requirement of activation energy for catalysing a reaction and these are least effected by the original activation energy of the system. Enzymes are thermolabile. Increase in substrate concentration or enzyme concentration increases the rate of reaction.

(83) **(A).** Ribozymes are RNA molecules that are capable of performing specific biochemical reactions. They play very important role in therapeutic agents.

(84) (A)

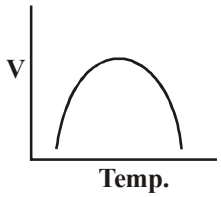
(85) **(C).** Malonate inhibits succinate dehydrogenase is an example of competitive inhibition, which closely resembles the substrate succinate in structure. Such competitive inhibitors are often used in the control of bacterial pathogens.

(86) (C)

(87) **(B).** $NADH + H^+ + \frac{1}{2}O_2 \xrightarrow[\text{Oxidase}]{\text{Cytochrome}} NAD^+ + H_2O$

(88) (B)

(89) **(C).** Enzymes generally function in a narrow range of temperature. Each enzyme shows its highest activity at a particular temperature, called the optimum value.

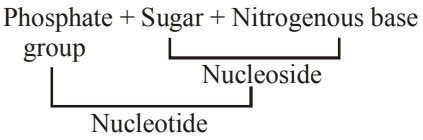


Low temperature preserves the enzyme in a temporarily inactive state whereas high temperature destroys enzymatic activity because proteins are denatured by heat.

EXERCISE-2

(1)	(A)	**(2)**	(D)	**(3)**	(C)	**(4)**	(D)
(5)	(C)	**(6)**	(A)	**(7)**	(A)	**(8)**	(A)
(9)	(C)	**(10)**	(A)	**(11)**	(D)	**(12)**	(C)
(13)	(D)	**(14)**	(A)	**(15)**	(C)	**(16)**	(B)
(17)	(C)	**(18)**	(C)	**(19)**	(A)	**(20)**	(C)
(21)	(A)	**(22)**	(A)	**(23)**	(B)	**(24)**	(A)
(25)	(B)	**(26)**	(A)	**(27)**	(D)	**(28)**	(B)
(29)	(C)	**(30)**	(B)	**(31)**	(D)	**(32)**	(C)
(33)	(A)	**(34)**	(C)	**(35)**	(C)		

(36) **(D).** Nucleoside is a compound formed by the union of a nitrogen base with a pentose sugar. It is a component of nucleotide. Each nucleotide is composed of three smaller units; a nitrogen base, a pentose sugar and a phosphate group.



The nucleoside combines with a phosphate group at 5' position by an ester bond to form a nucleotide, or nucleoside monophosphate. For example, the combination adenine ribose-phosphate and adenine-deoxyribose-phosphate are nucleotides.

(37) **(C).** Hard fats (e.g. butter, ghee) and oils (e.g. sunflower oil, mustard oil, groundnut oil etc.) are the examples of triglycerides.

(38) **(C).** Cellular pool is the aggregation of various kinds of biomolecules in a cell. It comprises of over 5000 chemical both inorganic and organic. Inorganic molecules generally occur in aqueous pool while organic molecules are found in both aqueous and non aqueous pool.

(39) **(C).** K_m or the Michaelis-Menten constant is defined as the substrate concentration at which half-maximum velocity in an enzyme catalyzed reaction is achieved. It indicates that half of the enzyme molecules (i.e. 50%) are bound with the substrate molecules when the substrate concentration equals the K_m value. It was given by Leonor Michaelis and Maud Menten (1913). K_m value is a characteristic feature of a given enzyme. It is a representative for measuring the strength of ES complex. A low K_m value indicates a strong affinity between enzyme and substrate, whereas a high K_m value reflects a weak affinity between them. For majority of enzymes, the K_m values are in the range of 10^{-5} to 10^{-2} moles.

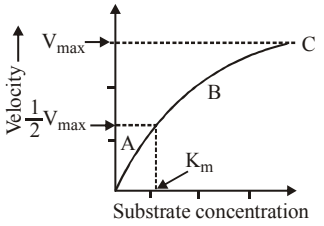
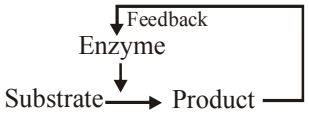


Fig. Effect of substrate concentration on reaction velocity (A-linear; B-curve; C-almost unchanged).

