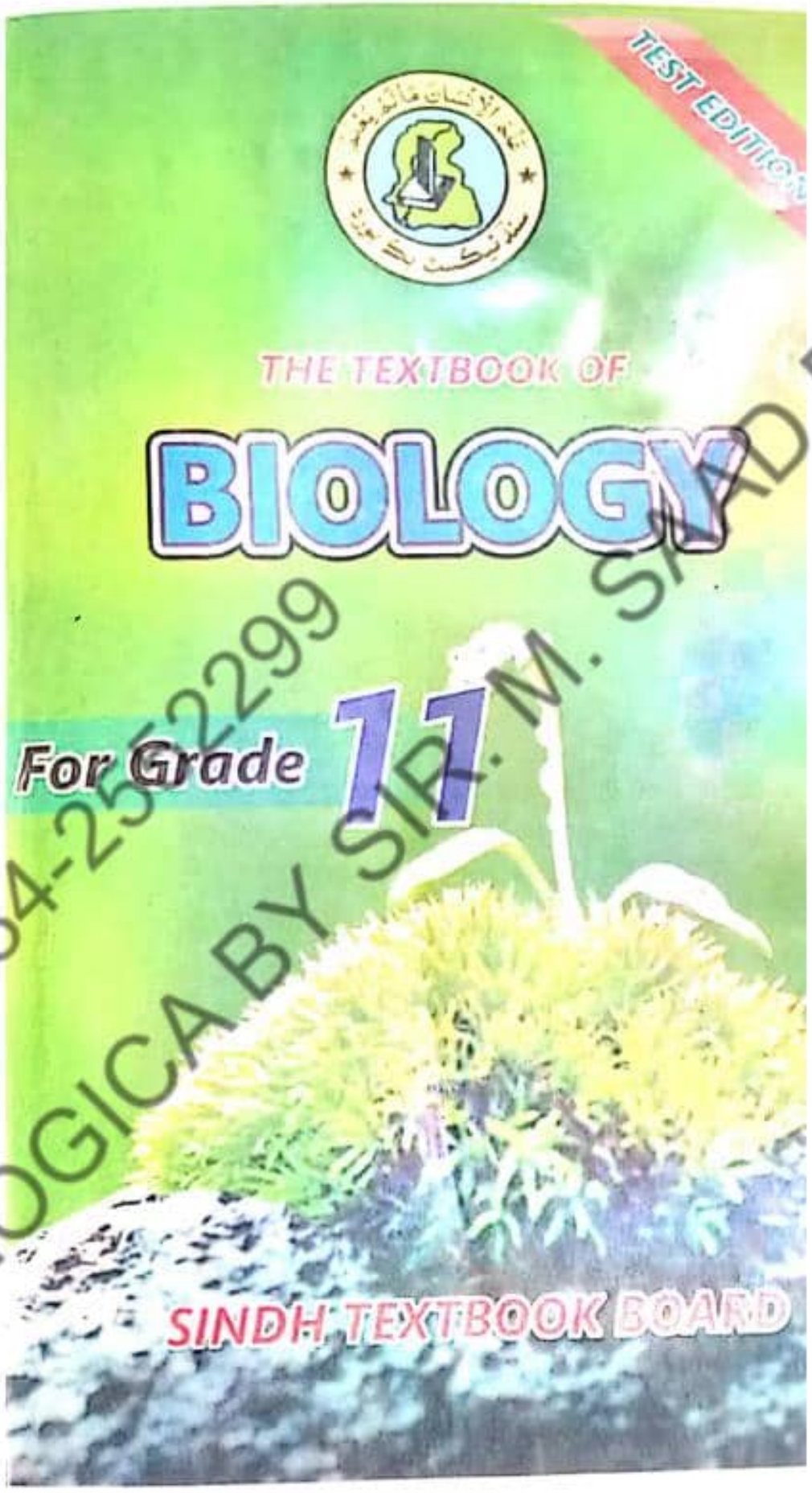


CONTENTS

Introduction of Biochemistry:

The branch of biology which explains the biochemical basis of life is called **Biochemistry**. It is one of the most important branch of biology due some reasons given below:

- It provides information about all the processes carried out in the living organisms from construction of body structures to flow of information from nucleus, especially DNA for enzyme/ protein synthesis and control of all the mechanisms.
- It provides information about abnormal mechanisms which lead to diseases. It ultimately open doors to the development of medicines and medical equipment to elucidate these abnormalities.
- The recent concept and technologies of biochemistry enabled us to investigate and understand most challenging and fundamental problems of biology and medicine e.g. how does cells find each other to form a complex organ? How does the growth of cells controlled? What are the causes of cancer? What is the mechanism of memory? Biochemistry is the only branch of science which answer these questions properly.

As we know that organisms are made up to tissues and cells while cells are made up of molecules, molecules are chemically bonded atoms. It means that fundamentally living things or organisms are made up to chemicals which explains the second postulate of cell theory i.e. structure and function of cell are dependent upon their chemical composition.

Therefore it is necessary to study the chemical composition of cell and reactions which carry down in these cells to understand the different structures and metabolisms of an organism.

1 CHEMICAL COMPOSITION OF CELL:

It is already established that all living organisms are structurally composed of cells and living cell contains a living matter called Protoplasm The actual chemical composition of protoplasm is still not known perfectly However, chemically it contains 70% to 90% of H_2O. If the water evaporated, the remaining mass of cell is called **Dry Weight** of cell, consi of many carbon containing long chain molecules called **Biomolecules** whi are the types of organic molecules. So, the compounds produced by livi organisms are called biomolecules.

The elements which are involved in the synthesis of biomolecules mainly six i.e. carbon, hydrogen, oxygen, nitrogen, phosphorus and sulp

The form approximately 98% of the biomolecules.

1.1.2 Fundamental types of Biomolecules:

Biomolecules can be divided into following groups according to variability in their structures and functions in cells and organisms i.e.

1. Carbohydrates
2. Proteins
3. Lipids
4. Nucleic Acids
5. Conjugated Molecules

Biomolecules	Units	Linkages
Carbohydrates (oligo & Polysaccharide)	Monosaccharides	Glycoside linkage
Proteins	Amino Acids	Peptide linkage
Lipids		
Fats & Oils	Glycerol & Fatty Acids	Ester linkages
Phospholipids	Glycerol, Fatty acids, Phosphate & Choline	Ester & c-c linkages
Terpenoids	Isoprenoids units	c-c linkages
Nucleic Acids		
DNA	Deoxyribonucleotides	Phosphoester linkage
RNA	Ribonucleotides	Phosphoester linkage
Conjugated molecules	Different biomolecules	Different linkages

There is a variation found in literature about the percentage biomolecules present in the cell. It is because, different cells within the sar body have different amount of biomolecules. Therefore, these values a always taken as average values. Approximate percentage of chemi composition of a typical bacterial and a typical mammalian cell is given able 2.2.

Table 2.2 Chemical compositions of cells (in %)

Molecules	Bacterial Cell	Mammalian Cell
Water	70	70
Protein	15	18
Carbohydrates	3	4
Lipids	2	3
DNA	1	0.25
RNA	6	1.10
Other Organic Compounds	2	2
Inorganic Ions	1	1

.1.3 Synthesis and Breakdown of macromolecules (Polymers):

(a) Synthesis of macromolecules (polymers) by Condensa

Molecules which form the structure and carry out activities of the e large in size and highly organized molecules called **macromole** hich are made up of large numbers of low molecular weight, olecules the subunits called **monomers** or building block. Therefo acromolecules are also called **polymers** (poly = many, mers = omolecules which are mentioned above are all macromolecu lymers.

Macromolecules are constructed from monomers by a process that resembles coupling of rail cars onto a train. The basic structure of each group of macromolecule is very similar in all organism from bacteria to human beings. In this process monomers are joined together by removing –OH from one monomers and –H from another monomers so both monomers form a new covalent bond between them, this process of joining two monomers by removing water molecule is called **condensation** or **dehydration synthesis**. Condensation always takes place by proper enzymes and energy expense.

