CHAPTER : 29

BIOMOLECULES

You are aware that our body, plants and other animals are made up of many chemical substances. There are certain complex organic molecules which form the basis of life. These build up living organisms and are also required for their growth and maintenance. Such molecules are called **biomolecules.** The main classes of biomolecules are carbohydrates, proteins, lipids, nucleic acids, enzymes, hormones etc. In this lesson, you will study about the structures and functions of some important biomolecules.

OBJECTIVES

After reading this lesson you will be able to :

- discuss different types of biomolecules;
- describe the important structural features of biomolecules;
- classify carbohydrates, proteins and lipids on the basis of their structure and functions;
- give the composition of proteins and nucleic acids;
- explain the difference between DNA and RNA;
- differentiate between oils and fats;
- explain the action of enzymes and their characteristic features and
- discuss important hormones and their importance
- name some important vitamins and give their deficiency symptoms.
- list the functions of biomolecules in biological systems.

29.1 CARBOHYDRATES

Carbohydrates form a very large group of naturally occurring organic compounds which play a vital role in daily life. They are produced in plants by the process of

photosynthesis. The most common carbohydrates are glucose, fructose, sucrose, starch, cellulose etc. Chemically, the carbohydrates may be defined as **polyhydroxy aldehydes** or **ketones** or **substances which give such molecules on hydrolysis**. Many carbohydrates are sweet in taste and all sweet carbohydrates are called as **sugars**. The chemical name of the most commonly used sugar in our homes is sucrose.

29.1.1 Classification of Carbohydrates

Carbohydrates are classified into three groups depending upon their behaviour on hydrolysis.

(i) **Monosaccharides**: A polyhydroxy aldehyde or ketone which cannot be hydrolysed further to a smaller molecule containing these functional groups, is known as a *monosaccharide*. About 20 monosaccharides occur in nature and glucose is the most common amongst them.

Monosaccharides are further classified on the basis of the number of carbon atoms and the functional group present in them. If a monosaccharide contains an aldehyde group, it is known as an **aldose** and if it contains a keto group, it is known as a **ketose**. The number of carbon atoms present is also included while classfying the compound as is evident from the examples given in Table 29.1. Name of some naturally occuring monosaccharides are given in brackets.

Table 29.1 Classification of monosaccharides

No. of carbon atoms	Type of monosaccharide	
present	Aldose	Ketose
3	Aldotriose (Glyceraldehyde	Ketotriose
4	Aldopentose ((Xylose)	Ketopentose
5	Aldotetrose (Erythrose)	Ketotetrose
6	Aldohexose (Glucose)	Ketohexose
7	Aldoheptose	Ketoheptose

(ii) **Disacccharides:** Carbohydrates which give two monosaccharide molecules on hydrolysis are called disaccharides e.g. sucrose, maltose, lactose etc.

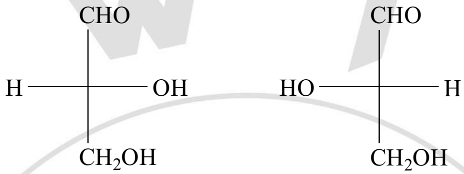
(iii) **Oligosacharides:** Carbohydrates that yield 2–10 molecules of monosascharides are called **oligosaccharides.**

(iv) **Polysaccharides:** Carbohydrates which yield a large number of monosaccharide units on hydrolysis e.g. starch, glycogen, cellulose etc.

29.1.2 Structure of Monosaccharides

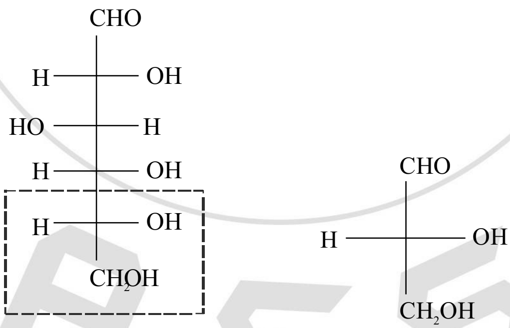
Although a large number of monosaccharides are found in nature.

D-or L-before the name of monosaccharides indicates the configuration of particular stereoisomer. Various stereoisomers are assigned relative configurations as D– or L –. This system of assigning the relative configuration refers to their relation with the glyceraldehyde. Glyceraldehyde contains one asymmetric carbon atom and hence exists in two enantiomeric forms as shown below.



D-(+) –glyceraldehyde **L-(–) –glyceraldehyde**

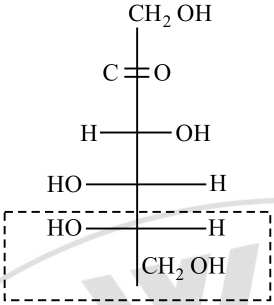
All those compounds which can be correlated to (+) -glyceraldehyde are said to have D-configuration and those can be correlated to (–) -glyceraldehyde are said to have L–configuration. In monosaccharides, it is the lowest asymmetric carbon atom (shown in the box) by which the correlation is made. As in (+) glucose, the lowest asymmetric carbon atom has –OH group on the right side which matches with (+) glyceraldehyde; hence, it is assigned D-configuration.



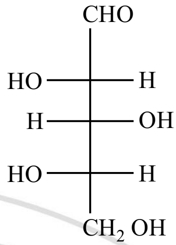
(+) – glucose or D-glucose **(+) – glyceraldehyde or D-glyceraldehyde**

L-Configuration Examples

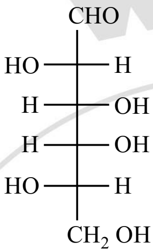
Some example of molecules having L-configuration are shown below:



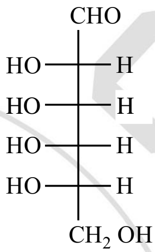
L - fructose



L - Xylose



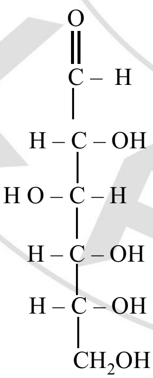
L - Galactose



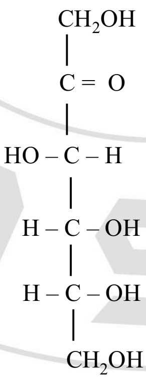
L - Allose

We will confine our discussion here to four of them only viz. D-glucose, D-fructose,D-ribose and 2-deoxy-D-ribose.