(40) **(B).** In polysaccharides, monosaccharides are linked together by glycosidic bond (C-O-C). It is formed by dehydration between two carbon atoms of two adjacent monosaccharides. Water has hydrogen bonding.

(41) **(C).**



In feed back inhibition, product of a reaction inhibits the enzyme catalysing that reaction. It is a type of control mechanism at the enzyme level. If the product is produced in sufficient amount, it inhibits the enzyme to stop the further production.

(42) **(B).** Each strand appears like a helical staircase. Each step of ascent is represented by a pair of bases. At each step of ascent, the strand turns the pitch would be 34Å. The rise per base pair would be 3.4 Å.This form of DNA with the above mentioned salient features is called B-DNA

(43) **(A).** Many enzymes show enzymatic (catalytic) activity only in association with certain non-protein substance. Such substances are called cofactor. Apoenzyme is the proteinaceous substance that combines with prosthetic group to form holoenzyme.

(44) **(A).** $CH_3(CH_2)_{14}COOH$ is the chemical formula of palmitic acid. It is a saturated fatty acid.

(45) **(C).** There are certain enzymes which have slightly different molecular structure but have similar catalytic function. Such enzymes are called isoenzymes or simply isozymes LDH (Lactic dehydrogenase) is a good example of isoenzymes.

(46) **(C).** Rennin, helicase and hyaluronidase, all are enzymes.

(47) **(C).** Glucose is degraded into lactic acid in skeletal muscles by a catabolic process as energy is liberated. Assembly of a protein from amino acids requires energy and hence, it is an anabolic process.

(48) **(A).** Cystine is a dimeric amino acid, which is formed by the oxidation of two cysteine residues, which covalently link to make a disulphide bond.

EXERCISE-3

(1)	(B)	**(2)**	(B)	**(3)**	(D)	**(4)**	(A)
(5)	(B)	**(6)**	(B)	**(7)**	(B)	**(8)**	(A)
(9)	(D)	**(10)**	(B)	**(11)**	(B)	**(12)**	(C)
(13)	(A)						

(14) **(D).** Acidic amino acids have an extra carboxylic group (mono-amino dicarboxylic), e.g., glutamate (glutamic acid, Glu), asparate (aspartic acid, Asp).

Basic amino acids have an additional amino group without forming amides (diamino monocarboxylic), e.g., arginine (Arg), lysine (Lys).

Neutral amino acids have one amino group and one carboxylic group (mono-amino mnocarboxylic) with noncyclic hydrocarbon chain, e.g., glycine (Gly), alanine (Ala), valine (Val), Leucine (Leu), Isoleucine (lie).

(15) **(D).** Homeostasis is the regulation by an organism of the chemical composition of its body fluids and other aspects of its internal environment so that physiological processes can proceed at optimum rates.

(16) **(B).** In competitive inhibition, the inhibitor (I) closely resembles the real substrate (S), and is regarded as a substrate analogue. The inhibitor competes with substrate and binds at the active site of the enzyme but does not undergo any catalysis. As long as the competitive inhibitor holds the active site, the enzyme is not available for the substrate to bind. A competitive inhibitor diminishes the rate of catalysis by reducing the proportion of enzyme molecules bound to

a substrate. At any given inhibitor concentration, competitive inhibition can be relieved by increasing the substrate concentration. Under these conditions, the substrate successfully competes with the inhibitor for the active site. Thus, competitive inhibition is usually reversible since the addition of more substrate tends to reduce the effect of the inhibitor. In competitive inhibition, the K_m value increases whereas V_{max} remains unchanged.

The enzyme succinate dehydrogenase is a classical example of competitive inhibition with succinic acid as its substrate. The compounds, namely, malonic acid, glutaric acid and oxalic acid, have structural similarity with succinic acid and compete with the substrate for binding at the active site of succinate dehydrogenase enzyme.