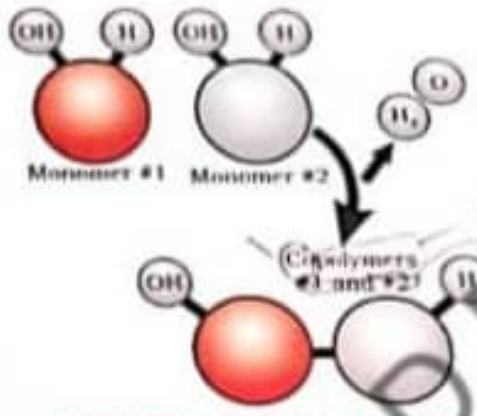


Fig 1.1 Condensation reaction

(b) Break down of macromolecule by hydrolysis:

Process where macromolecule (polymer) are broken down into their subunits (monomers) by addition of H_2O molecule is called **hydrolysis**. It is just revers of condensation, during this process a water molecule breaks into H^+ and OH^- ions with the help of enzyme, whereas –OH group to one monomer and –H attaches to the other by breaking linkage bond between two monomers. During this bond breaking energy is released and made available for other metabolic processes.

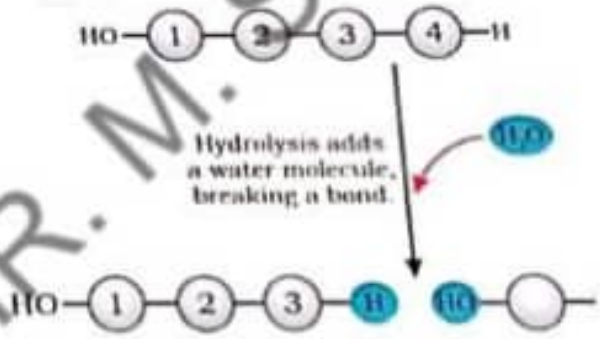


Fig 1.2 Hydrolysis: breaking down a polyn

During metabolism, macromolecules are either formed or brol lown in the cell, when cell rebuild many of its structures. In heterotro during digestion macromolecules broken into monomers by hydrolysis he help of hydrolytic enzymes, these monomers when reach to cell a orm macromolecules by the process of condensation. In autotrophs, oroduce monomers from inorganic molecules like CO_2, H_2O, NO_3^{-1}, SO_4^{-} These monomers latter on assembled to form macromolecules in sour ink tissues by the process of condensation, while the other cell when r hese molecules either for building purpose or to produce energy, nolecules break into monomers by the process of hydrolysis.

1.2 IMPORTANCE OF WATER:

Water is the most abundant component in living cell. Its amount varies approximately from 70% to 90%. It is the medium of life. Almost all reactions of a cell occur in the presence of water. It also takes part in many **biochemical** reaction such as hydrolysis, also provides raw material for photosynthesis.

The ability of water to play its wide variety of roles and the reasons for its importance in biological systems is due to the chemistry of H_2O molecule. The chemical formula of water is H_2O, which means that the two atoms of hydrogen are joined to one atom of oxygen.

Water is a polar molecule. It means that it has partial negative charge ($\delta-$) on oxygen and partial positive charge ($\delta+$) on hydrogen atoms due difference in electronegativities of hydrogen and oxygen atoms. The separation of electrical charges is called Dipole, which give the water molecule very important properties i.e. high polarity, formation of hydrogen bond, cohesion, adhesion, high specific heat, high heat of vaporization hydrophobic exclusion, ionization and low density of ice. These properties make it best solvent and cradle of life.

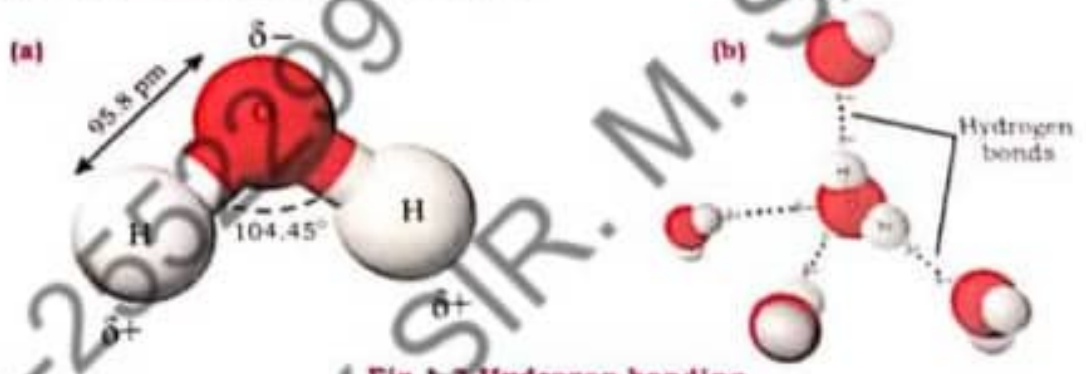


Fig 1.3 Hydrogen bonding

1.2.1 Hydrogen bond:

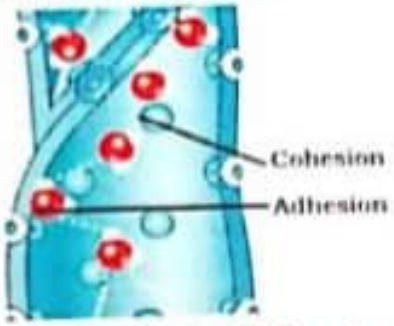
It is an intermolecular force of attraction formed between two m one of which contain partially charge $H^{+\delta}$ and other contain par charge as present in water. These charges attract two molecules, th of attraction due to $H^{+\delta}$ is called Hydrogen bond. Due to this H bonding two molecules have following two type of characters.

(a) Cohesion or Cohesive force of attraction:

The attractive force between similar molecules is called cohes of attraction. Due to polar nature water molecules attract each o form H-bonds between them to form a long chain of water molecu help it in flowing freely. It flows as protoplasm in cell, as blood vessels, as transporting fluid in the conducting tissues of plants.

(b) Adhesive force of attraction or Adhesion:

The attractive force between dissimilar molecules is called Adhesive force of attraction. Due to polar nature, water molecule attract other charged molecules and attached with them. It can hold the water molecules in the vessels and prevent them from backward flow.



Cohesion and adhesion create tension within xylem that helps move water upward.

Fig 1.4 Adhesion and cohesion

1.2.2 High specific heat:

Specific heat of a substance is the amount of heat energy required raise the temperature of 1gm of that substance by 1C° (e.g. 15C° to 16 The specific heat of water is high due to its polar nature and hydro bonding between their molecules. It means water required high amount heat to make changes in its temperature or warm up. It works as temperat stabilizer for organism and hence protect protoplasm against sudden ther charges.

1.2.3 High heat of vaporization:

The amount of heat required to change liquid state of water to vapour state s called heat of vaporization. Greater the heat of vaporization higher will be the chances of stability in state or vice versa. Water has very high heat of vaporization .e. 574 kcal/kg, therefore water requires o absorb high heat to change its state from liquid to vapors. It gives stability to water molecules and its state in cell. It plays an important role in thermoregulation. It also provides cooling effect when evaporate uring transpiration are perspiration.

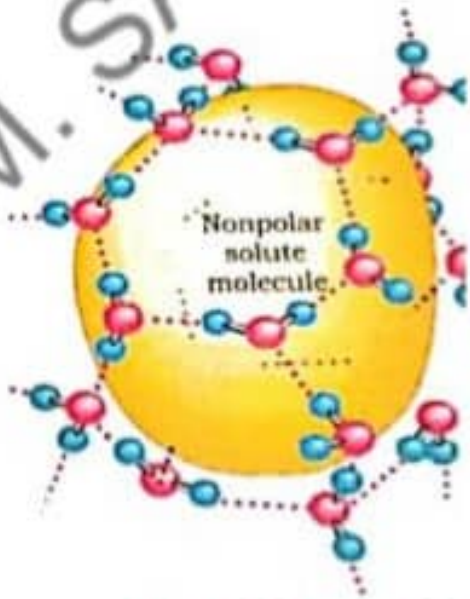


Fig 1.5 Vaporizatio

.2.4 Hydrophobic exclusion:

It is the tendency of water to coalesce oil drop into large drop ater molecules have hydrogen bonding between them which are d y the presence of hydrophobic oil and form new bonds. The water m ien form more hydrogen bonds with themselves and the nonpolar m ump together. This exclude hydrophobic substance (oil) from wate

.5 Ionization of water:

The water molecules ionize into H^+ and OH^-. Thus reaction is reversible also maintain equilibrium. Due to ionization property water may behave cid or base i.e. **Amphoteric** in nature. It also behaves as **buffer** due to nature. It maintains pH for enzymatic activities in cells and organs.