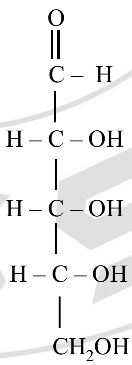
D-Glucose (an aldohexose) is the monomer for many other carbohydrates. Alone or in combination, glucose is probably the most abundant organic compound on the earth. D-Fructose (a ketohexose) is a sugar that is found with glucose in honey and fruit juices. D-Ribose (an aldopentose) is found in ribonucleic acids (RNA) while. 2-Deoxy-D-ribose is an important constituent of the deoxyribonucleic acids(DNA). Here, the prefix 2-Deoxy indicates that it lacks oxygen at carbon no. 2.



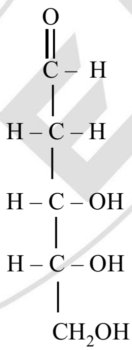
D-Glucose



D-Fructose



D-Ribose

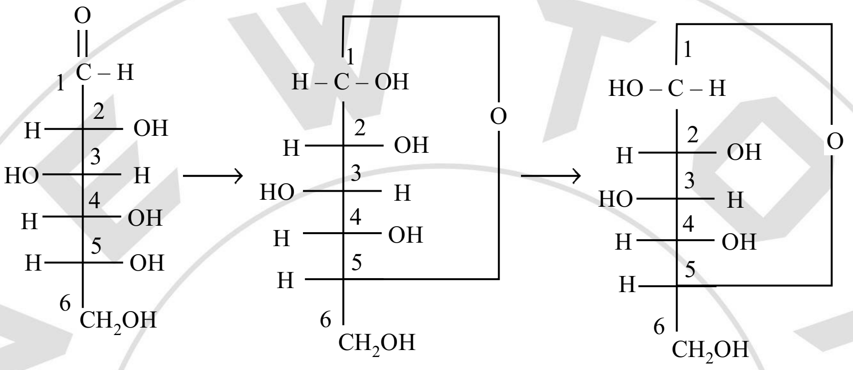


2-Deoxy-D-ribose

These monosaccharides generally exist as cyclic compounds in nature. A ring is formed by a reaction between the carbonyl group and one of the hydroxyl groups present in the molecule. Glucose preferentially forms the six membered ring which

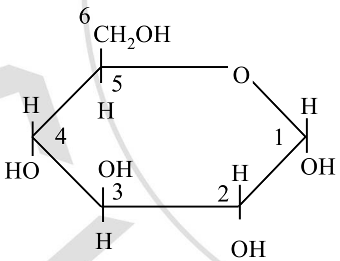
can be in two different isomeric forms called α- and β-forms (shown below as I and II). The two forms differ only in the arrangement of the hydroxyl group at carbon No.1. Such isomers are called **anomers**.

Formation of these cyclic structures (I and II) from the open chain structure can be shown as follows.

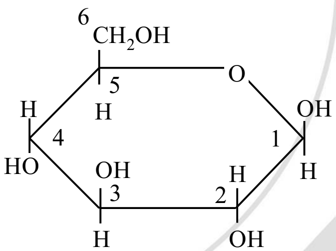


(I) α – D – glucose (II) β – D –glucose

The cyclic structures I and II are more appropriately represented as Ia and IIa.

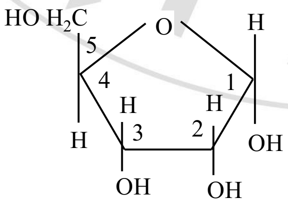


(Ia)

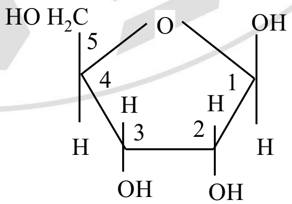


(IIa)

The α- and β-forms of other sugars also exist in the cyclic form. D-Ribose forms a five membered ring structure as shown below :



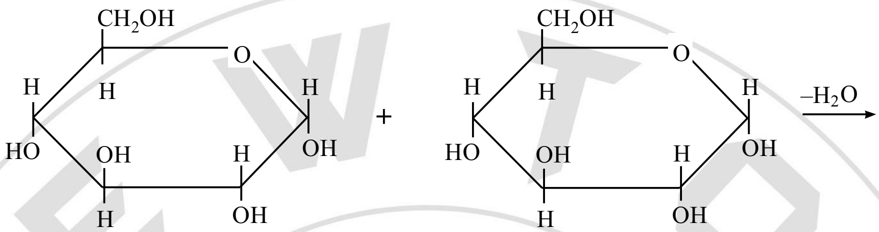
α – D – ribose



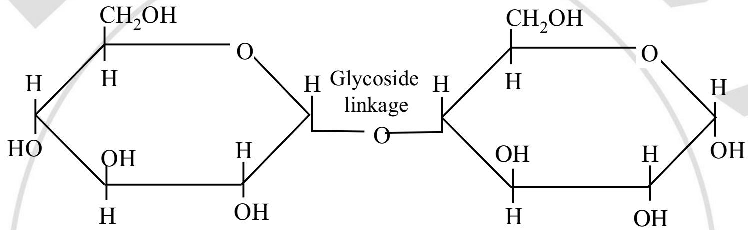
β – D – ribose

29.1.3 Structure of Di-Saccharides, Oligo Saccharides and Polysaccharides

Disaccharides are formed by the condensation of two monosaccharide molecules. These monosaccharides join together by the loss of a water molecule between one hydroxyl group on each monosaccharide. Such a linkage, which joins the monosaccharide units together is called **glycoside linkage**. If two α-glucose molecules are joined together, the disaccharide maltose is formed.

