

EXTENSIVE QUESTIONS

43. Describe the chemical composition of protoplasm.

Ans: Chemical Composition of Protoplasm:

Generally, the protoplasm consists of oxygen, carbon, hydrogen and nitrogen. Approximately the oxygen is 62%, carbon 20%, hydrogen 10% and nitrogen 3%. The remainder of 5% part contains about thirty elements, of which calcium (Ca), iron (Fe), magnesium (Mg), chlorine (Cl), phosphorus (P), potassium (K), sulphur (S), etc. are important ones. In addition to these, boron (B), copper (Cu), Fluorine (F), manganese (Mn) and silicon (Si) are found in small traces. In certain special cells alcohol, Cobalt (Co) and zinc (Zn) are also found.

All these elements are found in ionic state or essentially found in adenosine triphosphate (ATP). All reactions going on in the protoplasm obtain energy for their performance from ATP. The protoplasm contains 67 -75% of water. Moreover, certain gases such as carbon-dioxide and oxygen remain dissolved in it.

The protoplasm of each cell contains several Organic substances of which carbohydrates, fats, proteins, and nucleoproteins are important ones. These organic substances make protoplasm by molecular combination.

44. Distinguish carbohydrates, proteins, lipids and nucleic acids as the four fundamental kinds of biological molecules.

Ans: The four fundamental kinds of biological molecules are carbohydrates, proteins, lipids and nucleic acids.

i. Carbohydrates:

Carbohydrates are present in the inclusions of the cells and provide fuel for the metabolic activities of the cell.

ii. Proteins:

Proteins are present in the membranes, ribosomes, cytoskeleton and enzymes of the cell.

iii. Lipids:

Lipids are present on the membranes Of Golgi complex and inclusion of the cell. Lipids provide a reserved energy source, shape, protect and insulate the cells.

iv. Nucleic Acid:

The nucleic acid DNA is present in the chromosome. It controls the cell activity. The nucleic acid RNA is present in the nucleoplasm and cytoplasm. It transmits genetic information and takes part in protein synthesis.

OR (Second Answer)

Biological Molecules:

There are four basic kinds of biological macromolecules. They are carbohydrates, lipids, proteins and nucleic acids. These polymers are composed of different monomers and serve different functions.

- Carbohydrates - molecules composed of sugar monomers. They are necessary for energy storage. Carbohydrates are also called saccharides and their monomers are called monosaccharides. Glucose is an important monosaccharide that is broken down during cellular respiration to be used as an energy source. Starch is an example of a polysaccharide (many saccharides linked together) and is a form of stored glucose in plants.

- Lipids - water insoluble molecules that can be classified as fats, phospholipids, waxes, and steroids. Fatty acids are lipid monomers that consist of a hydrocarbon chain with a carboxyl group attached at the end. Fatty acids form complex polymers such as triglycerides: phospholipids, and waxes. Steroids are not considered true lipid polymers because their molecules do not form a fatty acid chain. Instead, steroids are composed of four fused carbon ring-like structures. Lipids help to store energy, cushion and protect organs, insulate the body, and form cell membranes.
- Proteins - biomolecules capable of forming complex structures. Proteins are composed of amino acid monomers and have a wide variety of functions including transportation of molecules and muscle movement. Collagen, hemoglobin, antibodies, and enzymes are examples of proteins.
- Nucleic Acids - molecules consisting of nucleotide monomers linked together to form polynucleotide chains. DNA and RNA are examples of nucleic acids. These molecules contain instructions for protein synthesis and allow organisms to transfer genetic information from one generation to the next.

45. Describe and draw sketches of dehydration synthesis and hydrolysis reactions for making and breaking of macromolecule polymers.

Ans: Condensation and Hydrolysis:

Macromolecule:

A macromolecule is high molecular weight compound which is made from many repeating units. Molecules built like this are also known as polymers.

The individual units of polymers are micro molecules which are also known as monomers. The interconversions of these molecules are carried out by condensation and hydrolysis.

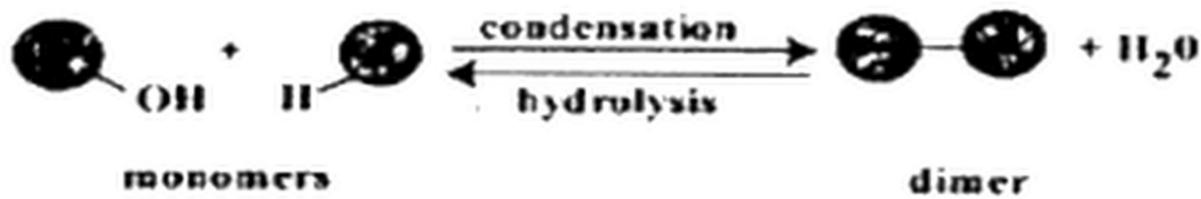
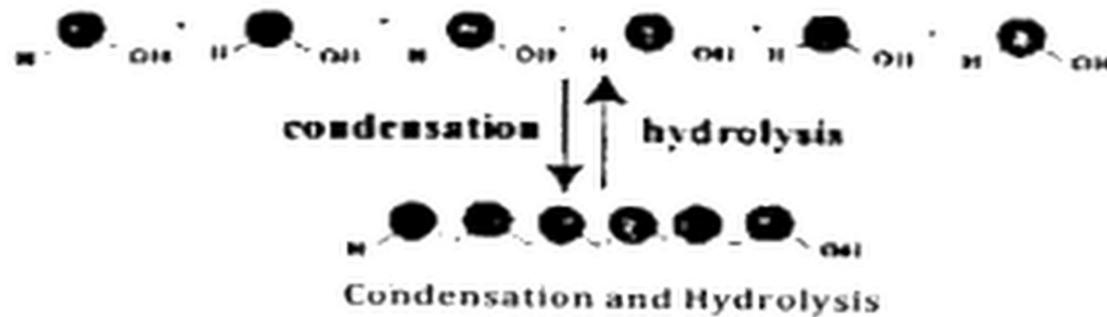


Condensation:

During condensation, when two monomers join, a hydroxyl (—OH) group is removed from one monomer and a hydrogen (—H) is removed from the other to make water and as a result a bond is synthesized between the monomers. The product of such reaction is called a dimer. If the same reaction is repeated several times the resulting molecule will be a polymer. Condensation is also called dehydration synthesis because water is removed (dehydration) and bond is made (synthesis). Condensation does not take place unless the proper enzyme is present and the monomers are in an activated energy-rich form.

Hydrolysis:

The hydrolysis is essentially the reverse of condensation i.e., the breakdown of a polymer into its monomers by the addition of water. During hydrolysis, an (—OH) group from water is attached to one monomer and (—H) is attached to the other monomer. Actually all (food) digestion reactions are examples of hydrolysis, which are controlled by enzymes such as carbohydrases, proteases, lipases, nucleases.

(1) Dimer**(2) Polymerisation**

46. How the properties of water make it the cradle of life?

Ans: Importance of Water:

Water is one of the main constituents on earth. More than two thirds of the earth are covered by water. Approximately 70 percent of the any organism is formed of water. Water is the most abundant component in any organism, the lowest is 20% in seeds and bones and highest IS 85-90% in brain cells. Jellyfish has exceptionally large amount of water i.e., 99% (hence the body shows transparency).

Properties of water:

The properties of water that make it the cradle of life are

1. High polarity:

Covalent Bonds:

The bonds which are formed by the mutual sharing of electrons between two atoms are called covalent bonds.

Nonpolar:

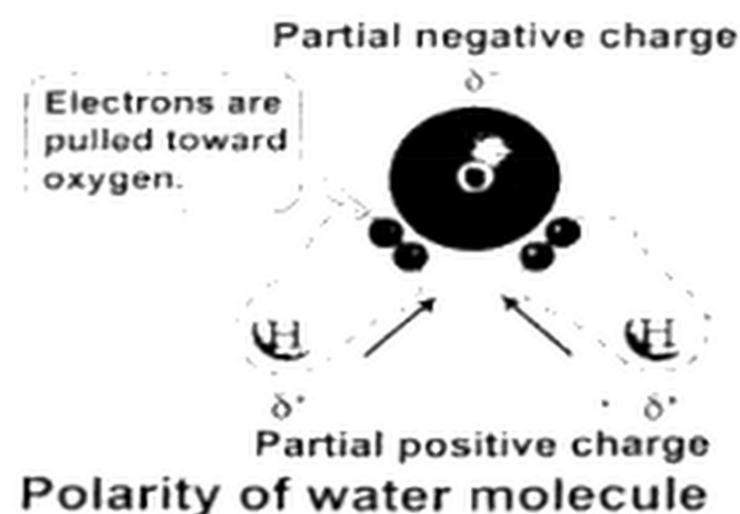
Normally the sharing of electrons between two atoms is fairly equal and the covalent bond is nonpolar.

Polar:

In the case of water, however the sharing of electrons between oxygen and hydrogen is not completely equal so the covalent bond is polar. A polar covalent bond is a chemical bond in which shared electrons are pulled closer to the more electronegative atom, making it partially negative and the other atom partially positive. Thus, in H_2O , the O atom actually has a slight negative charge and each H atom has a slight positive charge, even though H_2O as a whole is neutral. Because of its polar covalent bonds, water is a polar molecule i.e., it has a slightly negative pole and two slightly positive ones.

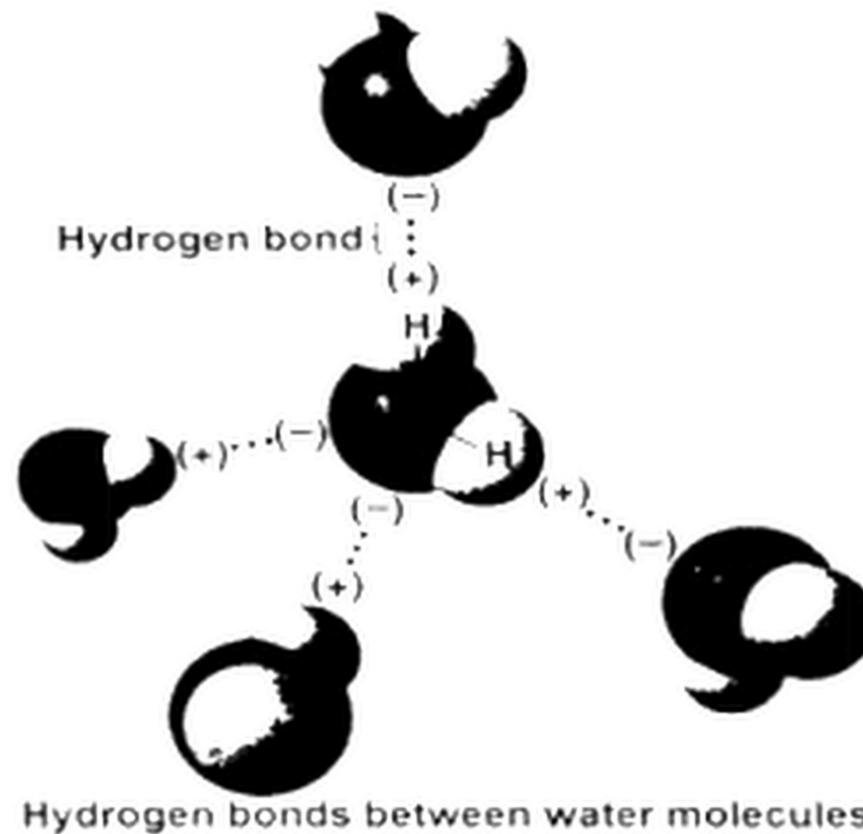
Water Use as Universal Solvent:

This is polarity of water molecules that makes it an excellent or universal solvent for polar substances. Ionic compound or electrolytes can be easily dissolved in water. Non-polar substances having charged groups in their molecules can also be dissolved in water. Such compounds when dissolved in water, dissociate into positive and negative ions and are in more favorable state to react with other molecules and ions. This is the reason why all chemical reactions in living beings occur in aqueous medium.



2. Hydrogen bonding:

The polarity of water molecules makes them interact with each other. The charged regions on each molecule are attracted to oppositely charged regions on neighboring molecules forming weak bonds, since the positively charged region in this special type of bond is always an H atom, the bond is called a hydrogen bond. This bond is often represented by a dotted line because a hydrogen bond is easily broken.



Importance of Hydrogen bonding in Water:

Because of hydrogen bonding, water is a liquid at temperatures suitable for life. The high cohesion and adhesion force of water is due to the presence of hydrogen bonds in water, which in turn makes water as transport medium.

3. Cohesion and adhesion:

Cohesion is the attraction among the water molecules which enables the water molecules to stick together.

Water flows freely due to cohesion. Water molecules also have attraction to polar surfaces. This attraction is called adhesion. Both cohesion

and adhesion are due to hydrogen bonds among water molecules. These properties of water enable it to circulate in living bodies and to act as transport medium.

4. High specific heat:

Heat capacity can be defined as the amount of heat required for minimum increase (1°C or 1°K) in temperature of a substance. The specific heat capacity of water can be represented as number of calories required to raise the temperature of 1g of water up to 1°C i.e., 1 Calorie (4.18 Joules). Water has relatively a very high heat capacity than any other substance due to its hydrogen bonding, because much of the heat absorbed by water is utilized in the breakdown of hydrogen bonding therefore it does not manifest itself to raise the temperature of water.

Hence, very large amount of heat can increase very little in temperature in water.

Importance of High Specific Heat:

Due to its high heat capacity water works as temperature stabilizer or regulator for organisms in the hot environment and hence protects the living material against sudden thermal changes.

5. High heat of vaporization:

Heat of vaporization is the amount of heat required to convert a unit mass of a liquid into gaseous form. Heat of vaporization of water represented as number of calories absorbed per gram vaporized. Water has high heat of vaporization i.e. 574 calories per gram. The high heat of vaporization means that a large amount of heat can be lost with minimal loss of water from the body.

Importance of High Heat of Vaporization:

This is high heat of vaporization of water that gives animals an efficient way to release excess body heat in a hot environment. When an animal sweats, body heat is used to vaporize the sweat thus cooling the animal. Due to this property of water, evaporation of only 2 ml out of one liter of water lowers the temperature of the remaining 998 ml water by 1°C.

6. **Hydrophobic exclusion:**

Hydrophobic exclusion can be defined as reduction of the contact area between, water and hydrophobic substances which are placed in water. For example, if you place few drops of oil on the surface of a water solution, the oil drops will tend to coalesce (to unite into one whole) into a single drop.

Importance of Hydrophobic Exclusion:

Biologically, hydrophobic exclusion plays key roles in maintaining the integrity of lipid bilayer membranes.

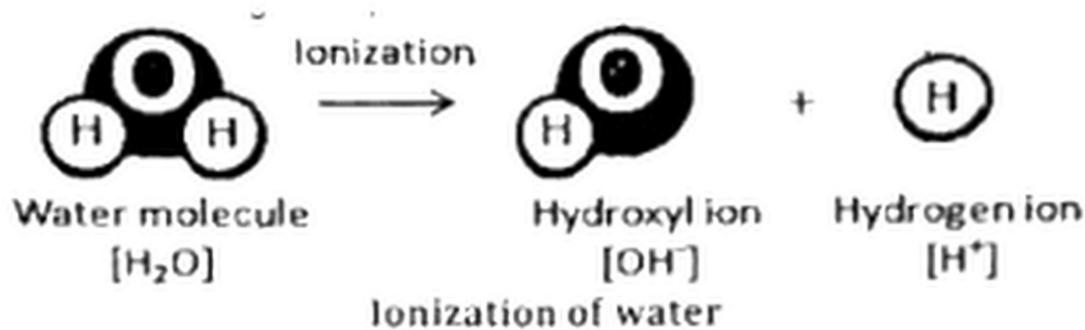


1. **Ionization:**

The dissociation of a molecule into ions is called ionization. When a water molecule ionizes, it releases an equal number of positive hydrogen and negative hydroxyl ions.