6 Anomalous behavior of water:

Water shows different behavior below 4°C. Usually matter contract at temperature but due to hydrogen bond below 4°C, water expands which eases its density so at 0°C water expands maximally in ice condition. The density water in ice become lighter, comes above the surface of high ity water of liquid. It makes the life possible under frozen water.

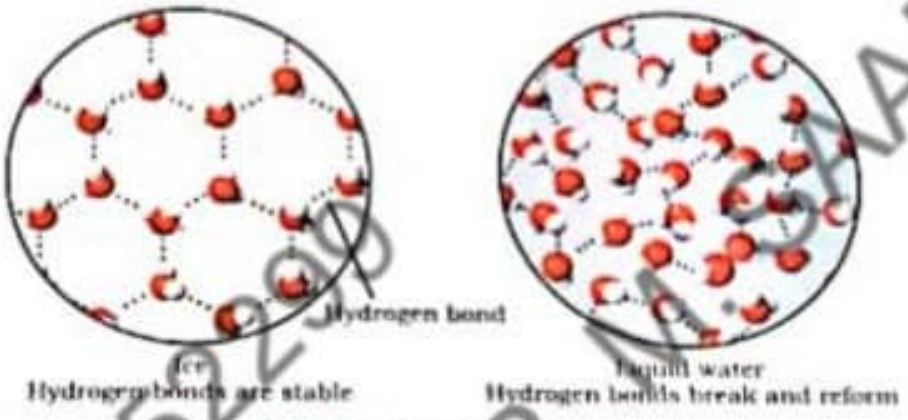


Fig 1.6 Behavior of water

CARBOHYDRATE (CARBO = CARBON, HYDRATE = WATER):

The literal meaning of word carbohydrate is hydrated carbon i.e. water ning carbon. Thus biomolecule contain C, H and O as element where drogen and oxygen are present in the simple ration of 2:1 as present er. The general formula of carbohydrate molecules is $C_nH_{2n}O_n$, whereas he whole number. According to I.U.P.A.C carbohydrates are defined as olyhydroxy carbonyl compounds", carbonyls are aldehydes or Ketones. Main source of carbohydrates are plants because they synthesise ydrate molecules as primary product during photosynthesis, othe lecules are produced from carbohydrate during different metaboli ays.

They are sweet in taste if feels therefore called sacchrum (ride. They are also called sugars.

Carbohydrate found abundantly in all organism, like cellulose in c plant, paper, starch is stored in cereal grains, tubers, sugar cane, e both structural and functional role.

.3.1 Classification of Carbohydrates

As we have discussed earlier that carbohydrate molecules are also alled 'Saccharides' these Saccharides are classified into three group.

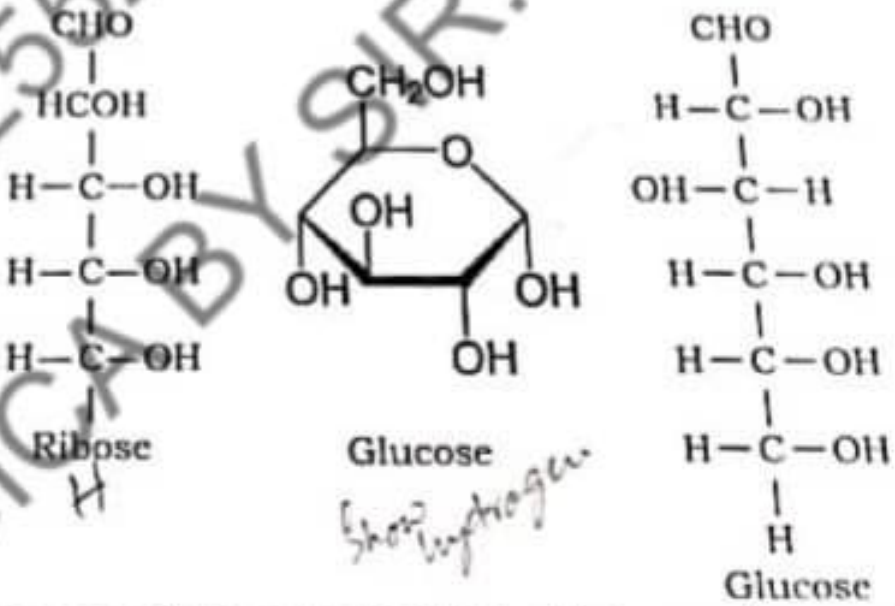
(i) Monosaccharide (ii) Oligosaccharide (iii) Polysaccharide

(i) Monosaccharide: (Mono = one; Saccharide = Sugar)

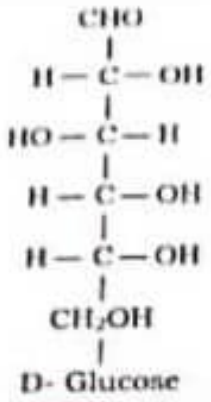
The group of carbohydrate molecules which contain only one sugar olecule. They cannot hydrolyses due to this reason. The empirical formula 'their molecules is $C_nH_{2n}O_n$ e.g. Ribose ($C_5H_{10}O_5$). Fructose $C_6H_{12}O_6$, etc; all e found in white crystalline solid with sweet taste and soluble in water. onosaccharide can further classified on the basis of C atoms present in em, the suffix 'Ose' use with no: of C atoms present in them as given in llowing table.

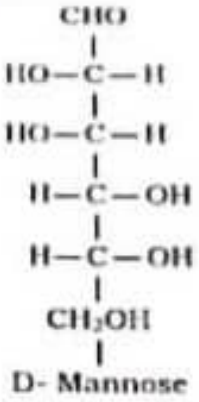
Class	Formula	Example
Triose	$C_3H_6O_3$	Glycerose (Glycer aldehy) Dihydroxy acetone etc.
Tetrose	$C_4H_8O_4$	Erythrose, Erythrulose etc.
Pentose	$C_5H_{10}O_5$	Ribose, Ribulose etc
Hexose	$C_6H_{12}O_6$	Glucose, Fructose, Galactose etc
Heptose	$C_7H_{14}O_7$	Glucoheptose.

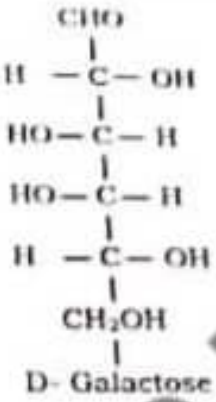
Glycerose and Dihydroxy acetone are important triose, produc ring respiration. Tetrose are rare in nature, it occurs in some bacte: ntose sugar form basic skeleton of nucleic acid. Hexose are most import gars from biological point of view. Glucose found in ripe fruit, sweet c d honey. It is also found in all known polysaccharide in combined st ıctose another hexose present in fruit so called fruit sugar usually found in ring structures but we can also draw their structure in in form:



The hexose are further divided into aldohexose isomers (hav :cular formula but different structural formula) like glucose, nos etc and ketohexose isomers like fructose, sorbose, psicose

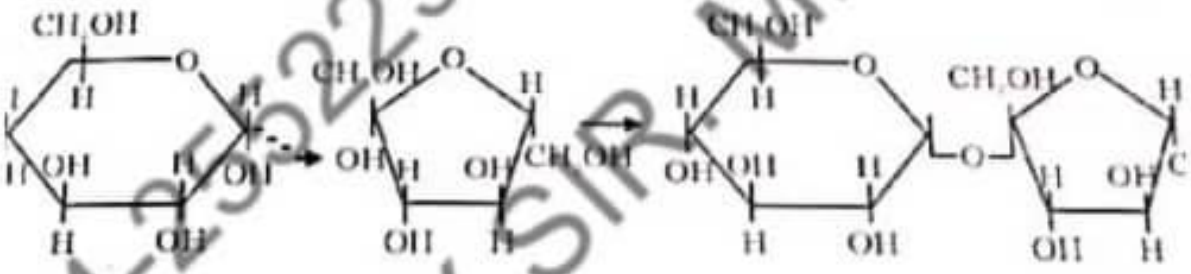

D- Glucose


D- Mannose


D- Galactose

(ii) Oligosaccharides:

The type of carbohydrate which are made up to 2 to monosaccharides. These are comparatively less sweet in taste and le soluble in water. They can hydrolyze. The most common type is disaccharic on hydrolysis yield two monosaccharides. The covalent bond between th wo monosaccharides is **Glycosidic bond** or linkage. A glycoside is simpl ing shaped sugar molecule that is attach to another molecule, the sugar r may be either 5 membered ring or a six membered ring. For example sucr s a disaccharide, composed of two sugar units a glucose and a fructose.



