CHAPTER 11

BIOMOLECULES

Topics Discussed

1. Introduction

The cells form the **basis** of each **organism**. Thus, the **cell** and its **constituents** play a **major role** in any **organism's life**. We know the **cell** is **made** up of a **membrane** and several **organelles** that are with or even without membrane, in details. The **cell** has **living** and **non-living materials** or **chemicals** in it. All the matter in an **organism** at **molecular level** looks **similar** which means that the **organisms share** the **molecular characters** also. The **molecular composition** in a **cell** and around it in a tissue is **similar** for all living organisms and also for the **earth's crust** as found in a study. However, the **hydrogen** and **carbon** contents are **more** in a **living tissue** or a cell.

Objectives of this Chapter

At the end of this chapter, you will be able to:

- Distinguish between several molecules.
- Realize their importance in a cells life.
- Learn all the compounds that are present in the cell.

The **science** which deals with the study of **chemical constituents** and the **reactions** between them in any **living organism** is called as **Biochemistry**. **Neuberg** used biochemistry term for first time and is also known as the "**Father of Biochemistry**". The cells **protoplasm** has organic as well as inorganic matter which is together called as **biomolecules** as these chemicals make **life possible** in a cell.

Table 11.1: Various elements present in Earth's crust and human body with their weight

Element	Earth's crust value in % weight	Human body value in % weight
Hydrogen	0.14	0.5
Carbon	0.03	18.5
Oxygen	46.6	65.0
Nitrogen	Very little	3.3
Sulphur	0.03	0.3
Sodium	2.8	0.2
Calcium	3.6	1.5
Magnesium	2.1	0.1
Silicon	27.7	Negligible

The **cellular biomolecules** together are also called as **cellular pool** which **includes water**, **inorganic materials** and **organic** materials. There are various types of divisions of the biomolecules:

- **Micromolecules and macromolecules**: The concentrations, weight, structure and solubilities of molecules in a cell differ for all the types present. The molecules which have low molecular weight, simple structures and higher solubilities are called as micromolecules, E.g. minerals, water, sugars (simple and complex), amino acids. The chemicals that have higher molecular weight, lower solubilities, and complex structures are called as macromolecules, e.g. nucleic acids, proteins.

- **Organic and inorganic compounds**: The molecules that have C, H, O together in their composition is called as organic compounds. E.g. carbohydrates, proteins, fats, nucleic acids. Enzymes, hormones, etc. the molecules that do not have C, H, O as a group in their composition is called as inorganic compounds. E.g. minerals, water.

- **Major elements and minor elements**: The elements that are in higher amounts in a cell is called as major elements. E.g. carbon (C), hydrogen (H), nitrogen (N), oxygen (O), phosphorus (P), sulphur (S). They in all make the 98% of protoplasmic weight, thus also termed as protoplasmic elements. Minor elements are the chemicals that are in less amounts in the cell. E.g. calcium (Ca), magnesium (Mg), potassium (K), chlorine (Cl), iodine (I), iron (Fe), sodium (Na). They make the 2% weight of the protoplasm.

2. How did Scientist Analysed the Chemical Components of the Cell?

- The cell usually is of micrometre size which is enclosed in a membrane or a wall. Thus, to study its constituents we need to open the cell and expose or reveal its compounds.
- The cell is hence extracted from a source (plant stem, animal liver, microbial colony, etc.) and then mixed with trichloroacetic acid (Cl_3CCOOH). This mixture is ground with pestle and mortar which is further strained through cheese cloth or cotton.
- The resultant has two fractions: filtrate is called as acid soluble pool, while the residue is called as acid insoluble fraction.
- The acid pool includes cytoplasmic composition. The cytoplasm and organelles have macromolecules which are insoluble in acid and thus are present in the residue.
- The fractions obtained are further separated to identify and study the components of the cell by various analytical techniques.
- The conclusions from the methods used are that the cell has both small and large molecules present in it. The filtrate is found to have small molecular weight chemicals called as biomicromolecules and large molecular weight chemicals are called as biomacromolecules.

Did You Know

The cell has fluid with all the structures of a cell within the limits of the cell membrane, called as **protoplasm**. Thus protoplasm is **plasma membrane**, **cytoplasm**, **cell organelles** and **nucleus**. Protoplasm of a single cell which has no cell wall is called as **Protoplast**.

- Protoplasm is a Greek word (Prots = first, Plasma = organization).
- **Corti** in 1772 **first observed** Protoplasm.
- Felix **Dujardin** called it as '**Sarcode**' in 1835 who observed animal cells have jelly like substance (protozoa).
- **J.E. Purkinje** in 1840 studied plant cells and found similar substance. He also coined the term 'Protoplasm'.

Did You Know

- **Hugo Van Mohl** in 1846 studied the nature of embryonic cell protoplasm of plants and also explained the protoplasm importance in the cell division.
- **Max Schultze** in 1861 studied the sarcode and protoplasm and laid their similarities. Schultze proposed protoplasm theory (name given by O. Hertwig). Max Schultze called protoplasm as "physical basis of life".
- **J.S. Huxley** in 1868 wrote and published book named "Protoplasm is physical basis of life"
- **Rinke and Roderwald** in 1881 first of all performed the chemical analysis of protoplasm.

Knowledge Builder

Physical Nature of Protoplasm

Theories that are proposed which explain the physical nature of protoplasm.

- Alveolar theory: "Butschli".
- Granular theory: "Altman".
- Fibrillar theory: "Flemming".
- Reticular theory: "Hanstein, Klein and Carnoy",
- The above listed theories were not accepted.
- Colloidal theory: "Fisher Hardy" and "Wilson"
    - This is the most acceptable theory for protoplasm in a cell. According to this theory, the protoplasm is a Polyphasic Colloidal System.

Compounds of Protoplasm

- The chemicals in a cytoplasm are present as free ions or as combined form where two three different elements form compounds.
- Inorganic compounds in a protoplasm are:
    - Water = 70%–90%
    - Salts, acids, bases, gases = 1%–3%

Knowledge Builder

- Organic compounds present in the cytoplasm are:
  - Proteins = 7%–14%
  - Lipids = 1%–3%
  - Carbohydrates = 1%–2%
  - Nucleic acids, enzymes and other = 1%–3%
- The dry weight of an animal cell have 60%–70% part of protein forms.
- The dry weight of a plant cell have 80% part of carbohydrate forms as plant cells have walls which are made up of cellulose (complex carbohydrate).

The acid insoluble pallet includes polysaccharides (carbohydrates) which is a macromolecule. Polysaccharides have monosaccharides in long chains, called as polymers. They are threads or fibers (literally a cotton thread) which are made up of different monosaccharides, called as building blocks. For example, cellulose which is a polymeric polysaccharide made from only one type of monosaccharide - glucose. Thus, cellulose is a homopolymer. Starch is different from a homopolymer and is as a store for energy source in all the plant tissues. Animals have glycogen which is again a different homopolymer, a storage compound of energy. Inulin is a polymer made up of fructose. A polysaccharide chain has two different ends, the right end is called as the reducing point while the left end is called as the non-reducing point. Starch is a homopolymer which has helical secondary structures. Starch has the ability to capture iodine molecules in the helical portion and turns the solution in blue colour. Cellulose on other hand lack the ability to hold the iodine molecules and thus do not turn the iodine solution blue.

Cellulose is a major constituent of cell wall in almost all the plants. Paper which is made from plant pulp contains mainly cellulose. Cotton fiber also is majorly cellulose only. Not only these polysaccharides, but several more complex structures exist for polysaccharides in nature. They exist as building blocks, amino sugars and chemically modified sugars combined with several other compounds (e.g., glucosamine, N-acetyl galactosamine etc.). Exoskeletons of arthropods, is made up of complex polysaccharide called as chitin which is a heteropolymer.

3. Carbohydrates

- First respiratory substrate for the oxidation are carbohydrate which produce maximum energy in the body.
- They have **Carbon**, **Hydrogen** and **Oxygen** in a 2:1ratio of the H : O, thus also called as **hydrates of carbon**.
- Generalized formula of carbohydrates is **$Cx(H_2O)_y$** where x and y are real natural numbers from 1, 2, 3…
- There are **simple carbohydrates** and **complex carbohydrates**. The simple ones are **soluble in water** and **taste sweet** which are called as "**Sugar**". The complex ones are **insoluble in** water and have no taste at all.
- The structure of simple carbohydrates has an **aldehyde** group and complex carbohydrates has **ketone** group.

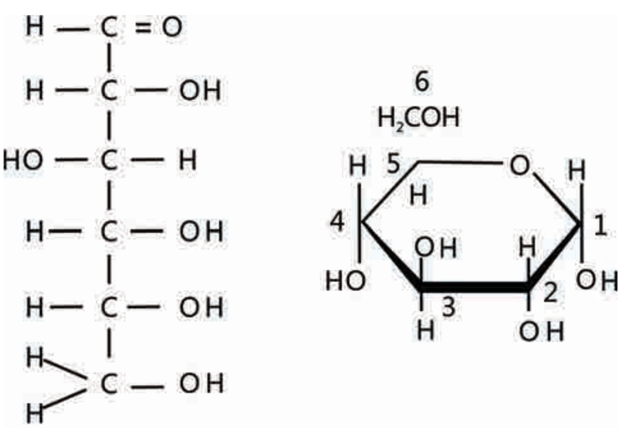
Classification of Carbohydrates

The **saccharide number changes** in **carbohydrates** which forms the **basis of classification**. Major classes are Monosaccharides, Oligosaccharides and Polysaccharides.

3.1 Monosaccharides

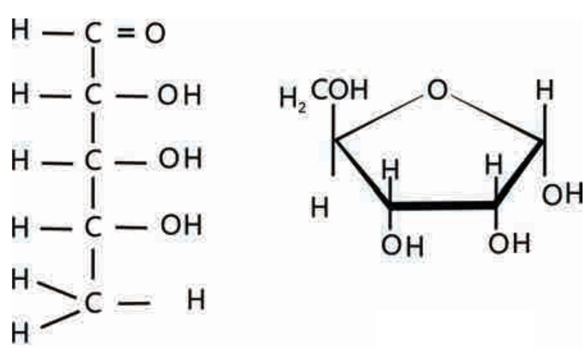
3.1.1 General Characteristics

- They are the **simplest sugars** which cannot be further hydrolysed.
- The formula is $Cn(H_2O)n$ for monosaccharides.
- Monosaccharides occur in **D** and **L conformation** with the **exception** of **Dihydroxy acetone** which does not has **chiral carbon** in its structure. **Chiral carbon** is the **central carbon** which has all its **four valences** satisfied by **different functional groups**



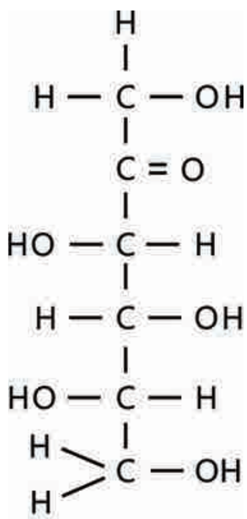
Open chain Ring form

Figure 11.1: Structure of glucose



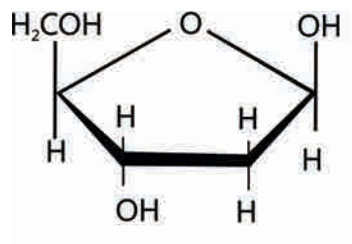
Open chain Ring form

Figure 11.2: Structure of ribose



Open chain

Figure 11.3: Structure of L-Fructose



Deoxyribose in ring form
(Occurs in DNA)

Figure 11.4: Deoxyribose structure

- The **saccharides** have either **ring** or **straight chain structure**.
  Epimer: Isomer formed after there is interchange in the functional group – OH and – H groups on 2, 3 and 4 carbon atom in glucose structure, are known as Epimer. **Example: Epimer of Glucose are** Mannose (Difference on C_2 carbon) and Galactose (Difference on C_4 carbon)

Table 11.2: Classification of monosaccharides on the basis of number of carbons

Class	Number of carbon atoms	Common formulae	Examples
Trioses	3	$C_3H_6O_3$	Glyceraldehyde, dihydroxyacetone
Tetroses	4	$C_4H_8O_4$	Erythrose, erythrulose
Pentoses	5	$C_5H_{10}O_5$	Xylose, xylulose, deoxyribose, ribose ribulose
Hexoses	6	$C_6H_{12}O_6$	Rhamnose, mannose, galactose, gucose, fructose,
Heptoses	7	$C_7H_{14}O_7$	Seduheptulose

- **Ribulose:** Found in nucleoplasm.
- **Arabinose:** Found in Gum Arabic which is obtained from organisms like *Acassia Arabia*, *Acassianilotica*, *Acassia Senegal.* Common use is in cold drinks.
- **Xylose:** Found in cell wall of plants.
- **Xylusose:** Is a component of hemicelluloses in the woods of plants.
- **Glucose:** High amounts in grapes, thus is known as grape sugar. High levels in blood and thus called as blood sugar. Forms main energy source and is respiratory substrate in the cell. The mirror image is also called as dextrose.
- **Fructose:** Has sweetest taste. Present in high amounts in honey and sweet fruits and thus termed as fruit sugar. Thaumatin is sweetest carbohydrate which is extracted from *Thaumatococcus danielli* bacteria. Aspartame/Aspartin is commonly used as an artificial sweetener in most of the foods. It is non carcinogenic.
- **Galactose:** Brain sugar is it's another name as it is in high amounts in brain and nervous tissue. This sugar is always a part of some compound (never present in free form). E.g. Hemicellulose, lactose, pectin, glycolipid.
- **Mannose:** Even this sugar is accompanied with some other component and not available in free form. e.g. Albumin - Egg, Hemicellulose – Wood.
- **Rhamnose:** The second carbon atom in the structure lacks one oxygen atom and the molecular formula is $C_6H_{12}O_5$. The sugar is present in phloem.

3.1.2 Derivatives of Monosaccharides

- **Amino sugars:** The hydroxyl group in the second carbon atom is displaced with the amino group. E.g. Glucosamine, Galactosamine.
- **Sugar alcohol:** The aldehyde group (-CHO) in the sugar is displaced with the primary alcohol ($-CH_2OH$). E.g. Sorbitol and Mannitol are formed from glucose and mannose, respectively.
- **Sugar acids:** The terminal –CHO or – CH_2OH group of the sugar gets oxidised to produce a carboxyl functional group –COOH. E.g. Glucoronic acid, galacturonic acid.

3.2 Oligosaccharides

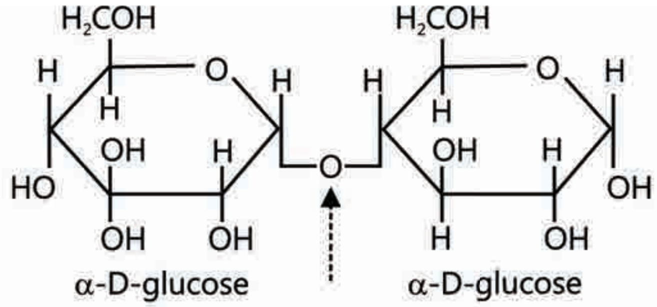
3.2.1 General Characteristics

- The **carbohydrates** on **hydrolysis** give **2** to **10 monosaccharide** units (monomers) are called as oligosaccharides.
- The monosaccharides have **glycosidic bonds** that bind them together. The glycosidic bond is formed when the aldehyde or ketone group of one monosaccharide reacts with the alcoholic group of another monosaccharide. The structure loses one molecule of H_2O during the glycosidic bond formation (dehydration synthesis).

3.2.2 Types of Oligosaccharides

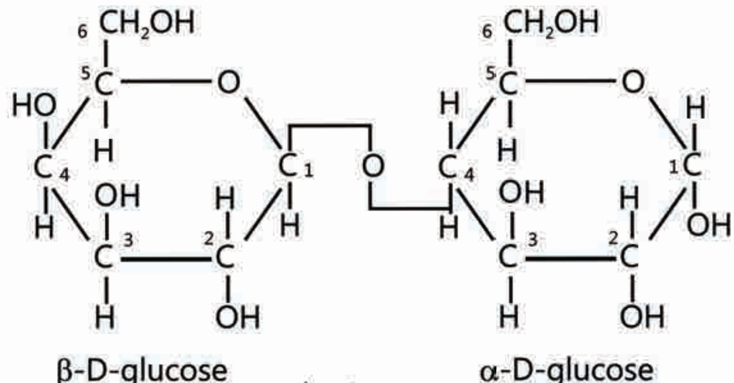
Disaccharide: Has two monosaccharide units in the structure. E.g. Maltose, Sucrose, Lactose, Trehalose.

- All the disaccharides are water soluble and taste sweet, thus are called as sugar.
- **Maltose**, commonly known as malt sugar which is an intermediate compound in the starch digestion by enzymes. Maltose has 1- 4 glycosidic linkage between α – D glucose and α – D glucose so maltose is reducing sugar.
- **Lactose** is milk sugar with β-1-4 glycosidic linkage between β-D-glucose and β-D-galactose so lactose is reducing sugar.
- Lactose is almost tasteless or very less sweet.
- Human milk contains maximum lactose which is 7%.
- The sugar in plants is transported in the form of **sucrose**.
- Sucrose is called by many names: invert sugar, Cane Sugar or Table Sugar or common sugar or commercial sugar.
- Sucrose is made up of α – D-glucose and β – D-fructose units.
- The haemolymph of insects has trehalose. There is glycosidic linkage between the two anomeric carbon atoms (α-Glucose and β-Glucose) or 1-1 linkage. Thus, trehalose is a non-reducing sugar.



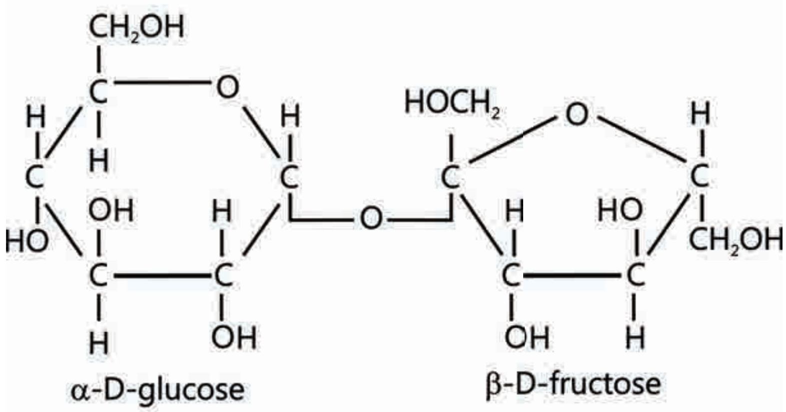
Maltose

(α-1, 4-glycosidic)



Lactose

(β-1, 4-glycosidic linkage)



Sucrose

(α-1, 2-glycosidic linkage)

Figure 11.5: Structural formulae of some disaccharides

Trisaccharide: Has three monosaccharide units in the structure. **e.g. Raffinose (Galactose + Glucose + Fructose)**

Tetrasaccharide: Has four monosaccharide units in the structure. **e.g. Stachyose (Galactose + Galactose + Glucose +Fructose)**

Pentasaccharide: Has five monosaccharide units in the structure. **e.g. Barbascose (Galactose + Galactose + Glucose + Fructose)**

Raffinose and Stachyose are present in phloem cells in plants and can also be used for translocation of carbohydrates in phloem.

3.3 Polysaccharides

3.3.1 General Characteristics

- Polysaccharides are made up of large number of monosaccharide units.
- The **names** end in or **suffixed** with '**-an**' so that they are called as glycans.
- **Pentose** polysaccharides are commonly termed as **pentosans** for e.g. Araban (from L-arabinose), xylan (from D-xylose), present in cell wall.
- **Hexose** polysaccharides are called as "**hexans**" for e.g. mannans (from mannose) cellulose, starch etc. present in plants and animals.
- Polysaccharides are non-soluble in water, non-reducing and taste sweet less.
- They are classified as nutritive and structural polysaccharides on the basis of their functional group.

3.3.2 Types of Polysaccharides

(i) Homopolysaccharides: They have same monomers in their structures. The important ones in terms of biology are as follows:

a. Cellulose: is a **linear polymer** of β-D-glucose units (6000 to 10,000 Dal) which have β 1-4 linkage among the glucose molecules. When the cellulose is partially digested it gives a **cellobiose** unit (Disaccharide).

- Cellulose forms major component in a plant cell
- Cellulose are 50% in wood and is 90% in cotton.
- It is the most abundant molecule for its organic matter on earth.
- Urochordates have cellulose like material called as "Tunicin" which is also called as Animal cellulose.
- It is used in manufacture of the Rayon fibre (Artificial silk).

