BASUDEV GODABARI DEGREE COLLEGE, KESAIBAHAL

BLENDED LEARNING STUDY MATERIALS

UNIT-II

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DEPARTMENT OF BOTANY

1st SEMESTER PAPER-II - BIOMOLECULES AND CELL BIOLOGY

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KESAIBAHAL, SAMBALPUR, 768228

Basudeb Godabari Degree College, Kesaibahal

Department of Botany

"SELF STUDY MODULE"

Module Details:-
Class- 1st Semester (2020-21)
Subject Name- Botany
Paper Name- Biomolecules and cell Biology
Paper – IIND

Unit-II

i. Lipids: Definition and major classes of storage and structure lipids Fatty acids structure and function. Essential fatty acids. Triacylglycerols structure, function and properties.
ii. Proteins : Structure and classification of amino acids, peptide bonds, Levels of protein structure, primary, secondary, tertiary and quaternary, Isoelectric point, protein dinaturation and biological roles of proteins.
iii. Nucleic acid: Structure of nitrogenous bases, structure and function of nucleotides, types of nucleic acids, Structure of A,B,Z type of DNA, Types of RNA, Structure of Trna.

Learning objectives:

After learning this unit you should be able to

1. Defind lipids and classify them.
2. What are the steroids and sterols? Describe their structure and function.
3. How essential fatty acids differ from fatty acids.
4. What are triglycerides and what is sapontification?
5. Describe the difference between simple and complex lipids.
6. How do storage lipids and structural lipids differ?
7. Describe the structure of proteins at primary, secondary and quesstenary levels ?
8. How can proteins be separated using SDS-PAGE.
9. Discuss the significance of isielectic point.
10. How amino acids undergoes peptide bond formation to make proteins.
11. What is the role of proteins denaturation in cell physiology.
12. Describe the double helical structure of DNA.

13. What is phosphodiester bond.
14. Which for bases are generally found in DNA, RNA.
15. Demonstrated DNA is a genetic materials.
16. What is Z-DNA and how does it differ from B-DNA.
17. Describe the similarities and difference between the structure of DNA and RNA.
18. Describe the structure of mRNA molecules.
19. Describe the secondary structure of t-RNA.
20. Describe briefly the there major types of RNA involved in protein synthesis.

You can use the following video link to –

https://youtu.be/EHUsXCz_B-Q .....lipid
https://youtu.be/vfko79vz300 .....proteins
https://youtu.be/29wJigW5xiY .....Nucleic acid

You can also used the following books

1. Bimolecules and cell biology – by Arun Chandra Sahu, Kalyani publication
2. Notes – Lipids, proteins and Nucleic acids.

Plan- Unit- II

No of period to be taken – 10

Date	Time	Period	Topic Covered	Signature
02.01.21	9.30 to 10.30am	01	Definition and major classes of storage and structural lipids. Fatty acids structure and function. Essential fatty acids.	
09.01.21	9.30 to 10.30am	01	Triacylglycerols structure and major function and properties of lipids.	
16.01.21	9.30 to 10.30am	01	Doubt clearing class.	
18.01.21	9.30 to 10.30am	01	Introduction of proteins. Structure and classification of amino acids, peptide bonds, levels of protein structure primary, secondary, tertiary and quaternary	
27.01.21	9.30 to 10.30am	01	Isoelectric points, proteins denaturation and biological roles of proteins.	
06.02.21	9.30 to 10.30am	01	Doubt clearing Class.	
08.02.21	9.30 to 10.30am	01	Introduction to nucleic acids, structure of nitrogenous bases structure and function of nucleotides.	
13.02.21	9.30 to 10.30am	01	Types of nucleic acids, structure of A,B,Z type of DNA.	
20.02.21	12.30 to 1.30pm	01	Types of RNA, Structure of t-RNA.	
27.02.21	12.30 to 1.30pm	01	Doubt clearing class Revision.	27.02.21.

31

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 :

- identify and define different types of biomolecules;
- describe the important structural features of biomolecules;
- classify carbohydrates, proteins and lipids on the basis of their structure & 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
- list the functions of biomolecules in biological systems.

31.1 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.

31.1.1 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 31.1. Name of some naturally occuring monosaccharides are given in brackets.

Table 31.1 Classification of monosaccharides

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

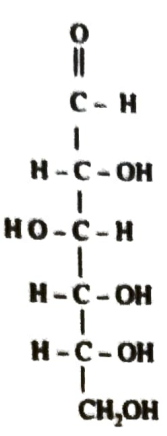
(ii) **Disaccharides**: Carbohydrates which give two monosaccharide molecules on hydrolysis are called disaccharides e.g. sucrose, maltose, lactose etc.

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

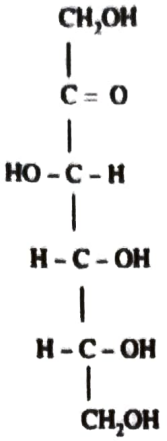
31.1.2 Structure of Monosaccharides

Although a large number of monosaccharides are found in nature, we will confine our discussion here to four of them only viz. D-glucose, D-fructose,D-ribose and 2-deoxy-D-ribose.

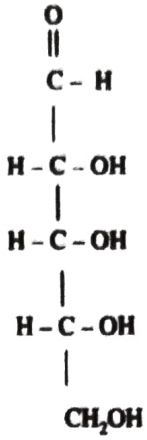
D-Glucose (an aldohexose) is the monomer for many other carbohydrates. Alone or in combination, glucose is probably the most abundant organic compound on the earth. D-Fructose (a ketohexose) is a sugar that is found with glucose in honey and fruit juices. D-Ribose (an aldopentose) is found in ribonucleic 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.



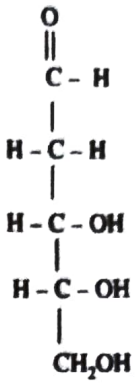
D-Glucose



D-Fructose



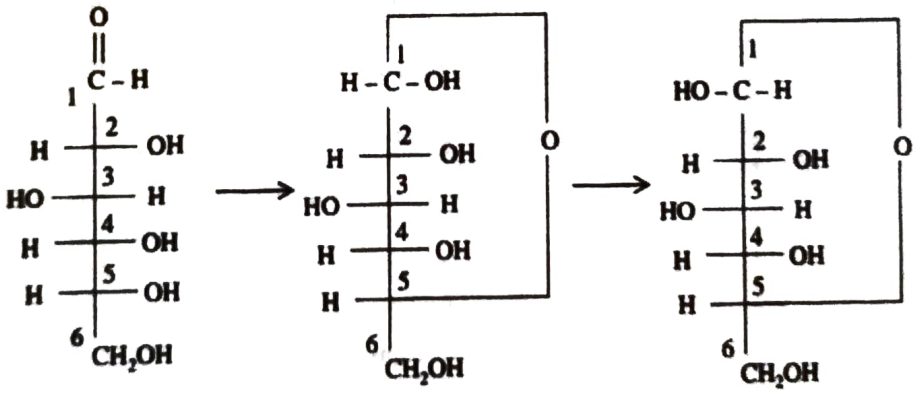
D-Ribose



2-Deoxy-D-ribose

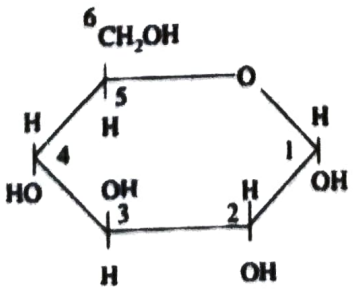
These monosaccharides generally exist as cyclic compounds in nature. A ring is formed by a reaction between the carbonyl group and one of the hydroxyl groups present in the molecule. Glucose preferentially forms the six membered ring which can be in two different isomeric forms called α- and β-forms (shown below as I & 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.