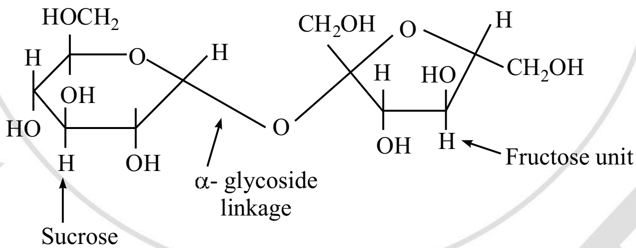


2 molecules of α – glucose

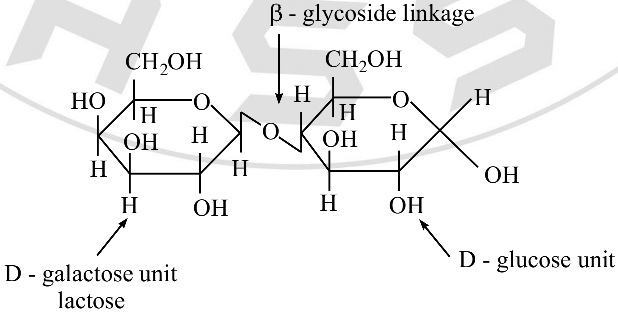


Maltose

Similarly, sucrose (the common sugar) consists of one molecule of glucose and one molecule of fructose joined together.



Lactose(or milk sugar) is found in milk and is formed by joining of one molecule of glucose and one molecule of galactose.



lactose

If a large number of monosaccharide units are joined together, we get polysaccharides. These are the most common carbohydrates found in nature. They have mainly one of the following two functions- either as food materials or as structural materials. Starch is the main food storage polysaccharide of plants. It is a polymer of α-glucose and consists of two types of chains- known as **amylose** and **amylopectin**.

Amylose is a water soluble fraction of starch and is a linear polymer of α-D-glucose. On the other hand, amylopectin is a water insoluble fraction and consists of branched chain of α-D-glucose.

Cellulose is another natural polysaccharide which is the main component of wood and other plant materials. It consists of long chain of β-D-glucose molecules.

Glycogen

The carbohydrates are stored in animal body as glycogen and its structure is similar to amylopectin.

It is a polysaccharide containing the α-D-glucose monosaccharide and does the same energy storage function in animals which the starch does in plants. The carbohydrates which are not needed immediately by the body are converted by the body to glycogen for long term storage. Glycogen molecules are larger than those of amylopectin and are having more branched structure.

29.1.4 Biological Importance of Carbohydrates

(i) Carbohydrates act as storage molecules. For example they are stored as starch in plants and as glycogen in animals.

(ii) D-Ribose and 2-deoxy-D-ribose are the constituents of RNA and DNA, respectively.

(iii) Cell walls of bacteria and plants are made up of cellulose. It may be of interest to note that human digestive system does not have the enzymes required for the digestion of cellulose but some animals do have such enzymes.

(iv) Some carbohydrates are also linked to many proteins and lipids. These molecules are known as glycoproteins and glycolipids, respectively. These molecules perform very specific functions in organisms.

INTEXT QUESTIONS 29.1

1. Name three constituents of your diet which provide carbohydrates.
2. How are carbohydrates produced in nature?

3. What are the hydrolysis products of starch and sucrose?

4. Write the linear and ring forms of D-glucose.

29.2 PROTEINS

Proteins are the most abundant macromolecules in living cells. The name protein is derived from the Greek word **'proteios'** meaning 'of prime importance'. These are high molecular mass complex amino acids. You will study about amino acids in the next section. Proteins are most essential class of biomolecules because they play the most important role in all biological processes. A living system contains thousands of different proteins for its various functions. In our every day food pulses, eggs, meat and milk are rich sources of proteins and are must for a balanced diet.

29.2.1 Classification of Proteins

Proteins are classified on the basis of their chemical composition, shape and solubility into two major categories as discussed below.

(i) **Simple proteins:** Simple proteins are those which, on hydrolysis, give only amino acids. According to their solubility, the simple proteins are further divided into two major groups **fibrous** and **globular proteins**.

(a) **Fibrous Proteins:** These are water insoluble animal proteins eg. collagen (major protein of connective tissues), elastins (protein of arteries and elastic tissues), keratins (proteins of hair, wool, and nails) are good examples of fibrous proteins. Molecules of fibrous proteins are generally long and thread like.

(b) **Globular Proteins:** These proteins are generally soluble in water, acids, bases or alcohol. Some examples of globular proteins are albumin of eggs, globulin (present in serum), and haemoglobin. Molecules of globular proteins are folded into compact units which are spherical in shape.

(ii) **Conjugated proteins:** Conjugated proteins are complex proteins which on hydrolysis yield not only amino acids but also other organic or inorganic components. The non-amino acid portion of a conjugated protein is called **prosthetic group**.

Unlike simple proteins, conjugated proteins are classified on the basis of the chemical nature of their prosthetic groups. These are

a. Nucleoproteins (protein + nucleic acid)

b. Mucoproteins and glycoproteins (protein+ carbohydrates)

c. Chromoproteins (proteins + a coloured pigment)

d. Lipoproteins (proteins + lipid)

e. Metalloproteins (metal binding proteins combined with iron, copper or zinc)

f. Phosphoproteins (proteins attached with a phosphoric acid group).

Proteins can also be classified on the basis of functions they perform, as summarized in table 29.2.

Table 29.2 : Classification of proteins according to their biological functions

Class	Functions	Examples
1. Transport Proteins	Transport of oxygen, glucose and other nutrients	Haemoglobin Lipoproteins
2. Nutrient and storage Proteins	Store proteins required for the growth of embryo	Gliadin(wheat) Ovalbumin(egg) Casein (milk)
3. Structural Protiens	Give biological structures, strength or protection	Keratin(Hair, nails,etc.) collagen(cartilage)
4. Defence Proteins	Defend organisms against invasion by other species	Antibodies Snake venoms
5. Enzymes	Act as catalysts in biochemical reactions	Trypsin,Pepsin
6. Regulatory Proteins	Regulate cellular or physiological activity	Insulin

29.2.2 Structure of Proteins

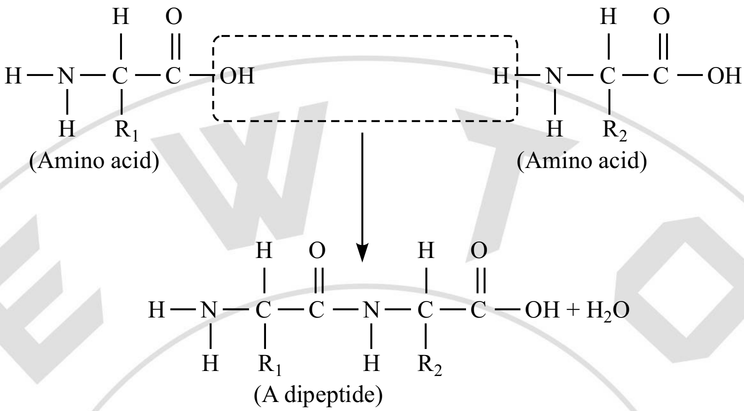
Protein molecules are polymers of different sizes and shapes with different physical and chemical properties. The monomer units for proteins are amino acids. All the amino acids that are found in proteins have an amino group(-NH_2) on the carbon atom adjacent to carbonyl group, hence are called α-amino acids. The general formula of α-amino acids is shown below.

$$\begin{array}{c} \quad COOH \\ \quad | \;\alpha\text{-carbon} \\ H_2N - C - H \\ \quad | \\ \quad R \end{array}$$

All proteins found in nature are the polymers of about twenty (20) different α-amino acids and all of these have L-configuration. Out of these ten (10) amino acids cannot be synthesized by our body and hence must form the part of our diet. These are called **essential amino acids**.