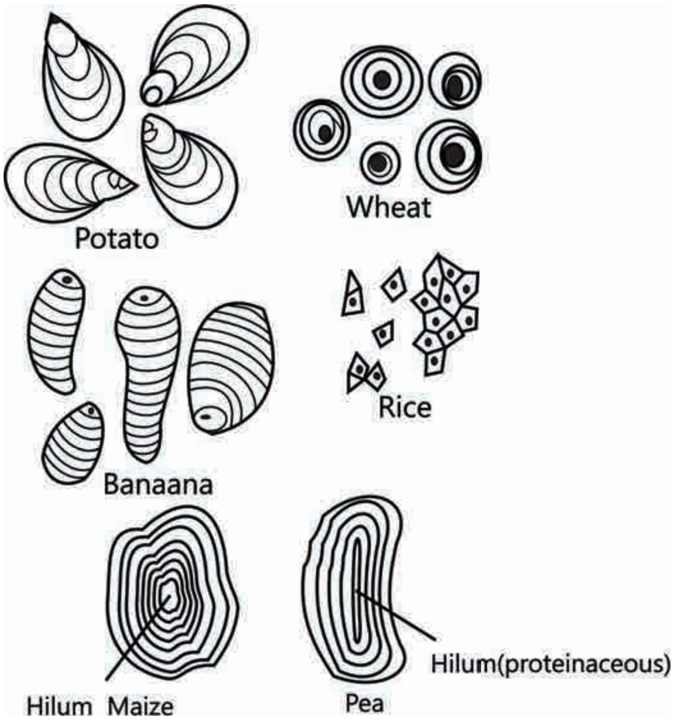


Figure 11.6: Structure of starch grains in various food

b. Starch: Storage food or carbohydrates in the plants. Starch is a **polymer of α –D-glucose** units. Starch consist of two types of chains.

i. **Amylose** is an unbranched polymer with 250–300 glucose units joined with α–1,4 linkage bonds.

ii. **Amylopectin** is a branched chain of 30 glucose units that are linked with α–1,4 and α–1,6 linkage bonds.

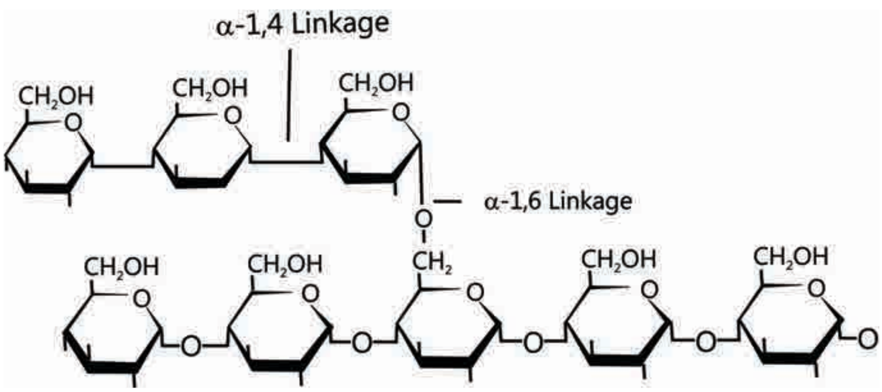


Figure 11.7: Structure of Amylopectin

- Amylose with iodine give blue colour while Amylopectin gives red colour.
- Starch contains 20% amylose and 80% amylopectin which is present in potato.
- Potato starch turns purple or violet in colour when mixed with iodine.

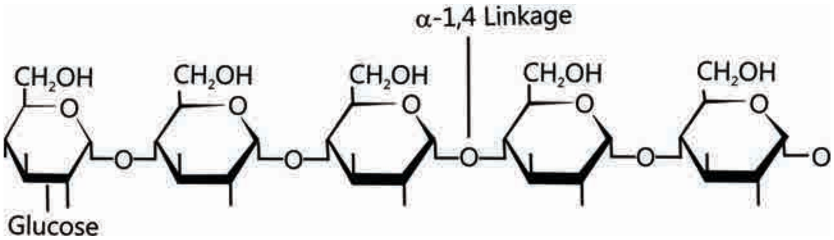


Figure 11.8: Structure of amylose

c. Glycogen: The storage carbohydrate present in animals, maximum amounts are present in liver and muscles. Glycogen is thus also called as animal starch. Glycogen is a highly branched polymer which is made up of α –D-glucose.

- This carbohydrate has the 1-4 bond linkage at long unbranched chain and 1-6 bond linkage at the branching points in the polymer.
- Glycogen turns red colour with iodine solution.
- Glycogen is a storage food of many fungi.

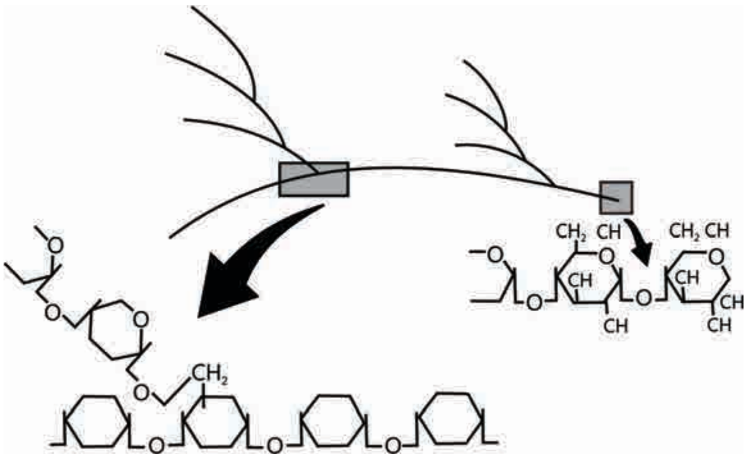


Figure 11.9: Diagram of glycogen molecule

d. Chitin: Linear polymer which consists of N-acetyl- D-glucosamine which is an amino acyl derivative of glucose bonding with β-1-4-linkage.

- Chitin forms exoskeleton of animals in Arthropoda phylum and cell walls present in fungi.
- It is the second most abundant molecule for organic matter on earth.
- It is also called as fungal cellulose as it is in their cell wall.

- **e. Inulin:** Linear polymer that consist of 25-35 fructose units linked together with β-1-2 bonds. Inulin is present in Dahlia and Artichoke roots. It is water soluble polysaccharide and it is used to know the glomerular filtration rate.
  - It is smallest storage polysaccharide.
- **f. Dextrin:** Dextrin is formed as an intermediate matter during the digestion of glycogen and starch. The hydrolysis of dextrin give glucose and maltose are formed. This is a storage food in yeast and bacteria.

(ii) Heteropolysaccharides: It has different monosaccharide units in the structure.

- a. **Hyaluronic acid:** Commonly observed in vitreous humour, umbilical cord, joints and connective tissue of the animals in the form of a lubricating agent. It is also present in animal cell coat which acts as a binding material (animal cement).
  - It is made up of D-Glucuronic acid and N-acetyl – D-glucosamine amyl group arranged in alternate orders in the chain. These different monosaccharides have β-1-3 linkage bonds while the disaccharides have β-1-4 linkage bonds.
- b. **Chondriotin:** D- glucuronic acid and N-acetyl galactosamine polymer.
  - Chondriotin is present in the connective tissue of animals.
  - Sulphate ester of the chondriotin is a main structural component which is present in the cartilages, tendons and bones of animals.
- c. **Heparin:** It is an anticoagulant of blood. Heparin has D-glucuronic acid and N-sulphate glucosamine molecules arranged in an alternate order in the polymer.
- d. **Pectins:** Methylated galacturonic acid, galactose and arabinose constitute the polymer.
  - Pectin is found in the plant cell walls where it binds the cellulose fibrils in bundles.
  - Salts of pectin which is pectates of Ca and Mg form the middle lamella in plants.
  - Thus, it is also called as plant cement.
- e. **Hemicellulose:** Mannose, Galactose, Arabinose and Xylulose form the structure of the polymer.
  - Phytalophus have hemicellulose as storage material which is an Ivory palm. This carbohydrate when extracted from this plant, has white, hard and shiny appearance. This is used in manufacture of billiard ball and artificial ivory.

3.4 Mucopolysaccharides

The slimy polysaccharides which have the capacity to bind proteins with the water molecules are called as mucopolysaccharides. Mucilage is a common mucopolysaccharide present in plants which are made up of galactose and mannose units.

Similarly hyaluronic acid (in streptococcus, animals sperm), chondriotin, heparin (in blood as anticoagulant) are other common examples.

Knowledge Builder

There are several other polysaccharides which are complex and made of three or more different compounds.

- **Cerebrosides:** They include amino alcohol named as sphingosine, a fatty acid and a sugar molecule in their structure. The polar head group in this structure is neutral as it is made up of sugar unit. Glucocerebrosides have D-glucose in their head region and are present in all the cell membranes. Galactocerebrosides have D-galactose in their head region and are present in all cell membrane of brain cells.
- **Gangliosides:** They include sphingosine or dihydro sphingosine, fatty acid, glucose, galactose, N-acetyl galactosamine and sialic acid in their structure. Gangliosides take part during the ion transport and are the receptor for many viral particles and toxins like cholera toxin. They are commonly found in grey matter of the CNS and vertebral cord.
- **Sphingomyelins:** These are lipids which lack glycerol however have a complex amino alcohol sphingosine. It is an esterified molecule, having one fatty acid and a phosphocholine or phosphor ethanolamine in the polar head region. Sphingomyelins are lipids present in many animals as a part of the cell membrane. They are also a major part in the myelin sheath or covering of nerve fibers.

4. Lipids

- The fats along with its derivatives are called as lipids.
- The term **Lipid** was coined by **Bloor**.
- C, H, O are present in all the lipids and the ratio of **Hydrogen** to **Oxygen** is never 2:1 like carbohydrates. The oxygen in lipids is very less.
- Lipids **solubilize** in **organic solvents** like **acetones**, **benzene**, **chloroform**, **ether**, **hot alcoho**l, etc.
- Lipids are **found** in **protoplasm** as **small globules**.
- Lipids do not form **polymer**.
- Lipids when **oxidized** provide **double amount** of the energy as compared to that of **carbohydrates**.
- The fats or lipids present in the subcutaneous layer is a **food reservoir** and also a **shock-absorber**.
- Lipid **occupies** less space during its **storage** unlike **carbohydrate** as lipid molecules are **hydrophobic** and **condense** in the cell.
- Animals **store** maximum food part in the form of **lipids**.
- Lipid on **oxidation** are also a **source** of **maximum amount** of **metabolic water** as **compared** with **carbohydrate** and protein.

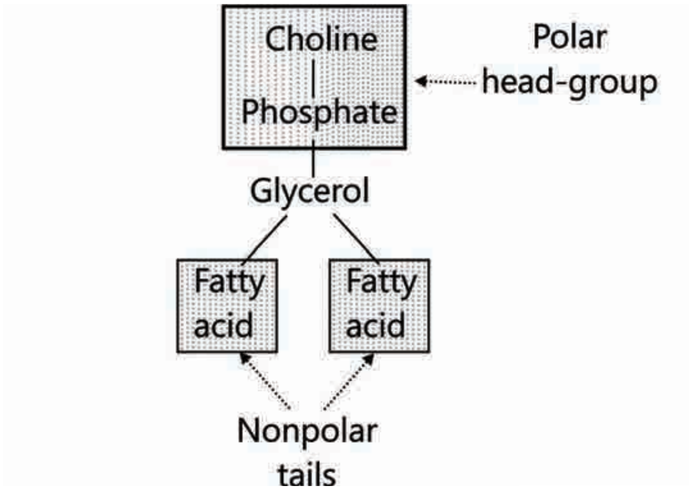


Figure 11.10: A phospholipid molecule showing polar head group and non-polar tails

4.1 Simple Lipid or Neutral Fats

4.1.1 General Characteristics

- These are **long chain fatty acids** and **alcohol esters**. In majority of simple lipids, the alcohol is a **trihydroxy sugar alcohol** i.e. **glycerol**.
- Three molecules of fatty acids are combined with one **molecule** of **glycerol**. The bond is called as "**ester bond**" and the lipids that have such bonds are called as **Triglycerides**. Three molecules of **water** are released when **triglycerides** are formed (dehydration synthesis)
- Similar or different fatty acids are present in the composition of a fat molecule. Simple lipids include two fatty acid types.

4.1.2. Types of Lipids or Fats

i. **Saturated fatty acids –** All the **carbon atoms** in the **hydro-carbon** chain are **saturated** or bonded with hydrogen atoms.
   - Palmitic acid – $CH3(CH_2)14\text{-}COOH$
   - Stearic acid - $CH3(CH_2)16\text{-}COOH$

ii. **Unsaturated fatty acids –** Some carbon atoms are not **valenced** with hydrogen atoms or remain **unsaturated**.
   - Oleic acid
   - Linoleic acid
   - Linolenic acid

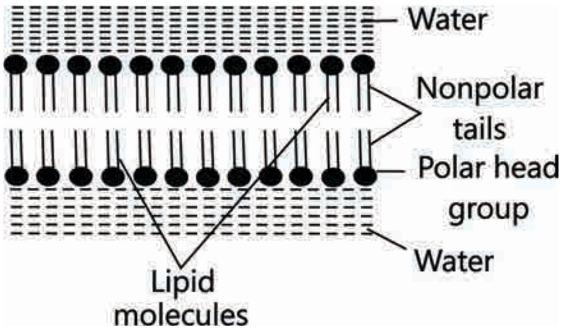


Figure 11.11: Lipid bilayer in aqueous solution

Polyunsaturated fatty acids have more than one double bond in their molecule e.g. **Arachidonic acid**, **Linoleic** acid, **Linolenic acid**, **Prostaglandins** (derivation of arachidonic acid)

- Unsaturated fatty acids are also called as essential fatty acids because these cannot be synthesized in the body.
- Simple lipids that have saturated fatty acids are present in solid state at normal room temperature e.g. fats.
- Simple lipids that have unsaturated fatty acids in the structure are liquid at room temperatures e.g. oils.
- Saturated fatty acids are almost inert or less reactive which tend to get stored in the body and cause obesity.
- Unsaturated fatty acids are more reactive and thus are metabolised in the body and provide energy.
- Oils with poly unsaturated lipids are best recommendation by physicians to patients suffering from **high blood cholesterol** or **cardio-vascular diseases**. This acts in increasing the poly unsaturated fatty acids amounts to saturated fatty acids, without increasing the **total fats** in the diet. This in all lowers the cholesterol level in blood.

iii. **Waxes:** are **mono glycerides** that have one molecule of fatty acid linked with a mono hydroxy alcohol. Waxes are an important molecule that protect the cell or tissue in which they are present. They form covering of hair and skin in animals and plants stem, leaves and fruits where waxes do not allow the water to stay on them or solubilize in water.

E.g. Bees Wax (Hexacosyl palmitate)

Carnauba (Myricylcerotate) present on leaves, stem and fruits.

Maximum amount of carnauba covers the leaf surface of the xerophytic plants preventing water loss.

Spermaceti present in the whale and Dolphin skull.

Cerumen or ear wax present in external auditory meatus or opening of ears.

Lanoline or **cholesterol ester** present in blood, sebum and gonadal ducts where it acts as a lubricating agent.

4.2 Conjugated or Compound Lipids

4.2.1 Phospholipids or Phosphatide or Phospholipins

- Two fatty acid molecules, glycerol, phosphoric acid (H_3PO_4) along with **nitrogenous compound**. **Phospholipids** are most **common** and **abundant lipid** present in the protoplasm.
- They have **hydrophilic polar** end (H_3PO_4 with nitrogenous compound) as well as **hydrophobic non polar end** (fatty acids). Such molecules are called as **amphipathic**. Phospholipids can thus form bimolecular layer in the cell membrane.
- Some **biologically important phospholipids** are as following:
  a. **Lecithin** or Phosphatidyl choline
     - Nitrogenous compound is choline in the lecithin.
     - Lecithin is present in the egg yolk, oil seeds and blood.
     - The lecithin in blood acts as a carrier molecule to transport other lipids.

  b. **Cephalin -** The nitrogenous compound is ethanolamine and it is similar to lecithin, present in nervous tissue, egg yolk and blood platelets.

  c. **Sphingolipids** or sphingomyelins are similar to lecithin however the glycerol is replaced with an amino alcohol sphingosine.

4.2.2 Sphingolipids

- They are present in the myelin sheath of nerves, other examples of phospholipid are Phosphatidyl serine, Phosphatidyl inositol, and plasmalogens.
- **Glycolipid –** 2 fatty acid molecules, sphingosine along with the galactose constitute the lipid.
- **Cerebrosides** are present in the white matter of human brain
- **Gangliosides** are present in the nerve ganglia and also spleen. These lipids have N-acetyl neuraminic acid and glucose along with the other compounds.
- Glycolipids that are found on the cell surface are helpful in recognition of the cell.

4.3 Derived Lipids

These are derived from the simple or conjugated ones and usually have complex structure. These lipids are insoluble in water however solubilize in organic solvents.

4.3.1 Steroids

The molecule has a tetracyclic structure termed as "Cyclopentane perhydrophenanthrene nucleus". Steroids are divided in two types on the basis of structure:

- **Sterols:** Alcoholic steroids like cholesterol which are abundantly present in the adrenal gland, brain, nervous tissue and also in skin. Cholesterol is a parent steroid from which other biologically important steroids are derived. 7 – Dihydro cholesterol present in the skin is a pro vitamin. When the skin gets exposed to ultraviolet radiation, cholesterol transforms into cholecalciferol commonly called as vitamin D. Cholesterol is also called as the "most decorated micro molecule in biology". Ergosterol: present in oil seeds, fungi like ergot and yeast. Ergosterol is the precursor for another Vitamin D-Ergocalciferol. Coprosterol: present in faecal matter produced from the decomposition of cholesterol carried by colon bacteria in intestine. Bile acid- Bile Juice has different steroid acids which help in fat emulsification. E.g. cholic acid, Lithocholic acid etc.
- **Sterones** are Ketonic steroids for E.g. sex hormones in animals. Male $\longrightarrow$ Testosterone and Female $\longrightarrow$ Progesterone.
- **Adreno corticoids:** The hormones secreted by adrenal cortex in total are known as adreno corticoid hormone.
- Ecdysone hormone is present in insects secreted by prothoracic glands.
- Diosgenin is extracted from yam plant (Dioscorea), which is used in the manufacture of antifertility or contraceptive pills.

4.3.2 Chromolipid

- It is also called as terpene.
- Most complex lipid which is present in the protoplasm.
- Chromolipids are made up of repeated isoprene units
- E.g.: Carotenoids; vitamin A, E, K; Natural Rubber (Polyterpene)

5. Proteins

Protein is derived from a Greek word that means "holding first place" (by Berzelius and Mulder)

5.1 General Characters of Proteins

- C, H, O, N are the essential elements present in the proteins. Many proteins also have sulphur.
- In some proteins iodine, iron and phosphorus are also present.
- Proteins are **second** most **abundant compounds** present in protoplasm. **7%–14%** amount of proteins approximately.
- Proteins are a **polymer** of **amino acid** (Fisher and Hofmeister). There are around 300 amino acids that exist however only **20** types of **amino acids** are used in **making of proteins**
- All the amino acids are **amphoteric** in nature as it contains one **acidic (–COOH)** and an alkaline group **($–NH_2$)**.

- There are **free amino acids** present in the protoplasm as **ions** (at isoelectric point).
- **Isoelectric point** is the **pH** point at which the **amino acids** are **stable** in the **electric field**.
- 1**0 amino acids** from total 20 are not **synthesized** and hence they are obtained from the diet or food. These **depending amino acids** are called as **essential amino acids**. E.g. Threonine, Valine, Lysine, Phenylalanine Tryptophan, Leucine, Isoleucine, Methionine, Arginine and Histidine where Arginine and Histidine are semi essential.
- 10 amino acids are synthesized in animal body which are called as **non-essential amino acids**. For e.g. Glycine, Proline, Alanine, Aspartic acid, Glutamine, Serine, Glutamic acid, Cysteine, Asparagine, Tyrosine.
- Eukaryotic proteins have L conformation amino acid while bacteria and antibodies have D-conformation amino acid.
- **Amino** acids are linked 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.