Importance of Ionization:

This reaction is reversible but equilibrium is maintained at 25°C. The H⁺ and OH⁻ ions affect and take part in many of the reactions that occur in cells e.g. it helps to maintain or change the pH of the medium.

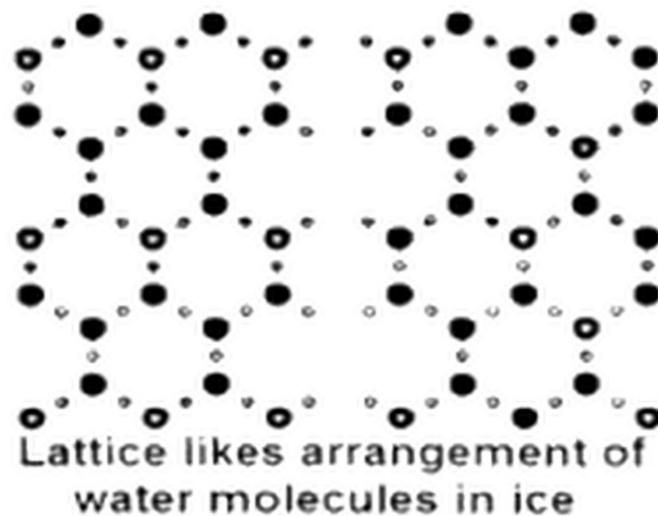


2. Lower density of ice:

Ice floats on water. This is because ice is less dense than water. The reason is that ice has a giant structure and show maximum number of hydrogen bonding among water molecules, hence, they are arranged like a lattice.

Importance of Lower Density of Ice:

In freezing weather, ice forms on the surface of ponds and lakes forming an insulating layer above the water below. This provides a living environment for some organisms until the ice melts. Organisms can also live under the ice.



47. Distinguish the properties and role of monosaccharides.

Ans: Monosaccharides:

Monosaccharides are true carbohydrates which are either polyhydroxy aldehydes or polyhydroxy ketones. The range of number of carbons in monosaccharide is 3 to 7, All the carbon atoms in a monosaccharide except one, have a hydroxyl group (-OH) while the remaining carbon atom is either the part of aldehyde or ketone. The general formula for the representation of monosaccharides is $C_nH_{2n}O_n$, where, n is the number of carbon atoms in monosaccharides.

Table: Examples and functions of monosaccharide:

Class	Formula	Aldoses	Ketoses	Function
Trioses (3C)	$C_3H_6O_3$	Glyceraldehyde	Dihydroxy acetone	Intermediates in photosynthesis and cellular respiration
Tetroses (4C)	$C_4H_8O_4$	Erythrose	Erythrulose	Intermediates in bacterial photosynthesis
Pentoses (5C)	$C_5H_{10}O_5$	Ribose, Deoxyribose ($C_5H_{10}O_4$)	Ribulose	Ribose and deoxyribose are components of RNA and DNA respectively is an intermediate in photosynthesis

Hexoses (6C)	$C_6H_{12}O_6$	Glucose, Galactose	Fructose	Glucose is respiratory fuel (initial substrate) Fructose is an Intermediate in respiration, Galactose is the component of milk sugar
Heptoses (7C)	$C_7H_{14}O_7$	Glucoheptose	Sedoheptulose	intermediates photosynthesis

48. Write the empirical formula of monosaccharides and classify them.

Ans: Monosaccharides:

Monosaccharides are the simplest carbohydrates in that they cannot be hydrolyzed to smaller carbohydrates. They are aldehydes or ketones with two or more hydroxyl groups.

Empirical Formula of Monosaccharides:

The general formula for the representation of monosaccharides is $C_nH_{2n}O_n$ where, n is the number of carbon atoms in monosaccharides.

Classification of monosaccharides:

Classification of monosaccharides is based upon functional group and number of carbon atoms. On the basis of functional group, the monosaccharides containing aldehyde are called aldoses while those

containing ketone are called ketoses on the other hand monosaccharides are classified into five groups based upon number of carbon atoms i.e., trioses (3C), tetroses (4C), pentoses (5C), hexoses (6C) and heptoses (7C).

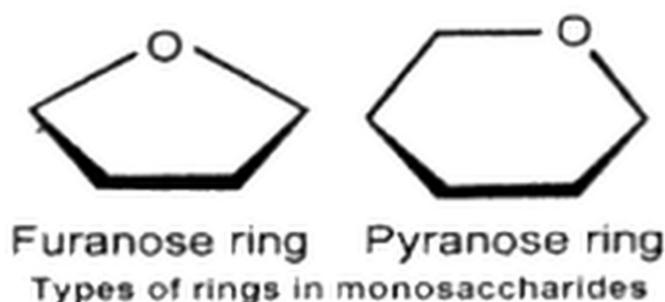
Chemical structures of monosaccharides:

Monosaccharides are usually found in open chain structure in crystalline form but when they are dissolved in water most of them (pentoses and hexoses) are converted into ring chain structure.

Two types of ring structures are found in monosaccharides i.e., furanose and pyranose.

i. Furanose:

Furanose a five membered ring in which one oxygen atom and four carbon atoms are found, oxygen atom is linked with C1 and C4. All pentoses and ketohexoses are converted into furanose ring.

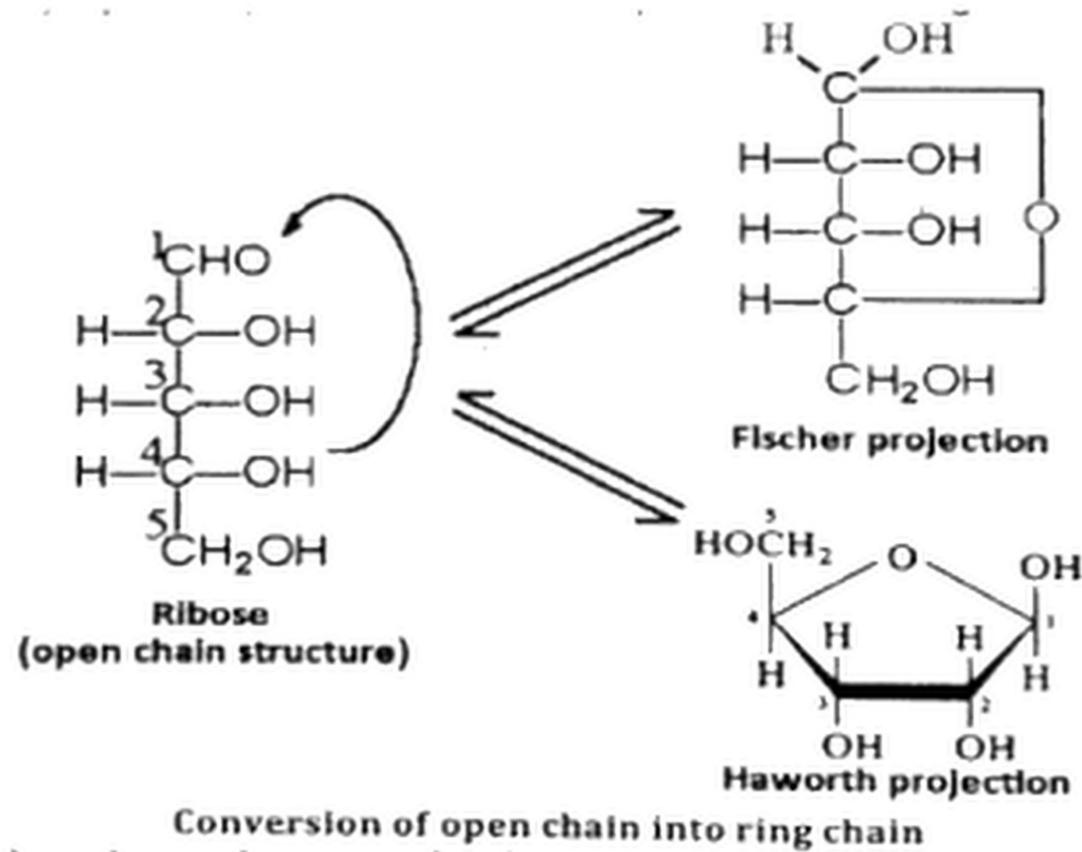


ii. Pyranose:

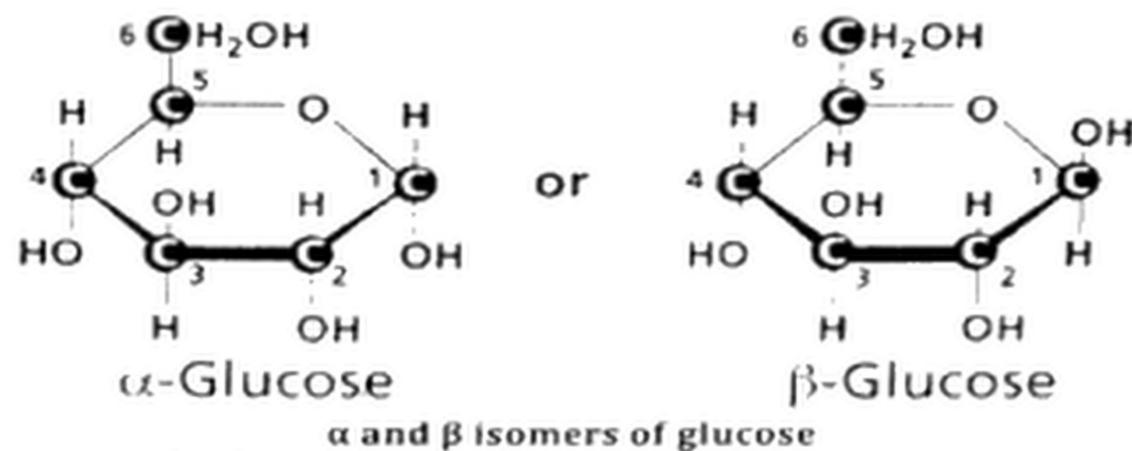
Pyranose is a six membered ring in which one oxygen atom and five carbon atoms are found, oxygen atom is linked with C1 and C5. Only aldohexoses are converted into pyranose ring.

Let us understand it by taking ribose as an example Ribose is an aldopentose, with the molecular formula $C_5H_{10}O_5$. It can exist in open chain structure in dried form but it exists in furanose ring in aqueous medium. When it is dissolved in water, the oxygen atom from aldehyde group reacts with penultimate carbon (second last carbon i.e., C4 in case of ribose) in this way oxygen atom forms a link between C1 and C4 while the OH group of C4 is

shifted to C1. After this modification ring structure of ribose is formed. The ring structure demonstrated by Emil Fischer is called Fischer projection (a two-dimensional representation of ring structure) while that represented by an English chemist Norman Haworth is called as Haworth projection (a three-dimensional representation of ring structure).



Each pentose or hexose molecule in ring structure exists in either a or β form depending upon the position of —H and —OH group on C-1. If —OH group is found downward on C-1 then it is called a sugar and if —OH is present upward on C-1 then it is known as β sugar as shown in the figure.

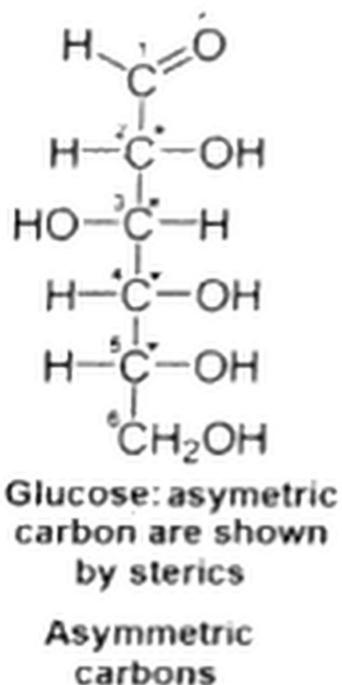


49. Compare the isomers and stereoisomers of glucose.**Ans: Isomers:**

Isomers are molecules that have the same molecular formula, but have a different arrangement of the atoms in space. That excludes any different arrangements which are simply due to the molecule rotating as a whole, or rotating about particular bonds.

Stereoisomerism in monosaccharides (Glucose):

Those isomers in which —H and —OH groups are arranged in different pattern to the asymmetric carbon atoms are called stereoisomers. An asymmetric carbon atom is that which makes bonds with four different atoms around it. For example, in glucose, the C-2, C-3, C-4 and C-5 are asymmetric carbon atoms, in monosaccharide the number of stereoisomers, actually depends upon the number of asymmetric carbons in its structure and can be calculated by the formula 2^n , where n is the number of asymmetric carbon atoms so glucose has 16 stereoisomers.

**Classification of Stereoisomerism:**

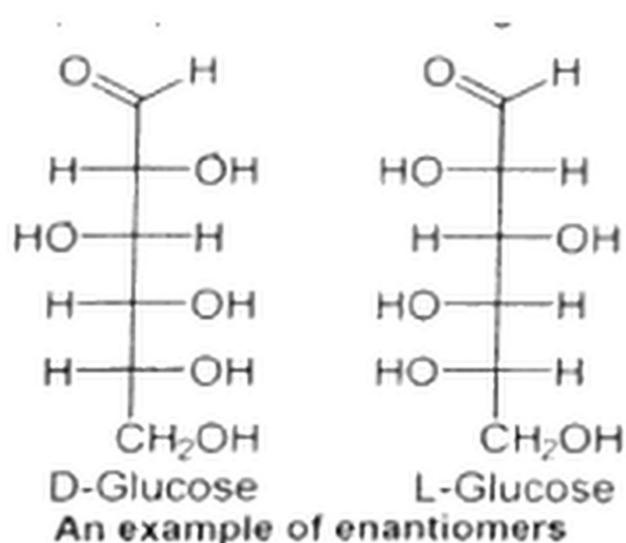
Stereoisomers can be classified in three groups.

i. Enantiomers:

Those stereoisomers which are non-superimposable mirror images of one another are called enantiomers

Example:

An example of an enantiomer is the D and L Isomers of glucose, as shown in figure In D isomers (also called right handed form) the asymmetric carbon atom farthest from aldehyde group (second last carbon or C-5 in case Of glucose also called penultimate carbon) has —OH group on right side whereas in L isomers (also called left handed form), the —OH group is projected on left Side penultimate carbon atom, Out of 16 stereoisomers of glucose, 8 are enantiomers of other 8.



(ii) Diastereoisomers:

Those stereoisomers which have different arrangement of —H and —OH groups at more than one asymmetrical carbon atoms are called diastereoisomers. Unlike an enantiomer, diastereoisomers are not mirror images.

Example:

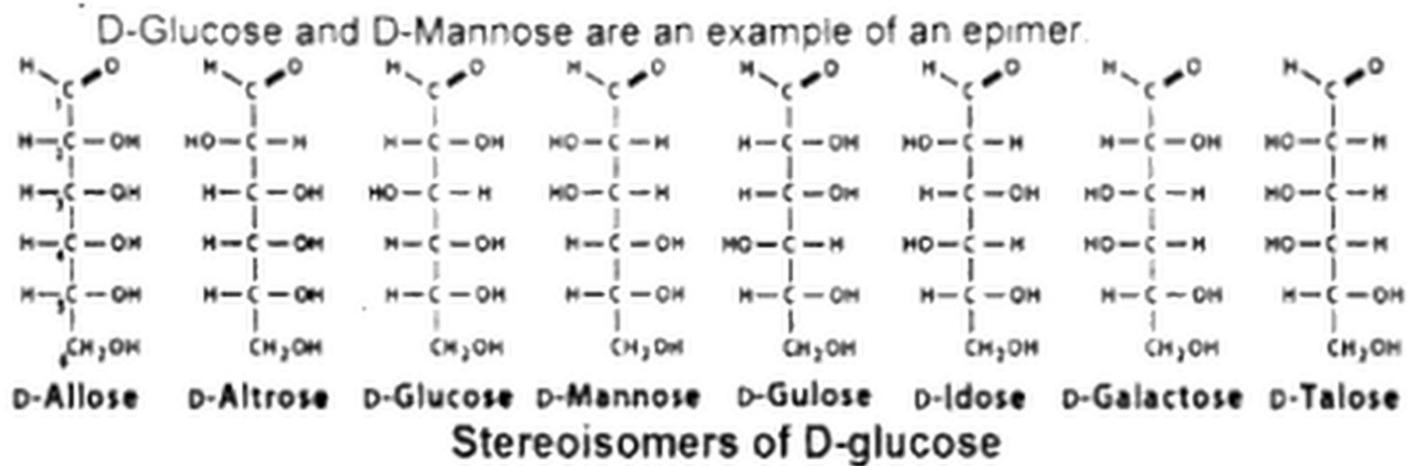
For example, the two carbohydrates that are diastereoisomers are D-Glucose and D-Altrose.