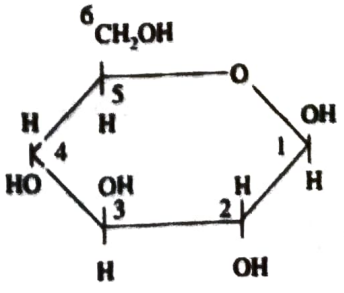


(I) α – D – glucose (II) β – D –glucose

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

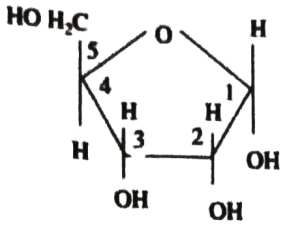


(Ia)

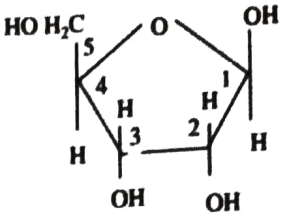


(IIa)

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

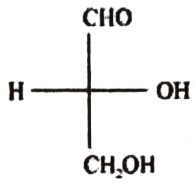


α – D – ribose

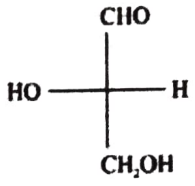


β – D – ribose

D-before the name of above example indicates the configuration of particular stereoisomer. Stereoisomers are assigned relative configurations as D– or L –. This system of assigning the relative configuration refers to their relation with glyceraldehyde. Glyceroldehyde contains one asymmetric carbon atom so exists in two enantiomeric forms as shown below.

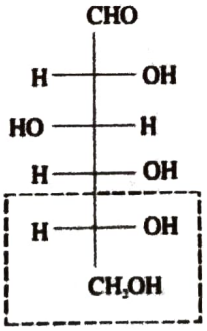


(+) –glycaraldehyde

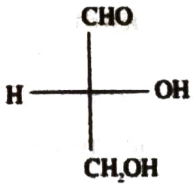


(–) –glyceraldehyde

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

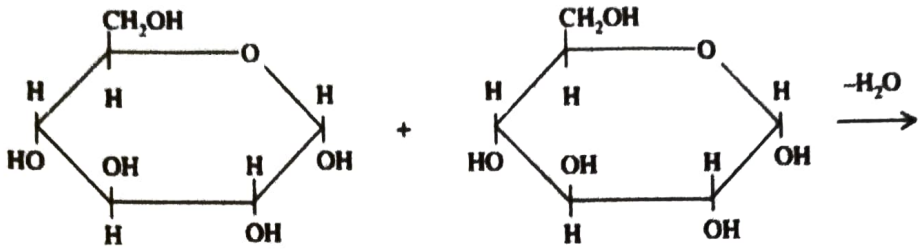


(+) – glyceraldehyde or D-glyceraldehyde

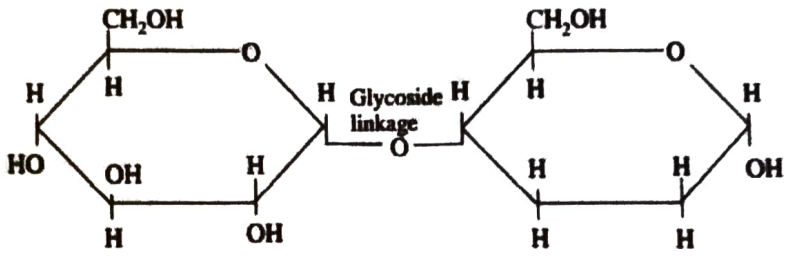
31.1.3 Structure of Di-Saccharides and Polysaccharides

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 contains one molecule of glucose and one molecule of galactose.

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.

The carbohydrates are stored in animal body as glycogen which is also a polymer of α-glucose and its structure is similar to amylopectin.

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.

31.1.4 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 31.1

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.

31.2 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.

31.2.1 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).

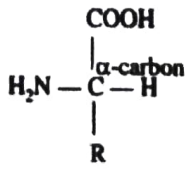
Proteins can also be classified on the basis of functions they perform, as summarized in table 31.2.

Table 31.2 : Classification of proteins according to their biological functions

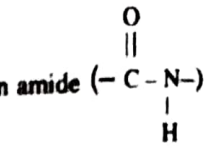
	Class	Functions	Examples
1.	Transport Proteins	Transport of oxygen, glucose and other nutrients	Haemoglobin Lipoproteins
2.	Nutrient and storage Proteins	Store proteins required for the growth of embryo	Gliadin(wheat) Ovalbumin(egg) Casein (milk)
3.	Structural Protiens	Give biological structures, strength 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

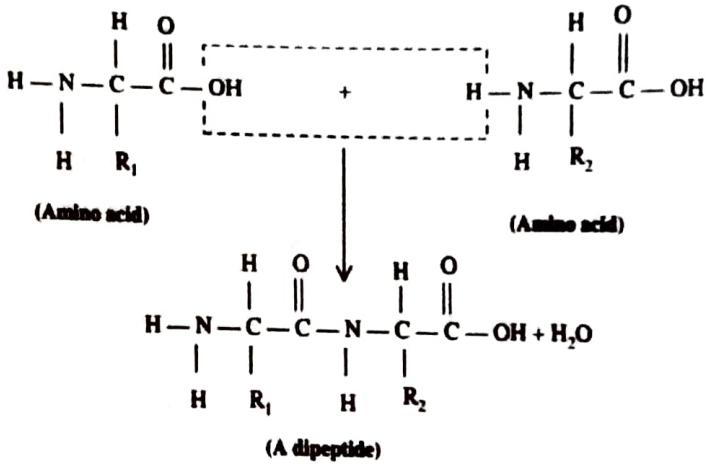
31.2.2 Structure of Proteins

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.



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  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 $-\overset{\overset{O}{\|}}{C}-$ and >N – H group

Two types of secondary structures have been reported. These are – α helix (Fig 31.1) when the chain coils up and β-pleated sheet (Fig. 31.2) when hydrogen bonds are formed between the chains.