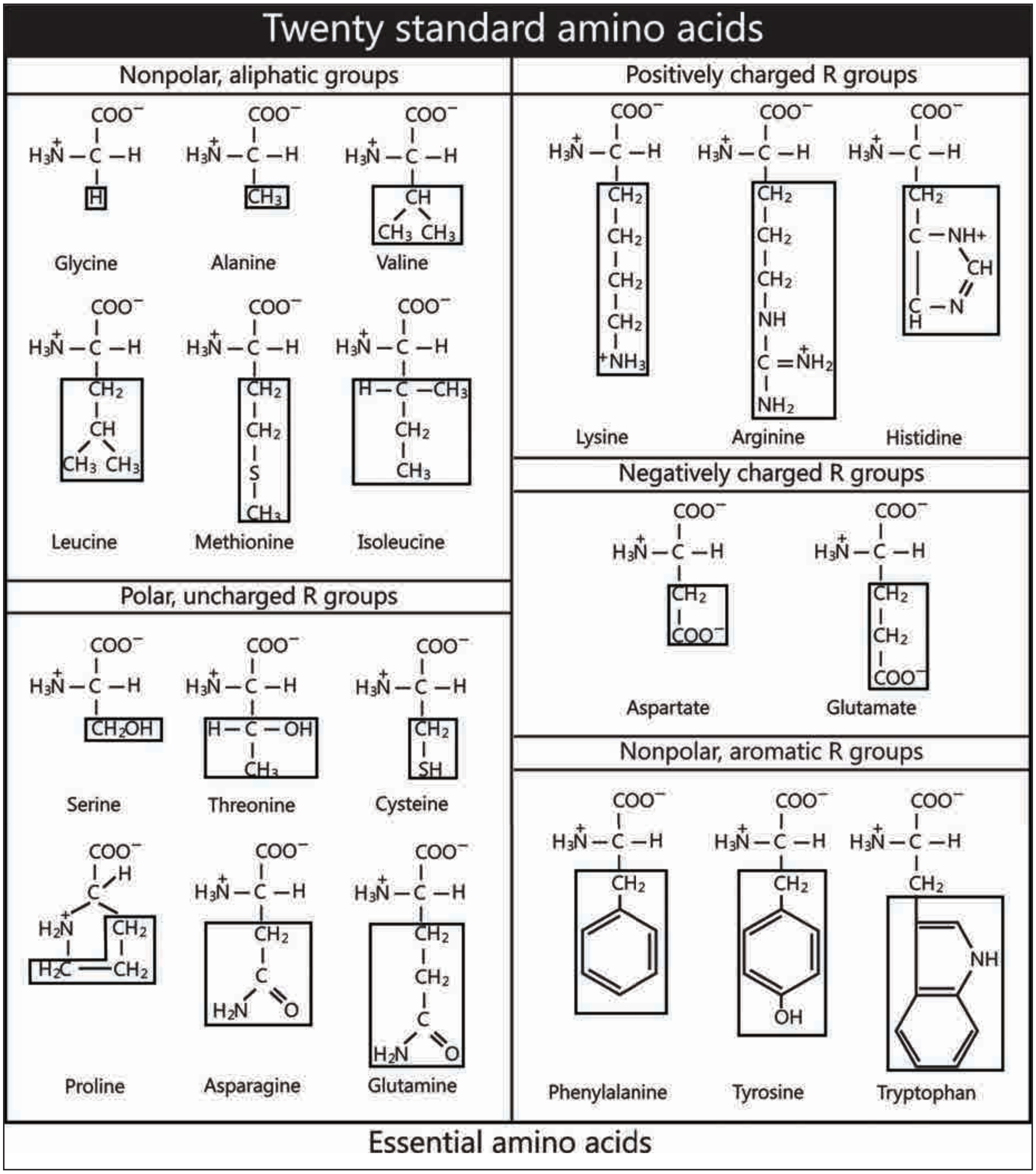


Figure 11.12: Structures of all 20 essential amino acids

Special Amino acids

- **Tryptophan:** The **most complex** amino acid which is helpful in the **synthesis** of **I.A.A.** (Indole-3-Acetic Acid) **a plant growth** hormone.
- **Tyrosine:** This helps in the synthesis of the melanin pigment in the skin, Thyroxine hormone, Adrenaline (epinephrine) hormone, and even nor adrenaline (nor epinephrine) hormone.
- **Proline** and **hydroxyl proline** amino acids have **imino group** (-NH) is present in **place** of usual **amino** (-NH_2) group so these **two amino acids** are also known as **imino acid**.
- **Cysteine** and **methionine** have sulphur in their amino acid.
- **Tyrosine** has a polar side group in the amino acid.

Classification of the amino acids on the basis of carboxylic groups and amino groups number.

- **Acidic amino acid** (mono amino di carboxylic amino acid)
  - There are one amino and **two carboxylic** groups present in their structure. Net charge is **-ve**, thus they **move towards** the **anode** in electric field. E.g. Glutamic acid, Aspartic acid.
- **Alkaline amino acid** (Di amino mono carboxylic amino acid)
  - There are two amino and one carboxylic group present in the structure.Net charge = **-ve**, so they **move towards** the **cathode** in electric field. E.g. Histidine, Arginine, Lysine.
- **Neutral AA** (Mono amino mono carboxylic AA)
  - There are **one amino** and **one carboxylic** group present in the structure.
  - The amino acid as whole has no charge, present in the form of zwitter ions and thus do not move in the electric field. E.g. Remaining all 15 AA

5.2 Configuration of Protein Molecule

5.2.1 Primary Configuration or Structure

The amino acids that are linked by the peptide bonds are arranged in a straight chain form the primary structure of proteins. The protein structure is newly produced on the ribosomes are primary structure and are highly unstable.

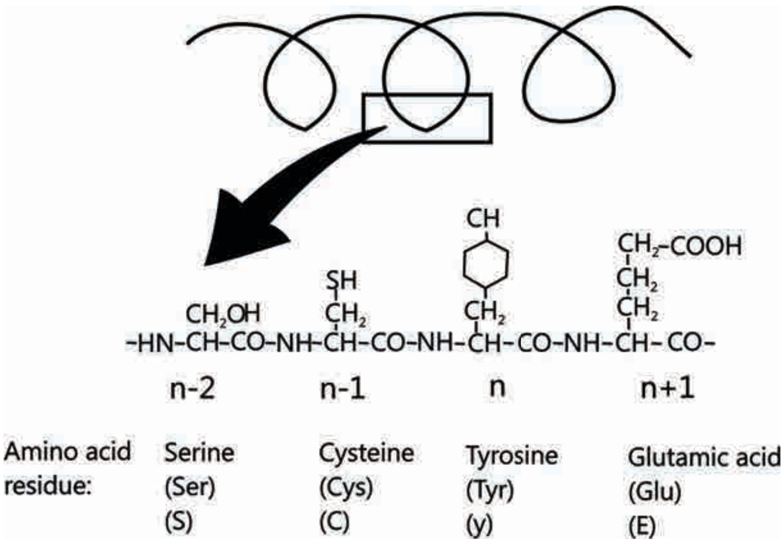


Figure 11.13: Primary structure of a peptide

- **Secondary configuration –** The protein molecules are spirally coiled in the secondary structure. Now the amino acids are also linked by hydrogen bonds which are formed between the oxygen of one amide group and the hydrogen of another amide group. Proteins are insoluble in water and have fibrous appearance. This structure is of two types:
  - α**-Helix:** Right hand rotation of the **spirally coiled** chain with approximately $3\frac{1}{2}$ amino acids present in each turn. There are intramolecular hydrogen bonds between two amino acids of same chain present in the structure e.g. Keratin, Myosin, Tropomyosin.
    - Keratin is a sclera protein which is fibrous, tough, and resistant in terms of digestion. There is abundance of cysteine amino acid in the structure which gives the hardness to keratin.
  - β**-Helix** or β pleated sheath: Protein structure here has **zig – zag** arrangement. The protein molecules are held together by the intermolecular hydrogen bonding. E.g. Fibroin (in silk).

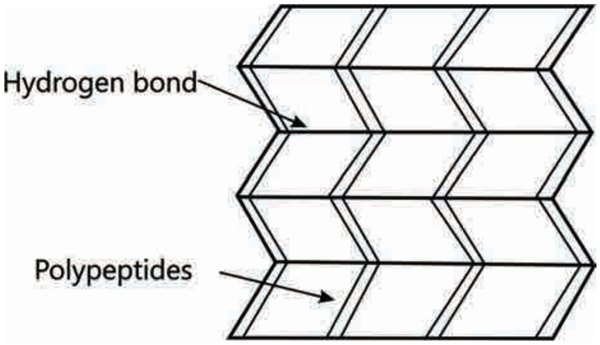


Figure 11.14: β pleated sheets

- **Tertiary Structure:** Proteins in the tertiary structure are highly folded and form a globular appearance. They are water soluble (form colloid solution). This structure has following bonds:
  - **Peptide bonds** are the strongest bond present in proteins.
  - **Hydrogen bonds** between H and O of the amino acid.
  - **Disulphide bonds:** The bond is between S and H group of amino acid (Cysteine) which are the second strongest bond in the protein and stabilize the tertiary structure.
  - **Hydrophobic bonds:** The bond between the amino acids that contain the hydrophobic side chains e.g. Aromatic amino acid.
  - **Ionic bond:** The formation of the ionic bonds between the two opposite ends of a protein molecule is due to the electrostatic attraction between them.
    - Majority of the proteins and enzymes present in the protoplasm exhibit tertiary structure.

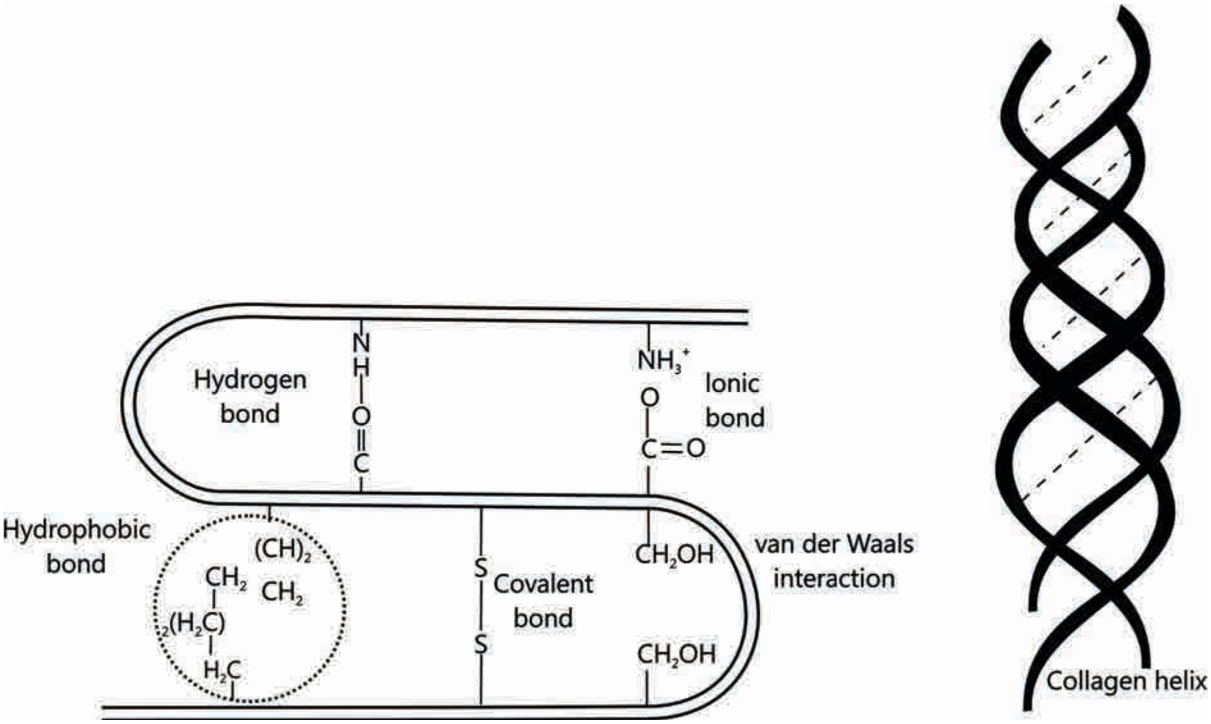


Figure 11.15: Tertiary structure of peptide showing various bonds. and collagen fibres

- **Quaternary structure:** The polypeptide chains that have tertiary structure are linked by different bonds to form the quaternary structure of a protein. There are different polypeptide chains with similar (lactic – dehydrogenase) or dissimilar types (Haemoglobin, insulin).
    - Quaternary structure is the most stable structure of a protein.

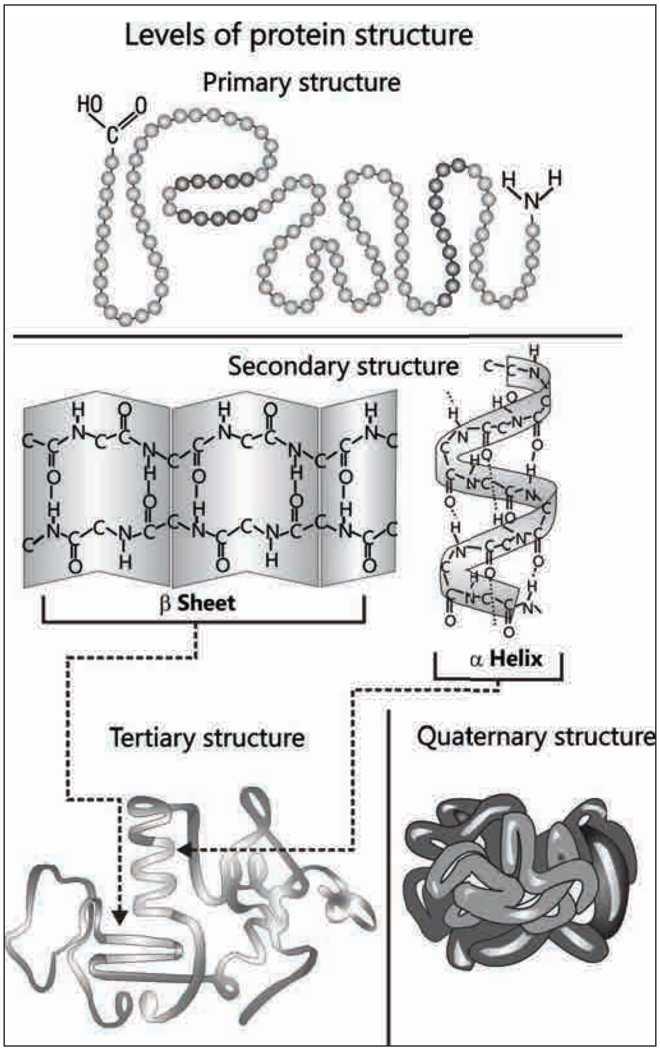
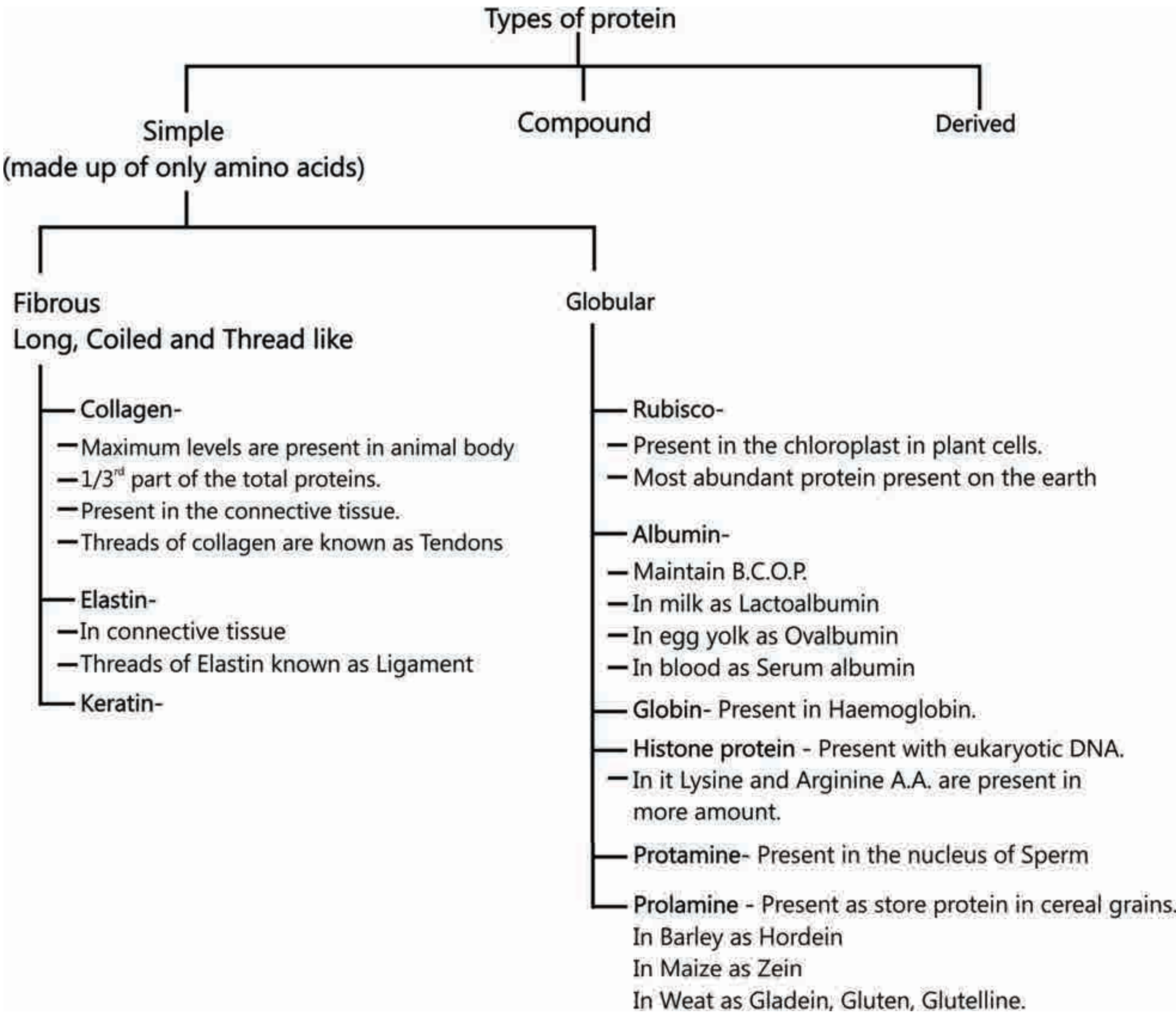


Figure 11.16: Structures in a peptide and protein

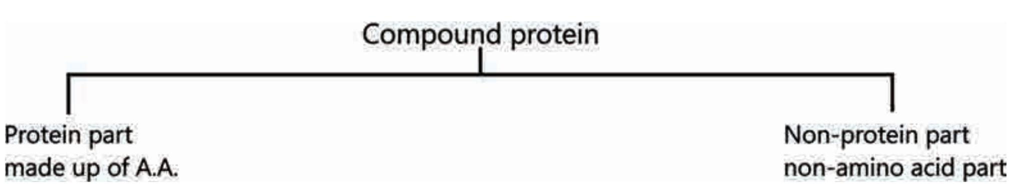
5.3 Types of Proteins



Flowchart 11.1: Classification of Proteins

- Elasticity in wheat flour is due to Glutelline.

5.3.1 Compound Protein



Flowchart 11.2: Parts of a compound protein

Types of compound protein on the basis of prosthetic group.

(i) Nucleoprotein – Prosthetic group is nucleic acid.

- Eg. Chromosome = DNA + RNA + Protein
- Ribosome = rRNA + Protein
- Virus

(ii) Chromoprotein – Prosthetic group is Porphyrin pigment (metal + porphyrin ring)

- Eg. Metal Colour
- Haemoglobin Fe Red
- Cytochrome Fe Red
- Chlorophyll Mg Green
- Haemocyanin Cu Blue

(iii) Lipoprotein – Prosthetic group is lipid

- Eg. Plasma membrane
- Lipovitelline membrane on egg surface.

(iv) Phosphoprotein – Prosthetic group is phosphoric acid (H_3PO_4)

- Caseinogen – Milk
- Pepsin – Protein digesting emzyme.
- Phosvitin Egg
- Ovovitelline

(v) Lecithoprotein – Prosthetic group is Lecithin

- E.g. Fibrinogen – Blood

(vi) Metalloprotein – Prothetic group is metal

- E.g. Enzyme with its co-factor

(vii) Glycoprotein – Prosthetic group is carbohydrate (less than 4% carbohydrate)

- Mucin – Saliva
- Erythropoietin hormone – Kidney.
- A and B antigen of blood.
- α, β, γ globulin of blood.
- FSH – Follicular stimulating hormne
- LH – Leutinizing hormone

Glycoproteins which are present on cell surface are helpful in cell recognition.

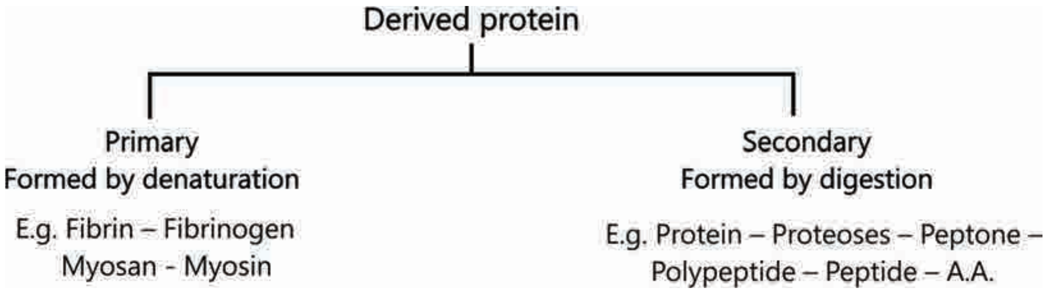
Human = Egg surface – Fertilizin – Glycoprotein

Sperm surface – Antifertilizin – Simple protein.

(viii) Mucoprotein prosthetic group is carbohydrate (more than 4% carbohydrate)

- E.g. Mucoids of synovial fluid, Osteomucoprotein of bones,
- Tendomucoprotein of tendons, Chondromucoprotein of cartilage.

5.3.2 Derived Protein



Flowchart 11.3: Derived protein

Special points of Protein

- **Monomeric protein:** Protein composed of one polypeptide chain.
- **Oligomeric / Polymeric / Multimericprotein:** Protein composed of more then one polypeptide chains.
- **Peptide:** A molecule of a short chain of Amino acid like dipeptide, Tripeptide, Tetrapeptide.
- **Polypeptide:** It usually has more than 20 Amino acids.
- **Protein:** It contains minimum 50 Amino acids or more than 50 Amino acids.