(iii) Epimers:

Those stereoisomers which have different arrangement of —H and —OH groups at only one asymmetrical carbon atom are called epimers.

Example:

D-Glucose and D-Mannose are an example of an epimer.



50. Distinguish the properties and role of disaccharides.

Ans: Disaccharides:

Two monosaccharides combine to form a disaccharide. It is a kind of oligosaccharides.

Properties and role of disaccharides:

Disaccharides are less sweet in taste and less soluble in water. These can be hydrolyzed to give monosaccharides.

Examples are: maltose, lactose, sucrose.

General Formula of Disaccharide:

The general formula of disaccharide is $C_{12}H_{22}O_{11}$.

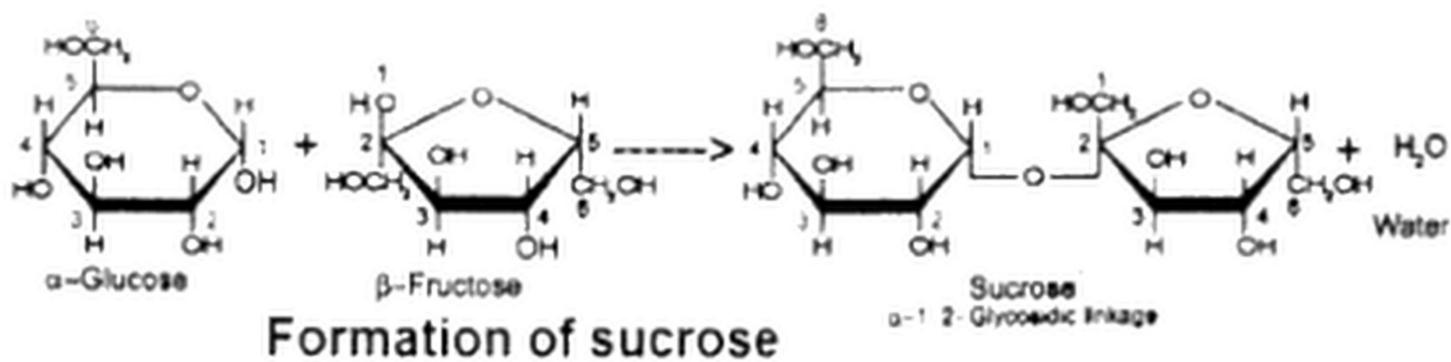
Some common disaccharides are as follows:

Sucrose:

It is commonly known as cane Sugar because it occurs abundantly, in Sugarcane beside it many other plants also have sucrose in considerable amount like sugar beet, pine apple, Sorghum and all sweet fruits. It is widely used as sweetener at homes for making sweet dishes. In plants sucrose is also called transport disaccharide as prepared food in plants is transported in the form of sucrose, upon hydrolysis sucrose yields a molecule of α -glucose and a molecule of β -fructose.

Formation of Sucrose:

Therefore, the sucrose is formed by the condensation of glucose and fructose. In this reaction, the —OH group at C-1 of glucose reacts with the —OH group at C-2 of fructose, liberating a water molecule and a linkage is formed between C-1 of glucose and C-2 of fructose known as α -1,2-glycosidic linkage.



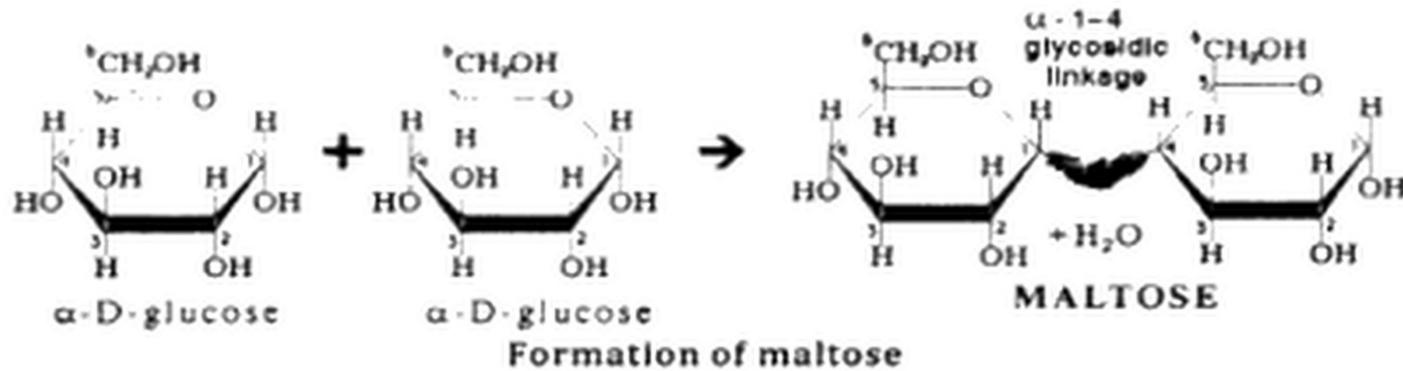
Maltose:

It is commonly known as malt sugar. It is an intermediate disaccharide produced during the breakdown of starch and glycogen. Maltose is generally found in germinating seeds. In brewing industry, the maltose is produced from the breakdown of barley starch by the help of amylase enzyme. This process is known as malting, upon hydrolysis it yields two molecules of α -glucoses.

Formation of Maltose:

Therefore, the maltose is formed by the condensation of α -glucoses. In this reaction, the —OH group at C-1 of one glucose reacts with the —OH group

at C-4 of other glucose, liberating a water molecule and a linkage is formed between C-1 Of one glucose and C-4 of other glucose, known as α -1, 4-glycosidic linkage.

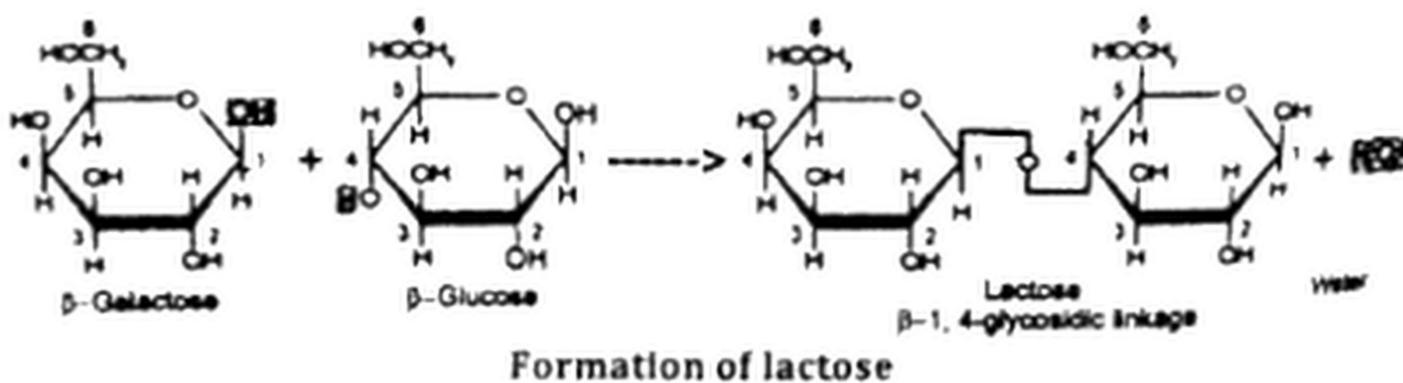


Lactose:

It is commonly known as milk sugar as it is found in milk of mammals i.e., 4- 6% in cow's milk and 5-8% in human milk. It is also a byproduct in the manufacture of cheese. Upon hydrolysis it yields a molecule of β -galactose and a molecule of α - glucose.

Formation of Lactose:

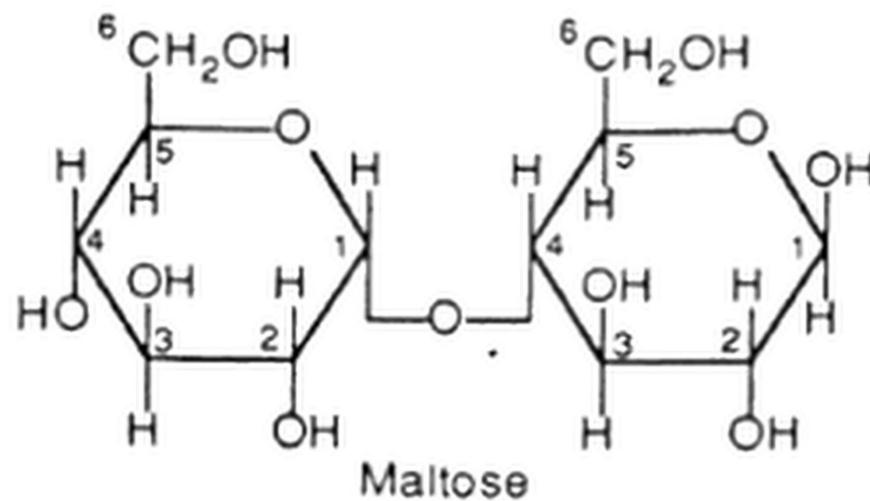
Therefore, the lactose is formed by the condensation of β -galactose and β - glucose. In this reaction, the $-\text{OH}$ group at C-1 of galactose reacts with the $-\text{OH}$ group at C-4 of glucose, liberating a water molecule and a linkage is formed between C-1 of galactose and C-4 of glucose, known as β -1, 4-glycosidic linkage.



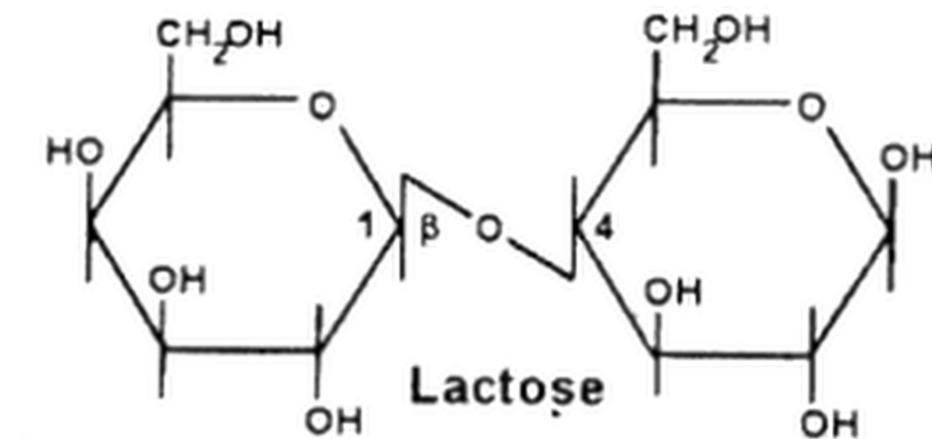
51. Describe glycosidic bond in the transport of disaccharides.

Ans: When 2 monomer bonds together covalently, they form disaccharides. This is formed via a condensation reaction and a "bridge" is created. This "bridge" is called a glycosidic bond. Some of these disaccharides are maltose, lactose and sucrose.

Maltose: The glycosidic bond of maltose is formed between the OH of carbon 1 and carbon 4 of 2 glucose monomers. Therefore, it forms an α -1, 4 glycosidic bond.

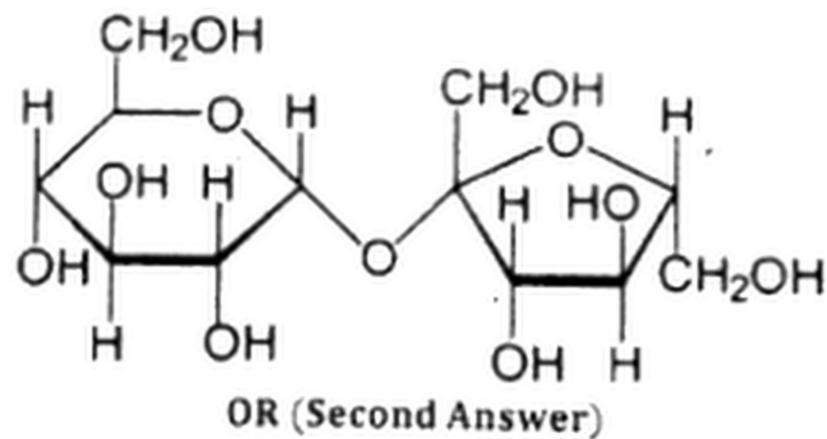


Lactose: This is a milk sugar, composed of a glucose and a galactose monomer. They form a β -1, 4 glycosidic bond.



Sucrose:

Sucrose links the anomeric hydroxyls of glucose and fructose to form an α -1, 2 glycosidic bond.



Disaccharides:

Two monosaccharides combine to form a disaccharide. It is a kind of oligosaccharides.