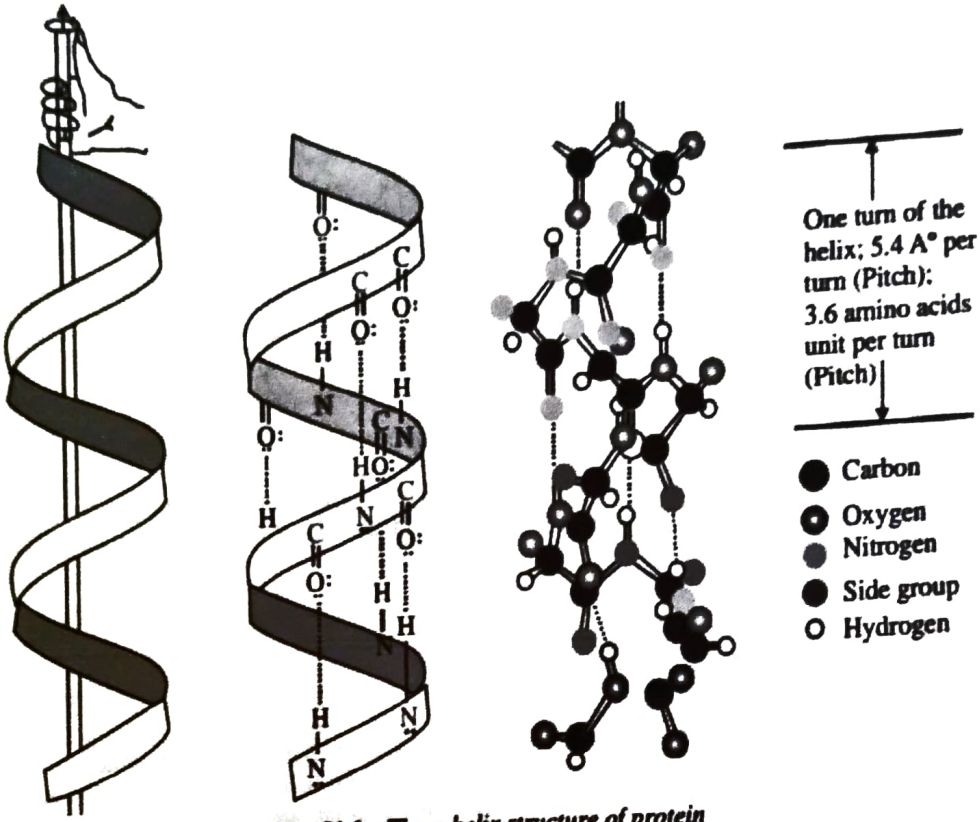


Fig. 31.1 : *The α-helix structure of protein*

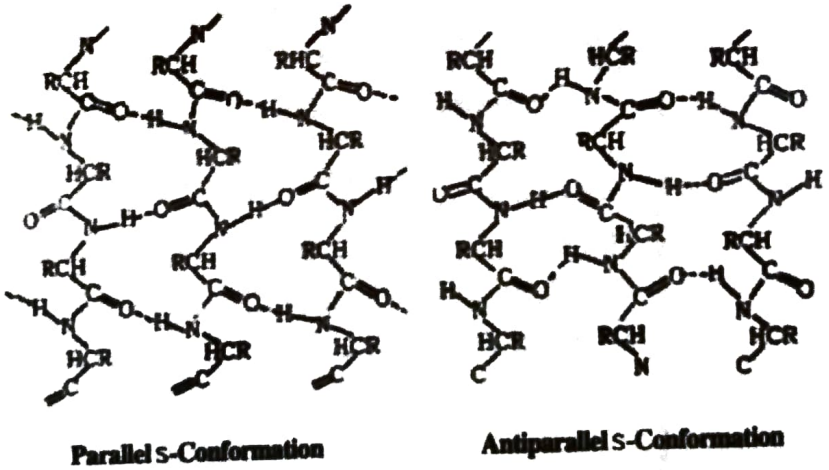


Fig. 31.2 : *The β-pleated-sheet structure of protein*

(iii) Tertiary structure: It is the three-dimensional structure of proteins. It arises due to folding and superimposition of various α-helical chains or β-plated sheets. For example Fig. 31.3 represents the tertiary structure for the protein myoglobin.

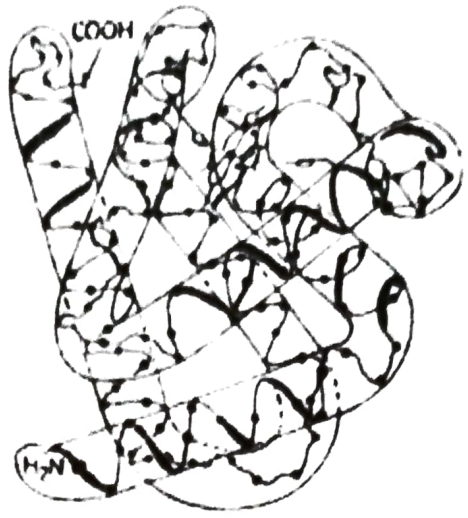


Fig. 31.3 : *Structure of myoglobin*

(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.

31.2.3 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 *p*H 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.

31.2.4 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 31.2

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 α-amino acid?

   .....

4. What are conjugated proteins ?

   .....

31.3 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.

31.3.1 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.

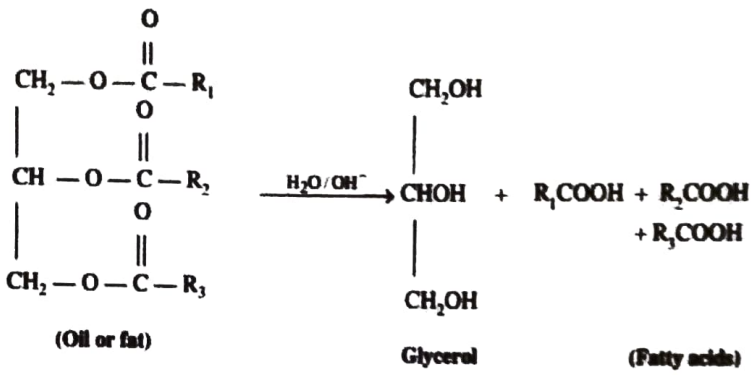
(iii) **Derived Lipids:** Compounds which are formed from oils, fats etc. during metabolism. They include steroids and some fat soluble vitamins.

31.3.2 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:



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 constitutent of bees wax obtained from the honey comb of bees is myricyl palmitate:

myricyl palmitate

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

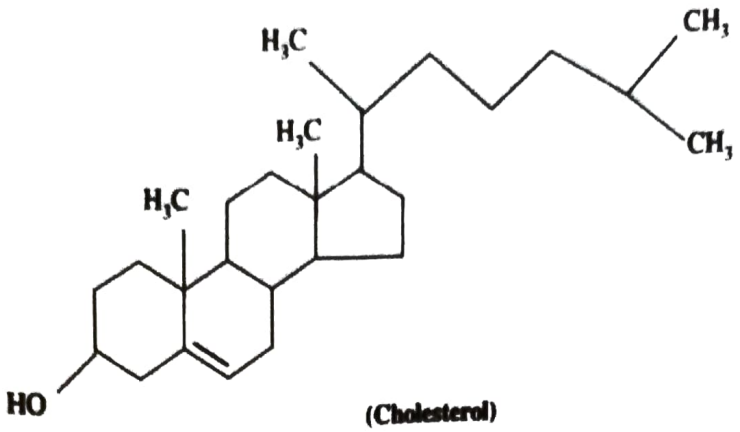
(ii) Compound Lipids

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.

31.3.3 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 31.3

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?

.....

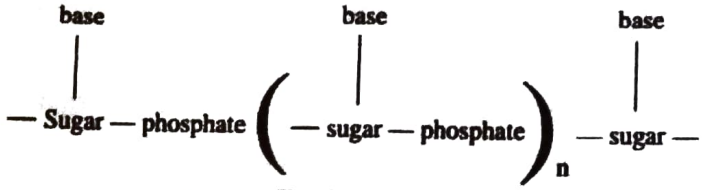
31.4 Nucleic Acids

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 19th 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.

31.4.1. 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.



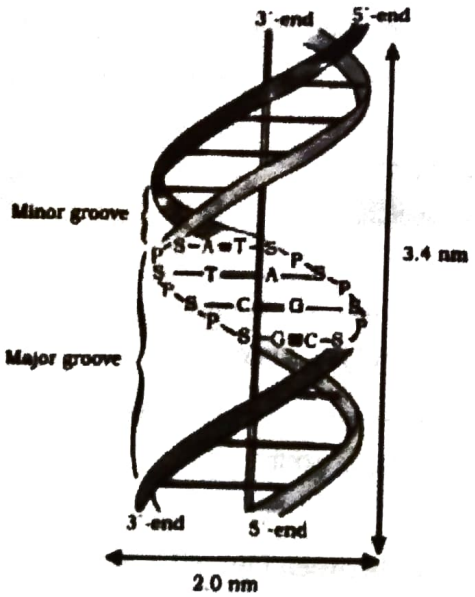
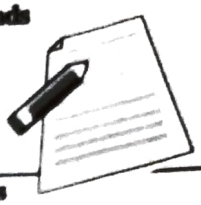


Fig. 31.4 : *Watson and Crick's double helix structure of DNA*

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. 31.4). 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.