6. Nucleic acids

- **F. Meischer** discovered **nucleic acid** in the **nucleus** of a **pus cell** and named the acid as "**nuclein**". "**Altman**" later **termed nucleic acid**.
- Nucleic acids are made up of **nucleotides polymer**.
- They contain **nitrogen base**, **pentose sugar** and **phosphate** in their structure.

There are different types of nitrogen bases which form the basis of classification. They are broadly of these two types:

Pyrimidines: the structure has one pyrimidine ring which has a skeleton composed of four carbon atoms and two nitrogen. E.g. Cytosine, Thymine and Uracil.

Purines: The structure has two rings – one pyrimidine ring (2N+4C) and the other one imidazole ring (2N+3C). e.g. Adenine and Guanine.

Pentose Sugar

Nitrogen base forms the bond with the first carbon atom of the pentose sugar which forms a nucleoside. Nitrogen atom in the third place (N3) forms bond with the sugar in pyrimidines while nitrogen of the ninth place (N9) forms bond with sugar in purines.

Phosphate part forms ester bond (covalent bond) with the fifth carbon atom of the sugar to form a complete nucleotide in purines.

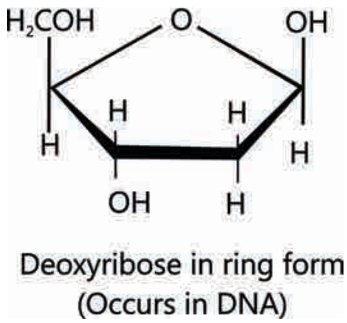


Figure 11.17: Structure of Deoxyribose

6.1 Types of Nucleosides and Nucleotides

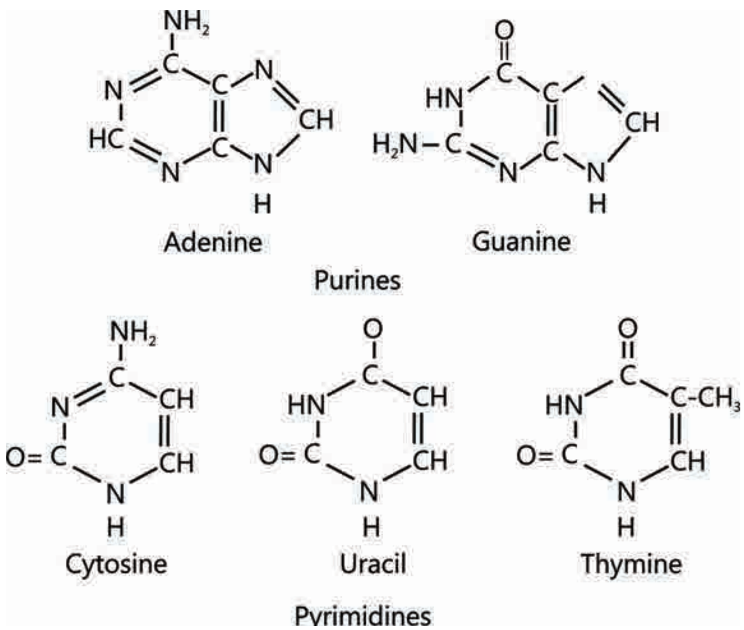


Figure 11.18: Structure of purines and pyrimidine

- Adenine + Ribose = Adenosine
    - Adenosine + Phosphate = Adenylicacid (AMP)
- Adenine + Deoxyribose = Deoxy adenosine
    - Deoxy adenosine + P = Deoxyadenylic acid (dAMP)
- Guanine + Ribose = Guanosine
    - Guanosine + P = Guanylicacid (GMP)
- Guanine + Deoxyribose = Deoxyguanosine
    - Deoxyguanosine + P= Deoxyguanylic acid (dGMP)
- Cytosine + Ribose = Cytidine
    - Cytidine + P= Cytidylic acid (CMP)
- Cytosine + Deoxyribose = Deoxycytidine
    - Deoxycytidine + P = Deoxycytidylic acid (dCMP)
- Uracil + Ribose = Uridine
    - Uridine + P = Uridylicacid (UMP)
- Thymine + Deoxyribose = Deoxy thymidine
    - Deoxythymidine + P = Deoxythymidylic acid (dTMP)

6.2 Deoxyribo Nucleic Acid (DNA)

- Meischer discovered the DNA while the term was given by Zacharis.
- The pentose sugar is deoxyribose sugar and the nitrogen bases are of four types A, T, G, and C.
- **Wilkins** and **Franklin studied** the **DNA** molecule with the X-Ray crystallography technique.
- **Watson** and **Crick** (in 1953) proposed a **double helix model** for DNA with the help of same technique. Watson, Crick and Wilkins were awarded for the same with a Noble Prize in 1962.
- DNA is made up of two polynucleotide antiparallel chains as per the model.
- The **polynucleotide** chains are **complementary** as well as **antiparallel** to each other.
- The word **antiparallel** means that the **strands of the DNA are in the opposite direction** of **phosphodiester** bond. If the **direction** of a **phosphodiester bond** is **3'- 5'** in **one** strand then it is **5'-3'** in **another** strand while the nitrogen bases remain complementary to each other.
- The DNA strands are held together by the hydrogen bonds which are present between the nitrogen bases of both the strand.
- **Adenine** binds to **thymine** with the two hydrogen bonds while **cytosine** binds to **guanine** with the three hydrogen bonds. (A=T) (G C).
- Chargaff's equivalency rule for DNA: In a double stranded DNA, the amount of purine nucleotides is equal to the amount of pyrimidine nucleotides.
    - Purine = Pyrimidine

- $[A]+[G]=[T]+[C]$
- $\frac{[A]+[G]}{[T]+[C]}=1$
- Base ratio = $\frac{A+T}{G+T}$ = constant for a given species.

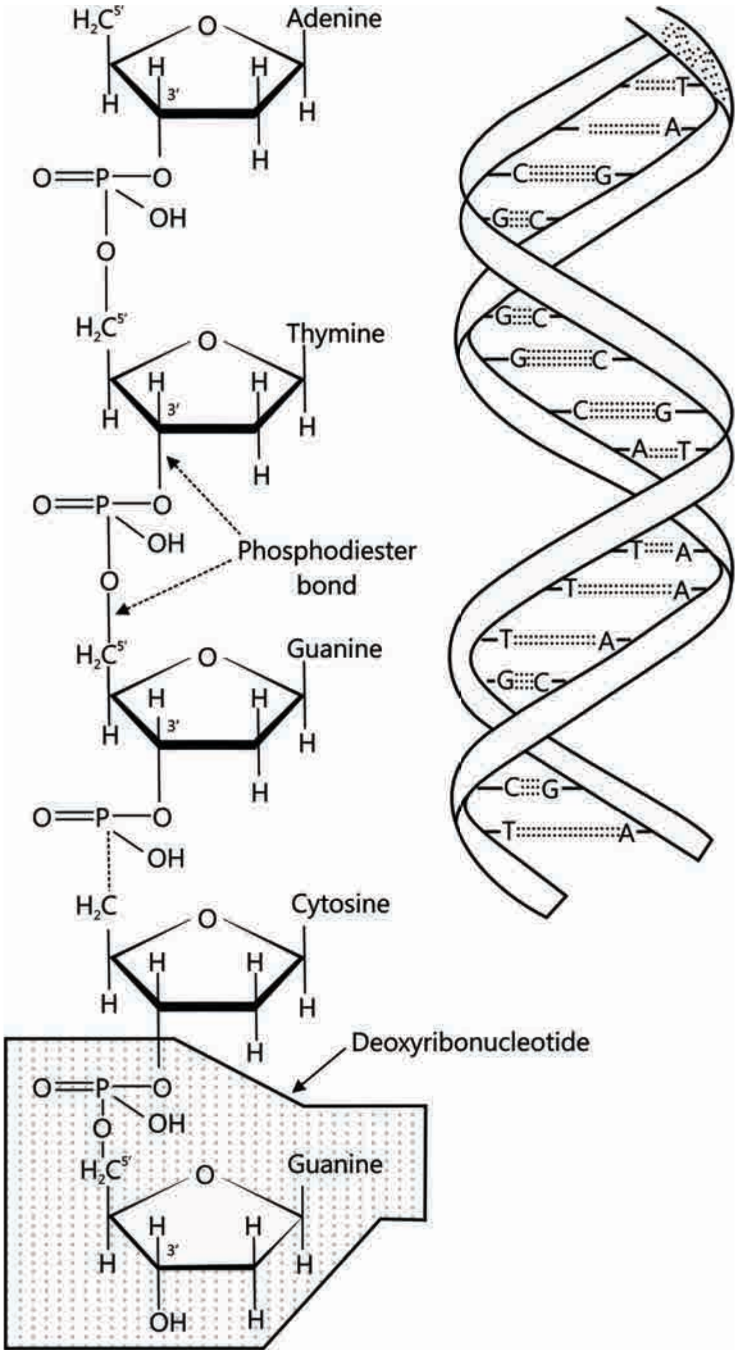


Figure 11.19: A polynucleotide structure of DNA and DNA double helix structure

- In a DNA, when A+T> G+C, the DNA is A-T type. Base ratio of A-T DNA type is more than one. e.g. Eukaryotic DNA
- In a DNA, when G+C> A+T, the DNA is G-C type. Base ratio of G-C DNA type is less than one. e.g. Prokaryotic DNA
- **Melting point** of DNA depends on its **G-C** contents as it has three hydrogen bonds which require comparatively more energy for its breakage than A-T content.
- Tm = Temperature of melting.
  - Tm of prokaryotic DNA > Tm of Eukaryotic DNA
  - More the G-C content more the temperature requirement to break the DNA.
- The strand of **DNA** that participates in transcription among the two strands, is called as **Antisense strand** or **non-coding strand** or **template strand**.
- Another strand of DNA which remains silent during transcription and does not participate in it is called as sense strand or coding strand.
- **Denaturation of DNA:** When the normal DNA molecule is placed at **high temperature** (80°-90°C), then both the strands of **DNA** get **separated** from each other as the **hydrogen bonds** between the two strands **break**, called as **DNA-denaturation**.
  - **Renaturation of DNA:** When this **denatured DNA** molecule is cooled or **brought down** to **normal temperature**, then both the DNA strands is **attached** after the **hydrogen bonds** are formed between both the strands, called as **renaturation of DNA**.
- **Hyperchromicity:** When a double stranded **DNA** is exposed to heat that causes its **denaturation**, then the denatured DNA molecule **absorbs more** amount of **light**, this phenomenon is called as **Hyperchromicity**.
- **Hypochromicity:** When this double stranded denatured DNA molecule cools down slowly, then returns back to the double stranded form and it absorbs less amount of light. This phenomenon is called **Hypochromicity**.

6.2.1 Configuration of DNA Molecule

- The two strands of DNA are **helically coiled** similar to a **revolving ladder**. **Back bone** of DNA is made up of phosphates and sugars while the steps (bars) are the pairs of **nitrogen bases**.
- The two **successive steps** have a **distance** of **3.4 Å**. The **single complete turn** of DNA molecule have 10 steps or 10 pairs of nitrogen bases. Hence one complete turn is 34 Å long which is called as **helix length**.
- Diameter of DNA molecule or the distance between two strands phosphates is **20 Å**.
- Distance between the two strands is 11.1 Å.

- The **hydrogen bonds** that are between the **nitrogen bases** are **2.8-3.0Å** long. **Angle** between the nitrogen base and the first carbon atom of pentose is **510**.
- DNA have a molecular weight of **106** to **109** dalton.
- The **eukaryotic nucleus** have the DNA associated with **histone protein** which forms **nucleoprotein**. The protein **Histone** occupies **major groove** of the DNA at an angle of **300**.
- The DNA and Histone have salt linkage or bond (Mg^{+2}).
- Chromosomal DNA is linear while prokaryotic, mitochondrial and chloroplast DNA is circular.
- Sinsheimer isolated the DNA in ∮ **×174 bacteriophage** and found that it is **single stranded**.
  - G-4, S-13, M-13, F1 and Fd are all bacteriophages that have ss-circular DNA.

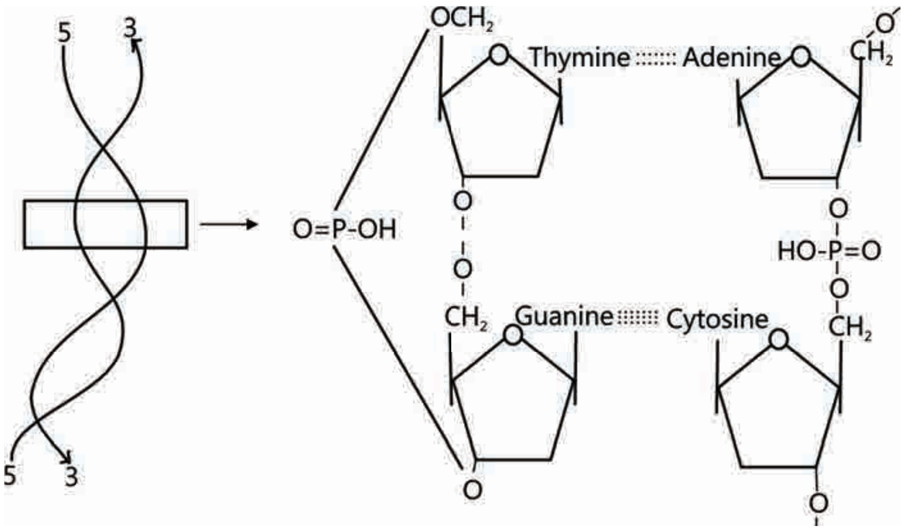


Figure 11.20: Secondary structure of DNA

6.2.2 Types of DNA

There are two types of DNA depending upon the direction of twisting.

1. Right Handed DNA:
   - **Clockwise** twisting of the helix e.g. Watson and Crick model of DNA was **'B' DNA**.
   - Left handed DNA –
   - **Anticlockwise** twisting of the helix e.g. Rich discovered **Z-DNA model**. Phosphate and sugar backbone has zig-zag arrangement.

Did You Know

DNA molecule is Dextrorotatory while RNA molecule is Laevorotatory.

6.2.3 DNA Replication

- **DNA** is the only **molecule** which has the **capability** of **self-duplication** and thus is also called as a "**Living molecule**"
- All the **living beings** are capable enough to reproduce because the DNA is replicating, thus the cell also replicates.
- D.N.A. gets **replicated** in the "**S Phase**" of the **cell cycle**. During cell division, the DNA divides to give double equal DNA amount, each set in both the daughter cells. **Delbruck** put forward the three theoretical methods of DNA replication i.e.
  - Dispersive
  - Conservative
  - Semi – conservative

The semi conservative method of D.N.A. replication is most accepted method as it also proves that the DNA and genes get transferred in all the generations with minor variations and crossing over.

6.3 Ribo Nucleic Acid (RNA)

6.3.1 Configuration of RNA

The RNA is fundamentally the same as DNA in the structure, however there exist some differences also as follows:

- Deoxyribose sugar in DNA is replaced by Ribose sugar in RNA.
- Thymine in DNA is replaced by Uracil in RNA.
- **RNA** is **single stranded** with some loops which are also made up of only one polynucleotide chain.

Exception

RNA found in Reo viruses are double stranded (two polynucleotide chains).

6.3.2 Types of RNA

- **Genetic RNA** or **genomic RNA:** When the **DNA** is **not** available in the cell, **RNA works** as **genetic material** and even as gene for **protein synthesis** both. E.g. Reo virus, TMV, QB bacteriophage.

- **Non-genetic RNA** or Non genomic RNA:

  (A) r-RNA (B) tRNA (C) mRNA

(i) Ribosomal RNA (r-RNA)

- **80%** of the total **RNA** in a cell.
- **Kuntz** discovered **rRNA**.
- Present in **ribosomes** and **produced** in the **nucleolus** of a cell.
- The most **stable** form of RNA.
- **Eukaryotic** cells have **80S** ribosome who have **60S** and **40S** subunits. This type is made with four different units of rRNA.
- Prokaryotic cells have **70S** ribosome who have **50S** and **30S** subunits. There are three different types of units of rRNA.

Function:

- During protein synthesis, rRNA provides the attachment site for tRNA and mRNA which remain in the ribosome.
- Salt linkages are bonds that attach tRNA to the larger subunit of ribosome while mRNA to smaller subunit of ribosome.

(ii) Transfer – RNA (tRNA)

- 10%-15% of total RNA.
- Synthesized in the nucleus on DNA.
- Also called as soluble RNA (sRNA) or Adapter RNA.
- Hogland, Zemecknike and Stephenson discovered tRNA.
- The smallest RNA (4S).
- Single stranded RNA however the strand loops out to form a hair pin like or a clover like structure.

Function:

- During protein synthesis, it carries the amino-acid to the ribosome where it is made in polypeptide.

(iii) Messenger RNA (mRNA)

- The mRNA is 1%–5% of the cell's total RNA.
- Huxley, Volkin and Astrachan discovered messenger RNA while it was named by Jacob and Monad.
- The mRNA is produced by genetic DNA in the nucleus. This process is known as Transcription.

- It is least stable RNA.
- Also known as template RNA for protein synthesis.

Knowledge Builder

- **Wilkins**, **Franklin** and **Ashbury** studied **X-ray diffraction patterns** of **DNA** that were isolated from various organisms. It revealed that DNA is a right handed helical structure.
- **James Watson and F. C. Crick** used all the available chemical and physical information, concluded and gave **DNA's double helix model** and were awarded the Nobel prize for the same in 1962.
- The **two back bones** have width **equal** to that of a **base pair** and the **number remains constant** (i.e., width of a purine + a pyrimidine).
- The **base pairs** along the **molecule axis** have intervals of **3.4 nm** among them. Therefore, one **complete turn** of the **double helix** comprises **34nm** (10 base pairs).
- The **sequences** of **bases** in **one chain** have **no restriction**. However, the **sequence of one chain** as per rules for pairing,**determines** the **sequence** of the **other chain**. The **two chains** are **complementary**.
- The **double helix** has a **diameter** of **20Å** which is the **distance between the two** strands.
- The **DNA** has right handed helical structure. This type of DNA exists in 4 forms-
  - **B form:** The **DNA** that has **10 base pairs** per **turn** and the **length** is **34nm**.
  - **A form:** The **DNA** that has **11 base pairs** the base pairs are not perpendicular to the axis, but are titled.
  - **C form: Similar** to the **B form,** however, it has **9 bases pairs** per turn.
  - **D form: Similar** to **B form,** however, theyhave **8 base pairs** per turn.
- The **DNA** with **left handed coiling** is named as **Z-DNA** where the **repeating unit** is **dinucleotide instead** of usual **nucleotide**.

7. Enzymes

- An **enzyme** is a **protein** that functions as a **catalyst** to SPEED up a **chemical reaction** in the body. It is **NOT used** in the **chemical reaction**, rather it is **recycled** and **used over** and over **again**. All **enzymes** are **proteins**.
- **Enzymes** are **biological catalysts**. A **catalyst** is responsible to **speed** up the **reactions**. The **reactions** in which **enzymes** are **involved** would **take place anyway** (in absence of enzymes also), the **enzymes** just **speed** them up.

- **Kuhne** termed the **enzyme** name.

7.1 General Features

- **Enzymes** are **proteinaceous** in **nature**. The exception is the recently **discovered RNA enzymes**. The **tertiary level** structure of the **proteins** make them functional as **enzymes**. The two **RNA enzymes** are, **Ribozyme** (Cech *et al*, 1981, for removing introns) the ribozyme isolated from a protozoan named *Tetrahymena thermophila*, and Ribonuclease-P (Altman *et al*, 1983, for separating t-RNAs from hnRNA) which was isolated from a bacteria. Cech and Altman were honoured Noble prize (1989) for their "discovery of catalytic properties of RNA".
- Simple enzymes constitute only protein (tertiary structure) e.g., pepsin, trypsin, steapsin.
- Conjugate enzymes have two parts:

  a. A protein part: the **apoenzyme**

  b. (A non-protein part: the **co-factor**.

  The set made with these two parts is called as **holo-enzyme**.
- **Cofactor** may be either **organic** or **inorganic**.

  a. Organic cofactors are of the two types namely **co-enzymes** and **prosthetic groups**. Co-enzymes are easily separable non-protein organic cofactors like **NAD, FAD, FMN**.

  b. Inorganic cofactors are **metal activators** (essential elements) which are loosely connected to the **apoenzyme** part e.g., Mn++, Fe++, Zn++, Mg++, K+, Ca++. However, in some enzymes, like Fe (iron) in cytochromes are firmly held. Enzymes **requiring metal ions** are called as **metalloenzymes**.
- **Mitochondrion** contain **maximum** amounts of **enzymes** in a cell.
- **Enzymes vary in size and structure: Smallest** enzyme is **peroxides** while the **largest** enzyme is **catalase** (found in peroxisomes).
- Summer in 1926 **crystallized** the enzyme **urease** that was isolated from Jack bean *Canavalia* and **proved** the **protein** nature of **enzymes**.
- **Enzymes** like proteins have **three dimensional structure**.
- The **chemical reaction proceeds** and **reaches** half its **maximum velocity** at a particular **substrate concentration** $\mathbf{K_m}$ (Michaelis Menten Constant). The value is the **same** as that of an **inverse value** of the **enzyme affinity** towards its **substrate**. $\mathbf{K_m}$ **decreases** while the **substrate affinity increases**. **Allosteric enzymes** are **exceptions** to the K_m constant.
- Around **2000 enzymes** have been known to exist which are synthesized in or on the living cells. The enzymes many times remain and function inside the cells which are called as **endoenzymes** or intracellular enzymes. The enzymes that get excreted from the cells and function outside them are called as **exoenzymes** or extracellular enzymes. These enzymes retain their catalytic

ability after they are extracted from the cells. **Rennet tablets** which have the enzyme **rennin** extracted from the **calf's stomach** are used to coagulate the milk protein and convert it in **casein** (cheese from milk).