The disaccharide may be reducing or non-reducing sugar. ducing sugar is any carbohydrate which is capable of being oxidized uses the reduction of other substances without hydrolysis. It is due esence of free aldehyde or free ketone group. Examples are maltose, l :. The non-reducing sugars are carbohydrate which are unable dized and do not reduce other substance. It is due to absence ehyde or ketone groups, e.g. sucrose or refinose etc.

Living organisms especially plants transport their sugar from f) to sink (fruit) tissues in the form of non-reducing sugar where gly ds are formed between 'carbonyl' groups of both sugars. Sucros gar which is non-reducing. It contains more energy i.e, it is energy ransport and storage. During transport it is not oxidized and rea er substance so no intermediate reaction with other molecules oc

(iii) Polysaccharide:

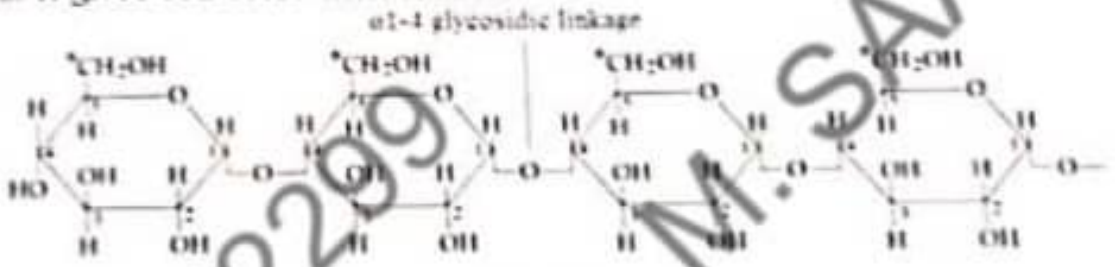
These are high molecular weight carbohydrates which on hydrolysis yield many monosaccharides. These are formed by the condensation of hundreds or thousands of Monosaccharide units, e.g. starch, glycogen, cellulose and chitin.

1.3.2 Starch:

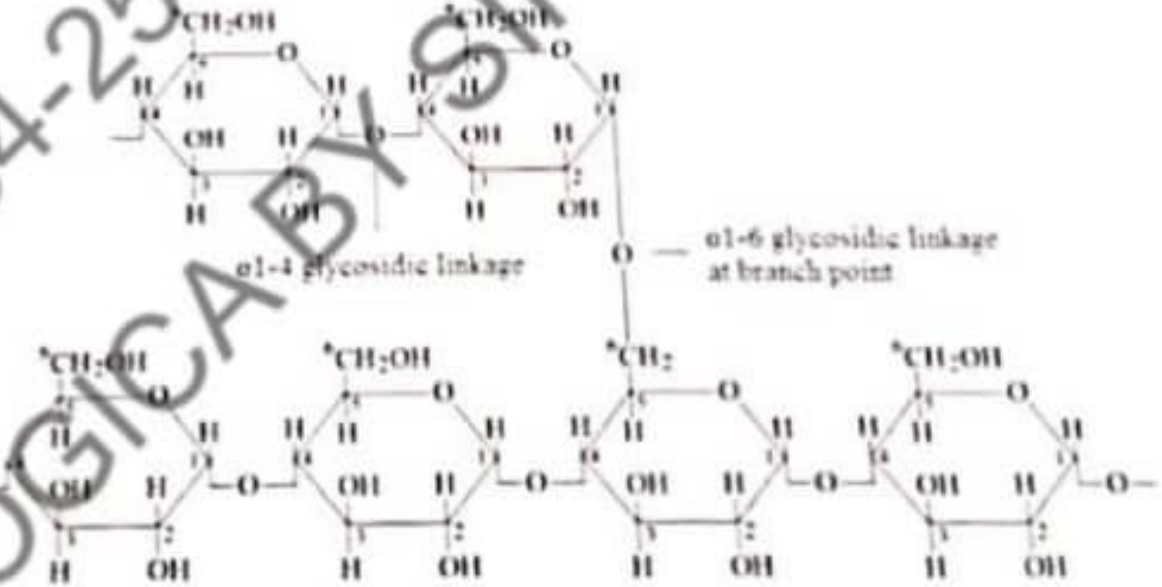
It is the most important and abundant reserve food material of higher plants, found in cereals, legumes, tubers and other vegetables. It is made up of many glucose molecules joined together in straight chain **amylose** which is soluble in hot water and a branched chain **amylopectin**, which is insoluble in hot and cold water. It gives blue color to iodine.

1.3.3 Glycogen:

It is also a polymer of glucose. Its molecular structure is similar to starch but found in animal therefore it is commonly called animal starch. It is mainly found in bacteria, fungi, in animals abundantly found in liver and muscles. It gives red color with Iodine.



Amylose



Amylopectin

1.3.4 Cellulose:

It is also a polymer of glucose, most abundant carbohydrate found in nature. It is highly insoluble in water. It is not digested in human body. In cellulose the glucose units are joined in straight chain and no branch chain present in it. This straight chain become spirally coiled and condensed to form tubes. These tubes of cellulose form cell-wall of plant cells. Cellulose give no colour to iodine.

Fig 1.7 Structure of cellulose

1.3.5 Chitin $(C_8H_{13}O_5N)_n$:

It is a long chain polymer of N-acetyl glucosamine, an amide derivative of glucose. The structure of chitin is similar to cellulose, forming crystalline Nano fibrils. Functionally, it is comparable to Keratin protein. Chitin is modified polysaccharide contains Nitrogen which allows for increased hydrogen bonding between adjacent polymers, giving it more strength.

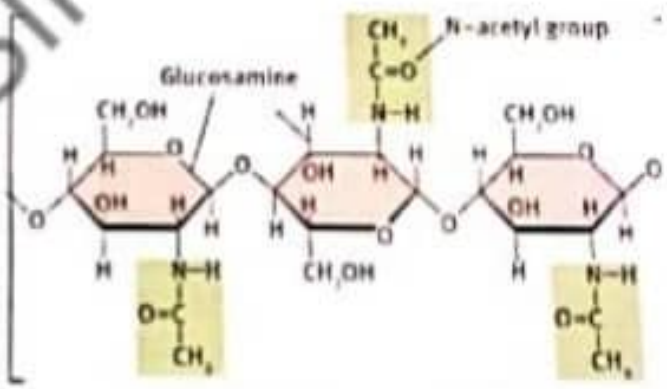


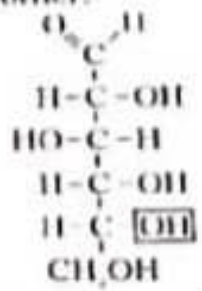
Fig 1.8 Structure of chitin

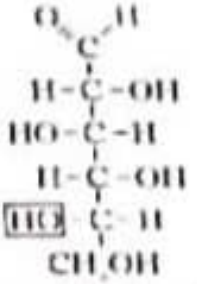
In its pure and unmodified form chitin is translucent, pliable, resili and quite tough in most arthropods but it is mostly found in modified fo such as proteineceous matrix form exoskeleton of insects, with $CaCO_3$ in shells of mollusks and crustaceans, composite material is much harder stiffer than pure chitin.

Stereoisomers in Carbohydrates and its role in artificial sweetness:

Many sugar molecules have stereoisomers i.e. the molecules are mirror images of each other.