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)

31.4.2 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).

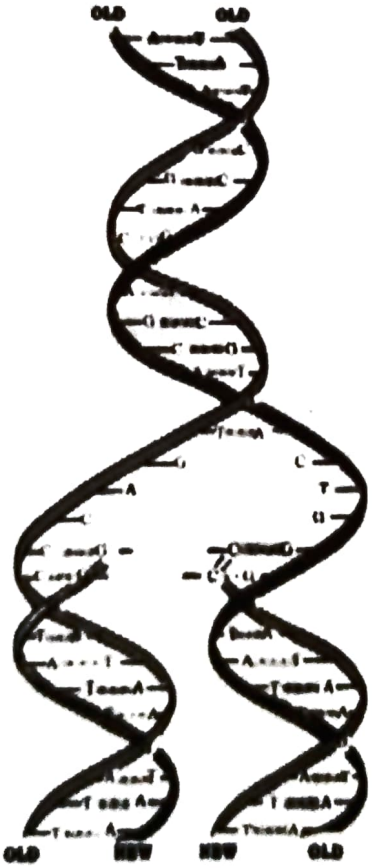


Fig. 31.5 : *Replication of DNA*

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 31.4

1. What is a nucleotide?

   .....

2. Why structure DNA is called a "doublehelix"?

   .....

3. Write two main structural differences between DNA and RNA.

   .....

31.5 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.

31.5.1 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.31.6). This

Unit-II

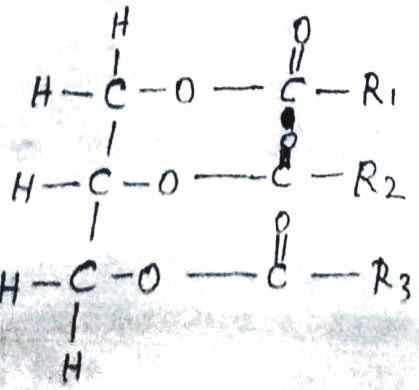
:(i) LIPIDS:-

→ Lipids are heterogenous groups of substances which yeild fatty acid on hydrolysis.
→ Fats and their derivations collectively called Lipids.
→ These are chemically called lipids. These are chemically esters of fatty acids and glycerol.
→ The term Lipid was first used by Bloor (1943).
→ Lipids are insoluble in water but soluble in organic solvents like ether chloroform, benzene, hotalcohol, carbon disulphide etc.
→ Lipids are widely distributed in plants and animals.

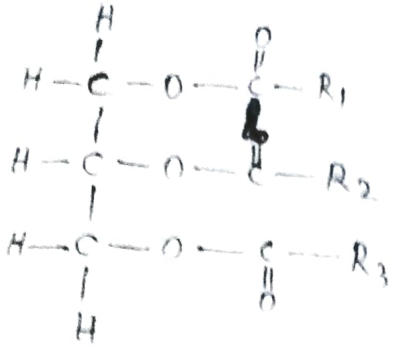
CLASSIFICATION:- On the basis of composition lipids are of 3 types i.e :- (A) Simple Lipids
(B) Compound Lipids
(C) Derived Lipids

(A) SIMPLE LIPIDS:- Simple Lipids are ester of fatty acids with various alcohol, Simple Lipids are of 2 types:-
(1) Neutral facts
(2) Waxes

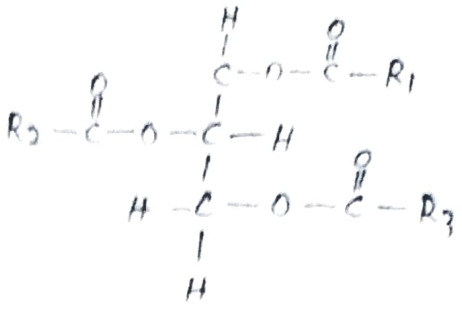
(1) Neutral facts:- Neutral fats are triglycerates. The triglycerides are easters of glycerol with 3 fatty acid.



The 2nd carbon is an assymetric carbon hence triglycerides has two optical isomers.
(i) L - Form
(ii) D - Form

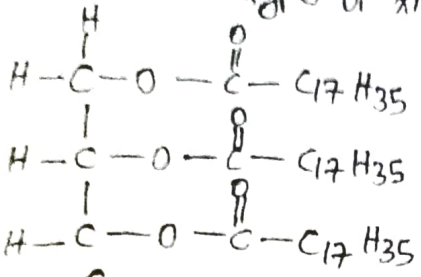


(D-Form)



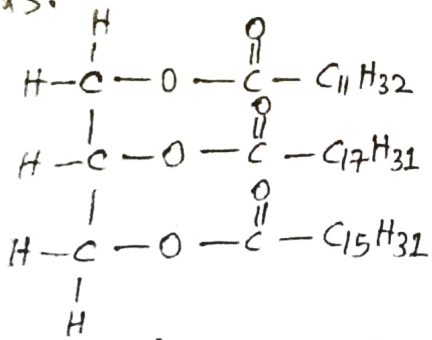
(L-Form)

(i) Simple Triglycerides:- If all the 3 fatty acid molecules are of the same type of these it is called simple triglycerides.



(Stearic acid 18 carbons)

(ii) Mixed Triglycerides:- It contains 2 or 3 different fatty acid units.



(Palmitic acid 16 carbon)

(iii) Fatty Acid:-

Fatty acid are long chain of carboxylic acid usually mono-carboxylic acids. They processess even unbranched chain.

The fatty acids may contain double bond or single bond. The fatty acid which contains single bond is saturated fatty acid. The fatty acid with double bond is unsaturated fatty acid.

(a) Saturated Fatty Acids:-

The general formula for saturated fatty acid is R-COOH. Palmitic acid is a saturated fatty acid which does not contain double bond with formula $CH_3(H_2)_{14}COOH$.

(b) Unsaturated Fatty Acids:- The unsaturated fatty acid contain 1 or more double bond in their hydrocarbon chain. The general formula is $R-CH=CH(H_2)_n-COOH$.

Oleic acid is monolensaturated fatty acid containing only one double bond, but in olic acid contains 3 double bonds.

(2) WAXES:- These are the easters of long chain saturated and unsaturated fatty acids with long chain monohydric alcohol. The long chain fatty acids contain C_{14} to C_{36}. similarly alcohol contains C_{16} to C_{30}.

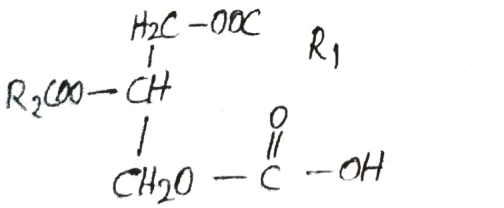
Ex- Lanolin, Bee waxes, Spermatic **otl.**

B-COMPOUND LIPIDS:- Compounds lipids are those lipids which are easter of fatty acid and glycerol combines with non-fatty compound like phosphate, sulphate, other sugar derivatives or proteins.

PHOSPHOLIPIDS:- These are lipids containing lycerol phosphoric acid and fatty acids phospolipids are of 2 types.

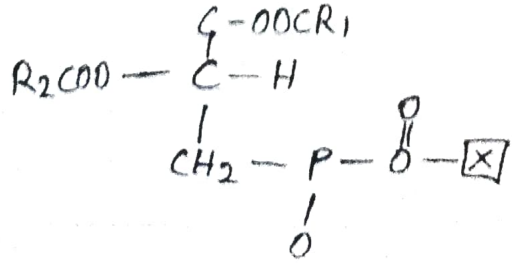
(1) Glycerophospho lipids
(2) Sphingophospo lipids.