- **Enzymes** have their own optimum pH for **maximum efficiency**. The pH shift from that range towards alkaline or acidic range, affects the **efficiency**, mostly **decreases** the activity. The reason for the decrease is the **denaturing** of the enzyme molecule (change in shape). Pepsin of gastric juice has pH 2.0 as optimum, while trypsin has pH 8.0.
- **Enzymes** similarly have a **specific optimum temperature** in which they work best. The activity of enzyme almost doubles when the temperature rises by 10°C in a range of 0–40°C. Thus, the temperature coefficient is (Q_{10} = 2).

  Temperature range of 25°C is optimum for several enzymes.

7.2 Classification of Enzymes

Thousands of enzymes have been discovered, isolated and studied. Most of these enzymes have been classified into different groups based on the type of reactions they catalyze. Enzymes are divided into 6 classes each with 4-13 subclasses and named accordingly by a four-digit number.

- **Oxidoreductases/dehydrogenases:** Enzymes which catalyze oxidoreduction between two substrates For example, S and S' **S reduced + S' oxidised $\rightarrow$ S oxidised + S' reduced**
- **Transferases:** Enzymes that catalyze a transfer of a group. For example, G (other than hydrogen) between a pair of substrate S and S' **S - G + S' $\rightarrow$ S + S' – G**
- **Hydrolases:** Enzymes that catalyze hydrolysis of ester. For example, ether, peptide, glycosidic, C-C, C-halide or P-N bonds.
- **Lyases:** Enzymes that catalyze removal of groups from substrates by mechanisms other than hydrolysis leaving double bonds.

  For example:

$$\begin{array}{c} X \quad Y \\ | \quad\; | \\ C-C \end{array} \longrightarrow X-Y+C=C$$

- **Isomerases:** All enzymes that catalyze inter-conversion of optical, geometric or positional isomers.
- **Ligases:** Enzymes that catalyze the linking together of 2 compounds. For example, enzymes which catalyze joining of C-O, C-S, C-N, P-O etc. bonds.

Mind Map

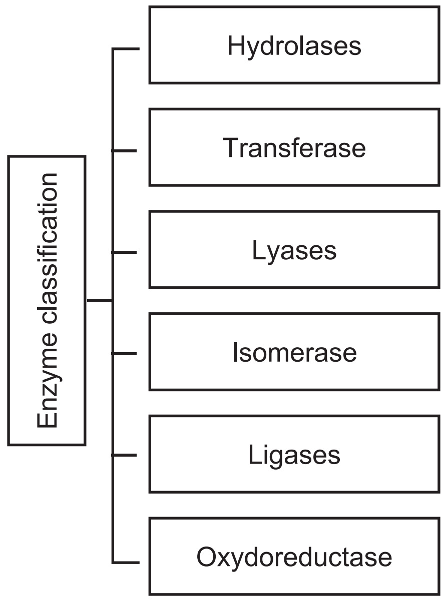


Figure 11.4: Classification of enzyme

7.3. Factors Affecting Enzyme Function

- **Temperature:** Enzyme functions optimally at certain temperature. As the temperature increases the kinetic energy also increases, molecules move faster and it increases the chance of substrate colliding the enzyme's active site and binding followed by reaction. But if the temperature is too high, the enzyme protein denatures (cools), thereby destroying the shape of active binding site (cannot bind to the substrate anymore) and decreasing the enzyme reaction rate.

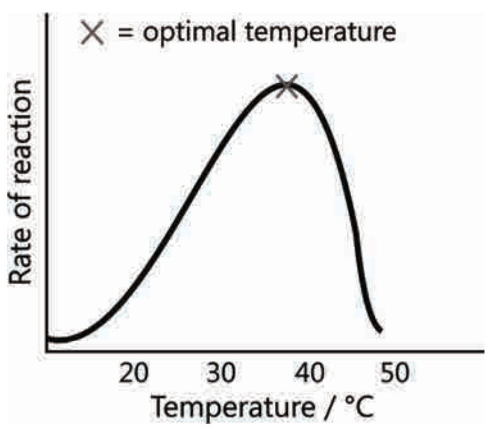


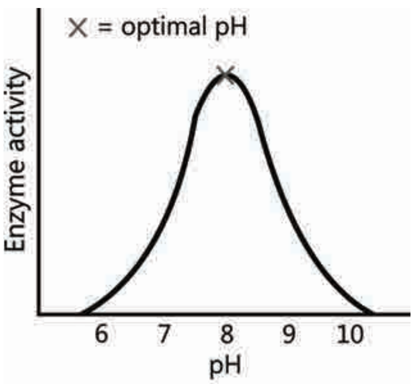
Figure 11.21: Graph of rate of reaction vs temperature

Knowledge Builder

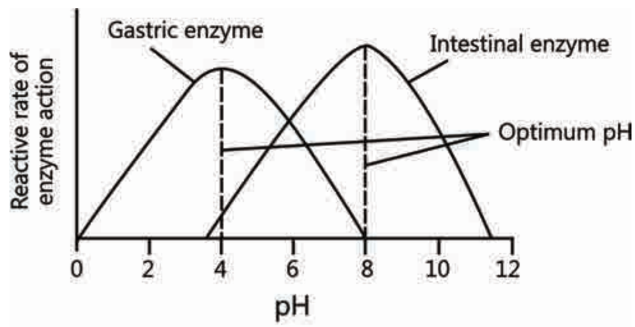
Optimal temperature: It is the temperature at which enzyme works the best and the rate of chemical reaction is the highest. The optimal temperature for most of the enzymes in the human body is 37° C.

At cold temperature, the enzyme works slowly or not at all. It works best at normal temperature and denatures at high temperatures.

- **pH (measure of acidity):** Enzymes function optimally at certain pH and are certainly sensitive to the changes in the pH. Changes in the pH can make or break chemical bonds in the active binding site and thereby decreasing its effectiveness. If the pH is too high (acidic) or low (basic), the enzyme denatures. However there are exceptions, digestive enzymes in the stomach function at pH of 3-4.



Optimal pH for most of enzyymes in our body is pH 8



Optimal pH of the digestive enzyymes

Figure 11.22: Graph of enzyme activity vs pH of medium

Figure 11.23: Graph of rate of reaction vs pH of medium

- **Concentration of the substrate:** As the enzyme concentration increases, the rate of reaction also increases until a point when the amount of substrate available becomes limited. Similarly, when the substrate concentration is low, the rate of reaction is also slow.

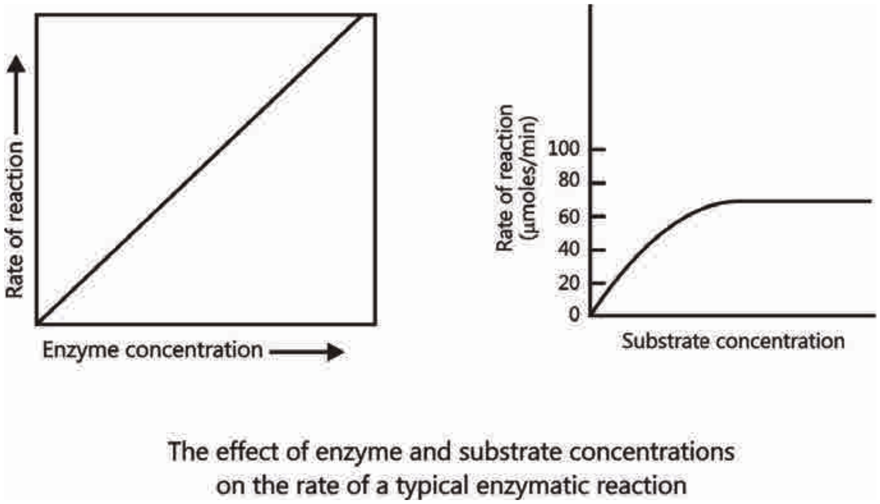


Figure 11.24: Graph of rate of reaction vs enzyme concentration and rate of reaction vs substrate concentration

7.4 Enzymes Speed Up Reactions

The chemical reactions require a certain amount of energy to initiate which is called as **activation energy** or **free energy** for the **activation**. A cell has several substrates, which have average kinetic energy, in which some have higher and some lower than the average energy. In normal temperature, the molecules with relatively high energy probably react to form the product. This is a slow process.

The increase in the reaction rate is due to the raise in the mixture temperature. The heat increases the molecular kinetic energy that causes collisions and reaction between them.

Enzyme fastens the reaction as it lowers the required activation energy and allows several number of molecules to react at time. It is a known fact that the enzymes have substrate slot where it combines and bring several similar ones closer which collide in the most suitable location and directions where the reaction occurs. The inorganic catalysts work in the same manner. When the substrate binds to the enzymes, there is a comformational change in the enzyme active sites that actually "push" or let a substrate molecule to start an interaction.

Starch hydrolysis which gives glucose is an organic chemical reaction. The physical or chemical process rate is equal to the amount of product formed per unit time.

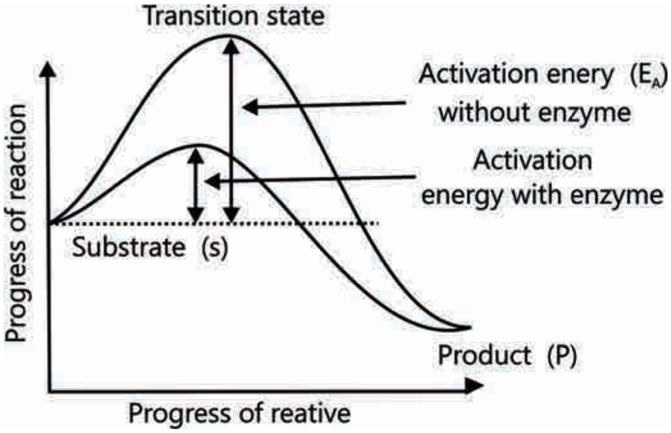


Figure 11.25: Graph of potential and progress of reaction

Requirement of Activation energy uncatalysed and enzyme-catalysed reactions.

Reactants take energy from their surroundings to climb the hill or raise their activation energy (EA) so that they reach the short-lived, unstable and transitional state.

Enzymes reduce the uphill climb activation energy required to reach the transition state. Here the reactants are in an unstable condition and reaction can occur.

7.5 Mode of Enzyme Action

- **Emil Fischer** in 1894 proposed **Lock and key hypothesis**.
- **Koshland** in 1959 proposed the **Induced Fit Theory** of the enzymes. According to this theory the active site of the enzyme contains two groups, buttressing and catalytic. The buttressing group is meant for supporting the substrate.

7.5.1 Mechanism of Enzyme Action

Two hypothesis have been put forward to explain the mode of enzyme action.

Substrate: It is the reactant in the chemical reaction that is catalyzed by the enzyme. **Active site:** It is the part of the enzymes that bind to the substrate. The shape of the active site determines which substrate binds with that particular enzyme.

ES-Complex: When the enzyme binds temporarily to the substrate, enzyme–substrate complex is formed.

Activation energy is required for the chemical process to occur. At the end of the chemical process, the activation energy is reduced. New product or products are formed after the completion of the reaction and the enzyme is released to be reused.

- **Lock and Key model:** Enzyme specificity is often described using lock and key model. The shape of the **active site (lock)** determines which **substrate (key)** will fit into the enzyme. If the substrate cannot fit into the active site, the enzyme cannot catalyze the chemical reaction.

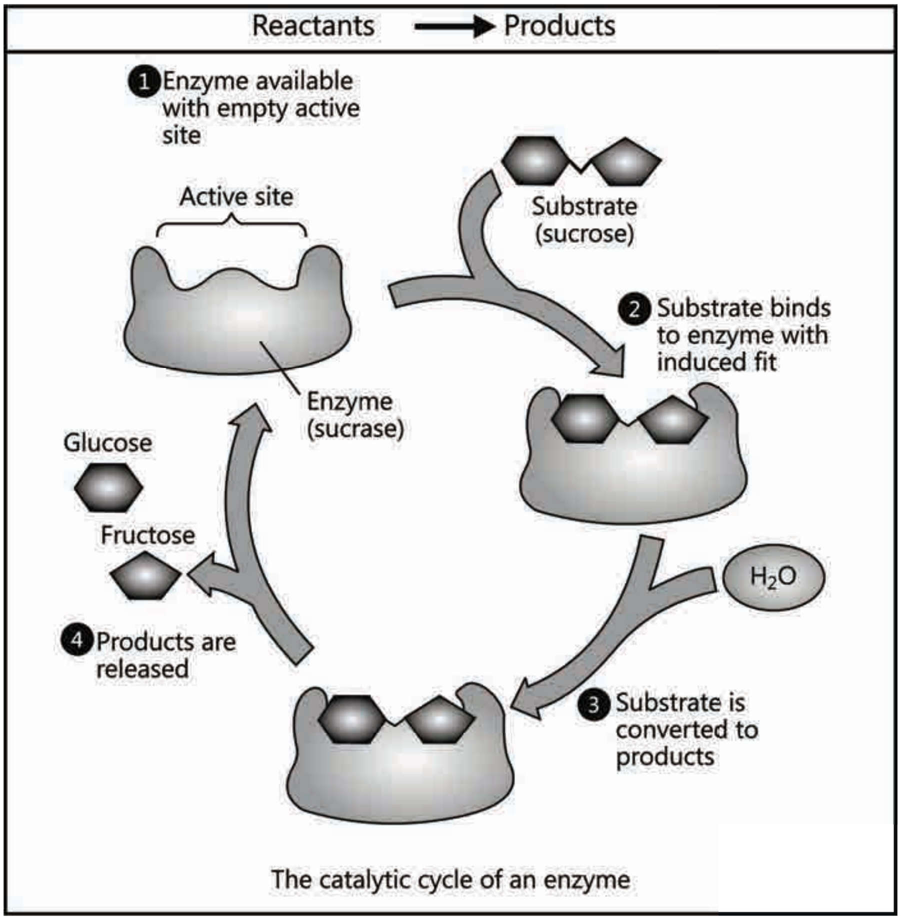


Figure 11.26: Diagram of enzyme action on substrate to produce product

The active sites have special molecules with **$–NH_2$, -COOH, -SH** that ensure the enzyme contact with the substrate molecules. Like a lock which can be opened with its **specific key**, a substrate molecule can only bind to a particular enzyme. Once substrate comes in contact with the enzyme active site, the substrate molecules or reactants form a complex enzyme-substrate complex. In the enzyme substrate complex, the substrate molecules **undergo chemical changes** to form **products**. The product now leaves the enzyme as it no longer fits into the **active site**. Thus it leaves the enzyme unchanged which can participate in the other reactions.

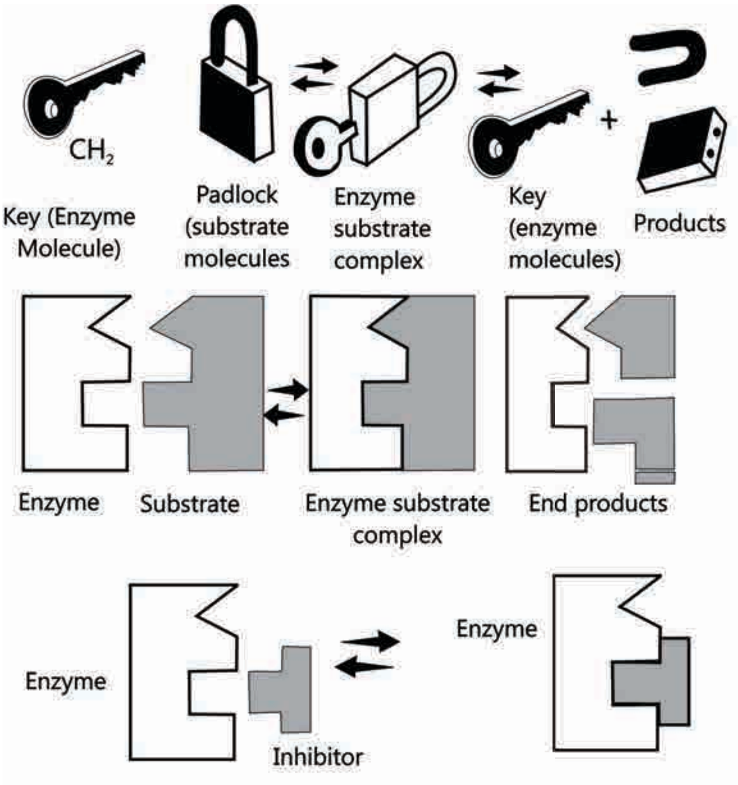


Figure 11.27: Lock and key hypothesis in enzymes

Enzyme + Substrate $\rightleftharpoons$ Enzyme – Substrate Complex

Enzyme – Substrate Complex $\rightleftharpoons$ Enzyme + End Products

- **Induced Fit Hypothesis:** The enzymes do not have **active site** in shape initially which is complementary to the substrate however it is induced so that enzyme has the complementary shape as the substrate binds the enzyme. Enzymes **active site** is a **crevice** or a **pocket** into which the substrate fits. Thus, enzymes through their active site, catalyse reaction at a high rate. The enzyme active site have two groups-(a) **Buttressing group** that supports the substrate. (b) **Catalytic group** that catalyses the reaction. As soon as the substrate is in contact with the buttressing group, the active site changes such that bring the catalytic group opposite the substrate bonds that are to be broken.

Iso-enzymes

Enzyme has multiple molecular forms and similar substrate activity (synthesized on different genes) that are present in the same cell which are called as iso-enzymes. **100 enzymes** are known to have iso-**enzyme** such as

α -**amylase** of wheat endosperm has **16** iso-enzymes.

Lactic acid dehydrogenase has 5 iso-enzymes

Alcohol dehydrogenase has 4-iso-enzymes

7.5.2 Site of Enzyme Action

- **Intracellular Enzymes:** The **endoenzymes** are dissolved in the **cytoplasmic matrix**. The liver cells are ground in water and the contents have all the **eleven enzymes** that are necessary to change glucose into **lactic acid**. Similarly several enzymes are bound to particles, such as ribosomes, **mitochondria** and **chloroplast**.
- **Extracellular Enzymes:** The **exoenzymes** are secreted from the cells and function outside them. The mainly include the digestive enzymes, e.g., salivary amylase, gastric pepsin, pancreatic lipase; which are secreted from the salivary glands, gastric glands and pancreas, respectively. Tears have lysozyme and the **nasal seccretion** work outside the cell in which they are produced.

7.5.3 Inhibition of Enzyme Action

The enzyme activity is sensitive to specific chemicals that bind to the enzyme. When the **chemical binding** closes the **substrate site** then the **enzyme activity stops**, the process is called as inhibition and the chemical responsible is called an **inhibitor**.

Following types of enzyme inhibition can occur

- **Competitive Inhibition**

The enzyme action may be reduced or inhibited in the presence of chemical that is similar to the substrate in molecular structure, called as a Competitive Inhibitor of that enzyme. The inhibitor competes with the substrate as both can attach to the enzyme for the substrate-binding site. Consequently, the substrate product reaction does not occur. e.g., the inhibition of succinic dehydrogenase by molecule malonate, which is similar to the substrate succinate in structure.

- **Non-competitive Inhibition**

For example **Cyanide** kills an animal as it inhibits the cytochrome **oxidase**, which is a **mitochondrial enzyme** required in cellular respiration. Here the **inhibitor** (cyanide) is different from the substrate (cytochromec) and thus does not bind the enzyme at the substrate-binding site. However, the inhibitor binds at some other site of the enzyme. Thus, **substrate binding** does occur, however, reaction for product formation does not take place.

- **Allosteric Modulation or Feedback Inhibition**

The activities of some enzymes, (which form a part of a chain of reactions like in metabolic pathway), are regulated in the cell. There are specific low molecular weight chemicals that are the product(s) of another enzyme further on in the chain, acts as the inhibitor. Such a modulator substance binds with a specific site of the enzyme which is different from its substrate-binding site. This binding increases or decreases the enzyme action. Such enzymes are called Allosteric Enzymes.