D-Glucose
Right handed sugar





L- Glucose
Left handed sugar

Most of the sugars in our body are right handed. The taste of right handed and left handed sugars are same, protein (Enzymes) are also right handed and left handed. The enzymes which are present in our body are also right handed therefore right handed enzymes metabolize right handed sugars only. They are unable to digest or metabolize left handed sugars. The artificial sweetener which are used by diabetic patients usually are left handed sugars, these sugars have same mass and same sweetens but have zero calories these sugars are not digested in our body because all of our enzymes are right handed and they are specific to break down the right handed sugars the left handed won't fit into catalytic site consequently there will be no breakdown of these sugar, no metabolism and no calories.

1.4 PROTEIN: (GR: PROTEIOS MEANS 'FIRST RANK')

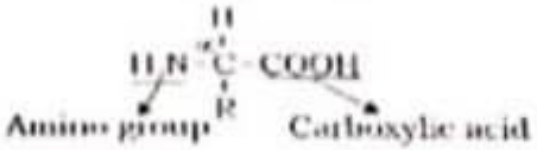
Proteins can be defined as the polymers of specific amino acid arranged in a particular manner which perform definite function. Proteins are the most important organic compounds of the cell which carry out virtually all of the cell's activities. They constitute major part of the dry weight of a cell.

Proteins are the complex organic compounds having C, H, O and N elements, sometimes they contains S also. Due to presence of N in large proportion they are called **nitrogenous compounds**. Proteins are building blocks of tissues. Many parts of the body such as hair, nails feathers are also protein. Whereas meat, fish, milk and pulses are the main source of protein.

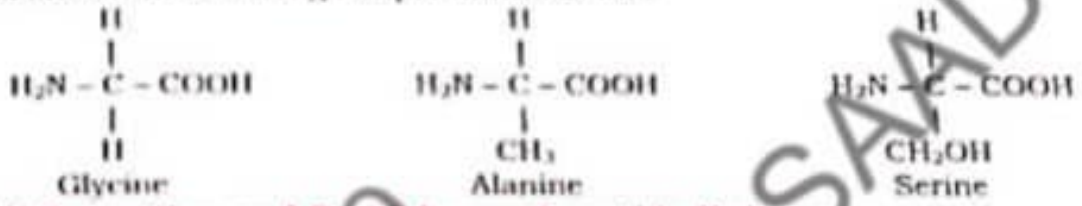
1.4.1 Amino acid as a building block of protein

Proteins are macromolecule or polymers of amino acids. These amino acids are monomers and linked with each other by a covalent bond **peptide bond or peptide linkage**. As we have defined above that protein has a unique sequence of amino acids that gives the unique properties to these molecules. There are twenty basic amino acids constitute each type of protein, found in viruses to human beings.

Amino acids are organic compounds which contain at least one amino group (NH_2) which work as base and one carboxylic acid, work as acid, both are chemically bonded to an asymmetric carbon, this carbon is also called α Carbon. The general structure (empirical formula) of amino acid is

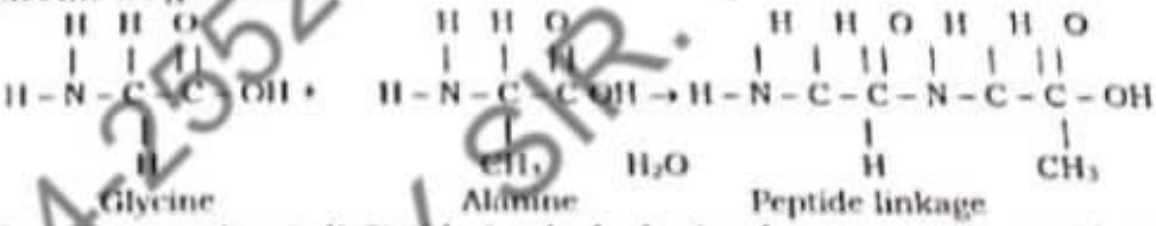


All 20 amino acids have same formula except R group i.e. Radical group, which is variable, the types of 20 amino acids based on the variability of R as shown in following simple amino acids.

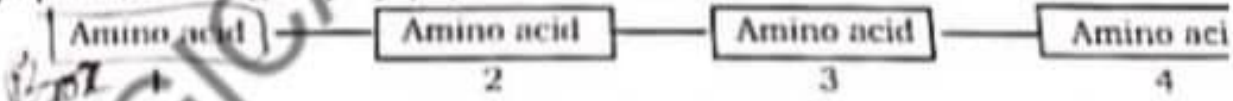


1.4.1.1 Formation and Breakdown of peptide linkage

The protein or polypeptide chain is formed by linking amino acids b peptide bond. The peptide bonds are formed by linking amino group of on amino acid with carboxylic acid of another amino acid by releasing one wat molecule as given below



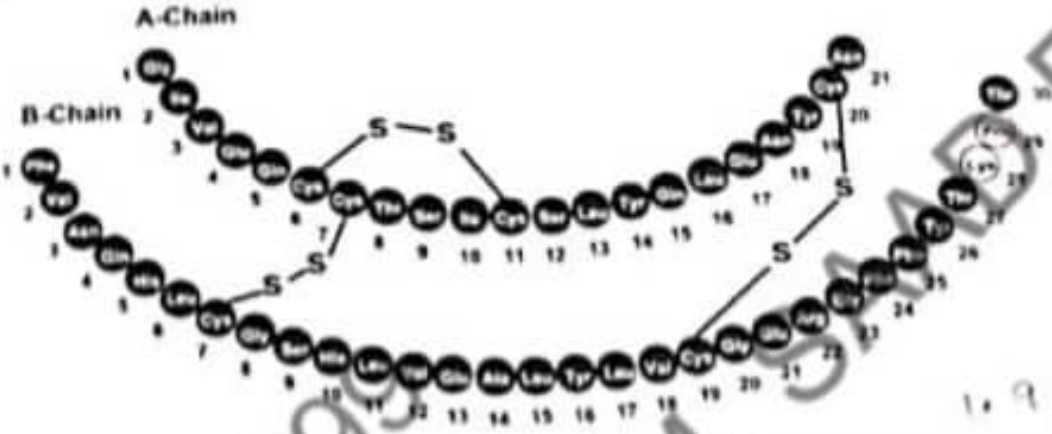
The resultant dipeptide is glyclyalanine has two amino acid sub called **dipeptide**. A dipeptide has an amino group of one end and a carbo acid group at the other end of the molecule. In this way both reactive g are again available for further peptide linkage to produce tri, tetra, p peptide, leading to poly peptide chains.



The polypeptide chain can be broken by breaking peptide bon the process of hydrolysis with the help of hydrolytic enzymes. The p chain can be broken into small chain of more than 10 amino acids **peptone**, whereas peptone can be hydrolysis further into small units amino acid called **peptide** which are further hydrolysis into amino ac

1.4.1.2 Significance of the sequence of amino acids

F. Sanger was the first scientist who determined the sequence of amino acids in a protein molecule. He found that Insulin is composed of 51 amino acid in two chains. One had 21 amino acid and other had 30 amino acids they held together by disulphide bonds. Same is found in Hemoglobin, which is composed of 4 chains, two alpha (α) and two Beta (β) chains. Each alpha chain has 141 amino acids, while each beta chain contain 146 amino acids.



Human body has more than 10,000 protein. These protein composed of unique and specific arrangement of 20 amino acids. sequence is determined by gene as DNA, the arrangement of amino acic protein molecule is highly specific for its proper functioning. If the sequ of any amino acid will change the protein fails to carry its normal func One of the example is sickle cell anemia i.e. abnormality in hemoglobir change of one amino acid out of 574 amino acid. Only valine is rep by Glutamic acid at(8th position. Due to this little change the hemoglobi carry sufficient O_2 which leads to death of the person.