Properties and role of disaccharides:

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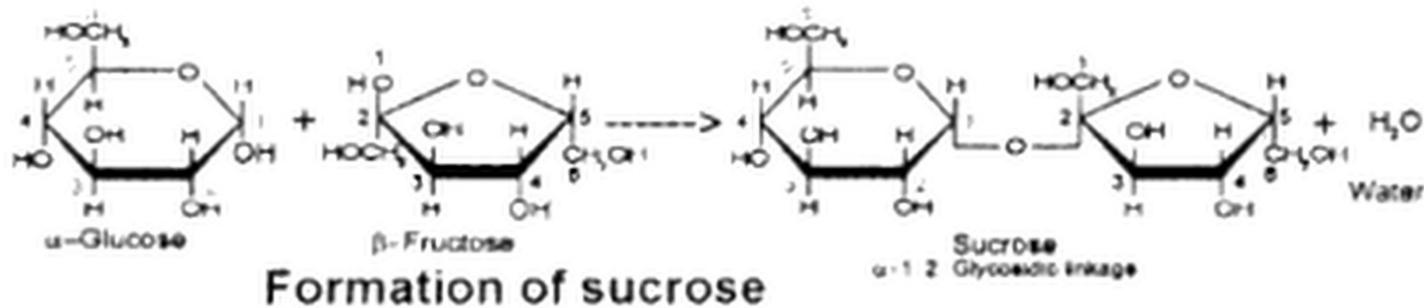
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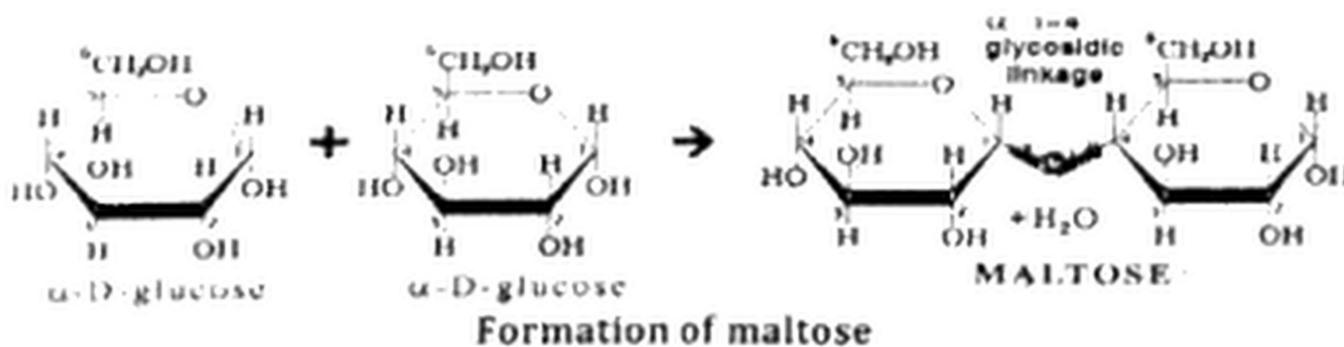


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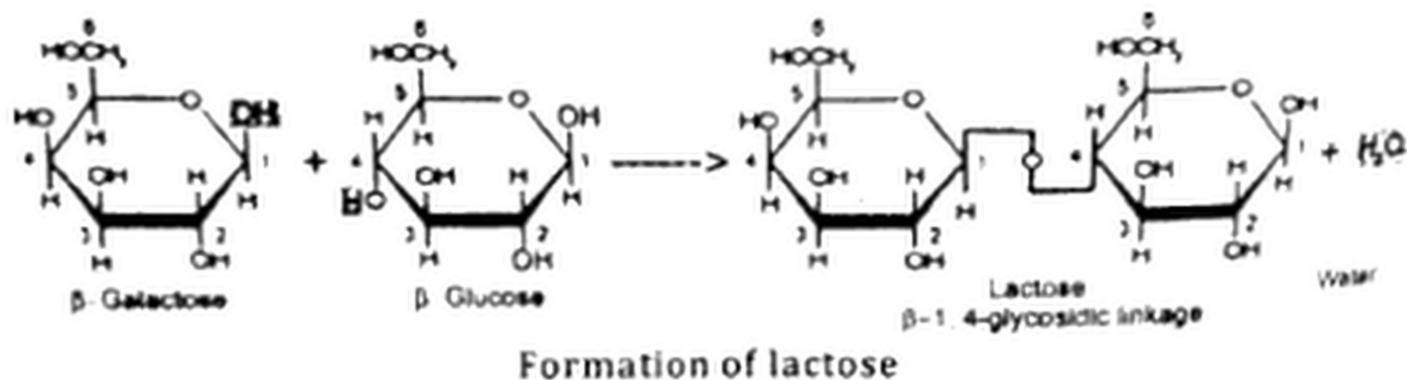


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52. Distinguish the properties and role of polysaccharides.

Ans: Polysaccharides:

Those carbohydrates which upon hydrolysis yield more than ten monosaccharide units are called polysaccharides. This is largest group of carbohydrates.

Composition of Polysaccharides and their Types:

The polysaccharides which are composed by the condensation of only one kind of monosaccharides are called homopolysaccharides e.g., starch, glycogen, cellulose, chitin; whereas the polysaccharide which are

composed by the condensation of different kind of monosaccharides are - called heteropolysaccharides e.g., agar, pectin, peptidoglycan. Polysaccharides function chiefly as food and energy stores, e.g., starch, glycogen, and structural material. e.g., cellulose and chitin.

Role of Polysaccharides:

They are convenient storage molecule for several reasons. Their large size makes them more or less insoluble in water, so they exert no osmotic or chemical influence in the cell; they fold into compact shapes and they are easily converted to sugars by hydrolysis when required. Some common polysaccharides e.g., starch, cellulose, and chitin are being discussed here.

53. Describe the properties and roles of starch, glycogen, cellulose and chitin.

Ans: Starch:

Starch is a homopolysaccharides which is formed by the condensation of hundreds of α -glucoses.

Storage of Starch in Plants:

It is storage carbohydrate of plants, it is mainly stored in root, stem and seeds.

Role of Starch:

Cereal grains and potato tubers are rich sources of starch in human diet. Starch is digested in oral cavity and in small intestine by the enzyme amylase upon hydrolysis. It yields maltose first and then maltose is further digested by maltase enzyme and yields glucoses. The presence of starch in a given sample can be confirmed by iodine test as it gives blue color with iodine solution.

Types of Starch:

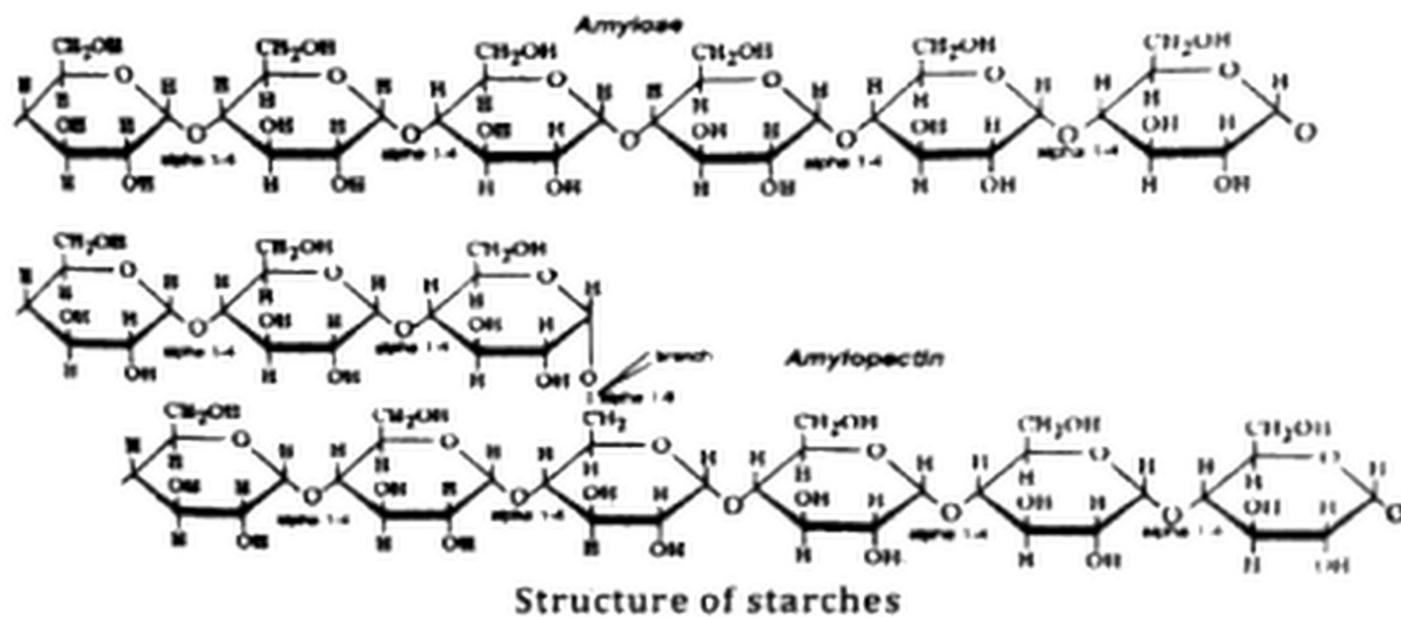
There are two types of starches i.e., amylose and amylopectin.

Amylose:

Amylose is un-branched a linear chain of glucoses in which glucoses are attached together by α -1, 4-glycosidic linkages. It is soluble in hot water only.

Amylopectin:

On the other hand, amylopectin has branched structure i.e. a linear chain of glucoses but more chains of glucoses in the form of branches are also attached by α -1, 6-glycosidic linkages. It is completely insoluble in water.



Glycogen:

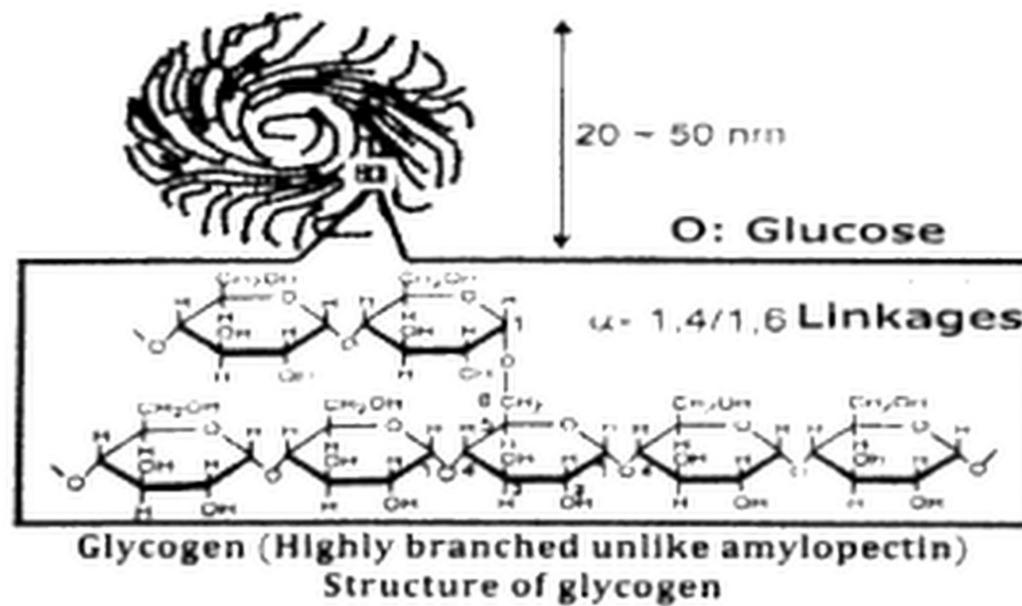
Like starch, glycogen is also a homopolysaccharides composed of α -glucoses.

Storage of Glycogen in Animals:

It is storage carbohydrate of animals. It is mainly stored in liver and muscles. Therefore, it is also known as animal's starch. The digestion of glycogen is also quite similar to that of starch. The presence of glycogen in a given sample can also be confirmed by iodine test as it gives red color with iodine solution.

Structure of Glycogen:

Structure of glycogen resembles with amylopectin starch but glycogen has much more branching than amylopectin.



Cellulose:

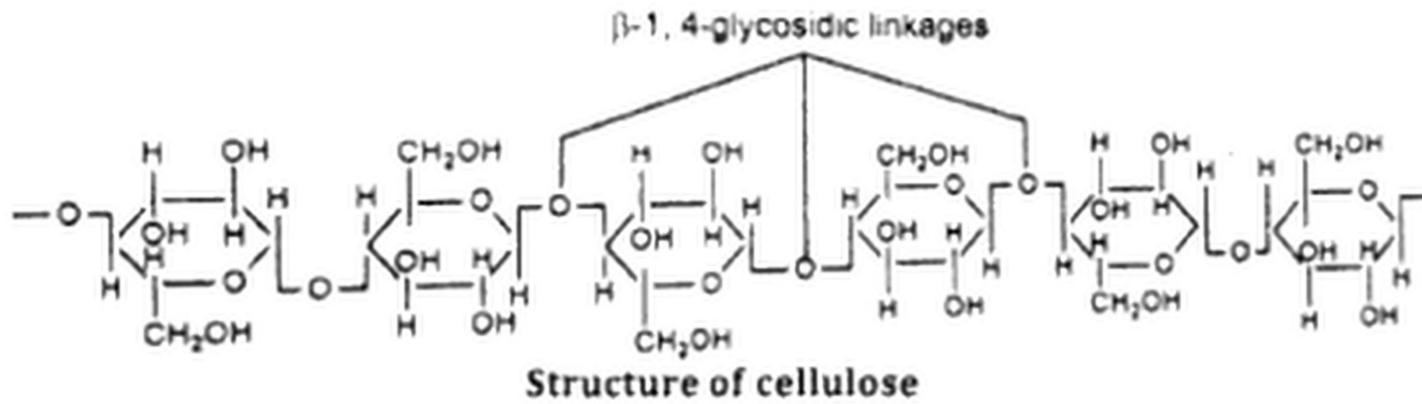
Cellulose is most abundant carbohydrate on earth. It is also a homopolysaccharides but unlike starch and glycogen it is formed by the condensation of hundreds of β -glucoses.

Examples of Cellulose:

It is structural carbohydrate of plants as it is major constituent of plant cell wall. Cotton and paper are the pure forms of cellulose. Cellulose shows no color with iodine solution.

Structure of Cellulose:

Structure of cellulose resembles with amylose starch in such a way that it has un-branched structure but it has β -1, 4-glycosidic linkages between glucose residues. Therefore, in a cellulose chain, the β -glucoses are alternatively arranged in upright and inverted manner.



Chitin:

Chitin is the second most abundant organic molecule on earth.

Role of Chitin:

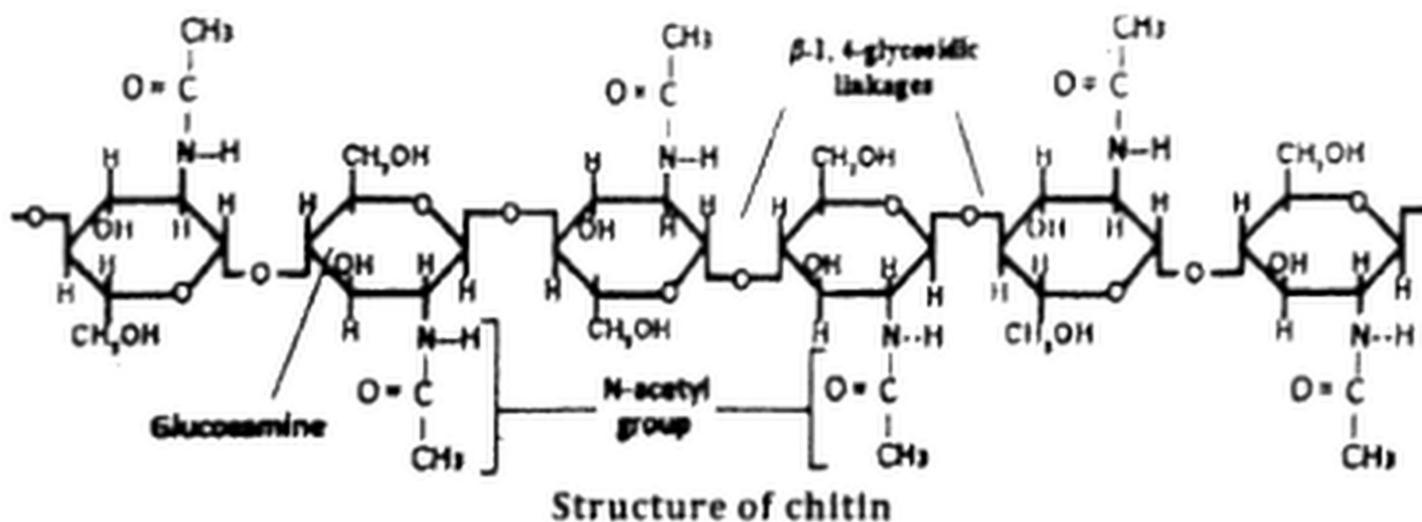
It is also a homopolysaccharides. It is a structural carbohydrate found in the cell walls of fungi and in the exoskeleton of arthropods, Due to the occurrence of chitin in fungal cell wall, it is also known as fungal cellulose.

Formation of Chitin:

Chitin is the derivative of N-acetyl glucosamine which is a modified form of glucose.

Structure of Chitin:

It has an un-branched structure like cellulose in which alternative upright and inverted N-acetyl glucosamine residues are linked together by β-1, 4-glycosidic linkages.



54. Justify the significance of the sequence of amino acids through the example of sickle cell haemoglobin.

Ans: Significance of Amino Acid Sequence:

Sequence of amino acid in a polypeptide is a characteristic feature of primary structure of protein which is responsible for proper functioning of protein. It is determined by the sequence of nucleotide in DNA.

Point Mutation:

Even due to point mutation (change of single or few nucleotides in DNA) the sequence of amino acid in a particular protein (polypeptide) may be disturbed which causes severe defects in the body as it happens 'n sickle cell anemia, a hereditary disease.