(1) GLYCEROPHOSPHO LIPIDS:- It has aglycerol back bone two fatty acids and a phosphoric acid. So the compound is phosphatidic.



(Phosphatidic acid)

The phosphatidic acid gives rise to several derivative due to esterification of phosphoric acid.



If 'x' is a choline then the compound is called phospatidyl Choline or lecethin. If 'x' is a ethanol amine then the compound is called phosphatidyl ethanol amine or cephalin.

2-SPHINGIOPHOSPHOLIPIDS:- It has a sphingomine or sphingesine instead of glycerol.

Ex - Sphingomyceltin.

GLYCOLYSIS:- It has an alcohol backbone, fatty acid and monosaccharides. Glyceltipids are of 2 types.

(a) Cerebrosides
(b) Gangliosides.

(a) Cerebrosides:- Cerebrosides are lipid molecules having sphingenin, long chain, fatty acid and monosaccharides.

Ex- Phercynostin, Kerostin.

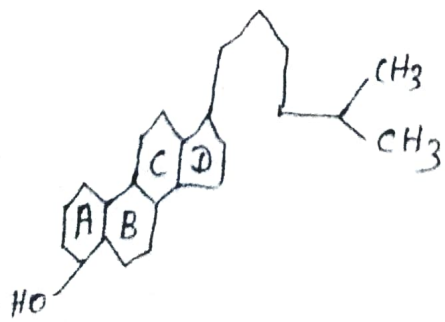
(b) Gangliosides:- Gangliosides are lipid molecules having ceramite (amide or sphingenine and fatty acid) and N-acety murcamic acid (sialic acid) and other monosaccharide.

(C) DERIVED LIPIDS:- The derived lipids includes the hydrolysis product of simple and compound lipids. These are of 3 types.

(1) Stercoids.
(2) Terpens.
(3) Carcotenoids.

(1) Stercoids:- It is a group of lipid having 4 fused rings (A, B, C, D) called cyclopentanoper. phydrophenathrene (Sterene) nucleus carbon atom of the ring are numbered as 1 to 12.

Ex - cholesterol



(2) TERPENES:- These lipids have hydrocarbon and their oxygen derivatives having less than 40 carbon atoms.

Ex - Myrcene Geronal

(3) CAROTENOIDS:- Carotenoids are tetraterpens. They are isoprene derivative with high degree of unsaturation.

Ex - Lycopene, Carotene, Xanthophyl.

PROPERTIES OF FATTY ACIDS AND FATS:-

PHYSICAL PROPERTIES:-

→ Fats containing saturated fatty acids are solid at room temperature, but fats containing unsaturated fatty acids are liquid.
→ Fats are colourless, odourless but tasted.
→ Fats and fatty acids are soluble inorganic solvent like petroleum, ether, benzene, and chloroform but insoluble in water.
→ The unsaturated fatty acid show cis trans isomerism due to presence of double bonds.
→ They are bad conductors of head.
→ Melting points of fat depends on the length of fatty acids chain.
→ Specific gravity of fat is less then 1 i.e 0.96.

CHEMICAL PROPERTIES OF FATS:-

(1) HYDROLYSIS:-

$$\begin{array}{l} CH_2O\ OCC_{15}H_{23}HO \\ CH_2O\ OCC_{15}H_{23}HO \\ CH_2O\ OCC_{15}H_{23}HO \end{array} \xrightarrow{\text{enzyme}} \begin{array}{l} CH_2OH \\ CHOH \\ CH_2OH \\ \text{(glycose)} \end{array} + 3\,C_{15}H_{23}OH$$

(2) HYDROGENATION:- Fats containing unsaturated fatty acids when reacts with gaseous hydrogen produce saturated fatty acids.

$$\text{Oleic acid} \xrightarrow[Pt, Pd, Ni]{H_2} \text{Stearic acid}$$

(2) TERPENES:- These lipids have hydrocarbon and their oxygen derivatives having less than 40 carbon atoms.

Ex Myrcene geraniol

(3) CAROTENOIDS:- Carotenoids are tetraterpenes. They are isoprene derivative with high degree of unsaturation.

Ex - Lycopene, Carotene, Xanthophyl.

PROPERTIES OF FATTY ACIDS AND FATS:-

PHYSICAL PROPERTIES:-

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→ The unsaturated fatty acid show cis trans isomerism due to presence of double bonds.
→ They are bad conductors of head.
→ Melting points of fat depends on the length of fatty acids chain.
→ Specific gravity of fat is less then 1 i.e 0.86.

CHEMICAL PROPERTIES OF FATS:-

(1) HYDROLYSIS:-

$$\begin{array}{l} CH_2O\ OCC_{15}H_{23}HO \\ CH_2O\ OCC_{15}H_{23}HO \\ CH_2O\ OCC_{15}H_{23}HO \end{array} \xrightarrow{\text{enzyme}} \begin{array}{l} CH_2OH \\ CHOH \\ CH_2OH \\ \text{(glycose)} \end{array} + 3\,C_{15}H_{23}OH$$

(2) HYDROGENATION:- Fats containing unsaturated fatty acids when reacts with gaseous hydrogen produce saturated fatty acids.

$$\text{Oleic acid} \xrightarrow[Pt, Pd, Ni]{H_2} \text{Stearic acid}$$

(3) HYDROGENALYSIS:- Oils and Fats are converted into a glycerol and a long chain of aliphatic alcohol when excess of air the presence of copper.

This splitting of fat by hydrogen is called hydrogenalysis.

Triesterrain $\xrightarrow[300\,atm]{CH_2CuCr}$ glycerol + Octade acyl alcohol.

RACIDITY:-

Oils and fats on long storage in contact with heat, light, air and moisture develops an unpleasant adour, such oils and fats are known as rancid oils and fats. The rancidity develops due to certain chemical changes taking place in the Fat. The changes includes.

A→ENZYMATIC HYDROLYSIS:- In the presence of enzyme and micro-organism the fats and oil from bad smelling lowers fatty acid.

B→AIR OXIDATIVE OF UNSATURATED FATTY ACIDS:-

During air oxidation the unsaturated fatty acid protein of fats are oxidised at the site of double bonds into aldehydes and ketones with unpleasant adour.

C→B-OXIDATION OF SATURATED FATTY ACIDS:-

The saturated fatty undergo B-oxidation followed by decarboxylation to from ketones of unpleasant adour.

EMULSIFICATION:- The Process of breaking large sized fat molecules into smaller one is known as emulsification. The emulsification agents are water, soaps, proteins and guns.

BIOLOGICAL IMPORTANCE OF FAT:-

(1) Fat serve as reserve food in seeds. They are deposited during the development of seeds. They are mobilized and reutilized as a source of energy during the germination and growth of seeding.

(2) Oils are used by human beings for various. The edible oil are contained from the soil.

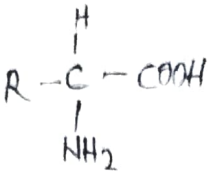
(3) Lipids serves as prime fues for metabolism it provides more energy than carbohydrates and protein.

(4) They help in insolution the body of animals when deposit in body and insulate against heat.

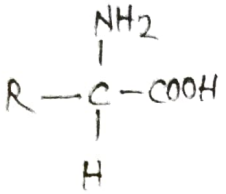
(5) Sex hormones and steroid hormones like adreno cortical hormones are also synthesized from fats.