(17) **(D).** Aromatic amino acids possess cyclic structure in the side chain e.g., phenylalanine, tryptophan (actually heterocyclic) or tyrosine (having OH group).

(18) **(D).** The multiple molecular forms of an enzyme occurring in the same organism and having a similar substrate activity are called isoenzymes or isozymes. They have similar properties but different molecular weights and location. Over 100 enzymes are known to have isoenzymes. α-amylase of wheat endosperm has 16 isozymes, lactate dehydrogenase has 5 isozymes.

(19) **(A).** DNA (Deoxyribose nucleic acid) is a helically twisted double chain polydeoxyribonucleotide macromolecule which constitutes the genetic material of almost all organisms. A deoxyribonucleotide of DNA is formed by cross-linking of three chemicals- deoxyribose sugar ($C_5H_{10}O_4$), a nitrogen base and phosphoric acid (H_3PO_4). The backbone of a DNA strand is built up of alternate deoxyribose and phosphoric acid groups. The phosphate group is connected to carbon 5' of the sugar residue of its own nucleotide and carbon 3' of the sugar residue of the next nucleotide by phosphodiester bonds.

(20) **(A).** In the figure given in question, curve 'a' shows normal enzyme reaction while curve 'b' shows a competitive inhibition reaction, in which competitive inhibitors that resemble the substrate molecules, binds to the active site of the enzyme whereas curve 'c' shows non-competitive inhibition reaction, in which the inhibitor binds to a part of the enzyme or enzyme substrate complex, other than the active site, known as the allosteric site.

EXERCISE-4

(1) **(D).** A saturated or unsaturated fatty acid esterified to a glycerol molecule to which a phosphate group is also attached.

(2) **(D).** Transition state structure of the substrate formed during an enzymatic reaction is transient and unstable.

(3) **(A).** Essential chemical components of many coenzymes are vitamins, e.g., coenzyme nicotinamide adenine dinucleotide (NAD) and NADP contain the vitamin niacin.

(4) **(B).** Chitin or fungal cellulose that is nitrogen containing polysaccharide & heteropolymer of NAG. **(5)** (B) **(6)** (B)

(7) **(C).** In competitive inhibition, km value increases.

(8) **(B).** Exoskeleton of arthropods is made up of chitin.

Chitin is a polymer of N-acetyl glucosamine

(9) **(C).** Phosphodiester bond is formed between two nucleotides of nucleic acid.

(10) **(A).** Melatonin and serotonin are derivatives of tryptophan amino acid while thyroxine and tri-iodothyronine are tyrosine amino acid derivatives.

(11) **(B).** A typical fat molecule is triglyceride formed by esterification of one glycerol and three fatty acid molecules.

(12) **(D).** Glycine is simplest amino acid in which 'R' is replaced by H (Hydrogen).

(13) **(B).** Ribozyme is RNA acting like an enzyme or biocatalyst.

(14) **(D).** Ester bond is formed between sugar and phosphate in a nucleotide.

(15) **(B).** Potential energy of substrate is more than the product. So it is an exothermic reaction. 'A' represents the activation energy in the presence of enzyme while 'B' in the absence of enzyme i.e., enzyme lowers down the activation energy.

(16) **(D).** * Nucleic acids are polymers of nucleotides.

* Proteins are polymers of amino acids.

* Polysaccharides are polymers of monosaccharides.

* Lipids are the esters of fatty acids and alcohol.

(17) **(B).** Holoenzyme is conjugated enzyme in which protein part is apoenzyme while non-protein is cofactor. Coenzyme are also organic compounds but their association with apoenzyme is only transient and serve as cofactors.

(18) **(D).** Sugar is a common term used to denote carbohydrate.

Carbohydrates are polyhydroxy aldehyde, ketone or their derivatives, which means they have carbonyl and hydroxyl groups.

(19) **(C).** Concanavalin A is a secondary metabolite e.g is lectin, it has the property to agglutinates RBCs.

(20) **(B).** Coenzyme or metal ion that is tightly bound to enzyme protein is called prosthetic group. A complete catalytic active enzyme with its bound prosthetic group is called holoenzyme.

(21) **(B).** Purines found both in DNA and RNA are Adenine and guanine.