Haemoglobin (Hb[^]):

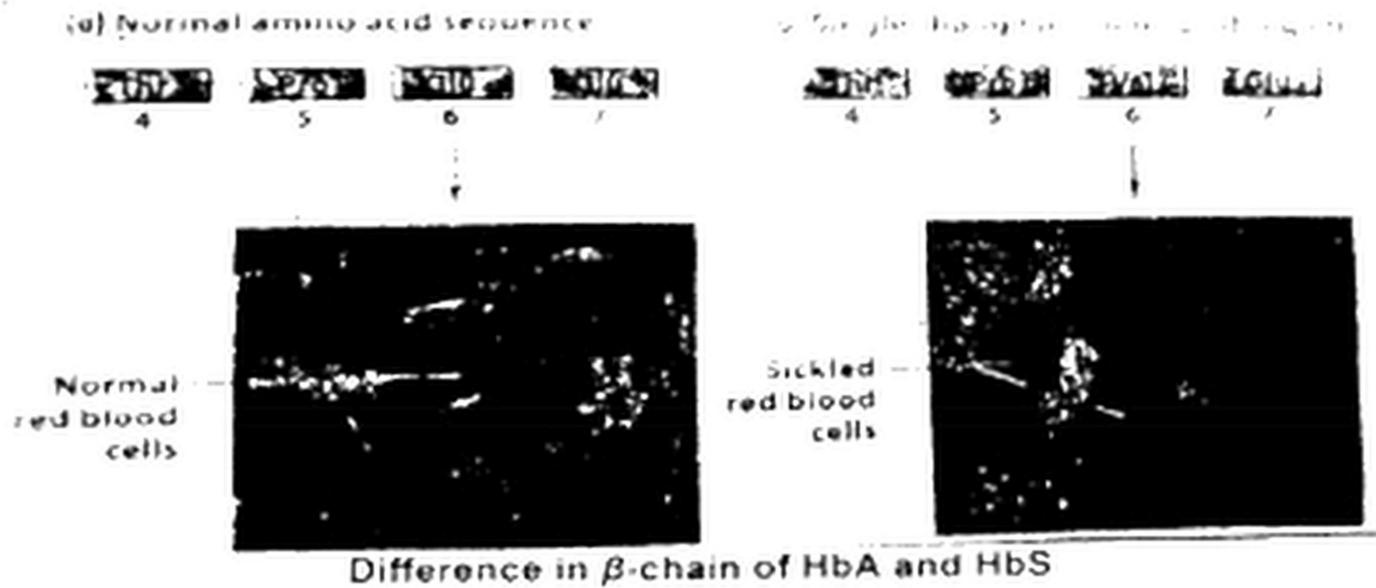
Normal red blood cells are disc-shaped and look like doughnuts without holes in the center. They move easily through your blood vessels. Red blood cells contain an iron-rich protein called haemoglobin. This protein carries oxygen from the lungs to the rest of the body. Normal haemoglobin (Hb[^]) contains four polypeptides i.e., two α -chains which consist of 141 amino acids each and two β - chains which consist of 146 amino acids each.

Sickle cell anemia:

Sickle cell anemia is a serious disorder in which the, body makes sickle or crescent shaped red blood cells Sickle ceils contain abnormal hemoglobin called sickle haemoglobin (HbS) Sickle haemoglobin causes the cells to develop a sickle or crescent, shape. Sickle cells are stiff and sticky. They tend to block blood flow in the blood vessels of the limbs and organs. Blocked blood flow can cause pain and organ damage.

Causes of Sickle cell anemia:

Sickle cell anemia is caused by a point mutation in β -globin gene in which only one nucleotide is replaced by another which causes a Change in amino acid sequence of β -chain of hemoglobin. Sickle cell haemoglobin (HbS) shows only one difference from HbA i.e., glutamic acid is replaced by valine at position number six in β -chain.



55. List examples and the roles of structural and functional proteins.

Ans: Role of Proteins:

Proteins are very important molecules in our cells. They are Involved virtually all cell functions. Each protein within the body has a specific function, some proteins are involved in support or composition of body parts i.e., structural role, while others are involved in various physiological activities like bodily movement or in defence against germs i.e., functional roles. A list of several types of proteins and their functions is given in tables.

Table: List of structural proteins:

Types	Role of proteins
Collagen	It establishes the matrix of bone and cartilages.

Elastin	Elastin provides support for connective tissues such as tendons and ligaments.
Keratin	It strengthens protective coverings such as hair, nails, quills, feathers, horns, and beaks.
Histone	It arranges the DNA into the chromosome

Table: List of functional proteins:

Types	Role of proteins
Enzymes	The most of enzymes are protein which control metabolism and speed up the biochemical reactions
Hormones	Some hormones are protein in nature which are involved in the regulation of physiological activities such as regulation of glucose level, calcium level, digestion, blood pressure etc.
Antibodies	These proteins are produced by WBCs in response to antigen (a foreign particle) and provide immunity.
Haemoglobin	It is found in RBCs and is involved in the transport of oxygen mainly and carbon dioxide to some extent.
Fibrinogen	It is found in blood plasma and is involved in blood clotting process.
Ovalbumin and Casein	Ovalbumin is found in egg whites and casein is a milk-based protein. Both of them are involved in the storage of amino acids

56. Describe the properties and roles of:

- (a) Acylglycerol** **(b) phospholipids**
(c) Terpenes **(d) waxes**

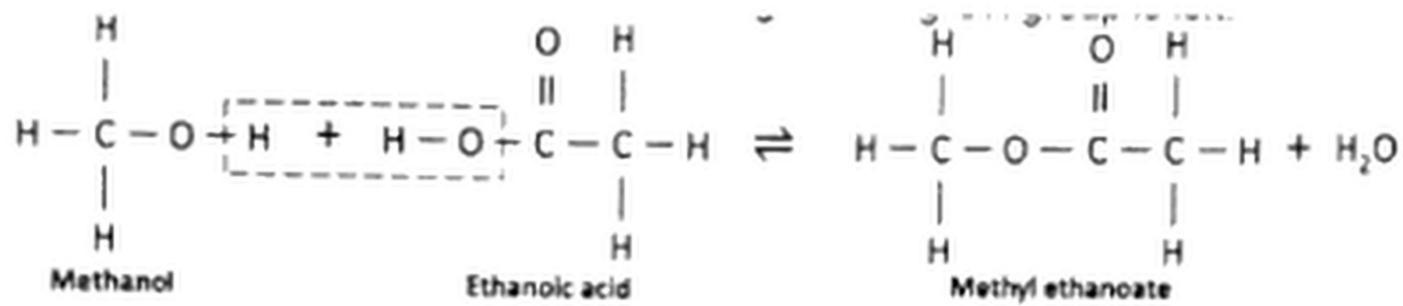
Ans: (a) acylglycerol

The most abundant lipids in living things are acylglycerol. Chemically, acylglycerols can be defined as esters of glycerol and fatty acids. An ester is the compound produced as the result of a chemical reaction of an alcohol with acid and a water molecule is released such a reaction is called esterification.

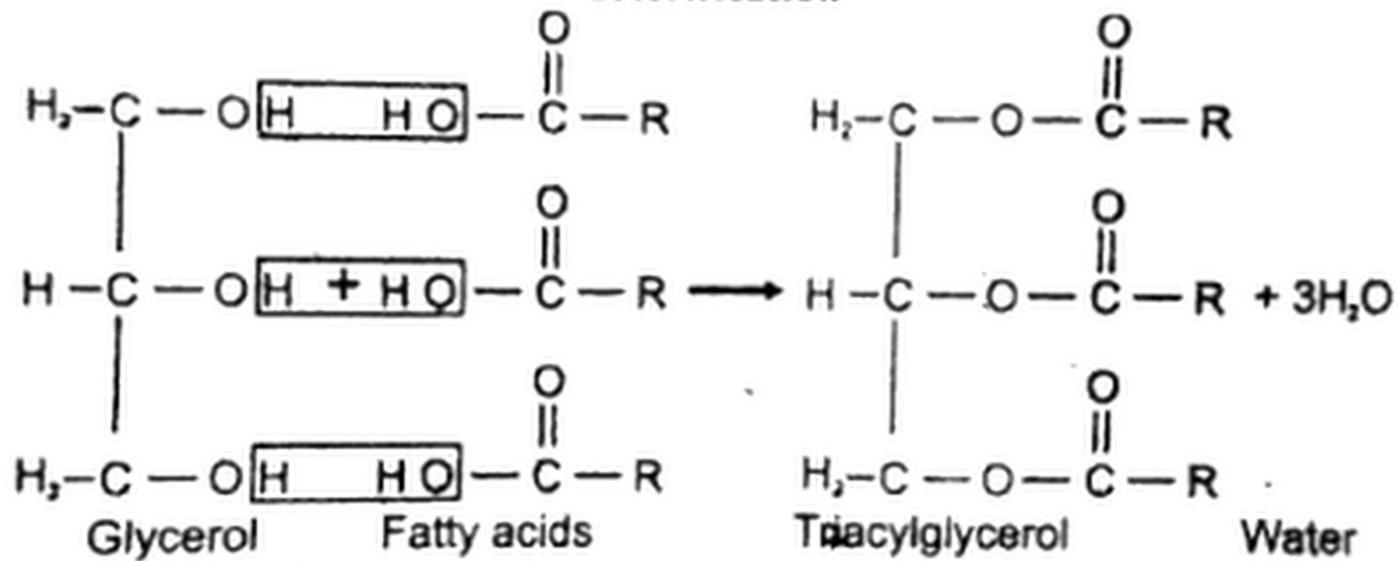
Glycerol is a trihydroxy alcohol which contains three carbons, each bears an OH group. A fatty acid is a type of organic acid containing one carboxylic acid group attached to a hydrocarbon. Fatty acids contain even number of carbons from 2 to 30. Each fatty acid is represented as R-COOH, where R is a hydrocarbon tail.

When a glycerol molecule combines chemically with one fatty acid, a monoacylglycerol (monoglyceride) is formed. When two fatty acids combine with a glycerol a diacylglycerol (diglyceride) is formed and when three fatty acids combine with one glycerol molecule a triacylglycerol (triglyceride) is formed.

Triacylglycerols are also called neutral lipid as all three OH groups of glycerol are occupied by fatty acids and charge bearing OH group is left.



Esterification



Formation of a triacylglycerol (neutral lipid)

Properties and types of fatty acids:

About 30 different fatty acids are found. Fatty acids vary in length. Acetic acid (2C) and butyric acid simplest fatty acid, whereas palmitic acid (16C) and stearic acid (18C) are most common fatty acids. Some properties of fatty acid are increased with an increase in number of carbon atoms, such as melting point, solubility in organic solvent and hydrophobic nature. Some common fatty acids are given in the table. Fatty acids are either saturated or unsaturated. Fatty acids in which all of the internal carbon atoms possess hydrogen side groups are said to be saturated fatty acids because they contain the maximum number of hydrogen atoms that are possible, e.g., palmitic acid. Saturated fatty acids tend to be solid at room temperature (higher melting point) and are more common in animal lipids (fats).

Unsaturated fatty acids have one or more pairs of carbon atoms joined by a double bond. They therefore are not fully saturated with hydrogen.

e.g., oleic acid. Unsaturated fatty acids are liquid at room temperature (lower melting point) and are more common in plant lipids (oils). Triglycerides containing hydrocarbon chains melt at a low temperature. This is useful for living things.

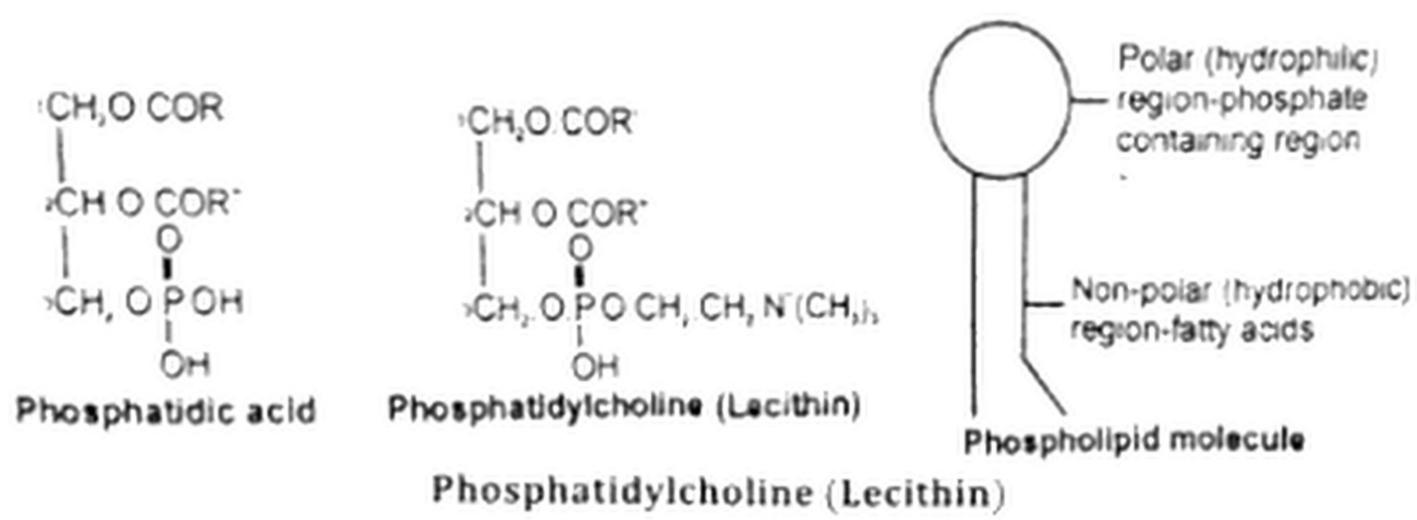
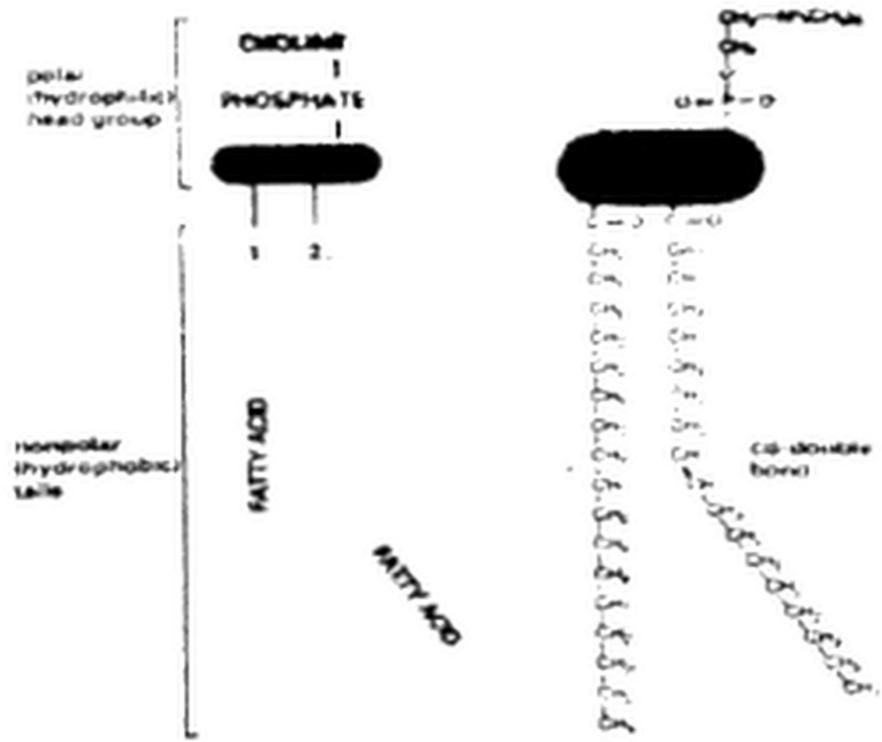
Table: Common types of fatty acids:

Name	Typical sources	No. of Carbon	Condensed formula	Melting point (°C)
Saturated				
1. Lauric	Coconut oil	12	$\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$	44
2. Myristic	Butter fat	14	$\text{CH}_3(\text{CH}_2)_{12}\text{COOH}$	58
3. Palmitic	Most fats and oils	16	$\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$	63
4. Stearic	Most fats and oils	18	$\text{CH}_3(\text{CH}_2)_{16}\text{COOH}$	70
Unsaturated				
5. Oleic	Olive oil	18	$\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	4
6. Linoleic	Vegetable oils	18	$\text{CH}_3(\text{CH}_2)_4\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$	-5

7. Linolenic	Soybeans and canola oils	18	$\text{CH}_3\text{CH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CHCH}_2\text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_2\text{OH}$	-11
8. Arachidonic	Lard (present in chicken etc)	20	$\text{CH}_3-(\text{CH}_2)_4-\text{CH}=\text{CH}-\text{CH}_2-\text{CH}=\text{CH}-\text{CH}_2-\text{CH}=\text{CH}-\text{CH}_2-\text{CH}=\text{CH}-(\text{CH}_2)_3-\text{COOH}$	-50

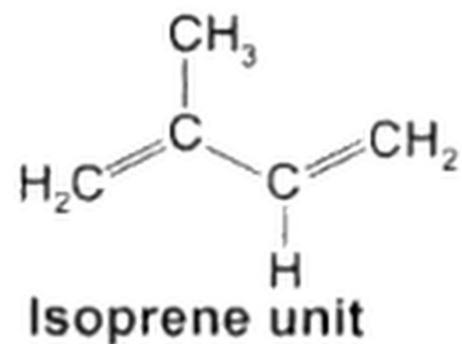
b) phospholipids:

Phospholipid is a type of compound/complex lipids. Commonly occurring phospholipids are derived from phosphatidic acid. A phospholipid is formed when phosphatidic acid combines with one of the four organic compounds such as choline (a nitrogenous base), ethanolamine (an amino alcohol), inositol (an amino alcohol) and serine (an amino acid). A phosphatidic acid molecule is most similar to diglyceride that it contains a glycerol, two fatty acids esterified with first and second OH groups of glycerol and a phosphate group esterified with third OH group of glycerol. Most common type of phospholipid is phosphatidylcholine also called lecithin in which choline is attached to phosphate group of phosphatidic acid. One end of the phospholipid molecule, containing the phosphate group and additional compound is hydrophilic i.e., polar and readily soluble in water. The other end, containing the fatty acid side chains is hydrophobic i.e., non-polar and insoluble in water. These phospholipids are major constituents of lipid bilayer of cell membrane.



(a) terpenes:

Terpenes are the types of derived lipids. All the terpenes are synthesized from a five-carbon building block known as isoprene unit. This unit condenses in different ways to form many compounds. Two isoprene units form a monoterpene e.g., menthol, four form a diterpene e.g. vitamin A, phytol (chlorophyll tail) and six form a triterpene e.g., ambrein. Natural rubber is a polyterpene.

**(b) waxes:**

Waxes are highly hydrophobic compounds.

Types of Waxes:

There are two types of waxes

i. Natural waxes:

Natural waxes are simple lipids. They are typically esters of long chain fatty acids and long chain alcohols, such as bee's wax (found in honeycomb), lanolin (obtained from sheep wool), cutin (on leaf surfaces of plants) and suberin (found in cell wall of endodermis of plant roots). These are chemically inert and resistant to atmospheric oxidation. Waxes have protective functions in plants and animals.

ii. Synthetic waxes:

Synthetic waxes are generally derived from petroleum or polyethylene and consist of mixtures of long-chain hydrocarbons (alkanes), alcohols, aldehydes, ketones and fatty acids e.g., paraffin wax which, is used to make candles, wax paper lubricants, and sealing materials.

57. Illustrate the molecular structure (making and breaking) of:

(a) acylglycerol (b) phospholipids (c) terpenes

Ans: (a) acylglycerol:

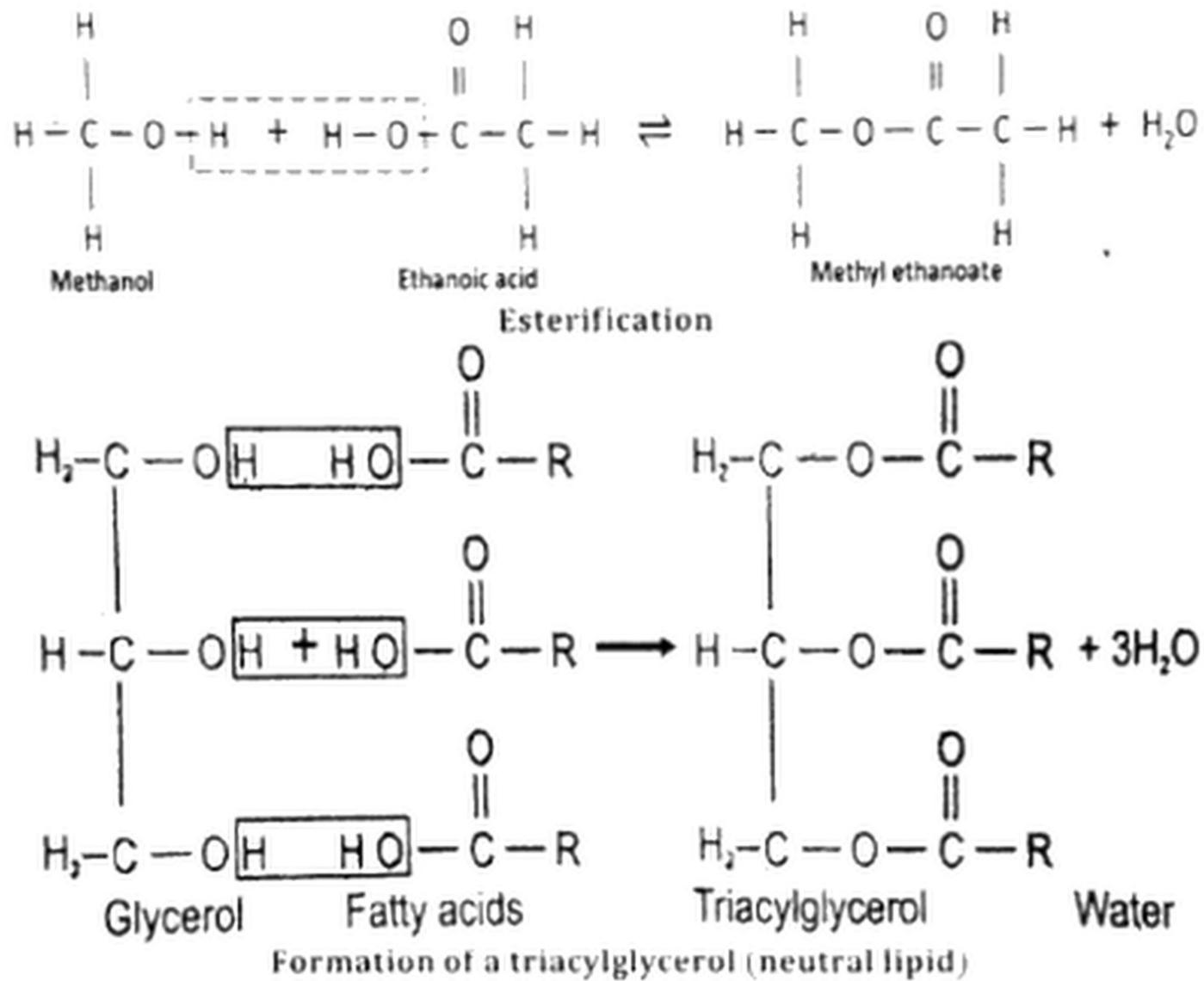
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An ester is the compound produced as the result of a chemical reaction of an alcohol with acid and a water molecule is released such a reaction is called esterification.

Glycerol is a trihydroxy alcohol which contains three carbons; each bears an OH group. A fatty acid is a type of organic acid containing one carboxylic acid group attached to a hydrocarbon. Fatty acids contain an even number of carbons from 2 to 30. Each fatty acid is represented as R-COOH, where R is a hydrocarbon tail.

When a glycerol molecule combines chemically with one fatty acid, a monoacylglycerol (monoglyceride) is formed. When two fatty acids combine with a glycerol a diacylglycerol (diglyceride) is formed and when three fatty acids combine with one glycerol molecule a triacylglycerol (triglyceride) is formed.

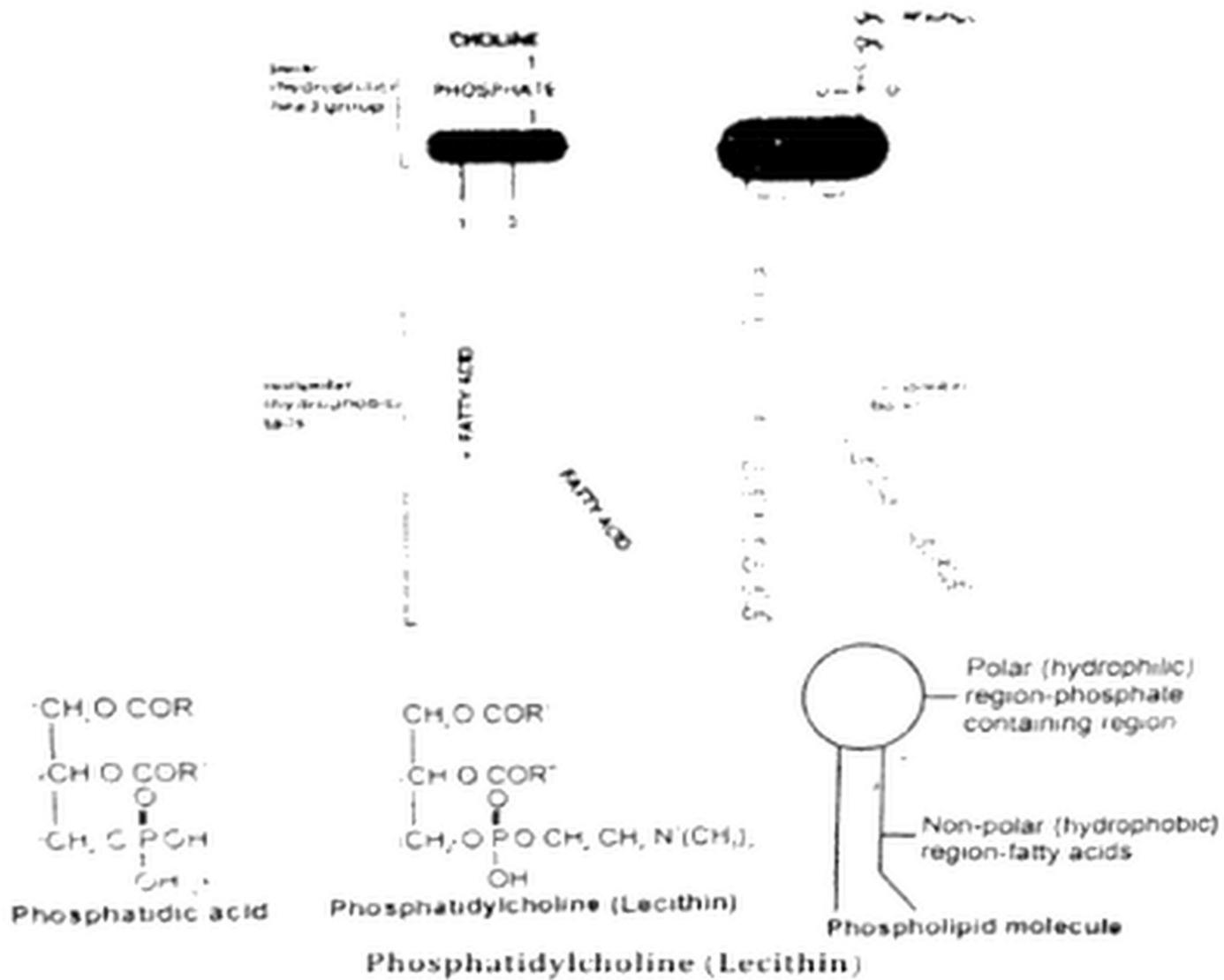
Triacylglycerols are also called neutral lipids as all three OH groups of glycerol are occupied by fatty acids and the charge-bearing OH group is left.



(b) phospholipids:

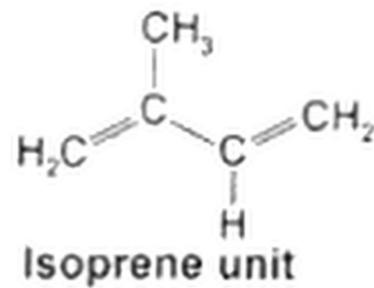
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compound is hydrophilic i.e. polar and readily soluble. In water. The other end, containing the fatty acid side chains is hydrophobic i.e., non-polar and insoluble in water. These phospholipids are major constituents of lipid bilayer of cell membrane.



(c) terpenes:

Terpenes are the types of derived lipids. All the terpenes are synthesized CH₃ from a five-carbon building block known as isoprene unit. This unit condenses in different ways to form many compounds. Two isoprene units form a monoterpene e.g. menthol, four form a diterpene e.g. vitamin A, phytol (chlorophyll tail) and six form a triterpene e.g. ambrein. Natural rubber is a polyterpene.



58. Evaluate the role of the following as important groups of lipids and describe their roles in living Organism:

(a) steroid (b) prostaglandins

Ans: (a) steroid:

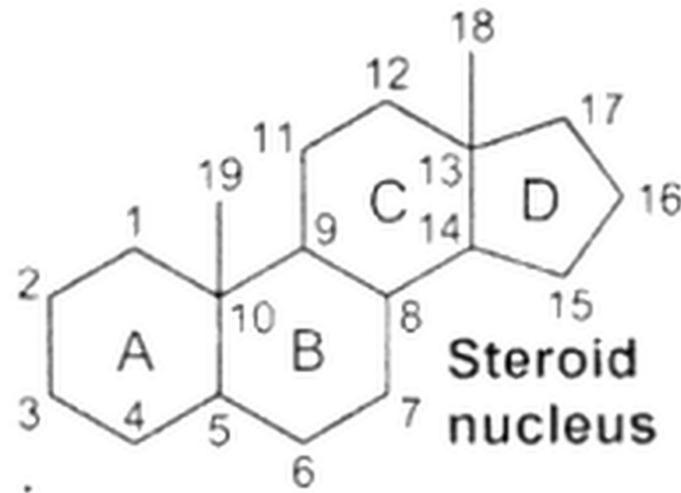
Steroids are lipids of high molecular weight which can be crystalline.

Composition Of steroid:

A steroid consists of 17 carbon atoms arranged in four attached rings, three of the rings contain six carbon atoms, and the fourth contains five. The length and structure of the Side chains that extend from these rings distinguish one steroid from other steroids. These structures are synthesized from isoprene units.

Role Of steroid in Living Organisms:

Cholesterol is a structural component of cell membrane; Cholesterol is the precursor of a large number of equally important steroids which include the bile acids male sex hormone testosterone female sex hormone progesterone and estrogen etc. Bile salts which emulsify fats and Vitamin D, which helps to regulate calcium metabolism are also steroid.