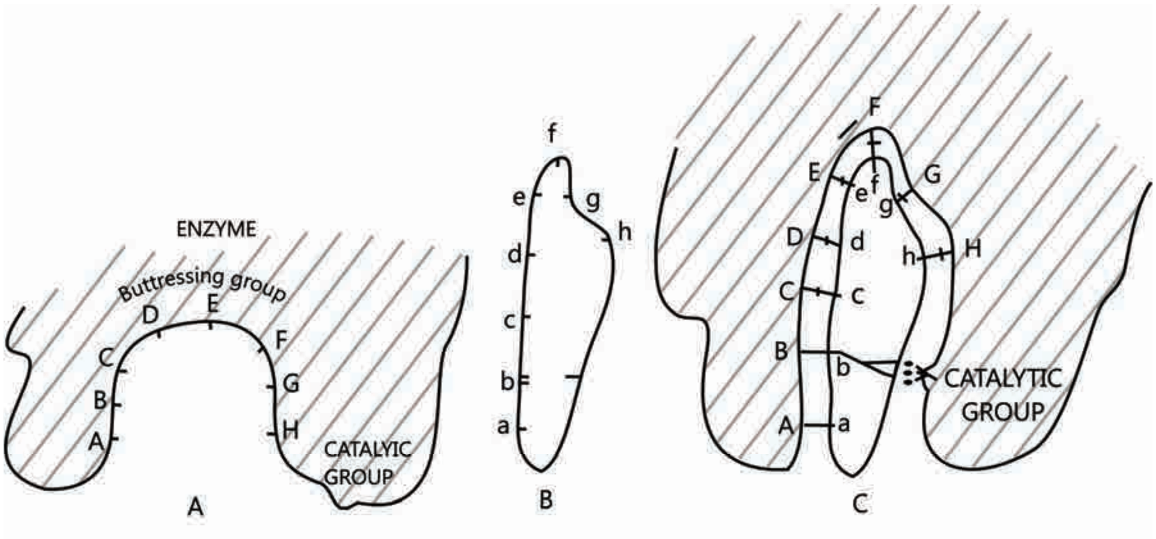


Figure 11.28: Induced fit enzyme theory: **A.** Active site of enzyme, **B.** Substrate molecule and **C.** Enzyme substrate complex

Examples:

- Hexokinase which changes glucose to glucose – 6 – phosphate in glycolysis. Decline in enzyme activity by the allosteric effect of the product is called Feedback Inhibition, e.g., allosteric inhibition of hexokinase by glucose-6-phosphate.
- Enzyme phosphofructokinase is activated by ADP and inhibited by ATP.
- Another example is inhibition of threonine deaminase by isoleucine. Amino acid isoleucine. Amino acid isoleucine is formed in bacterium *Escherichia coli* in a 5-step reaction from threonine. When isoleucine accumulates beyond a threshold value, its further production stops.

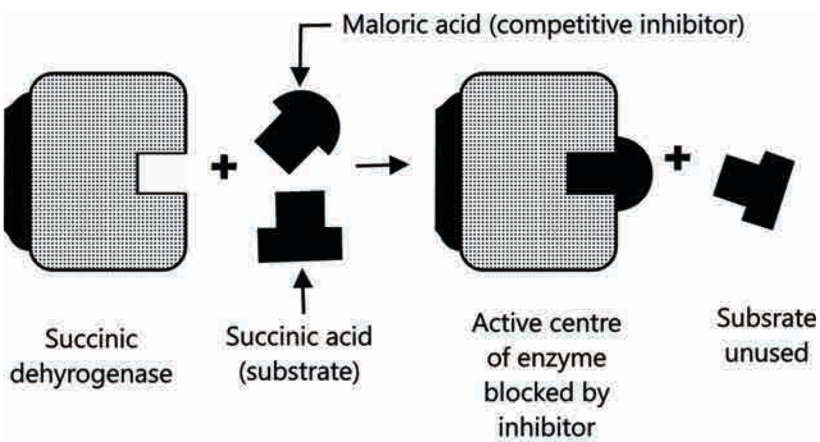


Figure 11.29: Competitive inhibition of enzyme

Inhibitors of Enzyme Activity

Any substances than can diminish the velocity of an enzyme-catalyzed reaction is called an inhibitor. Reversible inhibitors bind to enzymes through non-covalent bonds. Dilution of the enzyme-inhibitor complex results in dissociation of the reversibly-bound inhibitor and recovery of enzyme activity. Irreversible inhibition occurs when an inhibited enzyme does not regain activity upon dilution of the enzyme-inhibitor complex. Some irreversible inhibitors act by forming covalent bonds with specific groups of enzymes; for example, the neurotoxic effects of certain insecticides are due to their irreversible binding at the catalytic site of the enzyme acetylcholinesterase. The two most commonly encountered types of inhibition are competitive and noncompetitive.

- **Competitive inhibition:** This type of inhibition occurs when the inhibitor binds reversibly to the same site that the substrate would normally occupy, therefore, competes with the substrate for that site.
  - **Effect on V_{max}:** The effect of a competitive occurs when the inhibitor binds reversibly to the same site that the substrate would normally occupy, therefore, competes with the substrate for that site.
  - **Effect on K_m:** A competitive inhibitor increases the apparent Km for a given substrate. This means that in the presence of a competitive inhibitor more substrate is needed to achieve ½ V_{max}. E.g., sulpha drugs for folic acid synthesis in bacteria and inhibition of succinic dehydrogenase by Malonate.

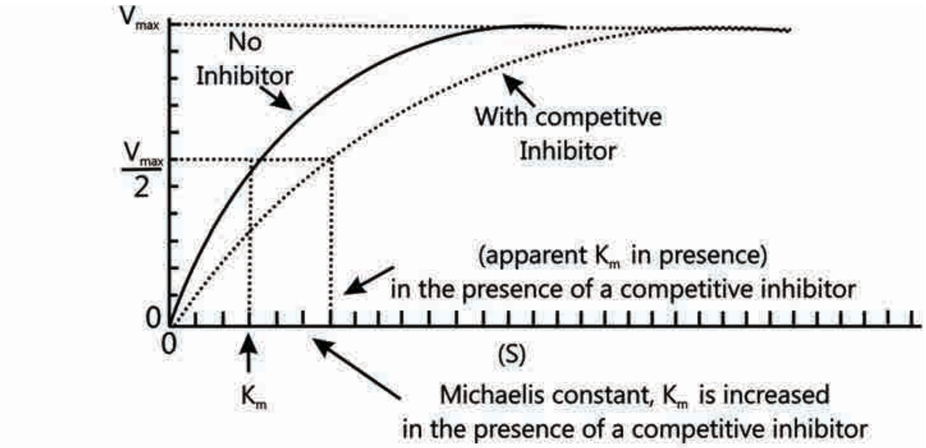


Figure 11.30: Competitive inhibitor affecting reaction velocity is plotted against substrate

- **Non-competitive inhibition:** This type of inhibition is recognized by its characteristic effect on V_{max}. Non-competitive inhibition occurs when the inhibitor and substrate bind at different sites in the enzyme. The non-competitive inhibitor can bind wither free enzyme or the ES complex, thereby preventing the reaction from occurring.
  - **Effect on V_{max}:** Non-competitive inhibition cannot be overcome by increasing the concentration of substrate. Thus, non-competitive inhibitors decrease the V_{max} of the reaction.
  - **Effect on K_m:** Non-competitive inhibitors do not interfere with the binding of substrate to enzyme. Thus, the enzyme shows the same K_m in the presence or absence of the non-competitive inhibitor. E.g., cyanide kills an animal by inhibiting cytochrome oxidase.

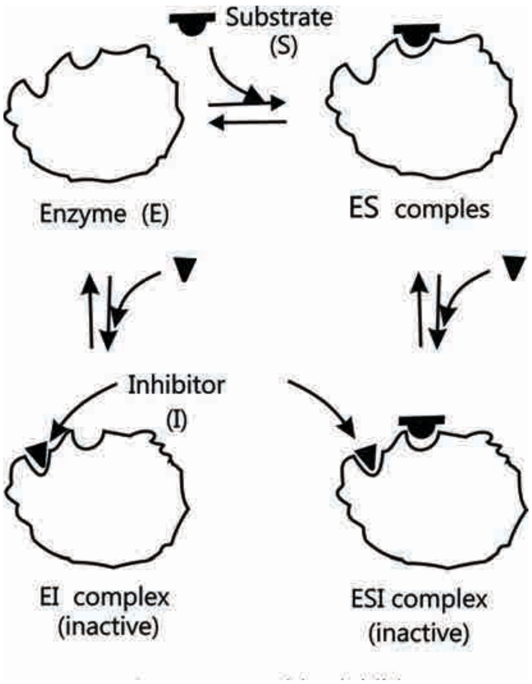


Figure 11.31: Non-competitive inhibitor binding to free enzyme forming a complex

7.6 How Do Enzymes Catalyze Chemical Reaction?

Enzyme speed up the chemical reaction by lowering the activation energy (the amount of energy required to start a reaction). A strain is applied on the 3-D shape of the substrate upon binding of the substrate to the active site of the enzyme and thus specific chemical bond in the substrate is weakened. Once the chemical bond is weakened, it takes less energy to break the bond.

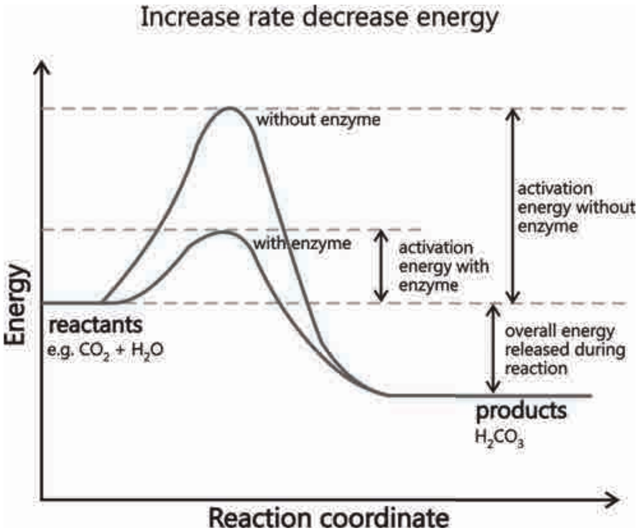


Figure 11.32: Graph of energy and reaction coordinate

7.7 Cofactors

The catalytic activity of an enzyme depends on the presence of small molecules called as **cofactors** which activate enzyme. An enzyme without its cofactor is termed as **Apo enzyme**.

Apo enzyme + Cofactor = Holoenzyme

There are three kinds of cofactors - prosthetic groups, co-enzymes and metal ions.

- **Prosthetic group:** These compounds are tightly integrated into the enzyme structure by covalent or non-covalent forces. For example, in peroxidase, the catalyze breakdown hydrogen peroxide to water and oxygen. Haem in haemoglobin is the prosthetic group and it is a part of the active site of the enzyme. It can be organic or inorganic (metal ions). Example: Organic: Flavin mononucleotide (FMN), Flavin adenine dinucleotide (FAD), Biotin Inorganic: metals are most common prosthetic group: Co, Cu, Mg, Mn, Zn, Fe
- **Co-enzymes:** Co-enzymes are organic compounds and their association with the apo enzyme is only during the course of catalysis. Furthermore, co-enzymes serve as co-factors in a number of different enzyme catalyzed reactions. The essential chemical components of many co-enzymes 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. This activity forms coordination bonds with side chains at the active site and at the same time, forms one or more coordination bonds with the substrate. For example, 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 co-factors play a crucial role in the catalytic activity of the enzym

Did You Know

- The Chargaff's rule is not valid (true) for RNA. It is valid only for double helical DNA. i.e. for RNA it is A $=$ U and G $\equiv$ C.
- The duplication of DNA was first of all proved in *E.coli* bacterium.
- *E.coli* bacterium is mostly used for the study of DNA duplication.
- Hargovind Singh Khurana first of all recognized the triplet codon for cysteine and valine amino acids.
- Cytoplasmic DNA is 1%–5% of total cell DNA.
- Three lady scientists named Avery, Mc-Leod and Mc Carty (by their transformation experiments on bacteria) proved that DNA is a genetic material.
- Hershey and Chase first of all proved that DNA is genetic material in bacteriophages.
- Frankel and Cornet proved, RNA as a genetic material in viruses (g-RNA).
- AUC
    - ACU These anticodons do not exist.
    - AUU

Did You Know

- The structure formed by the combination of mRNA and Ribosomes is known as polyribosomes/Polysomes/Ergosomes
- The formation of tRNA takes place from the heterochromatin part of DNA.
- The formation of mRNA takes place from the Euchromatin part of DNA.
- mRNA is least stable. It is continuously formed and finished.
- In cytoplasm, tRNA is present in the form of soluble colloid.
- Nucleases – Nucleases are the breaking enzymes of nucleic acids. These are of two types –
  - **Endo-nucleases –** These break down the nucleic acids from the inside.
  - **Exo-nucleases –** These break down the nucleic acids from the ends (terminal ends).
  - These separate each nucleotide.
- Tay-Sachs- disease-
  - This disease takes place due to excess storage of glycolipids.
- Excess storage of cerebrosides leads to Guacher's disease.
- Some Inhibitors of Bacterial Protein Synthesis :

Antibiotic	**Effect**
Tetracycline	Inhibits binding of amino-acyl tRNA to ribosome
Streptomycin	Inhibits initiation of translation and causes misreading
Chloramphenicol	Inhibits peptidyl transferase and so formation of peptide bonds
Erythromycin	Inhibits translocation of ribosome along mRNA
Neomycin	Inhibits interaction between tRNA and mRNA.

- Higher Nucleotide: Nucleotides which contain more than one phosphate i.e. ATP, ADP.

  ATP: Discover – Karl Lohmann. It is made up by Adenine, D-Ribose and three phosphate. It is a high energy compound that release energy when the bond between the phosphate is broken. In ATP two high energy bonds are present. ATP is also called energy currency of cell.
- $\oint$ ×174 bacteriophage has 5386 nucleotides. λ bacteriophage has 48502 base pairs, *Escherichia coli* has 4.6×106 base pairs and 6.6×109 base pairs in human (2n)

Summary

- There are diversity among living organisms, yet their chemical composition and metabolic reactions are similar. The living tissues and non-living matter when tested for the elements are found to be similar qualitatively and qualitatively. Finer details of the relative abundance of carbon, hydrogen and oxygen is higher in living systems as compared to the inanimate matter. The most abundant chemical in living organisms is water.

- There are thousands of small molecular weight (<1000Da) biomolecules. Amino acids, monosaccharide and disaccharide sugars, fatty acids, glycerol, nucleotides, nucleosides and nitrogen bases are major organic compounds present in all the living organisms. There are 21 types of amino acids and 5 types of nucleotides. Fats and oils are glycerides in which fatty acids are esterified to glycerol. Phospholipids have a phosphorylated nitrogenous compound. They are found in cell membrane. Lecithin is one example of a phospholipid. Living organisms have a numbers of carbon compounds in which heterocyclic rings can be found. Some of these are nitrogenous bases- adenine, guanine, cytosine, uracil and thymine, Which are attached to sugar, then called as nucleosides. When a phosphate group also gets esterified with the sugar, then they are called as nucleotides. DNA and RNA are nucleic acids in the cell which serve as genetic material.

  Adenosine, guanosine, thymidine, uracil and cytidine are nucleosides. Adenyclic acid, thymidylic acid, guanylic acid, uridylic acid and cytidylic acid and cytidylic acid are nucleotides.

- Three types of macromolecules: Proteins, nucleic acids and polysaccharides are found in living systems. Lipids are associated with the membranes get separated in the macromolecular fraction. Biomacromolecules are mostly polymers which are made up of different building blocks. Biomacromolecules have a hierarchy in their structural organization – primary, secondary, tertiary and quaternary. Proteins are heteropolymers made of amino acids. Proteins have several cellular functions. Many proteins are enzymes, some are antibodies, some are receptors, some are hormones and some others are structural proteins. Most abundant protein is collagen in animal world and Ribulose bisphosphate carboxylase-oxygenase (RubisCO) is the most abundant protein in the whole of the biosphere. Polysaccharides are present in plant, fungi cell wall, and also in the exoskeleton of arthropods. They also make the storage forms of energy (e.g. starch and glycogen).

- Enzymes are protein in nature which catalyze several biochemical reactions in the cells. Ribozymes are nucleic acids which can also catalyze. Proteinaceous enzymes are substrate specific, work best at optimum temperature and pH for maximal activity. They are denatured at high temperatures. Enzymes lower activation energy of reactions and enhance the rate of the reactions greatly. Nucleic acids carry hereditary information and are passed on from parental on from parental generation to progeny.

- Cofactors are non-protein parts which are bound to the enzyme so that it is catalytically active. The protein portion of such enzymes is called as the apoenzyme. Cofactors are prosthetic groups, coenzymes and metal ions.
- Prosthetic groups are organic compounds which are different from other cofactors. They have strong bonds with the apoenzyme. Peroxidase and catalase are enzymes that catalyze the hydrogen peroxide hydrolysis to water and oxygen, now in hemoglobin haem is the prosthetic group which is a part of the active site of the enzyme.
- Co-enzymes are organic compounds and their association with apoenzyme is temporary, during the catalysis. NAD, NADP are co-enzymes that contain niacin vitamin.
- Several enzymes require metal ions which form coordination bonds and side chains at the active site e.g. zinc is a cofactor for the proteolytic enzyme carboxypeptidase.

EXERCISE

Objective Questions

Q.1 Both in cells and extracellular fluids diabasic phosphate (HPO_4^{2-}) monobasic phosphate ($H_2PO_4^-$) act as acid base buffers to maintain

(A) K concentration of extracellular fluid

(B) Na^+ concentration of extracellular fluid

(C) Na^+ concentration of cellular fluid

(D) H^+ concentration of cellular fluid

Q.2 All the following statements are correct except

(A) Mitochondria are rich in manganese

(B) Molybdenum is necessary for fixation of nitrogen catalysed by the enzyme nitrogenase

(C) Magnesium is essential for a large number of enzymes, particularly those utilizing ATP

(D) Calcuium and magnesium have no effect on the excitability of nerves and muscles

Q.3 The most abundant element in cell/living matter is

(A) C (B) H (C) O (D) N

Q.4 Which element is/are found in cytochromes?

(A) Fe^{++} and Cu^{++} (B) Fe^{+++} and Mg^{++} (C) Mg^{++} (D) Cu^{++}

Q.5. He concentration of Na, K, and Ca in a cell in decreasing order is

(A) K – Na – Ca (B) K – Ca – Na (C) Na – K – Ca (D) Ca – K – Na

Q.6. All the macromolecules are the result of the process of polymerization, a process which repeating subunits termed monomers are bound into chains of different lengths except

(A) Nucleic acids (B) Carbohydrates

(C) Lipids (D) Proteins

Q.7. Raffinose has three monosaccharide units. Those are

(A) Glucose, pentose and maltose (B) Glucose, levulose and sucrose

(C) Glucose, fructose and sucrose (D) Fructose, fructose and galactose

Q.8. A monosaccharide is a simple poly hydroxy aldehyde or ketone molecules, which cannot be further hydrolysed into smaller units. The number of carbon atoms in monosaccharide vary from of carbon atoms in monosaccharide vary from

(A) 2-8 carbons (B) 2-7 carbons (C) 3-6 carbons (D) 3-7 carbons

Q.9. The sweetest amongst all naturally occurring sugars is

(A) Glucose (B) Fructose (C) Mannose (D) Galactose

Q.10. Glucose is

(A) Aldose hexose sugar (B) Ketose hexose sugar

(C) Pyranose pentose sugar (D) Furanose pentose sugar

Q.11. Glucose is also called

(A) Dextrose (B) Corn sugar (C) Grapes sugar (D) All of these

Q.12. Why sucrose and not glucose is used to preserve fruits products?

(A) Glucose is reactive as it has a CHO group

(B) Sucrose is move common in nature

(C) Sucrose is easily available and has both glucose and fructose

(D) None of these

Q.13. Honey has two sugars. They are

(A) Glucose and mannose (B) Glucose and galactose

(C) Dextrose and levulose (D) Dextrose and lactose

Q.14. Which of the following is not reducing sugar?

(A) Glucose (B) Lactose (C) Maltose (D) Sucrose

Q.15. Which of the following will yield only glucose on Hydrolysis?

(A) Sucrose (B) Lactose (C) Maltose (D) Raffinose

Q.16. Storing carbohydrates in the form of polysaccharides has following advantages

(A) During their formation many molecules of water are removed from monosaccharide (dehydration synthesis), condensing the bulk to be store

(B) When necessary polysaccharides are broken down by enzymes for the release of energy

(C) Unlike small carbohydrates polysaccharide are relatively easy to store

(D) All of these

Q.17. The most abundant organic compound in biosphere is

(A) Lignin (B) Cellulose (C) Pectin (D) Hemi-cellulose

Q.18. The largest amount (90%) of cellulose amongst the Natural materials is present in

(A) Wood (B) Cotton fibres (C) Rayon (D) Roughage

Q.19. Carbohydrates, the most abundant biomolecules on earth, are produced by

(A) Some bacteria, algae and green plants cells

(B) Fungi, algae and green plant cells

(C) All bacteria, fungi and algae

(D) Viruses, fungi and algae

Q.20. Cellulose is

(A) Heptopolysaccharide

(B) Heteropolysaccharise, branched

(C) Hexan polysaccharide, unbranched

(D) Pentosan polysaccharide, branched

Q.21. Which of the following is added to ice creams, cosmetics and medicines to emulsify and give a smooth texture?