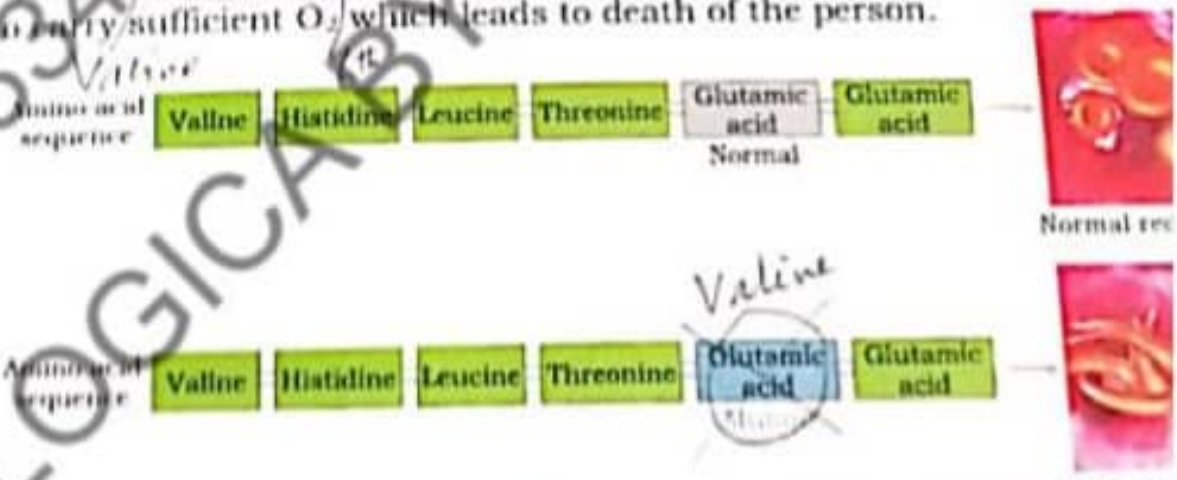


Fig 1.9 Normal and abnormal sequence of amino acid

1.4.2 Classification of Protein

Protein can be classified in many ways i.e. on the basis of structure or on the basis of function etc. Proteins can also be classified on the basis of shape in two following groups.

(i) Fibrous Protein (ii) Globular Proteins

(i) Fibrous Protein:

These are long fibers of proteins. The secondary protein (spiral) chains intertwine with each other's they are consist of more polypeptide chains in the form of fibrils these proteins are insoluble in water, non-crystalline and elastic in nature. They perform structural role in cells and organisms e.g. silk, spider web, myosin in muscles, fibers and clothing, Keratin of nails and hairs etc.

(ii) Globular Proteins:

These are spherical or ellipsoidal due to three dimensional fold of secondary protein. These are either tertiary or quaternary in structure. They are soluble in salt, acid or base containing aqueous medium or alcohol. They can be crystalized. These proteins work as enzyme, antibodies, hormones and hemoglobin.

(a) Collagen, a fibrous protein (b) Myoglobin, a globular protein

Fig 1.10 Globular Proteins

List of Structural Proteins

Actin	Muscle forming protein
Amyloid	Work as cell surface protein
Caddisfly (Fibroin)	Used to bind debris like rocks sticks twigs and shells f net of prey.
Chondrocitin	Form extra cellular matrix
Collagen	Give strength, turned elasticity to skin main component cartilage, ligaments, tendon, bone and teeth
Elastin	Provide resilience and elasticity to tissues and organs.
Fibrillin	Glycoprotein provide force bearing structural suppor elastic and non-elastic connective tissues
Gelatin	Nutritious protein derived from collagen of skin and bo
Influenza virus	
Nucleoprotein	
Sclera protein	Include Keratin, collage, elastin and fibrin
Titin	Provide elastic stabilization of myosin and action filam
Tubulin	Microtubules farming protein
Keratin	Nails and hairs farming protein

List of Functional Proteins

Type	Examples	Function
Digestive enzymes	Amylase, lipase, pepsin, trypsin	Help in digestion of food by hydrolysis into simple monomers
Transport	Hemoglobin, albumin	Carry O_2 and CO_2, other substances in the blood or lymph throughout the body
Hormones	Insulin, thyroxin	Co ordinate different functions of body
Defenses	Immunoglobulin, interferon	Protect the body from foreign pathogens
Contractile	Actin, myosin	Muscle contraction
Storage	Legume storage protein, egg white (albumin)	Provide nourishment at the time of development of embryo.

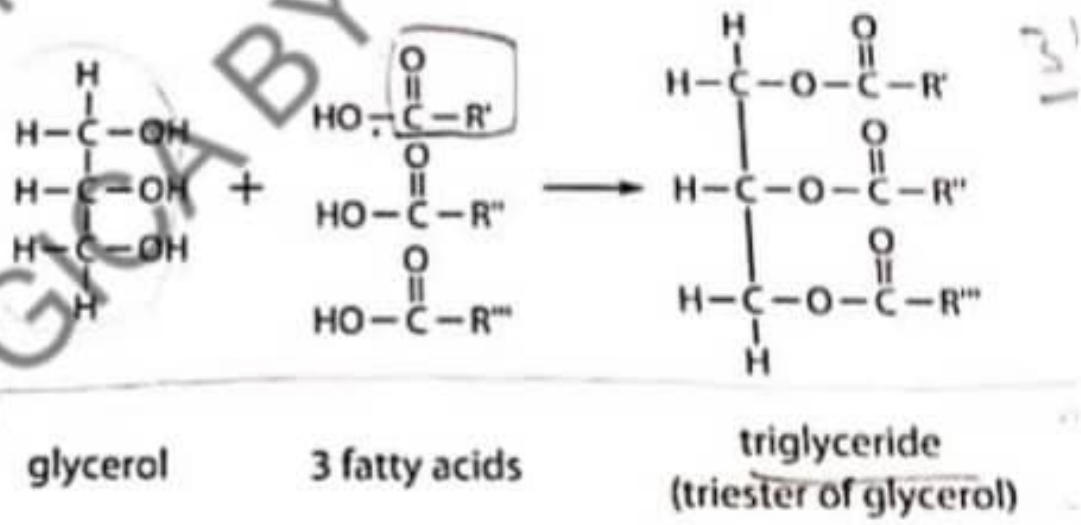
1.5 LIPIDS:

Lipids are the important diverse group of biological molecules, widel distributed among plants and animals. The term lipid is proposed by Blo n 1943, for those biomolecules which are insoluble in water and soluble rganic solvents like ether and alcohol etc. These compounds are made f C, H, O like carbohydrates but contain much lesser ratio of oxygen th arbohydrates e.g. stearin is a fat, has molecular formula ($C_{57}H_{110}O_6$). Due gh quantity of carbon and hydrogen, they contain almost double amou f energy than carbohydrates.

Following are some common groups of lipids.

1.5.1 Acylglycerol (Fats and oil):

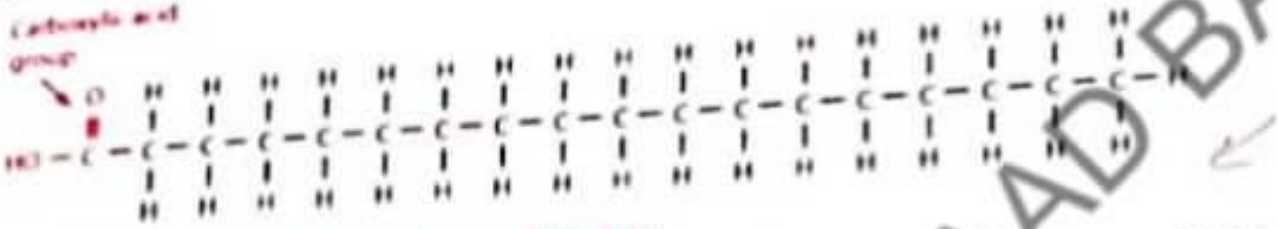
These are the condensation product of glycerol and three fatty a ommonly called **fats** and **oils**. They can be defined as the esters of glyc nd fatty acid. Ester is the bond or linkage formed between alcohol rganic acid by removing water, this reaction is called **esterification**.



Glycerol is a trihydroxy alcohol, made of three carbon atom each contain an OH group while a fatty acid is a type of organic acid containing one carboxylic acid group with long hydrocarbon chain. When three fatty acid combine with glycerol each at one OH, they form three ester bonds. A compound called **Triglycerol** (triglyceride) is formed. There triglycerol are neutral in nature because all three OH group of glycerol become bonded with fatty acids and no charge bearing OH is left. There are two types of acylglycerol.