All proteins have one common structural feature that their amino acids are connected to one another by *peptide linkages.* By a peptide linkage we mean an

amide $\left(-\overset{\overset{\large O}{||}}{C}-\underset{\underset{\large H}{|}}{N}-\right)$ bond formed when the carboxyl group of one amino acid molecule reacts with the α-amino group of another. In the process, a molecule of water is given off. The product of the reaction is called a *peptide* or more precisely a dipeptide because it is made by combining two amino acids, as shown below:



If a third amino acid is joined to a **dipeptide** in the same manner, the product is a **tripeptide**. Thus, a tripeptide contains three amino acids linked by two peptide linkages. Similar combinations of four, five, six amino acids give a **tetrapeptide**, a **pentapeptide**, a **hexapeptide**, respectively. Peptides formed by the combination of more than ten amino acid units are called **polypeptides**. **Proteins are polypeptides** formed by the combination of **large number of amino acid units**. There is no clear line of demarcation between polypeptides and proteins. For example insulin, although it contains only 51 amino acids, is generally considered a small protein.

The amino acid unit with the free amino group is known as the ***N***-terminal residue and the one with the free carboxyl group is called the ***C***-terminal residue. By convention, the structure of peptide or proteins written with the ***N***-terminal residue on the left and the ***C***-terminal on the right.

The actual structure of a protein can be discussed at four different levels.

(i) **Primary structure**: Information regarding the sequence of amino acids in a protein chain is called its primary structure. The primary structure of a protein determines its functions and is critical to its biological activity.

(ii) **Secondary structure**: The secondary structure arises due to the regular folding of the polypeptide chain due to hydrogen bonding between $-\underset{\underset{O}{\|}}{C}-$ and >N – H group. Two types of secondary structures have been reported. These are – α helix (Fig. 29.1) when the chain coils up and β-pleated sheet (Fig. 29.2) when hydrogen bonds are formed between the chains.

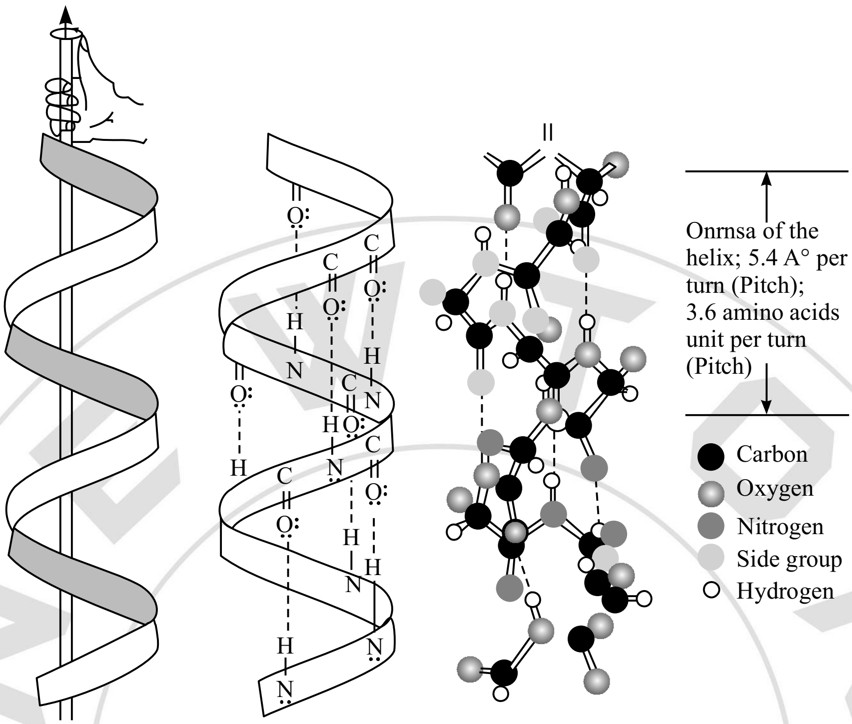
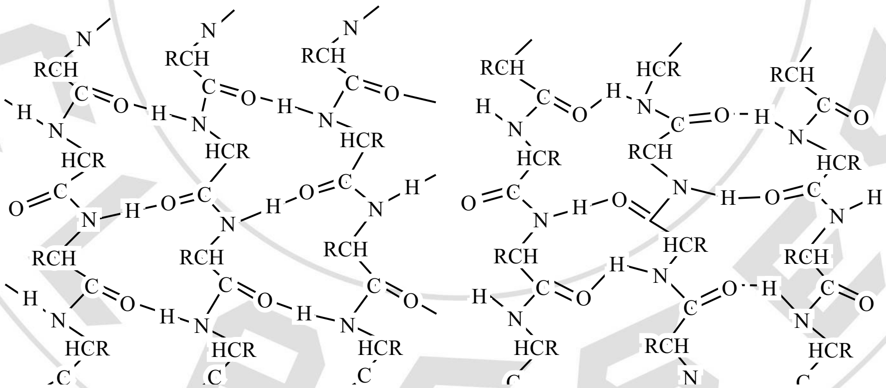


Fig. 29.1 : *The a-helix structure of protein*



Parallel β-Conformation **Antiparallel β-Conformation**

Fig. 29.2 : *The β-pleated-sheet structure of protein*

(iii) Tertiary structure: It is the three-dimensional structure of proteins. It arises due to folding and superimposition of various a-helical chains or b-plated sheets. For example Fig. 29.3 represents the tertiary structure for the protein myoglobin.