(A) Cellulose acetate (B) Cellulose nitrate

(C) Carboxy methyl cellulose (D) Cellulose

Q.22. Chitin is the second most abundant organic substance present in the exoskeleton of insects and crustaceans. It is a

(A) Protein

(B) Polysaccharide and the basic unit is N-acetyl glucosamine

(C) Protein and $CaCO_3$ deposits in it

(D) Lipid

Q.23. One of the following is correct sequence of carbohydrates in the order of increasing complexity of chemical structure

(A) Sucrose, starch, oligosaccharide, maltose, triose

(B) Triose, maltose, sucrose, oligosaccharide, starch

(C) Triose, glucose, maltose, oligosaccharide, starch

(D) Oligosaccharide, triose, starch, sucrose, maltose

Q.24. Which one is a carbohydrate?

(A) Inulin (B) Raphide (C) Aleurone (D) Cystolith

Q.25. The centre of the starch grains is called hilum. It is made up of

(A) Protein (B) Carbohydrate (C) Fat (D) Nitrogen

Q.26. Which one is a fibrous polysaccharide?

(A) Starch (B) Glycogen (C) Cellulose (D) Mucilage

Q.27. Glucose is stored as glycogen in

(A) Pancreas (B) Bone (C) Kidney (D) Liver

Q.28. Which of the following yield purgative?

(A) Hibiscus asculentus (B) Plantago ovate

(C) Aloe barbadensis (D) Both (B) and (C)

Q.29. Choose the odd one out

(A) Keratin phosphate (B) Plantago ovate (C) Chondriotin sulphate (D) Alginic acid

Q.30. A cellulose molecule is formed by the polymerisation of glucose. The number of glucose molecules present in a cellulose is

(A) 600 (B) 6000 (C) 60,000 (D) 60

Q.31. Mucilages are polysaccharides formed from galactose and mannose. They are slimy substances. one of the following is not a mucilage

(A) Agar (B) Alginic acid (C) Rayon (D) Carrageenan

Q.32. Starch grains of rice are

(A) Dumb-bell shaped (B) Simple eccentric

(C) Simple concentric (D) Compound

Q.33. Cellulose form a major portion of food of grazing cattle. It is

(A) Digested by the gut bacteria

(B) Digested by the animal itself

(C) Digested partly by animal and partly by the bacteria

(D) Passed out undigested

Q.34 The number of monosaccharide units in a polysaccharide is

(A) 2 (B) 7 (C) 10 (D) More than 10

Q.35. A bond which is formed between aldehyde or ketone group of monosaccharide and alcoholic group of another organic compound is known as

(A) Peptide bond (B) Glycosidic bond

(C) Phosphodiester bond (D) Ester bond

Q.36. Which one of the following is saturated fatty acid?

(A) Oleic acid (B) Linoleic acid

(C) Linolenic acid (D) Stearic acid

Q.37. Which of the following is the most essential fatty acid?

(A) Linoleic (B) Linolenic (C) Arachidonic (D) Stearic

Q.38. Lecithin is

(A) Fatty acid

(B) Phospholipid with choline attached to phosphate group

(C) Cholesterol

(D) Fat

Q.39. Bee wax is secreted by

(A) Drones (B) Workers (C) Queen (D) Honey

Q.40. Which of the following is a phospholipid?

(A) Lecithin (B) Glycerol (C) Oleic acid (D) Prostaglandin

Q.41. Keratin is a protein having larder amount of

(A) Sulphur (B) Calcium (C) Magnesium (D) Phosphorous

Q.42. Waxes are simple lipids formed by the combination of long chain fatty acid with long chain monohydric alcohol. Bee was is made up of

(A) Palmitic and mericyl alcohol (B) Hexacosyl palmitate

(C) Ergosterol (D) Both (A) and (B)

Q.43. Which is not a lipid?

(A) Lecithin (B) B-keratin (C) Sterol (D) Wax

Q.44. An antifertility steroid is

(A) Diosgenin (B) Cortisol (C) Estradiol (D) Progesterone

Q.45. In brain, most common types of lipids are

(A) Glycolipids (B) Lipoproteins (C) Phospholipids (D) Steroids

Q.46. Find the odd one out

(A) Palmitic acid, stearic acid (B) Oleic acid, linoleic acid

(C) Linoleic acid, oleic acid (D) Tripalmitin, linoenic acid

Q.47. Which of the following are basic amino acids?

(A) Glycine and Alanine (B) Lysine and Arginine

(C) Glutamic acid and Aspartic acid (D) Histidine and Proline

Q.48. Which of the following is the simplest amino acid?

(A) Alanine (B) Asparagine (C) Glycine (D) Tyrosine

Q.49. The hormone adrenaline (epinephrine) is formed from which of the following amino acids?

(A) Glycine (B) Tyrosine (C) Tryptophan (D) Alanine

Q.50. Which of the following amino acids is involved in the formation of heme?

(A) Tryptophan (B) Tyrosine (C) Glycine (D) Histidine

Q.51. Vitamin nicotinamide as well as the plant hormone indole-3-acetic acid are formed from

(A) Tryptophan (B) Alanine (C) Glutamic acid (D) Serine

Q.52. On losing the carboxyl group as carbon dioxide amino acids form biologically active

(A) Glucose (B) Amine such as histamine

(C) Alcohol (D) N-base

Q.53. Skin pigment melanin is formed from

(A) Tyrosine (B) Adrenaline

(C) Indole-3-acetic acid (D) Tryptophan

Q.54. Which one of the following is alcoholic amino acid pair

(A) Tyrosine and serine (B) Threonine and serine

(C) Phenylalanine and tyrosine (D) Tryptophan and phenylalanine

Q.55. One of the following is not an essential amino acid

(A) Tryptophan and valine
(B) Lysine and methionine
(C) Leucine and isoleucine
(D) None of these

Q.56. One of the following amino acids does not contain sulphur

(A) Tryptophan (B) Methionine (C) Cystine (D) Cysteine

Q.57. One of the following is heterocyclic amino acid

(A) Proline (B) Histidine (C) Hydroxyproline (D) All of these

Q.58. One of the following is a neutral amino acid

(A) Arginine (B) Glycine (C) Glutamic acid (D) Aspartic acid

Q.59. Which of the following is a non-polar amino acid?

(A) Alanine (B) Glutamic acid (C) Serine (D) None of these

Q.60. B-pleated structure of protein is present in silk fibres, the protein is

(A) Fibroin (B) Collagen (C) Rayon (D) Keratin

Q.61. Keratin of hair has

(A) Secondary structure
(B) Helical structure
(C) B-pleated structure
(D) Primary structure

Q.62. Most of the blood proteins in our body are

(A) Basic (B) Acidic (C) Neutral (D) Basic and Neutral

Q.63. Casein of milk is

(A) Glycoprotein
(B) Phosphoprotein
(C) Chromoprotein
(D) Metalloprotein

Q.64. Prolamines are

(A) Associated with nucleic acids
(B) Storage proteins
(C) Structural protein
(D) Structural protein

Q.65. Which of the protein is involved in the transport of organic compounds through phloem?

(A) Protamine (B) P-Protein (C) Myosin (D) Glutelin

Q.66 Cheese is a

(A) Protamine (B) P-Protein (C) Myosin (D) Glutelin

Q.67 The storage protein of wheat is

(A) Glutelin (B) Oryzin (C) Hordein (D) Zein

Q.68 The type of prolamines and glutelins found in wheat are

(A) Zein and gladin (B) Glutelin and hordein

(C) Gliadin and glutenin (D) Hordein and zein

Q.69 Which of the following is a contractile protein?

(A) P-protein (B) Myosin (C) Albumin (D) Permeases

Q.70 The storage protein found in castor oil seeds is

(A) Legumin (B) Tuberin (C) Ricin (D) Leucosin

Q.71 A fibrous protein is

(A) Keratin (B) Histone (C) Albumin (D) Glutelin

Q.72 Lysine is an essential amino acid because

(A) It is very rare

(B) It has a high nutritive value

(C) It is an important constituent of all proteins

(D) It is not formed in the body and has to be provided through diet

Q.73 The backbone of a nucleic acid strand in made up of

(A) Base and phosphate (B) Sugar and phosphate

(C) Sugar and base (D) Sugar, base and phosphate

Q.74 Which of the following is not present in DNA?

(A) Cytosine (B) Adenine (C) Guanine (D) Thiamine

Q.75 Nucleotides take part in

(A) Information transfer system

(B) Energy transfer system

(C) Formation of NAD and FAD which act as coenzymes of oxidising enzymes

(D) All of these

Q.76 A nucleotide is made up of

(A) (Base-Sugar-Phosphate)n

(B) Nitrogenous base and sugar

(C) Nitrogenous base, sugar and phosphate

(D) Phosphate and N-base

Q.77 Nucleoside on hydrolysis will not yield

(A) Sugar (B) Phosphoric acid

(C) Nitrogenous base (D) Sugar and nitrogenous base

Q.78 Most abundant RNA of the cell is

(A) t-RNA (B) r-RNA (C) m-RNA (D) t-RNA-threonine

Q.79 Which of the following RNA is a carrier that delivers the correct amino acid for protein synthesis?

(A) m-RNA (B) r-RNA (C) hn-RNA (D) t-RNA

Q.80 Anticodon occurs in

(A) DNA (B) t-RNA (C) m-RNA (D) r-RNA

Q.81 Nucleic acids were first discovered by

(A) Altmann (B) Flemming (C) Meischer (D) Koch

Q.82 Which nitrogenous base is not found in RNA?

(A) Adenine (B) Uracil (C) Thymine (D) Cytosine

Q.83 RNA is a polymer of

(A) Ribonucleotides (B) Deoxyribonucleotides

(C) Deoxyribonucleosides (D) Ribonucleosides

Q.84 t-RNA constitutes about

(A) 70% – 80% of the total RNA (B) 15% of the total RNA

(C) 5% of the total RNA (D) 1% – 3% of the total RNA

Q.85 The two strands of DNA are coiled around

(A) Each other (B) Differently

(C) A common axis (D) Different axis

Q.86 In DNA, adenine pairs with

(A) Guanine (B) Thymine (C) Cytosine (D) Uracil

Q.87 Distance between two strands of DNA is

(A) 34 Å (B) 20 Å (C) 3.4 Å (D) 340 Å

Q.88 The denaturation of DNA can take place due to

(A) High pH (B) High temperature

(C) Low pH (D) All of theses

Q.89 The two strands of DNA are held together by bonds of

(A) Nitrogen (B) Oxygen

(C) Hydrogen (D) Carbon

Q.90 The low melting area of DNA is

(A) A-T base pairs (B) A-U base pairs

(C) G-C base pairs (D) Both (A) and (B)

Q.91 Single stranded DNA is found in

(A) Rao virus (B) Bacteriophage

(C) Wound tumour virus (D) Retro virus

Q.92 The term enzyme was coined by

(A) Kuhne (B) Buchner (C) De Duve (D) Boveri

Q.93 All enzymes are proteins except

(A) Trypsin (B) Pepsin

(C) Steapsin (D) Ribozyme and Ribonuclease – P

Q.94 The non-protein organic factor firmly attached to apoenzyme is called

(A) Co-factor (B) Co-enzyme (C) Prosthetic group (D) Activator

Q.95 Enzymes are different from inorganic catatlysts in

(A) Not being used up in reaction (B) Being proteinaceous in nature

(C) Having a high diffusion rate (D) Working at high temperature

Q.96 Identify the correct statement

(A) Enzymes are not proteinaceous

(B) All enzymes participate in metabolic reaction

(C) All enzymes are exhausted in chemical reaction

(D) They are specific in their function

Q.97 The 'turnover number' of an enzyme depends upon

(A) Size of enzyme molecule

(B) Active sites of enzymes molecule

(C) Concentration of substrate molecule

(D) Molecular weight of enzyme

Q.98 What structural level enables the proteins to function as enzymes?

(A) Primary level (B) Secondary level

(C) Tertiary level (D) Quaternary level

Q.99 Enzymes, vitamins, hormones have one thing in common

(A) All are synthesized in organism (B) All enhance oxidative metabolism

(C) All are proteins (D) All aid in regulation metabolism

Q.100 Out of the total enzymes present in cell, mitochondrion alone has

(A) 95% (B) 64% (C) 70% (D) 20%

Q.101 Enzymes are proteins was shown by

(A) Summer (B) Miller (C) Leeuwenhoek (D) Pasteur

Q.102 Protein part of a conjugate enzyme is known as

(A) Apoenzyme (B) Coenzyme

(C) Prosthetic group (D) Cofactor

Q.103 Destructive effect of high temperature on enzyme action is due to

(A) Destruction of tertiary and quaternary structure of enzymes

(B) Formation of linkage between apoenzyme and its cofactor

(C) Acceleration of reverse reaction

(D) All of these

Q.104 Enzymes are

(A) Colloidal in nature
(B) Amphoteric in nature
(C) Highly sensitive
(D) All of these

Q.105 Which statement about enzyme action is wrong?

(A) Their molecular weight is high
(B) They are proteins with complex three dimensional structures
(C) Their rate of diffusion is very high
(D) They act as catalysts and are required in small concentration

Q.106 Enzymes have

(A) Same pH and temperature optima
(B) Same pH but different temperature optima
(C) Different pH but same temperature optima
(D) Different pH and different temperature optima

Q.107 The relationship between 'Turnover number' and K_m is

(A) Direct
(B) Inverse
(C) Linear
(D) None of these

Q.108 A specific low molecular weight substance such as the product of another enzyme in the chain reaction which binds with a specific site of the enzyme different its specific site of the enzyme different from its substrate binding site is called

(A) Competitive inhibitor
(B) Non-competitive inhibitor
(C) Irreversible inhibitor
(D) Allosteric modulator

Q.109 Sulpha drugs control bacterial pathogens by

(A) Non-competitive inhibition
(B) Allosteric modulation
(C) They are competitive inhibitors of folic acid synthesis in bacteria
(D) They control the bacterial pathogens by feedback inhibitions

Q.110 Cyanide kills an animals by

(A) Killing the brain cells
(B) Competitive inhibitor of enzyme cytochrome oxidise
(C) Inhibiting cytochrome oxidase, a mitochondrial enzyme essential for cellular respiration by non-competitive inhibition
(D) Killing the cells of cardiac muscles

Q.111 All are the examples of feedback inhibition except

(A) Inhibition of succinic dehydrogenase by malonate

(B) Inhibition of hexokinase by glucose-6-phosphate

(C) Inhibition of phosphofructokinase by ATP

(D) Inhibition of threonine deaminase by isoleucine

Q.112 One of the following is not a non-competitive inhibitor

(A) HCO_3^- (B) Malonic acid (C) Cyanides (D) H_2S

Q.113 In non-competitive inhibition

(A) The tertiary structure of enzyme is destroyed

(B) The enzyme gets hydrolysed completely

(C) The enzyme gets activated

(D) The inhibitor gets absorbed on the active site of the enzyme

Q.114 In enzyme pepsin

(A) The whole surface of enzyme is active

(B) Two third of amino acids are working actively as enzyme

(C) One third of amino acids are working actively as enzyme

(D) Only one amino acid tyrosine of this enzyme is active and rest amino acids are inactive

Q.115 The term feedback refers to

(A) The effect of substrate on the rate of enzyme action

(B) The effect of end products on the rate of enzymatic action

(C) The effect of enzyme concentration on its rate of action

(D) The effect of an external compound on the rate of enzymatic action

Q.116 Which of the following groups of enzymes catalyses the cleavage of specific covalent bonds and removal or groups without hydrolysis?

(A) Oxidoreductases (B) Hydrolases (C) Lysases (D) Isomerases

Q.117 Lock and key hypothesis was put forward by

(A) Emi fischer (B) Koshland (C) Buchner (D) Kuhne

Q.118 The best evidence for template theory of enzyme action is

(A) Enzymes speed up reactions by definite amounts

(B) Enzymes determine the direction of reaction

(C) Compounds similar in structure to the substrate inhibit the reaction

(D) Compounds dissimilar in structure to the substrate inhibit the eraction

Q.119 Alcohol dehydrogenase enzyme also exists as isoenzyme. The number of isoenzyme forms of alcohol dehydrogenose in maize are

(A) 16 (B) 4 (C) 100 (D) 5

Q.120 According to IUB system of nomenclature the enzymes are divided into

(A) 4 classes (B) 8 classes (C) 10 classes (D) 6 classes

Q.121 The pH required for action of trypsin is

(A) 2 (B) 7 (C) 8 (D) 4.5

Q.122 Enzyme bromelain is found in

(A) Papaya (B) Pineapple (C) Guava (D) Cucurbita

Q.123 Extra cellular enzymes are not found in

(A) Bacteria (B) Fungi

(C) Insectivorous plants (D) Green algae

Q.124 Electron transferring enzymes belong to

(A) Transferases (B) Oxidoreductases

(C) Lyases (D) Isomerases

Q.125 A competitive inhibitor of an enzyme will

(A) Increase K_m without affecting V_{max} (B) Decrease K_m without affecting V_{max}

(C) Increase V_{max} without affecting K_m (D) Decrease both V_{max} and K_m

Q.126 Respiratory distress syndrome in premature infants is due to inadequate secretion of which of the following lipids?

(A) Dipalmitoyl phosphatidylcholine (B) Sphingomyelin

(C) Cholestrol (D) Phosphatidyl inositol

Q.127 The lipoprotein particles that have the highest percentage of concentration in terms of cholesterol are A and in terms of liproprotein are B. Which one of the following is correct option for A and B?

(A) A-Chylomicrons and B-VLDLs
(B) A-HDLs and B-Chylomicron
(C) A-LDLs and B-Chylomicrons
(D) A-LDLs and B-HDLs

Q.128 Which of the following factor/s does not affect enzyme activity?

a. Temperature

b. pH

c. Enzyme concentration

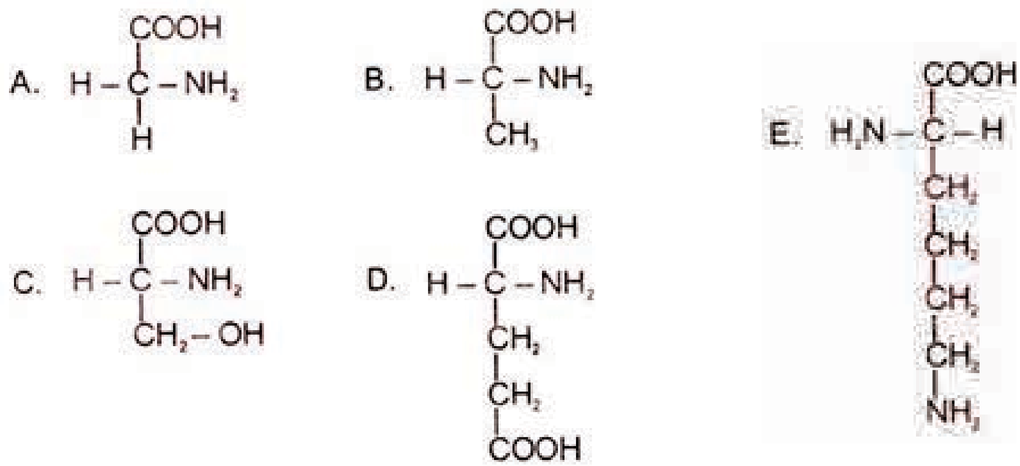
d. Product concentration

e. Substrate concentration

f. Activation energy

(A) c only
(B) c and d
(C) d only
(D) f only

Q.129 The structures of five amino acids are listed below:



Which of these amino acids are both polar and essential?