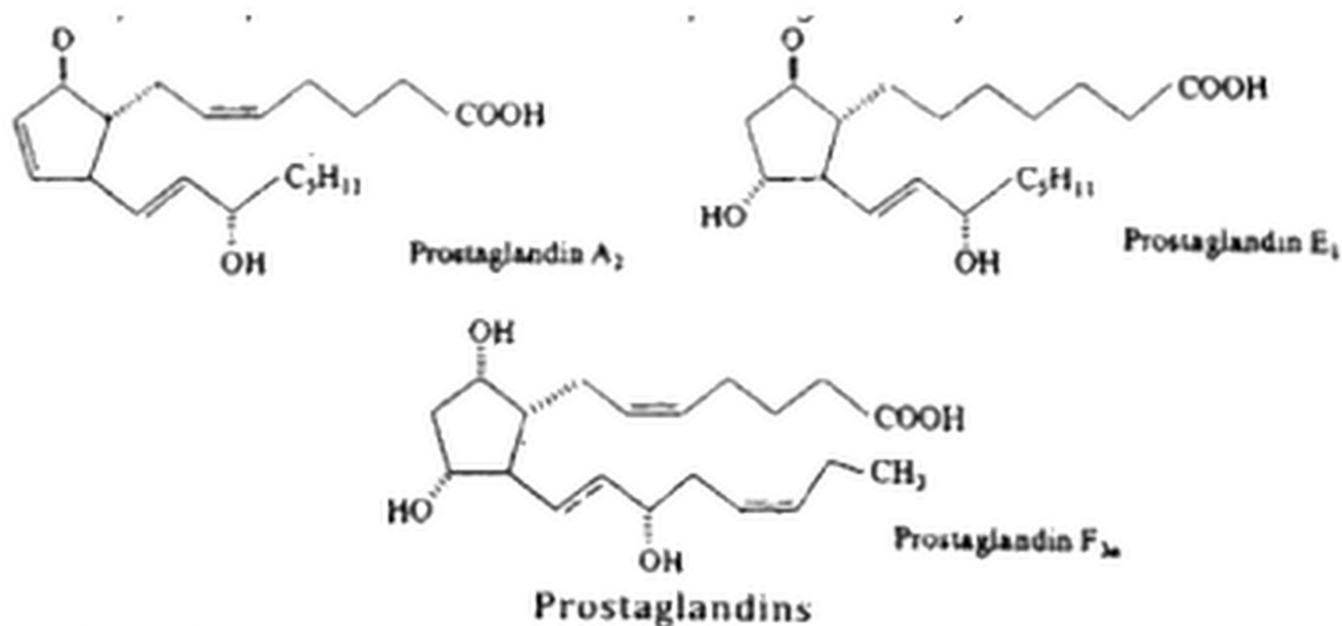


(b) Prostaglandins:

Prostaglandins exist in virtually every mammalian tissue, acting as local hormones. Prostaglandins are derived from arachidonic acid (a tetra unsaturated 20C fatty acid).

Role of Prostaglandins in Living Organisms:

Their functions vary widely depending on the tissue. Some reduce blood pressure, whereas others raise it. In the immune system, various prostaglandins help to induce fever and Inflammation and also intensify the sensation of pain. They also help to regulate the aggregation of platelets an early step in the formation of blood clots. Those synthesized in the temperature-regulating center of the hypothalamus cause fever In fact the ability of aspirin to reduce fever and decrease pain depends on the inhibition of prostaglandin synthesis.



59. Describe the molecular level structure of nucleotides.

Ans: Chemical Structure of Nucleic Acids:

Now it has been cleared that nucleic acids are of two types i.e. deoxyribo nucleic acid (DNA) and ribo nucleic acid (RNA). Both nucleic acids are linear un- branched polymers. The monomers of the nucleic acid are called nucleotides.

Composition of a nucleotide:

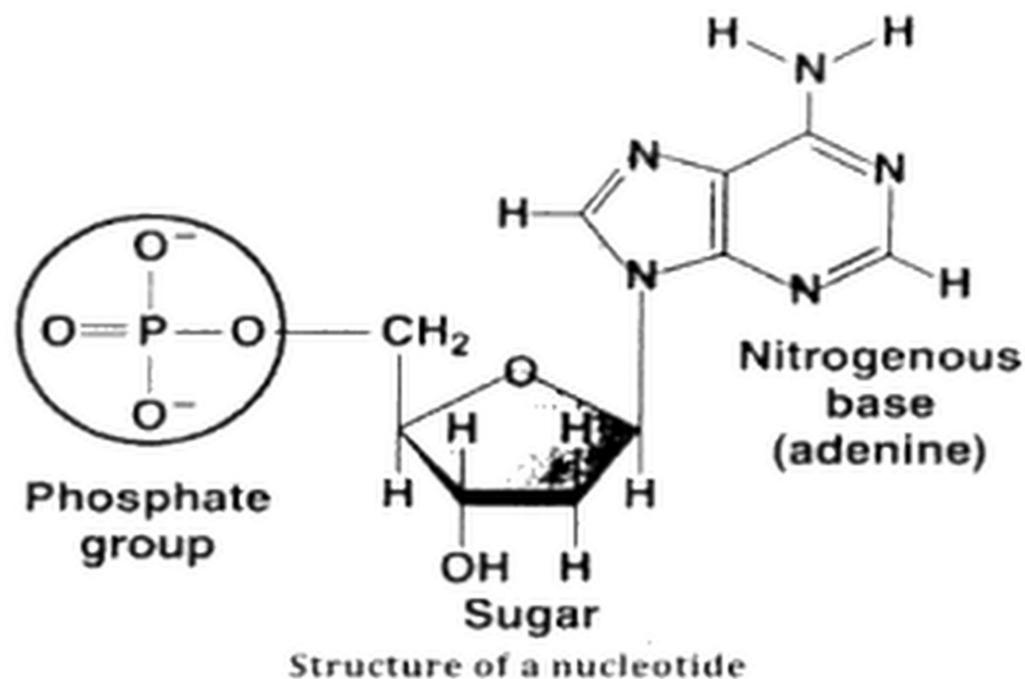
Nucleotides of DNA are called deoxyribonucleotides and Of RNA are known as ribonucleotides. Each nucleotide consists of pentose sugar, a phosphate and a nitrogen containing ring structure called base.

Pentose sugar:

The pentose sugar in deoxyribonucleotides is deoxyribose and in ribonucleotides is ribose.

Phosphoric acid:

Phosphoric acid is a common component of both nucleotides which provides acidic properties to DNA and RNA.



Nitrogenous bases:

The nitrogen containing ring structures are called bases because of unshared pair of electrons on nitrogen atoms, which can thus acquire a proton.

Classes of Nitrogenous Bases:

There are two major classes of nitrogenous bases i.e., single ring pyrimidine and double ring purines.

i. Pyrimidine bases:

Pyrimidine bases are-or three types i.e., cytosine (C), thymine (T) and uracil (U) Thymine is only found in DNA while the uracil is only found in RNA.

ii. Purine bases:

On the other hand, the purine bases are also of two types i.e., adenine (A) and guanine (G).

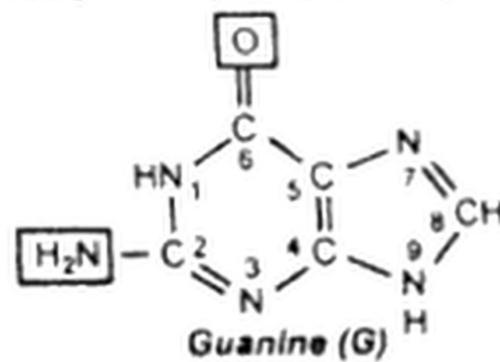
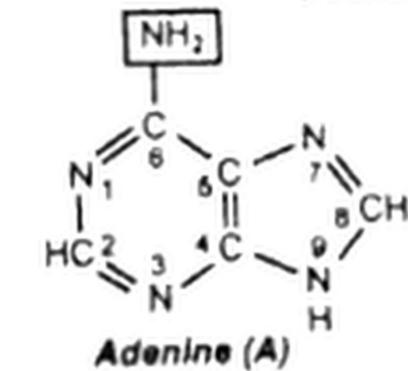
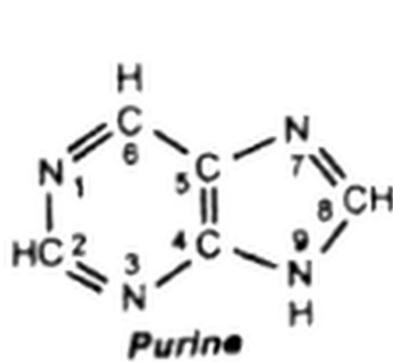
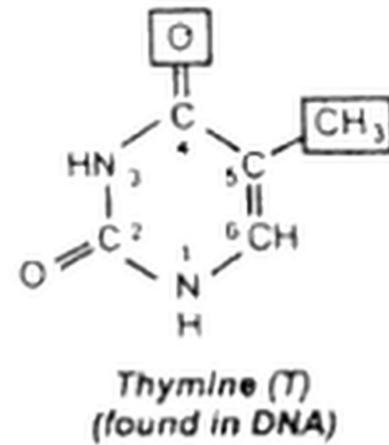
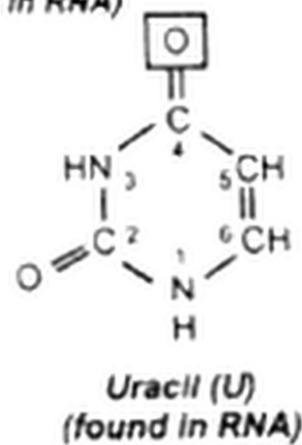
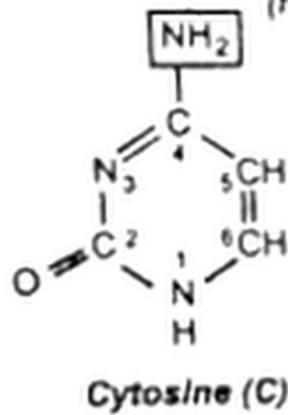
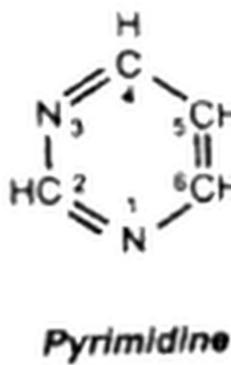
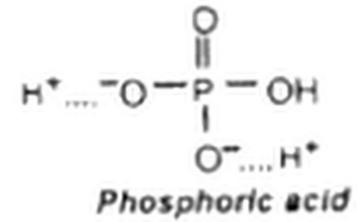
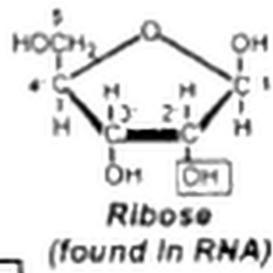
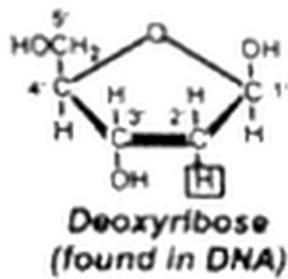
During the formation of a nucleotide, first nitrogenous base is linked with 1' carbon of pentose sugar. Such combination is called nucleoside. When a phosphoric acid is linked with 5' carbon of pentose sugar of a nucleoside, the nucleotide formed A nucleotide with one phosphoric acid is called nucleoside monophosphate with two phosphoric acids called nucleoside diphosphate and with three phosphoric acids called nucleoside triphosphate.

The nucleotides which take part in the formation of DNA or RNA must contain three phosphates but during their Incorporation into DNA or RNA polymer each nucleotide losses. Its two terminal phosphates Different terms used for nucleosides and nucleotides are given in the table.

Different types of nucleosides and nucleotides Of RNA and DNA:

Nitrogenous base	RNA	DNA

	Ribonucleotides (Ribose + Base)	Ribonucleotides (Ribose + Base+phosphate)	Deoxyribonucleosides (Deoxyribose + Base)	Deoxyribonucleosides (Deoxyribose + Base+phosphate)
Adenine	adenosine	AMP, ADP, ATP	d-Adenosine	dAMP, dADP, dATP
Guanine	Guanosine	GMP, GDP, GTP	d-Guanosine	dGMP, dGDP, dGTP
Cytosine	Cytidine	CMP, CDP, CTP	d-Cytidine	dCMP, dCDP, dCTP
Uracil/Thymine	Uridine	UMP, UDP, UTP	d-Thymidine	dTMP, dTDP, dTTP

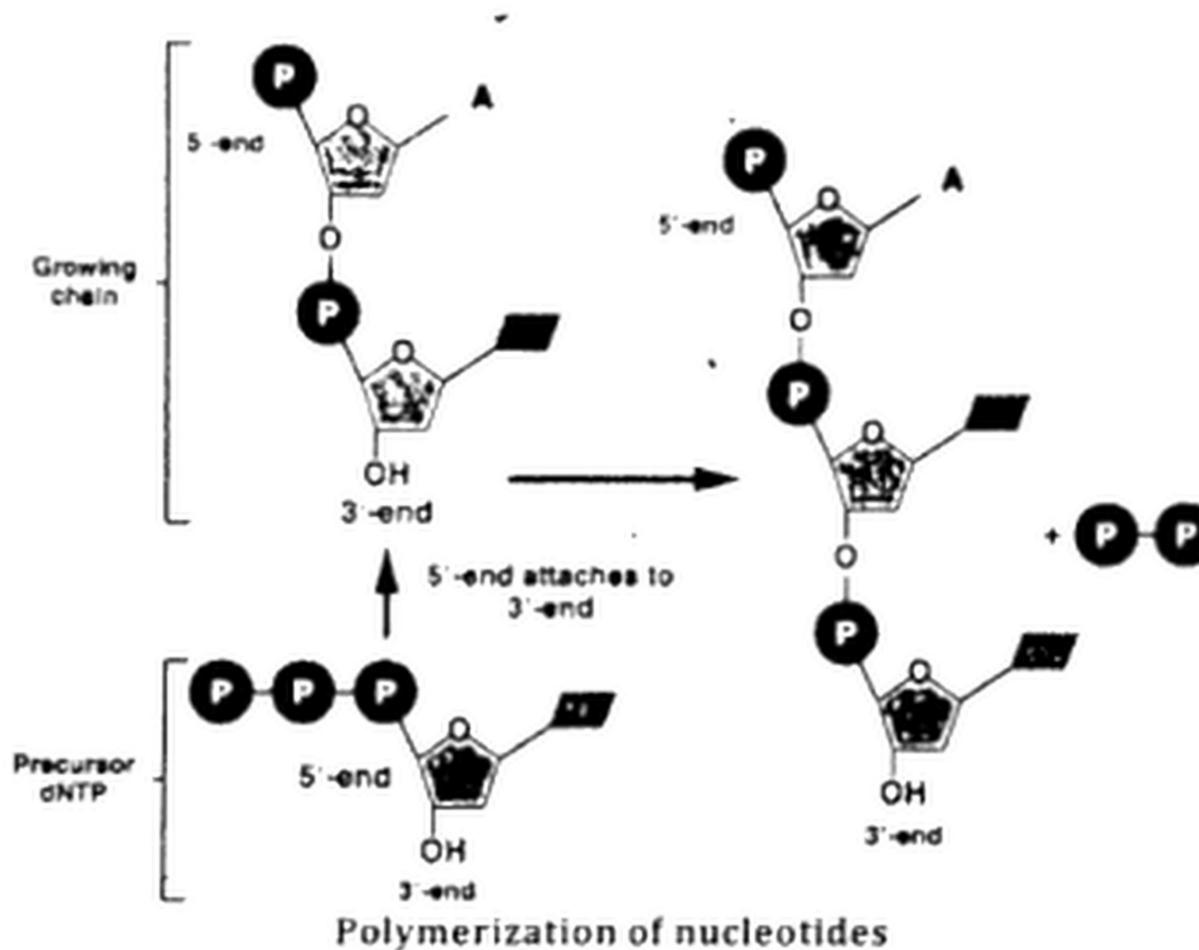


Components of nucleotides

Polymerization of nucleotides (Formation of polynucleotide):

Nucleotides are also joined together by a condensation reaction like other biomolecules. Unlike proteins, carbohydrates, and lipids. However, the molecule that is released is not water but pyrophosphate (two phosphate groups bound together). When pyrophosphate is cleaved by the addition of water, a great deal of free energy is released which drives the process. In this way nucleotides begin to link by phosphodiester bonds and a polymer of nucleotides (polynucleotide) is formed. Polynucleotides have a free 5' phosphate group at one end and a free 3' hydroxyl group at the other end. By convention, these sequences are named from 5' to 3'.