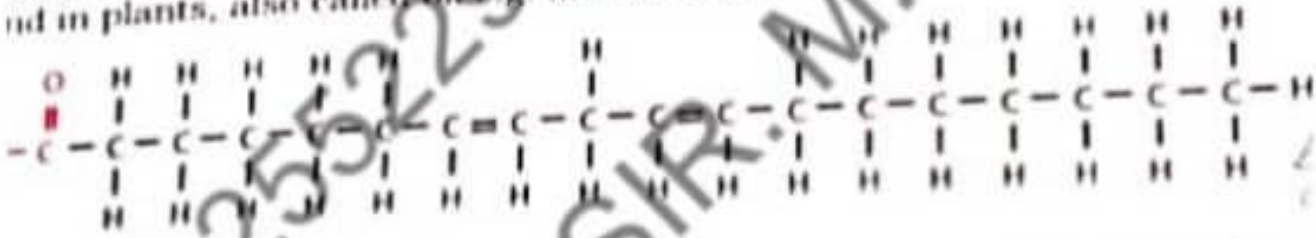
(a) Saturated acylglycerol (Fats):

They contain saturated fatty acid i.e. do not contain any double bond between carbon atoms of hydrocarbon chain e.g. stearin.



(b) Unsaturated acylglycerol (oils):

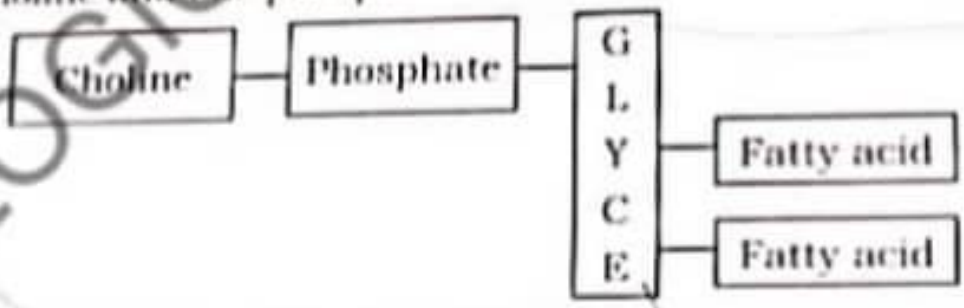
They contain unsaturated fatty acids i.e. contain one or more than one double bond between carbon atoms of hydrocarbon chain. They have liquid physical state, usually formed at liquid state at ordinary temperature, found in plants, also called oil e.g. linolin found in seed.



Acylglycerol provide energy for different metabolic activities and are rich in chemical energy, twice in amount of energy content than glycogen. It is estimated that a person of average size contains approx 1 of fats which contain 1.4×10^5 KCal of energy.

Phospholipids:

Type of lipids which is condensation product of Glycerol, two fatty one choline and one phosphate.



Phospholipid is the most important group of lipids from biolo
point of view. A phospholipid is similar to acyl glycerol, except that one
acid is replaced by phosphate which is attached with a nitroge
compound **choline**. It contains two ends, one which is made up of fatty
which form non-polar part therefore behave as water repellant so c
hydrophobic. The phosphate and choline form another end, which form
part, therefore attract water molecule so behave as water lovin
hydrophilic. Phospholipids are present in all living cells and form memb
They are related to vital functions such as regulation of cell permeabilit
transport processes. Properties of cell membrane depend on it phosph
component.

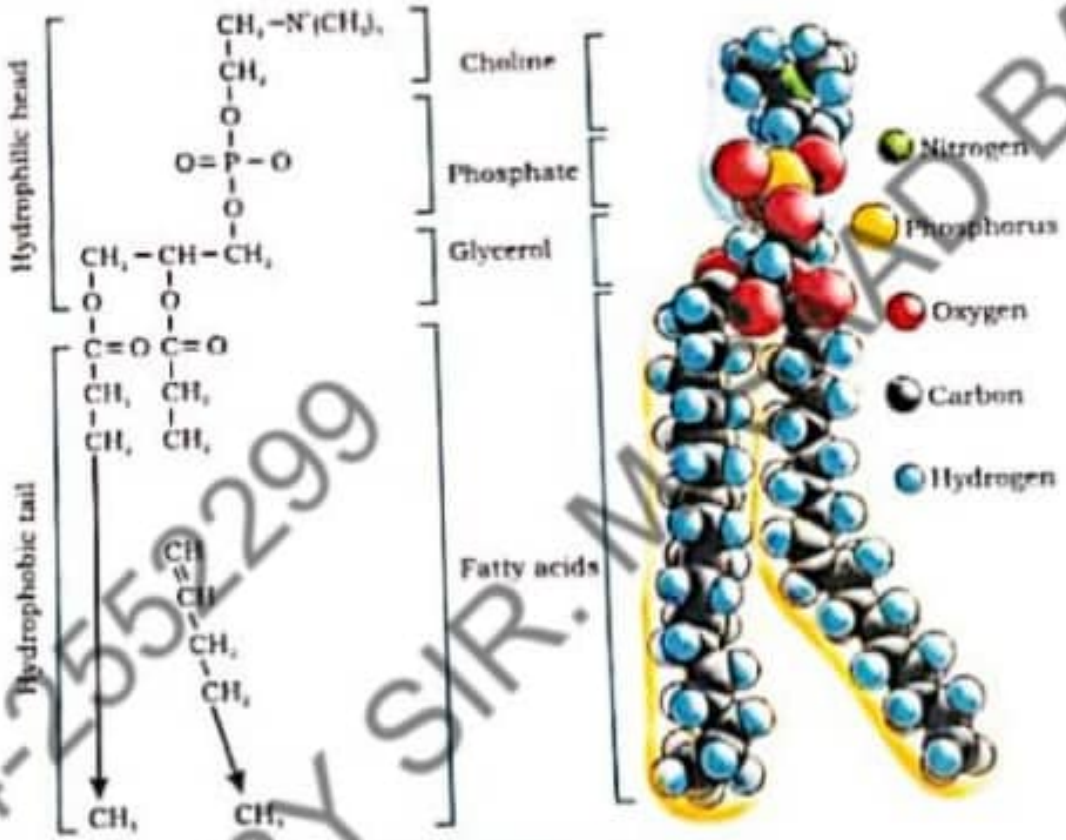
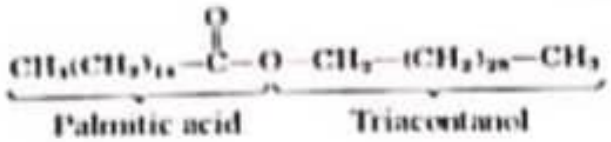


Fig 1.11 Phospholipid

1.5.3 Waxes:

They are esters of long chain mono-alcohol and long chain fa
These are simple lipid and found as protective coating on stem, stall
petals, fruits skin, animals skin, fur and feathers etc, these
repellant and non-reactive due to its non-polar nature i.e. hy
compounds. These are chemically inert and resistant to at
oxidation. There are two types of waxes i.e. Natural, like bee's wax
form cuticle of leaves and synthetic waxes, generally derived from
or polyethylene.

Waxes are of considerable commercial importance because they act as superior machine lubricants. Sperm whales were the principle source of these wax.



1.5.4 Terpenoids:

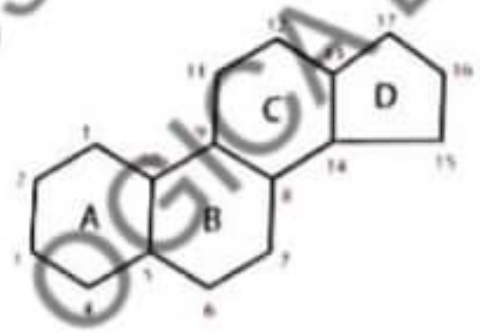
Terpenoid is a large and important class of lipids, made up of isoprenoid units (C_5H_8). Terpenes, steroids, carotenoids and prostaglandins are type of Terpenoids. These are found in cell membrane as cholesterol, as pigment like chlorophyll, fragrance as menthol etc.