(A) A and B
(B) B and C
(C) C and D
(D) E only

Previous Years' Questions

Q.1 Kwashiorkor disease develops to ***[MP-PMT-1979]***

(A) Malnutrition (B) Over eating (C) Catalysis (D) Mutation

Q.2 Glycogen is stored in ***[MPPMT, AIPMT-1979]***

(A) Liver and muscles (B) Liver only

(C) Muscles only (D) Pancreas

Q.3 Cholesterol is synthesized in ***[MPPMT-1994]***

(A) Pancreas (B) Brunners gland (C) Spleen (D) Dextrin

Q.4 Which is a disaccharide ***[MPPMT-1994]***

(A) Galactose (B) Fructose (C) Maltose (D) Dextrin

Q.5 Which element is normally absent in proteins ***[RPMT-1995]***

(A) C (B) N (C) S (D) P

Q.6 Which substance is not carbohydrate ***[RPMT-1994]***

(A) Starch (B) Clycogen (C) Wax (D) Glucose

Q.7 To get quick energy one should use ***[RPMT-1994]***

(A) Carbohydrate (B) Fats (C) Vitamins (D) Proteins

Q.8 Protein most abundant in human body is ***[RPMT-1994]***

(A) Collagen (B) Myosin (C) Actin (D) Albumin

Q.9 Which is not polysaccharide ***[RPMT-1994]***

(A) Sucrose (B) Starch (C) Glycogen (D) Cellulose

Q.10 Decreasing order of amount of organic compound in animal body ***[RPMT-1994]***

(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.11 Protoplasm in skin cells, is mostly present in which stage? ***[RPMT-1994]***

(A) Gel (B) Sol (C) Emulsion (D) Aerosol

Q.12 External Coat composed of cellulose like material occurs in ***[RPMT-1994]***

(A) Hemichordate (B) Urochordata
(C) Cephalochordate (D) Cyclostomata

Q.13 Common in feather and silk is ***[RPMT-1994]***

(A) Carbohydrate (B) Fats
(C) Protein (D) Nucleic acid

Q.14 Monosaccharide is ***[RPMT-1993]***

(A) Pentose sugar (B) Hexose sugar
(C) Only glucose (D) All of the above

Q.15 Sugar which found in heamolymph of insects is called ***[RPMT-1993]***

(A) Maltose (B) Lactose (C) Trehalose (D) Galactose

Q.16 Which substance is most abundant in cell ***[RPMT-1993]***

(A) Carbohydrates (B) Protein
(C) Water (D) Fats

Q.17 Proteins which present in protoplasm are very important because ***[RPMT-1993]***

(A) They provide definite shape to cell

(B) They function as biocatalyst

(C) They yield energy

(D) They are stored food

Q.18 Dipeptide is ***[RPMT-1993]***

(A) Structure of two peptide bonds

(B) Two amino acids linked by one peptide bond

(C) Bond between one amino acid and one peptide

(D) None of these

Q.19 Which amino acids is non-essential for human body ***[RPMT-1992]***

(A) Glycine (B) Phenyl alanine
(C) Arginine (D) Methionine

Q.20 In which form the extra sugars stored in the body ***[RPMT-1991]***

(A) Glucose monosaccharide (B) Sucrose disaccharide
(C) Glycogen polysaccharide (D) Fatty acid and glycerol

Q.21 Unit of protein is ***[RPMT-1989]***

(A) Amino acid (B) Monosaccharide
(C) NH_2 (D) Nucleotide

Q.22 Galactosemia disease in children can be prevented if they are provided ***[RPMT-1989]***

(A) Milk less food (B) Proteinaceous milk
(C) More milk (D) Vitamin less milk

Q.23 Glycogen is ***[RPMT-1988]***

(A) Polymer of fatty acid (B) Polymer of amino acids
(C) Poly hydroxyl aldehyde or ketone (D) None of these

Q.24 Carbohydrate is ***[RPMT-1988]***

(A) Polymers of fatty acid (B) Polymer of amino acids
(C) Poly hydroxyl aldehyde or ketone (D) None of these

Q.25 In which form, food stored in animal body ***[RPMT-1988]***

(A) Glucose (B) Glycogen (C) Cellulose (D) ATP

Q.26 Which compound produces more than twice the amount of energy as compared to carbohydrates ***[AIPMT-1975, BHU78]***

(A) Protein (B) Fats (C) Vitamins (D) Glucose

Q.27 What is the normal ratio of sugar in human blood. ***[BHU'1980'1981]***

(A) 0.01% (B) 0.1% (C) 1% (D) 0.18%

Q.28 Carbohydrates are stored in mammals as ***[AIPMT-1981]***

(A) Glucose in liver (B) Glycogen in muscles and spleen
(C) Lactic acid in muscles (D) Glycogen in liver and muscles

Q.29 Carbohydrate metabolism is controlled by ***[AIPMT-1978]***

(A) Parathormone (B) Insulin (C) Glucose (D) Vitamin B_{12}

Q.30 Fattiness is due to the excess of ***[AIPMT-1986]***

(A) Connective tissue (B) Blood
(C) Muscular tissue (D) Adipose tissue

Q.31 Which one of the following is polysaccharide ***[AIPMT-1986]***

(A) Sucrose (B) Lactose (C) Glycogen (D) Glucose

Q.32 Starving person will first use ***[AIPMT-1988]***

(A) Fats (B) Glycogen
(C) Blood protein (D) Muscle protein

Q.33 Units of proteins which unite in long chains to form proteins, are called ***[NCERT,1972 AIPMT-74,76 BHU 77,78]***

(A) Sugar (B) Purines (C) Pyrimidines (D) Amino acids

Q.34 Milk protein is ***[BHU-1981]***

(A) Lactogen (B) Myosin (C) Casein (D) Pepsin

Q.35 Chemically enzymes are ***[NCERT-1977, AIPMT-78]***

(A) Fats (B) Carbhohydrates
(C) Hydrocarbons (D) Proteins

Q.36 Long chain molecules of fatty acids are formed by ***[NCERT-1976]***

(A) Polymerization of 2 carbon compounds (B) Decomposition of fats
(C) Polymerization of glycogen (D) Conversion of glycogen

Q.37 Most simple amino acid is ***[BHU-1986]***

(A) Tyrosine (B) Lysine (C) Glycine (D) Aspartic acids

Q.38 Fats in the body are formed when ***[NCERT-1976]***

(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.39 For body growth and repair one needs ***[AIPMT-1988]***

(A) Carbohydrates (B) Fats (C) Proteins (D) Vitamins

Q.40 In india the best source for proteins in herbivorous persons is ***[NCERT-1976]***

(A) Pulses (B) Potato (C) Egg (D) Meat

Q.41 Proteins are conducted in the body in the form of ***[NCERT-1976]***

(A) Amino acdis (B) Natural proteins
(C) Enzymes (D) Nucleic acids

Q.42 Which is sweet in taste, but is not sugar ***[AIPMT-1983]***

(A) Starch (B) Saccharine (C) Lactose (D) Protein

Q.43 The formation of protein can be considered as ***[AIPMT-1986]***

(A) Dehydration synthesis (B) Dehydration analysis
(C) Hydration synthesis (D) Hydration analysis

Q.44 Translocation of sugars in flowering plants occurs in the form of
[AIPMT-1977-84 , DPMT 1983, RPMT 1998]

(A) Glucose (B) Sucrose (C) Fructose (D) Maltose

Q.45 Sucrose is composed of ***[RPMT-1989]***

(A) Glucose and fructose (B) Glucose and glycogen
(C) Two molecules of glucose (D) Glycogen and fructose

Q.46 Which of the following amino acid is essential ***[RPMT-1997]***

(A) Alanine (B) Glycine (C) Tryptophan (D) Tyrosine

Q.47 Which of the following disaccharides will give tow molecules of glucose on hydrolysationk
[RPMT-1997]

(A) Maltose (B) Sucrose (C) Lactose (D) None of these

Q.48 Which is very most structural part of the body ***[RPMT-1997]***

(A) Protein (B) Carbohydrates (C) Lipid (D) Nucleic acid

Q.49 Which of the following sugar is found in ATP ***[RPMT-1997]***

(A) Deoxyribose (B) Ribose (C) Trehalose (D) Glucose

Q.50 Deficiency of protein leads to ***[AIPMT-1998]***

(A) Rickets (B) Scurvy (C) Kwashiorkor (D) Carotenemia

Q.51 Lactose is composed of ***[RPMT-1998, AIPMT 1998]***

(A) Glucose + galactose (B) Glucose + fructose
(C) Glucose + glucose (D) Glucose + mannose

Q.52 True statement for cellulose molecule ***[AIPMT-1998]***

(A) β- 1'-4" linkage, unbranched (B) β- 1'-4" linkage, branched
(C) α- 1'-4" linkage, branched (D) β- 1'-6" linkage, unbranched

Q.53 Contractile protein is ***[AIPMT-1998]***

(A) Actin (B) Myosin (C) Troponin (D) Ropomyosin

Q.54 Variations in proteins are due to ***[AIPMT-1998]***

(A) Sequence of amino acids (B) Number of amino acids
(C) R-group (D) None of these

Q.55 The antibodies are ***[MP PMT-1998]***

(A) (Gamma)- globulins (B) Albumins
(C) Vitamins (D) Sugar

Q.56 Which of the following does not contain metal ***[AIPMT-1999]***

(A) Glycoproteins (B) Ferritin
(C) Cytochromes (D) Chromoproteins

Q.57 Which protein found in maximum amout ***[AIPMT-1999]***

(A) Catalase (B) Zinc carbonic anhydrase
(C) Transferase (D) RUBISCO

Q.58 Proteoglycan in cartilages which is part of polysaccharide ***[AIPMT-2000]***

(A) Condriotin (B) Ossein (C) Casein (D) Cartilegen

Q.59 Which of the following may be true of RNA ***[RPMT-1996]***

(A) A=U G=C (B) A=U G=C (C) A=U=G=C (D) Purines = Pyrimidines

Q.60 In the genetic code dictionary, how many codons are used to code for all the 20 essential amino acids ***[AIPMT-2003]***

(A) 20 (B) 64 (C) 61 (D) 60

Q.61 The enzyme which can cut molecules of DNA in to segments is known as ***[MP-PMT-2003]***

(A) DNA Polymerase (B) DNA Ligase
(C) Endonuclease (D) DNA Gyrase

Q.62 The genes concerned with the production of cancer are called ***[MP-PMT-1995]***

(A) Cancer genes (B) Carcino genes
(C) Carcinomas (D) Onco genes

Q.63 Quantity of nucleic acids in animal cells is ***[RPMT-1995]***

(A) 2% (B) 5% (C) 10% (D) 15%

Q.64 Nucleic acids are made up of ***[RPMT-1995]***

(A) Amino acids (B) Pentose sugars
(C) Nucleosides (D) Nucleotides

Q.65 Nucleic acids are polymer of ***[RPMT-1994, 85 AIPMT 78,81]***

(A) Nucleotides (B) Nucleosides (C) Amino acids (D) Nitrogen bases

Q.66 Who proved DNA as genetic material ***[RPMT-1994]***

(A) Griffith (B) Bacteria (C) PPLO (D) Hershey and chase

Q.67 Circular and double stranded DNA occurs in ***[RPMT-1994]***

(A) Golgibody (B) Mitochondria (C) Nucleus (D) Cytoplasm

Q.68 If there are 10,000 base pairs in DNA, then its length ***[RPMT-1994]***

(A) 340 nm (B) 3400 nm (C) 34000 nm (D) 340000 nm

Q.69 Code in RNA corresponding to AGCT in DNA ***[RPMT-1994]***

(A) TACA (B) UCGA (C) TCGA (D) AGUC

Q.70 Double helix model of DNA which was proposed by Watson and crick was of ***[RPMT-1993]***

(A) C-DNA (B) B-DNA (C) D-DNA (D) Z-DNA

Q.71 Mitochondrial DNA is ***[RPMT-1993]***

(A) Naked (B) Circular

(C) Double stranded (D) All of the above

Q.72 If there are 10,000 nitrogenous base pairs in a DNA than how many nucleotides are there ***[RPMT-1993]***

(A) 500 (B) 10,000 (C) 20,000 (D) 40,000

Q.73 The process of m RNA synthesis on a DNA is known as ***[RPMT-1992]***

(A) Translation (B) Transcription

(C) Transduction (D) Transformation

Q.74 Double helix model of DNA is proposed by ***[RPMT-1992, AIPMT-79, BHU-80, DELHI PMT-92]***

(A) Watson and Crick (B) Schleiden Schwann

(C) Singer and Nicholson (D) Komberg and Khurana

Q.74 Which of the following nitrogen base is not found in DNA ***[AIPMT'S; RPMT-1992]***

(A) Thymine (B) Cytosine (C) Guanine (D) Uracil

Q.75 Back bone in structure of DNA molecule is made up of ***[RPMT-1991]***

(A) Pentose sugar and phosphate (B) Hexose sugar and phosphate

(C) Purine and pyrimidine (D) Sugar and phosphate

Q.76 Which of the following is called adaptor molecule ***[RPMT-1991]***

(A) DNA (B) mRNA (C) tRNA (D) RNA

Q.77 Substance common in DNA and RNA ***[RPMT-1990]***

(A) Hexose sugar (B) Histamine (C) Thymine (D) Phosphate groups

Q.78 Which of following base pair is wrong ***[RPMT-1988]***

(A) A-T (B) G-C (C) A-C (D) A-U

Q.79 Which may be attached with adenine base in RNA **[RPMT-1988]**

(A) Guanine (B) Cytosine (C) Uracil (D) Thymine

Q.80 Nucleotide is **[RPMT-1988]**

(A) N_2 base, pentose sugar and phosphoric acid

(B) Nitrogen, hexose sugar and phosphoric acid

(C) Nitrogen base, pentose sugar

(D) Nitrogen base, trioses and phosphoric acid

Q.81 DNA differs from RNA in **[RPMT-1988]**

(A) Only sugar (B) Nitrogen base only

(C) Nitrogen base and sugar (D) None of these

Q.82 Who propounded the theory one gen one enzyme one chemical reaction **[BHU-1982,83]**

(A) Watson and Crick (B) George Beadle and Edward Tatum

(C) Abraham Trembley (D) T.H. Morgan

Q.83 A codon in m-RNA has **[BHU-1983]**

(A) 3-bases (B) 2-bases

(C) 1-base (D) Number of bases vary

Q.84 Unit of nucleic acids are **[NCERT-1976]**

(A) Phosphoric acid (B) Nitrogenous bases

(C) Pentose sugar (D) Nucleotides

Q.85 Which element is not found in nitrogenous base **[NCERT-1976]**

(A) Nitrogen (B) Hydrogen (C) Carbon (D) Phosphorus

Q.86 The link between successive generation is provided by **[AIPMT-1981, 84]**

(A) Nucleus (B) Cytoplasm (C) Chromosomes (D) Nucleic acid

Q.87 DNA was first discovered by **[AIPMT-1976, 85]**

(A) Meischer (B) Robert Brown (C) Flemming (D) Watson and Crick

Q.88 Nucleic acids are found in **[AIPMT-1980]**

(A) Nucleus (B) Cytoplasm

(C) Both nucleus and Cytoplasm
(D) Nucleus and ribosomes

Q.89 DNA is found in ***[AIPMT-1978, 80, M.P. PMT-86]***

(A) ER and ribosomes
(B) Mitochondria, plastid and nucleolus
(C) Spherosome and peroxysome
(D) Plasma membrane and lysosome

Q.90 Nucleic acid (DNA) is not found in ***[RPMT-1990, M.P. PMT-90]***

(A) Nucleus and nucleolus
(B) Peroxysome and ribosome
(C) Mitochondria and plastid
(D) Chloroplast and nucleosome

Q.91 The contribution fo cytoplasmic DNA is the total DNA of a cell ***[DELHI PMT-1986]***

(A) 90% – 99%
(B) 65% – 75%
(C) 5% – 15%
(D) 1% – 5%

Q.92 DNA is not present in ***[DELHI PMT-1983, RPMT-89]***

(A) Mitochondria
(B) Chloroplast
(C) Bacteriophage
(D) TMV

Q.93 A nucleic acid contains thymine or methylated uracil then it should be ***[BHU-1981]***

(A) DNA
(B) RNA
(C) Either DNA or RNA
(D) RNA of bacteria

Q.94 Prokaryotic genetic system contains ***[RPMT-1985]***

(A) DNA and histones
(B) RNA and histones
(C) Either DNA or histones
(D) DNA but no histones

Q.95 Which protein is attached to major groove of DNA in Eukaryotes? ***[JIPMER-1985]***

(A) Fibrinogen
(B) Histone
(C) Albumin
(D) All

Q.96 Genetic information is carried by the long chain molecules which are made up of ***[BANGALORE PMT-1981]***

(A) Amino acids
(B) Nucleotides
(C) Chromosomes
(D) Enzymes

Q.97 A N_2 base together with pentose sugar and phosphate forms (or) building –block unit of nucleic acid is ***[DELHI PMT-1984, RPMT 84, AIPMT-84, MPPMT-85, ALIGARH PMT-86]***

(A) Nucleoside (B) Polypeptide
(C) Nucleotide (D) Aminoacid

Q.98 One of the characteristics of DNA is ***[DELHI PMT-1984]***

(A) Uracil (B) Deoxyribose sugar
(C) Single strandedness (D) Ability of protein synthesis

Q.99 What replaces thymine in RNA ***[AIPMT-1981, ALLMS-82, BHU-85]***

(A) Guanine (B) Adenine (C) Uracil (D) Water

Q.100 Purine bases of DNA are ***[MPPMT-1986, BHU-85 AIPMT-83, 89, RPMT-92]***

(A) U and G (B) A and G (C) A and C (D) None of these

Q.101 Which of the following N_2 bases are pyrimidines ***[RPMT-1989]***

(A) T and C (B) T and A (C) A and C (D) G and T

Q.102 Which of the following is not a pyrimidine N_2 base ***[JIPMER-1985]***

(A) Thymine (B) Cytosine (C) Guanine (D) Uracil

ANSWER KEY

Objective Questions

Q.1. D	**Q.2.** D	**Q.3.** C	**Q.4.** A	**Q.5.** A	**Q.6.** C
Q.7. B	**Q.8.** D	**Q.9.** B	**Q.10.** A	**Q.11.** D	**Q.12.** A
Q.13. C	**Q.14.** D	**Q.15.** C	**Q.16.** D	**Q.17.** B	**Q.18.** B
Q.19. A	**Q.20.** C	**Q.21.** C	**Q.22.** B	**Q.23.** C	**Q.24.** A
Q.25. A	**Q.26.** C	**Q.27.** D	**Q.28.** D	**Q.29.** D	**Q.30.** B
Q.31. C	**Q.32.** D	**Q.33.** A	**Q.34.** D	**Q.35.** B	**Q.36.** D
Q.37. A	**Q.38.** B	**Q.39.** B	**Q.40.** A	**Q.41.** A	**Q.42.** D
Q.43. B	**Q.44.** A	**Q.45.** A	**Q.46.** D	**Q.47.** B	**Q.48.** C
Q.49. B	**Q.50.** C	**Q.51.** A	**Q.52.** B	**Q.53.** A	**Q.54.** B
Q.55. D	**Q.56.** A	**Q.57.** D	**Q.58.** B	**Q.59.** A	**Q.60.** A
Q.61. B	**Q.62.** B	**Q.63.** B	**Q.64.** B	**Q.65.** B	**Q.66.** C
Q.67. A	**Q.68.** C	**Q.69.** B	**Q.70.** C	**Q.71.** A	**Q.72.** D
Q.73. B	**Q.74.** D	**Q.75.** D	**Q.76.** C	**Q.77.** B	**Q.78.** B
Q.79. D	**Q.80.** B	**Q.81.** C	**Q.82.** C	**Q.83.** A	**Q.84.** B
Q.85. C	**Q.86.** B	**Q.87.** B	**Q.88.** D	**Q.89.** C	**Q.90.** A
Q.91. B	**Q.92.** A	**Q.93.** D	**Q.94.** C	**Q.95.** B	**Q.96.** B
Q.97. B	**Q.98.** C	**Q.99.** D	**Q.100.** C	**Q.101.** A	**Q.102.** A
Q.103. A	**Q.104.** D	**Q.105.** C	Q106. C	**Q.107.** B	**Q.108.** D
Q.109. C	**Q.110.** C	**Q.111.** A	**Q.112.** B	**Q.113.** A	**Q.114.** D
Q.115. B	**Q.116.** C	**Q.117.** A	**Q.118.** C	**Q.119.** B	**Q.120.** D
Q.121. C	**Q.122.** B	**Q.123.** D	**Q.124.** B	**Q.125.** A	**Q.126.** A
Q.127. C	**Q.128.** D	**Q.129.** D			

Previous Years' Questions

Q.1 A	**Q.2** A	**Q.3** D	**Q.4** C	**Q.5** D	**Q.6** C
Q.7 A	**Q.8** A	**Q.9** A	**Q.10** C	**Q.11** A	**Q.12** B
Q.13 C	**Q.14** D	**Q.15** C	**Q.16** C	**Q.17** B	**Q.18** B
Q.19 A	**Q.20** C	**Q.21** A	**Q.22** A	**Q.23** D	**Q.24** C
Q.25 B	**Q.26** B	**Q.27** B	**Q.28** D	**Q.29** B	**Q.30** D
Q.31 C	**Q.32** B	**Q.33** D	**Q.34** C	**Q.35** D	**Q.36** A
Q.37 C	**Q.38** C	**Q.39** C	**Q.40** A	**Q.41** A	**Q.42** B
Q.43 A	**Q.44** B	**Q.45** A	**Q.46** C	**Q.47** A	**Q.48** A
Q.49 B	**Q.50** C	**Q.51** A	**Q.52** A	**Q.53** A	**Q.54** A
Q.55 A	**Q.56** A	**Q.57** D	**Q.58** A	**Q.59** B	**Q.60** C
Q.61 C	**Q.62** D	**Q.63** D	**Q.64** A	**Q.65** D	**Q.66** B
Q.67 B	**Q.68** B	**Q.69** B	**Q.70** D	**Q.71** C	**Q.72** B
Q.73 A	**Q.74** D	**Q.75** A	**Q.76** C	**Q.77** D	**Q.78** C
Q.79 C	**Q.80** A	**Q.81** C	**Q.82** B	**Q.83** A	**Q.84** D
Q.85 D	**Q.86** D	**Q.87** A	**Q.88** C	**Q.89** B	**Q.90** B
Q.91 D	**Q.92** D	**Q.93** A	**Q.94** A	**Q.95** B	**Q.96** B
Q.97 C	**Q.98** B	**Q.99** C	**Q.100** B	**Q.101** A	**Q.102** C