:(ii) PROTEINS:-

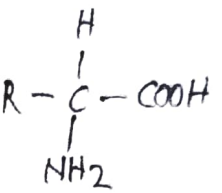
STRUCTURE OF AMINO ACID:- The amino acids are essential components of all living cells as building blocks of proteins. The amino acids are carboxylic acid containing at least one amino group in protein, aminoacid is always the α-carbon atom and are called α-amino acid is.



The amino acid exist in 2 forms, L-form and D-form.



(α-form)



(D-Form)

All amino acid which occure in proteins belongs to α-form. The D-form aminoacid have been discovered in bacteria and in antibiotics.

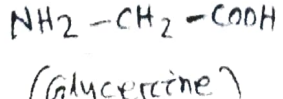
CLASSIFICATION OF AMINO ACID:- On the basis of their structure and properties.

(1) Aliphatic amino acid
(2) Aromatic amino acid
(3) Heterocyclic aminoacid

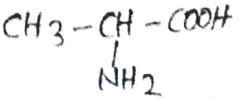
(1) ALIPHATIC AMINO ACID:- The amino acid having aliphatic structure are known as aliphatic amino acid. They are subdivided into 3 subclasses.

(a) Monoamino - Monocarboxylic Acid (Neutralamino Acid)

Ex - Glycerine, Alanine, Valine, Leucine, Isoleucine, serine, Theonine.



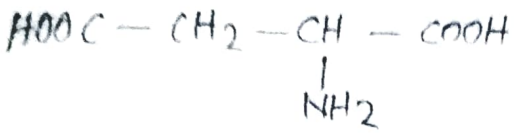
(Glycerine)



(Alanine)

(b) Monoamino - Dicarboxylic acid (Acidic Amino Acid)

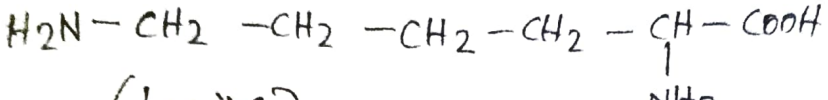
Ex - Aspartic Acid, Asparagine, Glutamic acid, Glutamine.



(Aspertic acid)

(C) Diamino - Monocarboxylic Acid (Basic Amino Acid)

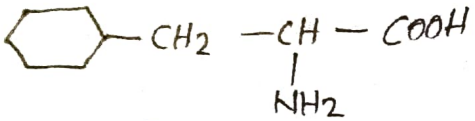
Ex - Arginine, Cystine, Cysteine, methionine.



(Lysine)

(2) AROMATIC AMINO ACID:- The amino acid having aromatic structure are known as aromatic amino acid.

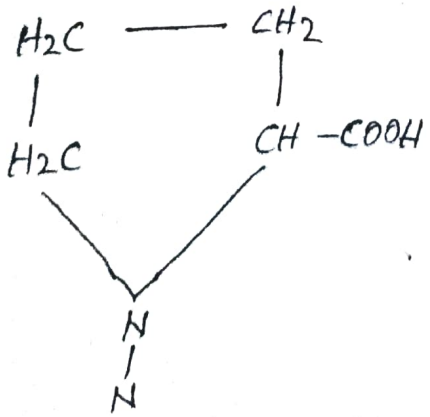
Ex - Phenyl alanine, Thyesine.



(phenyl alanine)

(3) HETEROCYCLIC AMINO ACIDS:- The amino acids having a closed chain ring of carbon with nitrogen are known as heterocyclic amino acid.

Ex - Proline, Hydroxyproline, Histidine, tryptophan.



(Proline)

PROPERTIES OF AMINOACIDS:-

PHYSICAL PROPERTIES:-

(i) Amino acids are colourless crystaline solids.
(ii) They have high boiling point.

SOLUBILITY:-

(i) The amino acids are polare molecule and soluble in wake.
(ii) The solubility varries for differcent aminoacids.
Ex- Aceline can dissolve upto 162gm perc 100ml of waterc at 25°C, but cystine is soluble only 0.011gm perc 100ml of waterc.

ISOMERISM AND OPTICAL ROTATION:-

(i) All aminoacids except glycine have 1 assymetrical carbon atom. So they are called chiral molecule showing isomercism.
(ii) They exist in D and L isomeric form with dextro or laevo rotatory properetries.
(iii) The D and L isomers rotate the plane of polarised light equally but in opposite direction.
(iv) The light whose vibration takes place only in one plane is called plane polarised light. The substance which rotate the plane polarised light towards right is called dextro-rotatory and to left is called laveorotatory.

ABSORPTION OF UV:-

(i) Amino acids like tryosine, tryptophan and phenyl alanine can absorb light in the UV range.
(ii) Cysteine absorb UV in 240 nm range and all other amino-acid absorb UV range in less than 220 nm.

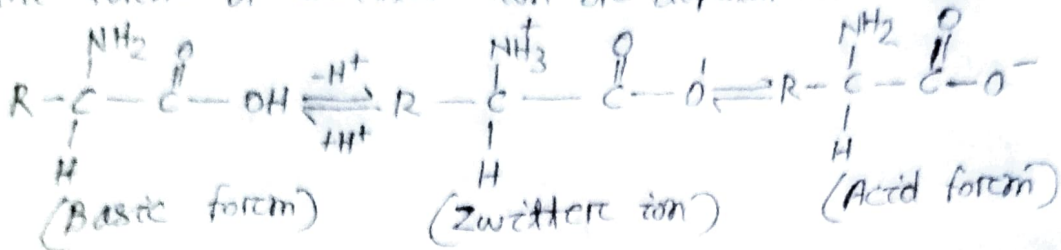
CHEMICAL PROPERTIES:- The chemical properetries of aminoacid depends upon theire reactive groups, -COOH and $-NH_2$.

(i) Amphoteric nature and zwitteric ion formation:-

The aminoacid contains both carboxyl and amino acid group. So they can react with acid and bases to form salts.

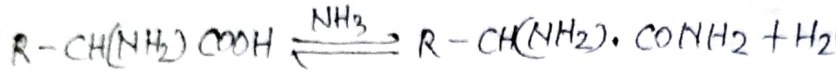
→Such compounds are called amphoteric compounds or ampholytes.

During the reaction the carboxyl group can either lose a proton or amino group can accept a proton. If both these groups are formed, the solution of amino acid is in the form of zwitter ion or dipolar ion.



(Basic form) (Zwitter ion) (Acid form)

(ii) Amide formation:- The aminoacid combine with ammonia to yield amides. In the natural synthesis of amides, the ammonia may be derived from other aminoacides.

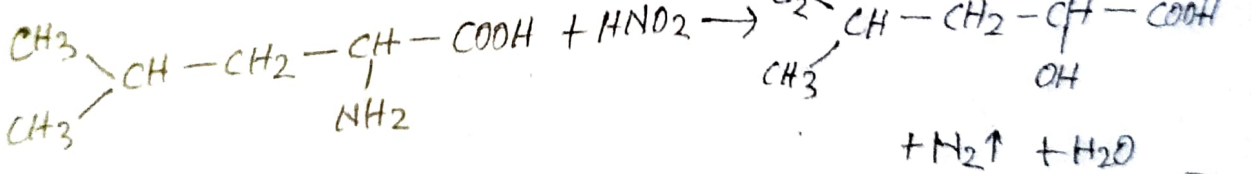


(Amino Acide) (Amide)

(iii) Reaction with nitrous acid:-

The aminoacid react with HNO_2 to liberate nitrogen gas from the amino group.

Ex- Leucine react with HNO_2 to liberate nitrogen gas from the amino group.