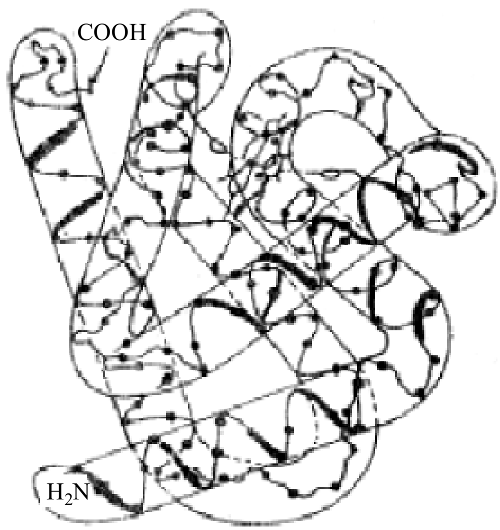


Fig. 29.3 : *Structure of myoglobin*

(iv) **Quaternary structure:** The quaternary structure refers to the way in which simple protein chains associate with each other resulting in the formation of a complex protein.

By different modes of bonding in secondary and tertiary structural levels a protein molecule appears to have a unique three-dimensional structure.

29.2.3 Denaturation

One of the great difficulties in the study of the structure of proteins is that if the normal environment of a living protein molecule is changed even slightly, such as by a change in pH or in temperature, the hydrogen bonds are disturbed and broken. When attractions between and within protein molecules are destroyed, the chains separate from each other, globules unfold and helices uncoil. We say that the protein has been denatured.

Denaturation is seen in our daily life in many forms. The curdling of milk is caused by bacteria in the milk which produce lactic acid. The change in *p*H caused by the lactic acid causes denaturation, coagulation and precipitation of the milk proteins. Similarly, the boiling of an egg causes precipitation of the albumin proteins in the egg white. Some proteins (such as those in skin, fingernails, and the stomach lining) are extremely resistant to denaturation.

29.2.4 Biological Importance of Proteins

(i) Proteins are structural components of cells.

(ii) The biochemical catalysts known as enzymes are proteins.

(iii) The proteins known as immunoglobins serve in defence against infections.

(iv) Many hormones, such as insulin and glucagon are proteins.

(v) Proteins participate in growth and repair mechanism of body tissues.

(vi) A protein called fibrinogen helps to stop bleeding.

(vii) Oxygen is transported to different tissues from blood by haemoglobin which is a protein attached to haeme part.

INTEXT QUESTIONS 29.2

1. What do you understand by primary structure of protein ?
2. What do you mean by a peptide bond?
3. Write the general structural formula of an a-amino acid?
4. What are conjugated proteins ?

29.3 LIPIDS

The lipids include a large number of biomolecules of different types. The term lipid originated from a Greek word '*Lipos*' meaning fat. In general, those constituents of the cell which are insoluble in water and soluble in organic solvents of low polarity (such as chloroform, ether, benzene etc.) are termed as *lipids*. Lipids perform a variety of biological functions.

29.3.1 Classification of Lipids

Lipids are classified into three broad categories on the basis of their molecular structure and the hydrolysis products.

(i) **Simple Lipids:** Those lipids which are esters and yield fatty acids and alcohols upon hydrolysis are called simple lipids. They include oils, fats and waxes.

(ii) **Compound Lipids:** Compound lipids are esters of fatty acids and alcohol with additional compounds like phosphoric acid, sugars, proteins etc.

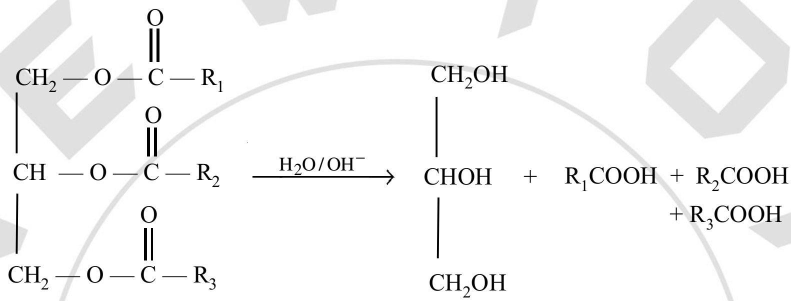
(iii) **Derived Lipids:** Compounds which are formed from oils, fats etc. during metabolism. They include steroids and some fat soluble vitamins.

29.3.2 Structure of lipids

The structure of all three types of lipids are breifly discussed below.

(i) Simple Lipids

The simple lipids are esters. They are subdivided into two groups, depending on the nature of the alcohol component. Fats and oils are triglycerides, i.e. they are the esters of glycerol with three molecules of long chain fatty acids. Variations in the properties of fats and oils is due to the presence of different acids. These long chain acids may vary in the number of carbon atoms (between C_{12} to C_{26}) and may or may not contain double bonds. On hydrolysis of a triglyceride molecule, one molecule of glycerol and three molecules of higher fatty acids are obtained as shown below:



(Oil or fat) **Glycerol** **(Fatty acids)**

By definition, a fat is that triglyceride which is solid or semisolid at room temperature and an oil is the one that is liquid at room temperature. Saturated fatty acids form higher melting triglycerides than unsaturated fatty acids. The saturated triglycerides tend to be solid fats, while the unsaturated triglycerides tend to be oils. The double bonds in an unsaturated triglyceride are easily hydrogenated to give a saturated product, and in this way an oil may be converted into a fat. Hydrogenation is used in the manufacture of *vanaspati ghee* from oils.

Fats and oils are found in both plants and animals. Our body can produce fats from carbohydrates. This is one method that the body has for storing the energy from unused carbohydrates. The vegetable oils are found primarily in the seeds of plants.