1.5.4.1 Terpenes:

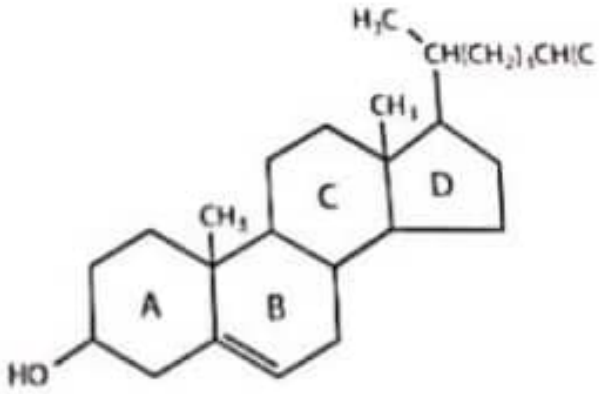
Terpens are the type of terpenoids which contain few isoprenoid uni like diterpens, Triterpens. These small size terpens are volatile in nature a produce special fragrance. Some of these are used in perfume e.g. Myrce from oil of bay, Geranoil from rose, Limonene from lemon oil, Menthol fr peppermint oil. Some component of vitamin A_1, and A_2, chlorophyll molecu as well as some other molecules which utilized in the synthesis of rubber a latex.

1.5.4.2 Steroids:

Steroids is a type of Terpenoid which form steroid nucleus made soprenoid units containin 17 Carbon atoms arranged in four attached ri hree of them are hexagonal and one is pentagonal in shape. The rad ttached with them as side chains distinguish them from one ano holesterol is one of the type of steroid. Cholesterol is the precursor for ynthesis of a number of steroids i.e. testosterone, progesterone strogens.



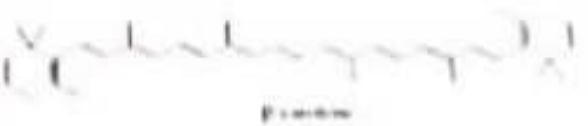
(a) Steroid skeleton



(b) Cholesterol

1.5.5 Carotenoids:

It is polyterpenes, consist of long chain of isoprenoid unit which contain isoprenoid rings at both or at one terminal. These compounds are pigments producing red, orange, yellow and brown color in plants. Some important carotenoids are plant pigments, like chlorophyll, cytochromes, phytochromes, latex, rubber etc.



1.5.6 Prostaglandins:

Prostaglandins is a group of lipids made by mammalian tissues at the sites of tissues damage or infection that are involved in dealing with injury and illness. They control different physiological process such as inflammation, intensity of sensation of pain, blood flow, and formation of blood clots, Immunity and the induction of labour. We use aspirin to reduce fever and decrease pain depend on the inhibition of prostaglandin synthesis.

1.6 NUCLEIC ACIDS:

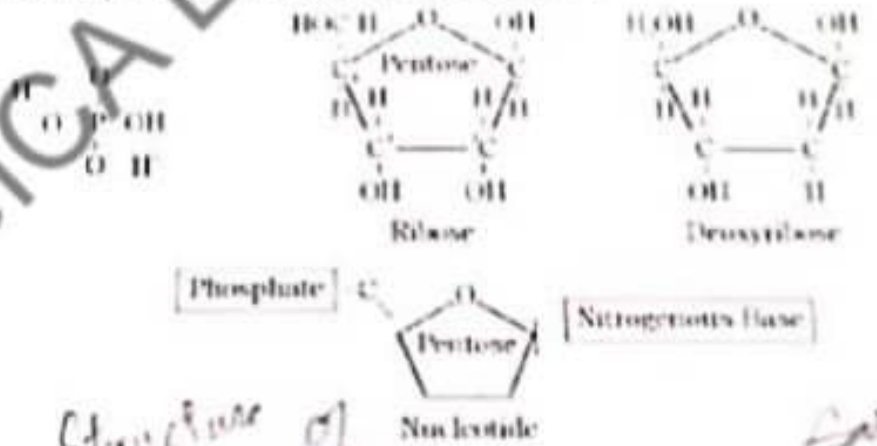
Fridrich Miesher a Swiss physician isolated a new compound from the nucleus of pus cells, which was quite different from other biomolecules therefore named "Nuclein" it was found that the nuclein had acidic properties and hence it was renamed **nucleic acid**.

The nucleic acids are polymers of five sugar based compound called **nucleotide**. These polymers have high molecular weight. These are present in all living things from virus to man.

There are two kinds of nucleic acids i.e. **Deoxyribo (Linear Nucleic Acid (DNA)** and **Ribo Nucleic Acid (RNA)**. Both nucleic acids are unbranched polymers. DNA is the polymer of Deoxyribo nucleotide and RNA is the polymer of Ribonucleotide.

1.6.1 Composition of Nucleotide:

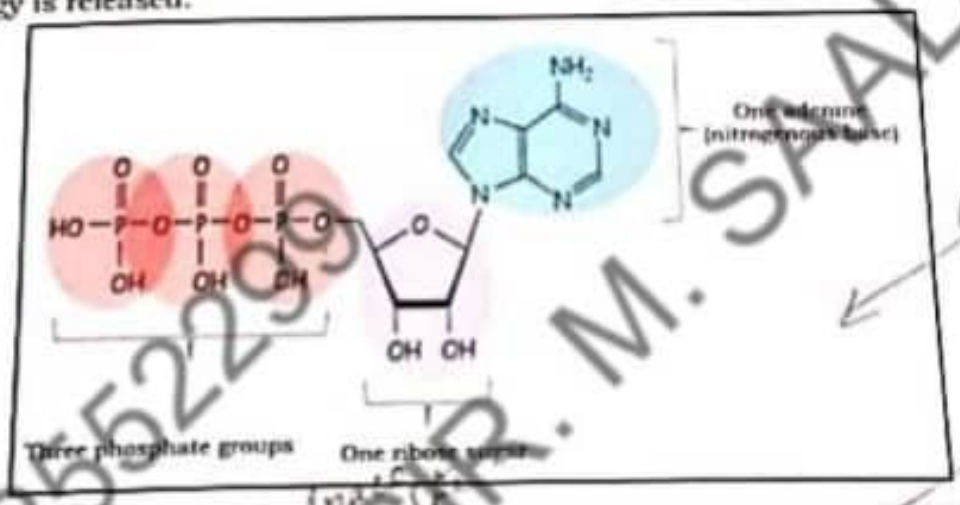
Nucleotide are the monomers of Nucleic acid, which is Pentose sugar used where a nitrogenous base molecules is attached at its first carbon phosphate is attached at 5th carbon of pentose sugar as shown below. Nucleotide without phosphate called Nucleoside.



The DNA and RNA are made up four types of nucleotides, which are variable on the basis of nitrogenous basis. There are two groups of nitrogenous bases i.e. Purine and Pyrimidine. Purines are of two types i.e. Adenine (A) and Guanine (G) while Pyrimidine includes three nitrogenous bases Cytosine(C), thymine (T) and Uracil (U). The structures are given below

1.6.2 Mononucleotide:

Generally, nucleotides are found in the nucleic acids as polynucleotide but sometime a single nucleotide also work independently as mono nucleotide, these mono nucleotide have extra phosphate group as AD (Adenosine phosphate) or ATP as (Adenosine Tri Phosphate). ATP work a energy storing, carrying and energy providing molecules to metabol reactions. This energy is utilized to derive energy demanding reactions suc as synthesis of proteins, lipids, carbohydrates, mechanical energy cyclosis, contractility, cell-divisions, movement of flagella, active transpo etc. During conversion of ATP into ADP, 7.3 Kcal/ mole or 31.81 kJ/ m energy is released.



1.6.3 Dinucleotide:

Sometimes two nucleotide are covalently joined together to form a compound called dinucleotide one of the well-known dinucleotide is NAD (**Nicotine amide** Adenosine Dinucleotide). A vitamin Nicotine is attached with these two nucleotide in NAD. It works as co-enzyme for Redox reaction. It carries $2e^-$ (electron), $2H^+$ (proton) and energy e.g. $NADH_2$, $FADH_2$ etc.

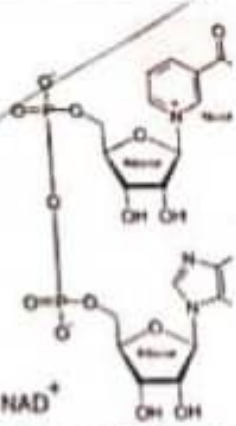


Fig 1.12 Dinucl