(Leucine) (α-hydroxycapric acid)

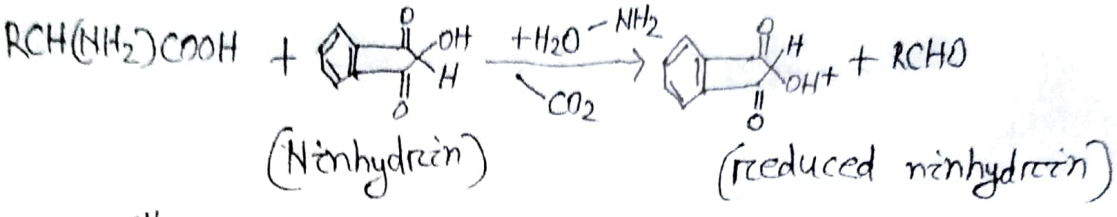
The aminoacids like proline, hydroxy proline don't have α- amino group. So they don't react with HNO_2.

(iv) Ninhydrine reaction:-

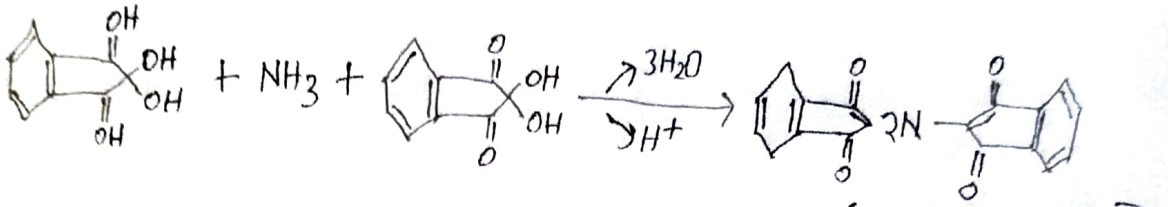
→ The amino acid react with ninhydrin (triketo hydrin hydrate) to yeild coloured product.

→ This reaction is used for quatitative estimation of CO_2 and NH_3.

→ The reduced ninhydrin reacts with ammonia and some ninhydrin to form blue-violet compound.



(Ninhydrin) (reduced ninhydrin)



(Coloured product purple-blue)

:PROTEINS:-

Proteins are colloidal naturally occurring organic compound and of high molecular weight. It occupy a central position on the architecture and functioning of living matter.

The term "Protein" was first proposed by Berzelius (1838). According to him proteins are complex heterogeneous organic molecules found in cells of living organisms. These are essential to all types of cell structure and function.

Chemically proteins are polymers of different amino-acid and in a definite sequence arranged by peptide bonds.

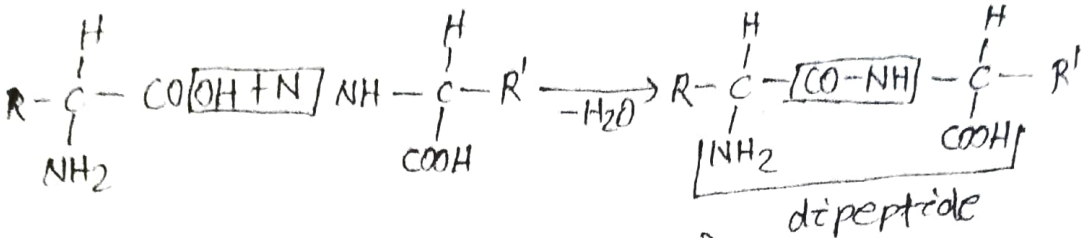
STRUCTURE OF PROTEINS:-

Different chemical bonds play important roles in the formation of a stable protein structure. They are:-

(1) Peptide bond
(2) Disulphide bond

(3) Hydrogen bond
(4) Hydrophobic bond

All proteins are macro molecules because of their. (-COOH) group of one amino acid linked with the amino group ($-NH_2$). of adjacent aminoacids forming peptide bond.



(Formation of peptide linkage)

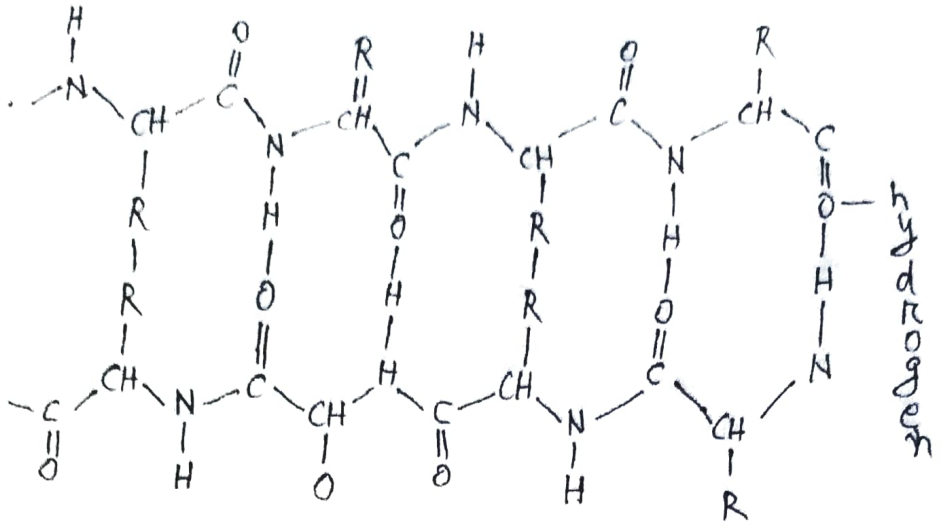
About 20 different amino acids take part in poly peptide chain. The no of aminoacid residues varries from protein to protein.

On the basis of structure and configuration primary proteins can be classified into 4 types.

(1) Primary structure
(2) Secondary structure
(3) Tertiary structure
(4) Quarcternary structure.

(1) PRIMARY STRUCTURE:-

(i) The primary structures of protein refers to the sequence of a aminoacid to form a polypeptide chain.
(ii) The covalent bond and disulphide bond are the characteristics of primary structure.
(iii) In it's primary form a protein may have a single or several polypeptides.
(iv) If the protein has one polypeptide chain it can have only one free α-amino group ($-NH_2$ terminal) and one free carboxyles (C-terminal group).
(v) Silk fibroin is a primary structure.