The second type of simple lipids are waxes. They are the esters of fatty acids with long chain monohydroxy alcohols 26 to 34 carbons atoms. Waxes are wide-spread in nature and occur usually as mixtures. They form a protective coating on the surfaces of animals and plants. Some insects also secrete waxes. The main constituent of bees wax obtained from the honey comb of bees is myricyl palmitate:

$$CH_3-(CH_2)_{14}-\overset{\overset{\large O}{||}}{C}-O-(CH_2)_{29}-CH_3$$

myricyl palmitate

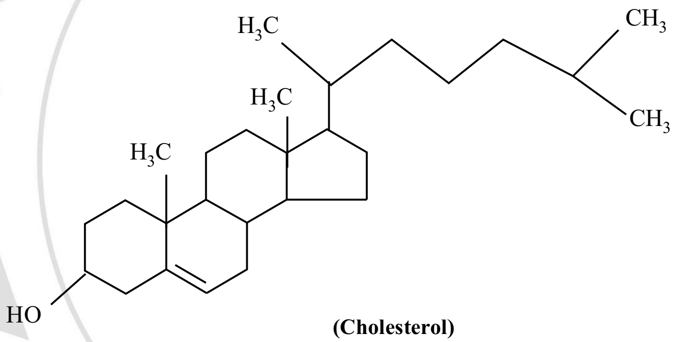
The waxes discussed above should not be confused with household paraffin wax which is a mixture of straight chain hydrocarbons.

(ii) Compound Lipids

Compound lipids on hydrolysis yield some other substances in addition to an alcohol and fatty acids. The first type of such lipids are called phospholipids, because they are the triglycerides in which two molecules of fatty acids and one molecule of phosphoric acid are present. Glycolipids contain a sugar molecule in addition to fatty acid attached to an alcohol.

(iii) Derived Lipids

Steroids are another class of lipids which are formed in our body during metabolism. These are the compounds with a distinctive ring system that provides the structural backbone for many of our hormones. Steroids do not contain ester groups and hence cannot be hydrolysed. Cholesterol is one of the most widely distributed steroids in animal and human tissues.



(Cholesterol)

Another important group of derived lipids is that of fat-soluble vitamins. This includes vitamins A, D, E and K, whose deficiency causes different diseases.

29.3.3 Biological Importance of Lipids

(i) Fats are main food storage compounds and serve as reservoir of energy.

(ii) Presence of oils or fats is essential for the efficient absorption of fat soluble vitamins A, D, E and K.

(iii) Subcutaneous fats serve as biological insulator against excessive heat loss.

(iv) Phospholipids are the essential component of cell membrane.

(v) Steroids control many biological activities in living organisms.

(vi) Some enzymes require lipid molecules for maximum action.

INTEXT QUESTIONS 29.3

1. What are lipids?
2. What are the products of hydrolysis of an oil?
3. Name two important types of compound lipids.
4. What is the basic difference between fats and oils?

29.4 NUCLEIC ACIDS

Why is a dog a dog and not a cat? Why do some people have blue or brown eyes and not black? From a chemical standpoint, how does the body know what particular type of protein is to be synthesized? How is this information transmitted from one generation to the next? The study of the chemistry of heredity is one of the most fascinating fields of research today. It was recognized in the 19^{th} century that the nucleus of a living cell contains particles responsible for heredity, which were called chromosomes. In more recent years, it has been discovered that chromosomes are composed of nucleic acids. These are named so because they come from the nucleus of the cell and are acidic in nature. Two types of nucleic acids exist which are called DNA (deoxyribonucleic acid) and RNA(ribonucleic acid).They differ in their chemical composition as well as in functions.

29.4.1 Structure of Nucleic Acids

Like all natural molecules, nucleic acids are linear polymeric molecules. They are chain like polymers of thousands of nucleotide units, hence they are also called polynucleotides. A nucleotide consists of three subunits: a nitrogen containing heterocyclic aromatic compound (called base), a pentose sugar and a molecule of phosphoric acid. So a nucleic acid chain is represented as shown below.

$$-\overset{\text{base}}{\overset{|}{\text{Sugar}}}-\text{phosphate}\left(-\overset{\text{base}}{\overset{|}{\text{sugar}}}-\text{phosphate}\right)_n-\overset{\text{base}}{\overset{|}{\text{sugar}}}-$$

In DNA molecules, the sugar moity is 2-deoxyribose, whereas in RNA molecules it is ribose. In DNA, four bases have been found. They are adenine (A), guanine (G), cytosine (C) and thymine (T). The first three of these bases are found in RNA also but the fourth is uracil (U).

The sequence of different nucleotides in DNA is termed as its primary structure. Like proteins, they also have secondary structure. DNA is a double stranded helix. Two nucleic acid chains are wound about each other and held together by hydrogen bonds between pairs of bases. The hydrogen bonds are specific between pairs of bases that is guanine and cytosine form hydrogen bonds with each other, whereas adenine forms hydrogen bonds with thymine. The two stands are complementary to each other. The overall secondary structure resembles a flexible ladder (Fig. 29.4). This structure for DNA was proposed by James Watson and Francis Crick in 1953. They were honoured with a Nobel Prize in 1962 for this work.

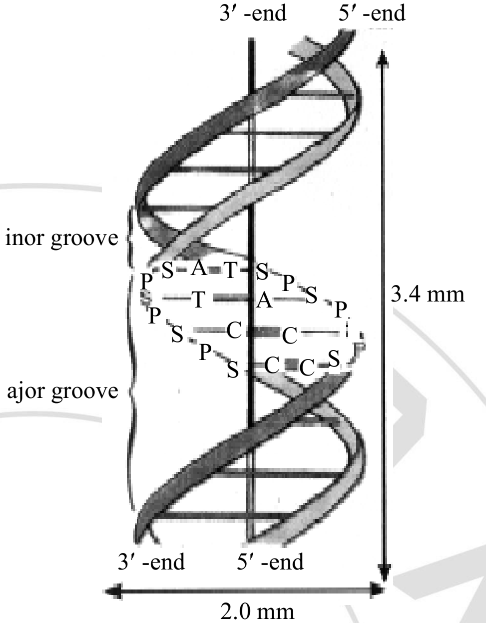


Fig. 31.4 : *Watson and Crick's double helix structure of DNA*

Unlike DNA, RNA is a single stranded molecule, which may fold back on itself to form double helix structure by base pairing in a region where base sequences are complimentary. There are three types of RNA molecules which perform different functions. These are named as messenger RNA(*m*-RNA), ribosomal-RNA(*r*-RNA) and transfer RNA (*t*-RNA)

29.4.2 Biological Functions of Nucleic Acids

A DNA molecule is capable of self duplication during cell divisions. The process starts with the unwinding of the two chains in the parent DNA. As the two strands separate, each can serve as a master copy for the construction of a new partner. This is done by bringing the appropriate nucleotides in place and linking them together. Because the bases must be paired in a specific manner (adenine to thymine and guanine to cytosine), each newly built strand is not identical but complimentary to the old one. Thus when replication is completed, we have two DNA molecules, each identical to the original. Each of the new molecule is a double helix that has one old strand and one new strand to be transmitted to daughter cells (Fig. 3.15).