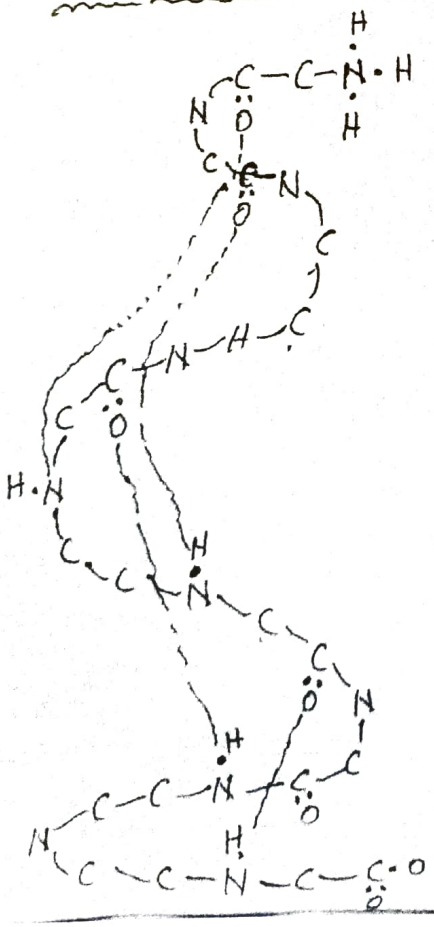
(2) SECONDARY STRUCTURE:-

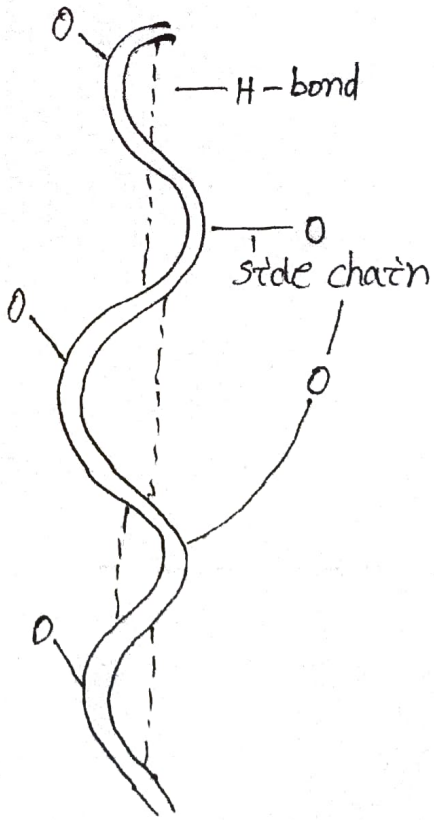
(i) If the polypeptide chain in a protein held together in coils of coiled upon each other are helically coiled like the rope is called a secondary structure.

(ii) The coiling is due to holding of one chain upon another by hydrogen bond beth the turens of a helix.

(iii) The most common type of secondary structure is α-helix of α-structure.

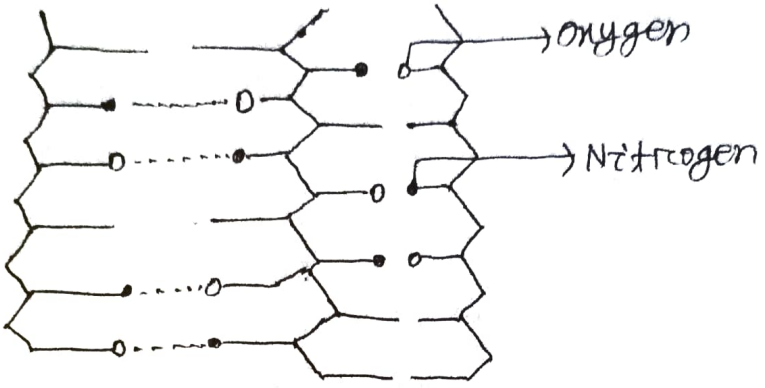
α - structure:-





(i) The α-structure of protein was proposed by pauling and corey in 1951.
(ii) The α-helix consist of a single strand twisted that a helical axis.
(iii) The coiling is by the H-bond beth C=O group and -NH group of the 3rd peptide residue.
(iv) Each amino acid is about 1.5 A° distance from next adjacent aminoacid.
(v) The pitch or spacing beth successive turn in 5.4°A°.
Ex - Myoglobin.

β-structure:-



(β-structure)

(i) Astubury and street (1933) proposed the β-structure of protein and modified by pouling and corey.
(ii) The β-structure is represented by parallel zig-zag polypeptide chain form a pleated sheet like structure.
(iii) The H-bond are formed beth -NH and C=O group on the neighbouring chain.
(iv) The side chain attached to the aminoacid residues present above and below the H-bonded sheets.
Ex - Milk Protein, Kercatin, Silk.

(3) Tercriary structure:-

(i) In a protein if α-helix is folded in definite pattern assuming globular configuration then it is called tercriary structure.
(ii) This due to the presence of sulphur containing amino acid residue in the chain.

(iii) 3 main types of bonds ionic, hydrogen and hydrophobic are also responsible for the formation of tertiary structure of a protein.

4-Quarternary structure:-

(i) Quarternary structure of protein concerns interaction by which 2 or more polypeptide chains are joined to form an biologically active protein.

(ii) Many of the enzymatic protein are of this kind of structure.

(iii) The quarternary structure of haemoglobin molecule was determined by perutz. in 1960. This made up 4 polypeptide chains.

Properties of Proteins:-

Physical Properties:-

(1) Proteins are colourless.

(2) Mostly tasteless but-serine is sweet.

(3) Homogenous and crystalline.

(4) The shape of protein ranges from simple crystaloid, spherical or globular from to long fibrilar structure.

(5) MOLECULAR WEIGHT:- The molecular weight of protein is very high ranges from 5×10^3 to 1×10^6. It depends on number of amino acid subunit.

(6) COLLOIDAL NATURE:- Protein exhibit the properties of colloids due to large size of particles, slow rate of diffusion.

(7) SOLUBILITY:- The solubility of protein is lowest at isoelectric point and increases with increasing acidity or alkalinity. Globulins are soluble in dilute salt solution of neutral pH.

Some proteins are soluble in acidic or basic solution. Ex - Glutenine, Prolamins, Another class of proteins which are soluble in alcoholic solution.

(8) AMPHOTERIC NATURE:- The proteins are amphoteric because they act both as acid and base. Net charge of a protein molecule depends on pH value of the medium.

CHEMICAL PROPERTIES:-

(1) Hydrolysis:- Proteins can hydrolysed by variety of hydrolyting agents to yield mono and dipeptides and on further hydrolysis to yield, aminoacids.

Protein → denatured protein → Metaprotein → Peptone → polypeptide → dipeptide → aminoacids.

The complete hydrolysis with about 20% boiling HCl or H_2SO_4 yield free amino acid.

Alkaline agents like NaOH can destroy aminoacids like serine, cysteine, arginine.

(2) Reaction with -COOH group:- Protein react with alkali form salts of their amino acids proteins reacts with at alcohol produce characteristic esters.

$$R-\underset{NH_2}{CH}-COOH + C_2H_5OH \longrightarrow R-\underset{NH_2}{CH}-COOC_2H_5 + H_2O$$

(3) Reaction involving $-NH_2$ group:- Reaction with acidic amino-acid residues of protein produce respective salts.

$$R-\underset{NH_2}{CH}-COOH + HCl \longrightarrow R-\underset{ClH-NH_2}{CH}-COOH$$

(4) Ninhydrin test:- Ninhydrin is powerful oxidizing agent causes oxidative decarboxylation of α-amino acid. This producing CO_2 and NH_3 and aldehyde.

(5) Reaction with Phosgene:- When an aminoacid reacts with phosgene it produces N-carboxy an hydride.

$$R-\underset{NH_2}{CH}-COOH + \begin{matrix} Cl \\ Cl \end{matrix}\!\!>\!CO \longrightarrow \begin{matrix} R-CH-CO \\ | \quad\quad | \\ NH-CO-O \end{matrix} + 2HCl$$

— o —

Question. core paper - II

No1 -

1 x 10

:- common example of a non. reducing diasachharides is _____

I- The initiation codon in eukaryotes is _____

II- Nucleic acids like DNA and RNA contain _____

V- chitin is a _____ sugars

'- The "repeating unit" polysachharides of glycogen is _____

I- mineral associated with cytochrome is _____

I- The basic repeating unit of a DNA molecules is _____

I- _____ is the most abundant biomolecules on earth ?

NADP contain vitamins _____

Inulin is made up of _____ and _____

3-2 (2-3 sentence)

Name the essential fatty acids.

what are the difference between fats and oils.

what is denaturation of protein ?

write the four sites of t-RNA

what is the elemental composition of carbohydrates ?

No-3 Long question

1- What are carbohydrates classify the carbohydrates with suitable example?

OR

Write note on

(a) - Oligosaccharides

(b) - Function of DNA

- What are lipids? give a brief account of structure and function of fatty acids.

OR

Write note on:

(a) - Types of Nucleic acid.

(b) - Glycogen.