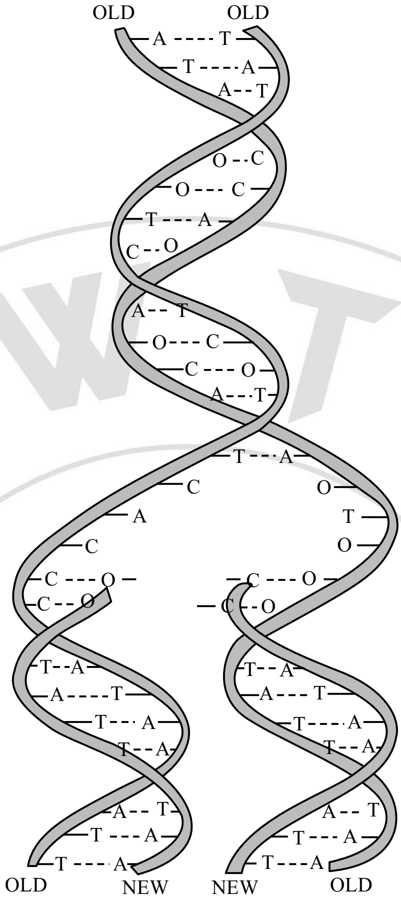


Fig. 29.5 : *Replication of DNA*

Another important function of nucleic acids is the protein synthesis. The specific sequence of bases in DNA represents coded information for the manufacture of specific proteins. In the process, the information from DNA is transmitted to another nucleic acid called messenger RNA, which leaves the nucleus and goes to the cytoplasm of the cell. Messenger RNA acts as template for the incorporation of amino acids in the proper sequence in protein. The amino acids are brought to the messenger RNA in the cell, by transfer RNA. Where they form peptide bonds. In short it can be said that DNA contains the coded message for protein synthesis whereas RNA actually carries out the synthesis of protein.

INTEXT QUESTIONS 29.4

1. What is a nucleotide?
2. Why structure DNA is called a "doublehelix"?
3. Write two main structural differences between DNA and RNA.

29.5 ENZYMES

In a living system, many complex reactions occur at the temperature of about 310K. An example of this is the digestion of food, during which stepwise oxidation to CO_2 and water and energy production. These reactions are carried out under such mild conditions due to presence of certain chemicals which are called enzymes. They act as catalysts for biochemical reactions in living cells. Almost all the enzymes are globular proteins.

Enzymes are very selective and specific for a particular reaction. They are named after the compound or class of compounds upon which they work or after the reaction that they catalyze. The ending of an enzyme name is- **ase**. For example, maltase is an enzyme that specifically catalyzes the hydrolysis of maltose into glucose. Similarly, an esterase is an enzyme which induces hydrolysis of ester linkage.

29.5.1 Mechanism of Enzyme Action

Just like chemical catalysts, enzymes are needed only in small quantities. Similar to the action of chemical catalysts, enzymes lower the energy barrier that reactants must pass over to form the products. For example, hydrolysis of the ester that needs boiling with aqueous NaOH in the laboratory, whereas it occurs at nearly neutral pH and at moderate temperature when catalyzed by an enzyme.

There is a particular enzyme for each substrate and they are said to have lock and key arrangement. It is said that first the substrate molecule binds to the active site of the enzyme which results in the formation of an enzyme-substrate complex. In this complex, the substrate is placed in the right orientation to facilitate a given reaction (Fig.29.6). This complex then breaks to give the molecule of the product and regenerates the enzyme for the next molecule of the substrate.

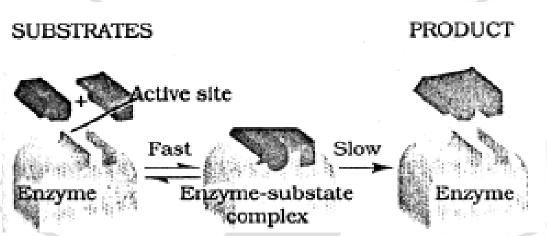


Fig. 29.6 : *Lock and Key arrangement of enzyme action*

29.5.2 Characteristics of Enzymes

(i) Enzymes speed up biochemical reactions up to ten million times compared to the uncatalysed reaction.

(ii) Enzyme catalysed reactions rapidly attain equilibrium.

(iii) Enzymes function in dilute aqueous solutions, at moderate temperatures and at a specific *p*H.

(iv) They are very specific and selective in their action on substrates.

(v) Enzymes are highly efficient and are needed in small amounts only.

(vi) In addition to the protein structure, most active enzymes are associated with some non-protein component required for their activity, called *coenzymes*. For example nicotinamide adenine dinucleotide (NAD) is a coenzyme which is associated with a number of dehydrogenation enzymes.

29.6 HORMONES

Hormones are chemical messengers which are secreted by endocrine glands. They are carried through the blood stream to the target tissues.

Majority of the hormones in humans are steroids. The two important classes of steroid hormones are **sex hormones** and **adrenocortical hormones**. The sex hormones control maturation, tissue growth and reproduction whereas the adreno-cortical hormones regulate various metabolic processes. Two most important male sex hormones or **androgens are testosterone** and **androterone**. They are responsible for the development of male secondary sex characteristics during puberty and for promoting tissue and muscle growth.

The female sex hormones or **estrogens** include **estrogen** and **estradiol** as examples. These hormones are responsible for the development of female secondary sex characteristics and for regular of menstrual cycle.

Another important female hormone is **progesterone** which prepares the lining of the uterus for the implantation of the fertilized ovum. The continued secretion of progerterone is important for the completion of the pregnancy.

Synthetic estrogens have been developed and they are used in combination with synthetic pregnancy hormones as oral contraceptines.

The adrenocritical hormones are secreted by adrenal glands which are small organs located near the upper end of each kidney. The **aldosterone** controls the tissue swelling by regulating cellular salt balance between Na^+ and K^+. Another hormone called **hydrocortisone** is involved in the regulation of glucose metabolism and in the control of inflammation.

Two important hormones which are polypeptides in nature are **vasopressin** and **oxytocin**. Oxytocin occurs in females only and stimulates uterine contraction during child birth. Vasopression occurs both in males and females and causes contraction of peripheral blood vessels and an increase in blood pressure.

Insulin, another important polypeptide hormone, is secreted from pancreases. It regulates the metabolism of glucose in the body. The deficiency of insulin in human causes diabetes mellitus.

INTEXT QUESTIONS 29.5

1. Name two important classes of steroid hormones.
2. What is oxytocin? Give its role.

29.7 VITAMINS : CLASSIFICATION AND THEIR FUNCTIONS

A variety of organic molecules act as coenzymes. Many of them are vitamins. Vitamins are small organic molecules which are taken in diet and there are required in trace amounts for proper growth.

Vitamins can be fat soluble or water soluble. A list of important vitamins and their deficiency symptoms is given below.

	Vitamin	Deficiency Symptom
A. Water Soluble		
(i)	Ascorbic Acid (Vitamin C)	Bleeding gums, Bruising
(ii)	Thiamin (Vitamin B_1)	Fatigue, Depression
(iii)	Riboflavin (Vitamin B_2)	Cracked lips, Scaly skin
(iv)	Pyridoxine (Vitamin B_6)	Anemia, Irritability
(v)	Niacin	Dermatitis, Dementis
(vi)	Folic acid (Vitamin M)	Megalobastic Anemia
(vii)	Vitamin B_{12}	Megalobastic Anemia, Neuro degeneration
(viii)	Pantothenic acid	Weight loss, Irreitability
(ix)	Biotin (Vitamin H)	Dermatitis, anorexia, depression
B. Fat Soluble		
(x)	Vitamin A	Night blindness, dry skin
(xi)	Vitamin D	Rickets, osteomalacia
(xii)	Vitamin E	Hemolysis of RBCs
(xiii)	Vitamin K	Hemorrahage, delayed blood clotting

INTEXT QUESTIONS 29.6

1. Match the following vitamins mix their deficiency symptoms:

(i) Vitamin C	(a) Anemia
(ii) Vitamin B_2	(b) Bleeding guns
(iii) Vitamin B_6	(c) Scaly skin

2. What is night blindness? Why is it caused?
3. How do enzymes increase the rate of a reaction?
4. What do you understand by lock and key arrangement?

WHAT YOU HAVE LEARNT

- Carbohydrates are polyhydroxy aldehydes or ketones or substances which provide such molecules on hydrolysis.
- They are classified as mono-, di-and polysaccharides.
- Proteins are the polymers of α-amino acids which are linked by peptide bonds.
- All proteins are the polymers of twenty different α-amino acids. Out of these 10 amino acids cannot be synthesized by our body and hence must form the part of our diet. These are called essential amino acids.
- Proteins are very important to us and perform many functions in a cell that are absolutely necessary for our survival.
- Chief sources of proteins are pulses, milk, meat, eggs, etc.
- Biomolecules which are insoluble in water and soluble in organic solvents are called lipids. They are classified as simple, compound and derived lipids.
- Nucleic acids are the compound which are responsible for the transfer of characters from parents to offsprings.
- There are two types of nucleic acids- DNA and RNA. They are polymers composed of repeating units called nucleotides.
- DNA contains a five carbon sugar molecule called 2-deoxyribose whereas RNA contains ribose.
- The four bases present in DNA are adenine, cytosine, guanine and thymine whereas RNA contains uracil in place of thymine.

- DNA is a double strand molecule whereas RNA is a single strand molecule.
- DNA is present in the nucleus and have the coded message for proteins to be synthesized in the cell.
- Proteins are actually synthesized by RNA which are of three types – messenger-RNA (*m*-RNA), ribosomal-RNA (*r*-RNA) and transfer- RNA (*t*-RNA).
- Enzymes are biocatalysts which speed up the reactions in biosystems.
- Chemically all enzymes are proteins. They are very specific and selective in their action on substrates.

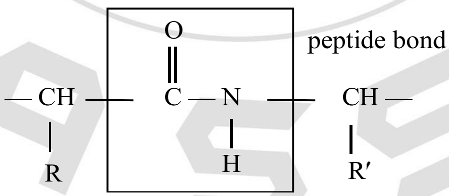
ANSWERS TO INTEXT QUESTIONS

29.1

1. Cereals, fruits and sugar.
2. Plants produce carbohydrates during photosynthesis.
3. Starch on hydrolysis gives glucose whereas sucrose on hydrolysis gives glucose and fructose.
4. Refer to section 29.1.2.

29.2

1. Information regarding the sequence of amino acids in a protein chain is called its primary structure.
2. Proteins are made up of many α-amino acids which join together by the formation of an amide bond between $-NH_2$ group of one amino acid and $-COOH$ group of another. When two amino acids combine in this way, the resulting product is called a dipeptide and the amide bond between them is called a peptide bond.



3. An α-amino acid may be represented as

$$\begin{array}{c} H_2N - \underset{\displaystyle R}{\underset{|}{CH}} - COOH \end{array}$$

4. Refer to section 29.2.1.

29.3

1. Biomolecules which are insoluble in water and soluble in organic solvents like benzene, ether or chloroform are called lipids.
2. Oils on hydrolysis give glycerol and long chain fatty acids.
3. Two types of compound lipids are phospholipids and glycolipids.
4. A triglyceride which is solid at room temperature is called a fat and if it is liquid then it is called an oil.

29.4

1. A nucleotide consists of three subunits which are (i) a nitrogen containing heterocyclic aromatic compound, also called a base; (ii) a pentose sugar (ribose or 2-deoxy ribose) and (iii) a molecule of phosphoric acid.
2. In DNA, two chains are wound around each other in the form of helix, hence the structure is called a double helix.
3. Two main structural differences between DNA and RNA are :
   (i) DNA molecules are double stranded whereas RNA are single strand molecules.
   (ii) In DNA molecules, the sugar moity is 2-deoxyribose whereas in RNA molecules, it is ribose.

29.5

1. Refer to section 29.5.1
2. Refer to section 29.5.1

29.6

1. Six hormones and adrenocortical hormones.
2. Oxytocin is a female hormone. It stmulates uterine contraction during child birth.
3. (i) – (b)
   (ii) – (c)
   (iii) – (a)
4. Night blindness is a deficiency sympton. It is caused by the deficiency of vitamin A.