Nucleotide Polymerization Reaction



60. Distinguish among the nitrogenous bases found in the nucleotides of nucleic acids.

Ans: Nitrogenous bases:

The nitrogen containing ring structures are called bases because of unshared pair of electrons on nitrogen atoms, which can thus acquire a proton.

Classes of Nitrogenous Bases:

There are two major classes of nitrogenous bases i.e., single ring pyrimidine and double ring purines.

i. Pyrimidine bases:

Pyrimidine bases are of three types i.e., cytosine (C), thymine (T) and uracil (U). Thymine is only found in DNA while the uracil is only found in RNA.

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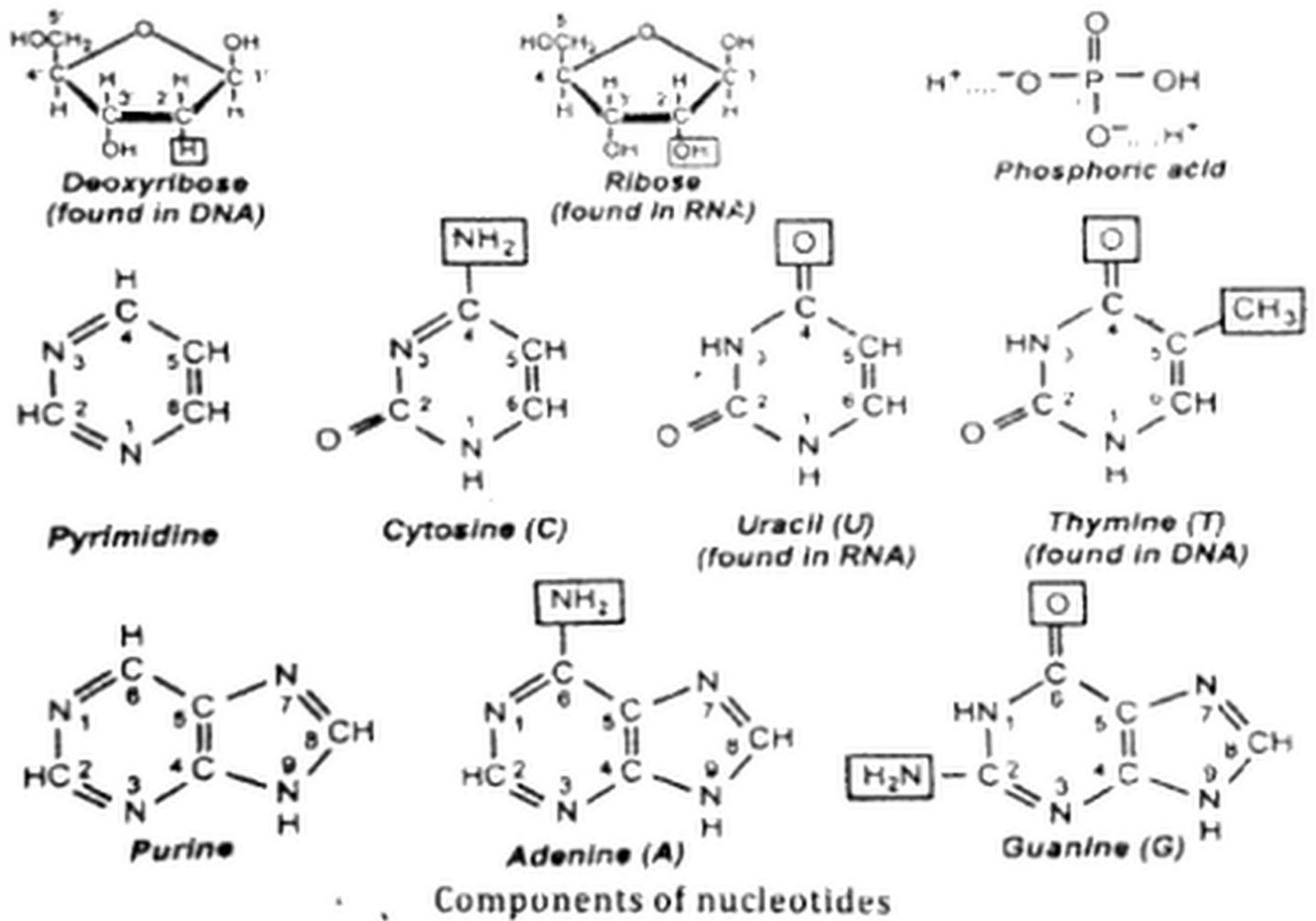
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The nucleotides which take part in the formation of DNA or RNA must contain three phosphates but during their incorporation into DNA or RNA polymer each nucleotide loses its two terminal phosphates. Different terms used for nucleosides and nucleotides are given in the table.

Different types of nucleosides and nucleotides Of RNA and DNA:

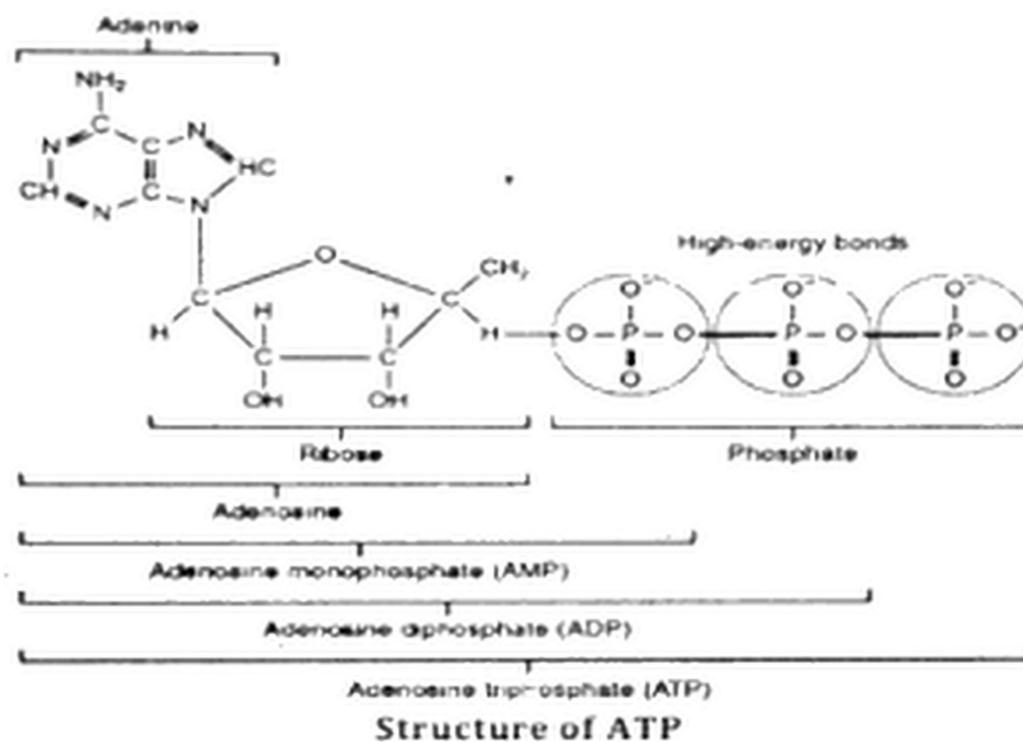
Nitrogenous base	RNA	DNA

	Ribonucleotides (Ribose + Base)	Ribonucleotides (Ribose + Base+phosphate)	Deoxyribonucleosides (Deoxyribose + Base)	Deoxyribonucleosides (Deoxyribose + Base+phosphate)
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Guanine	Guanosine	GMP, GDP, GTP	d-Guanosine	dGMP, dGDP, dGTP
Cytosine	Cytidine	CMP, CDP, CTP	d-Cytidine	dCMP, dCDP, dCTP
Uracil/Thymine	Uridine	UMP, UDP, UTP	d-Thymidine	dTMP, dTDP, dTTP



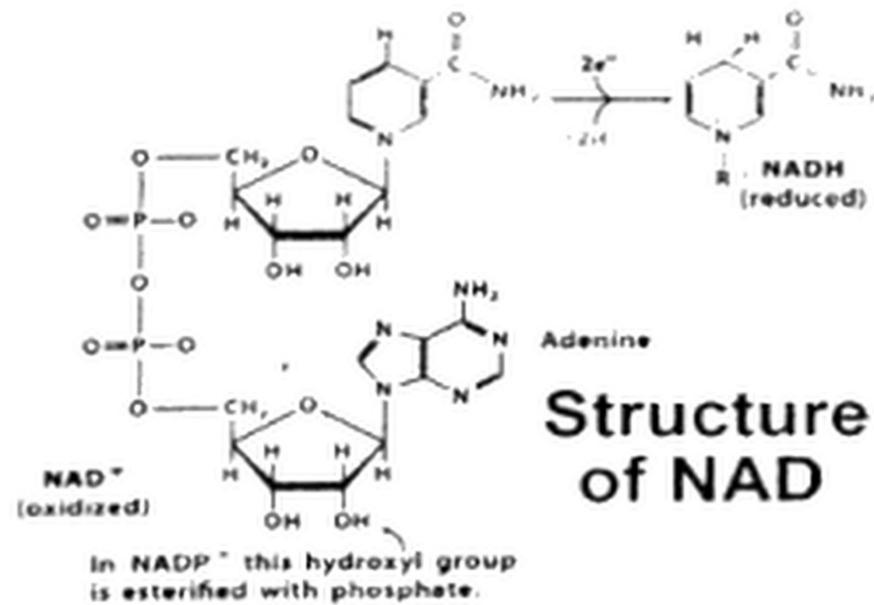
61. Describe the structure of a mononucleotide (ATP) and a dinucleotide (NAD). Ans: Mononucleotide (ATP):

Adenosine triphosphate (ATP) is a mononucleotide ATP has three parts connected by covalent bonds. (a) adenine, a nitrogen base, (b) ribose, a five-carbon sugar, (c) three phosphates. The two covalent bonds linking the three phosphates together are called high-energy bonds ATP can be converted to ADP and Inorganic phosphate (iP) by hydrolysis ATP is known as the energy currency of cells. ATP is made from the oxidation of organic molecules during respiration. Since the energy to add the phosphate to ADP comes from oxidation, the process is known as oxidative phosphorylation. Most of the ATP in the cell is made in mitochondria.



Chemical Nature and Role of NAD:

Nicotinamide adenine dinucleotide (NAD) consists of two nucleotides. One nucleotide consists of base-nicotinamide, sugar and phosphate. Other nucleotide consists of base-adenine-sugar and phosphate. The two nucleotides are joined by their phosphate group forming a dinucleotide NAD is a coenzyme. It works with dehydrogenases as oxidizing agent. Its reduced form is $\text{NADH} + \text{H}^+$ (NADH_2).



62. Explain the formation of phosphodiester bond.

Ans: Phosphodiester Bond:

A phosphodiester bond occurs when exactly two of the hydroxyl groups in phosphoric acid react with hydroxyl groups on other molecules to form two ester bonds.

Example:

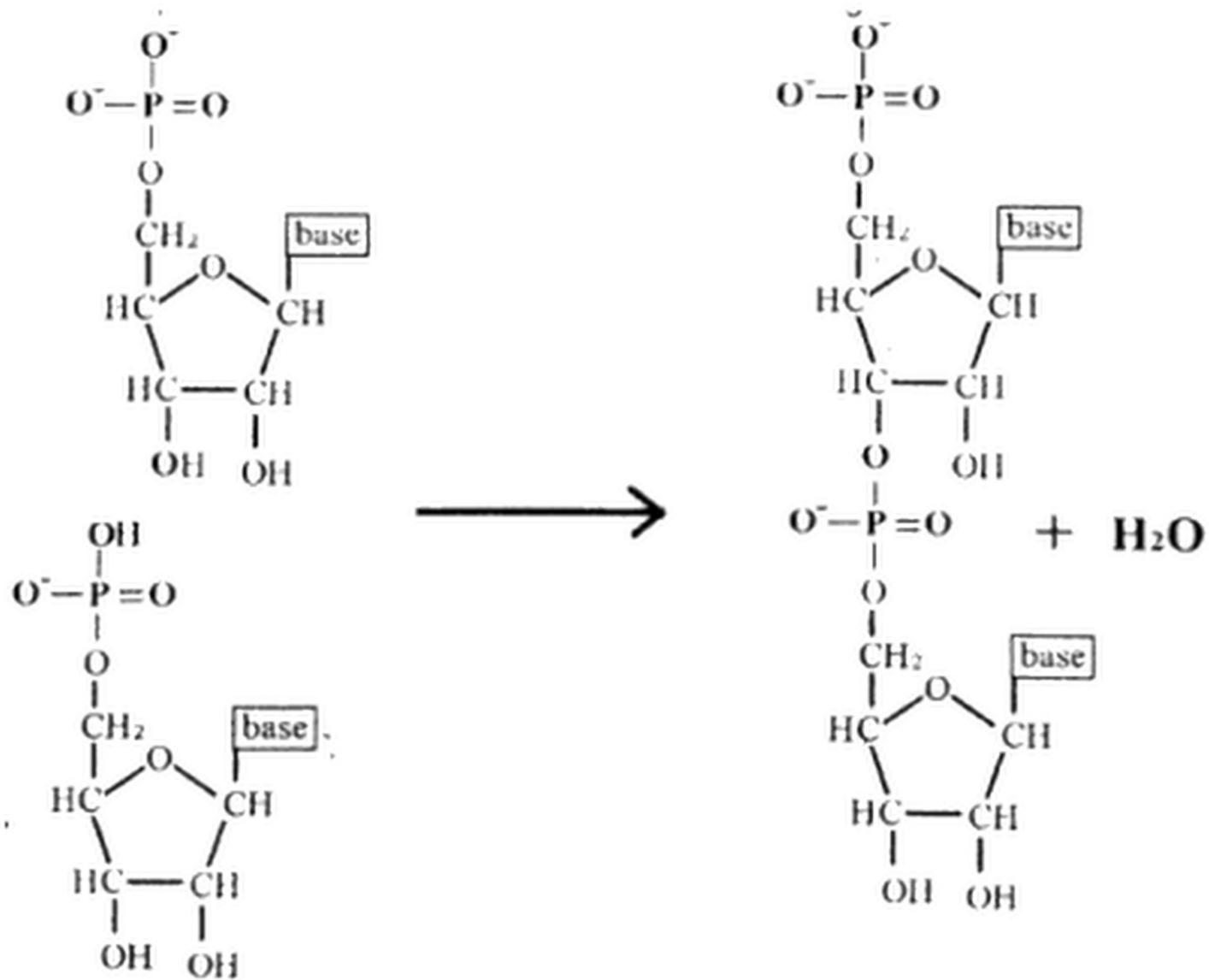
An example is found in the linking of two pentose (5 carbon sugar) rings to a phosphate group by strong, covalent ester bonds. Each ester bond is formed by a condensation reaction in which water is lost. This bond is a key structural feature of the backbone of DNA and RNA and links the 3' carbon of one nucleotide to the 5' carbon of another to produce the strands of DNA and RNA.

Formation of Phosphodiester Bond:

In phosphodiester formation two hydroxyl (OH) groups on the phosphate molecule bind to the 3' and 5' carbons on two independent pentose sugars. These are two condensation reactions, so two molecules of water are produced. The phosphate is then bonded to the sugars by two ester

bonds, hence the nomenclature of phosphodiester bond. This reaction is catalyzed by ligases, such as DNA ligase during DNA replication.

A representation of the reaction is shown in the diagram below.



63. Explain the double helical structure of DNA as proposed by Watson and Crick.

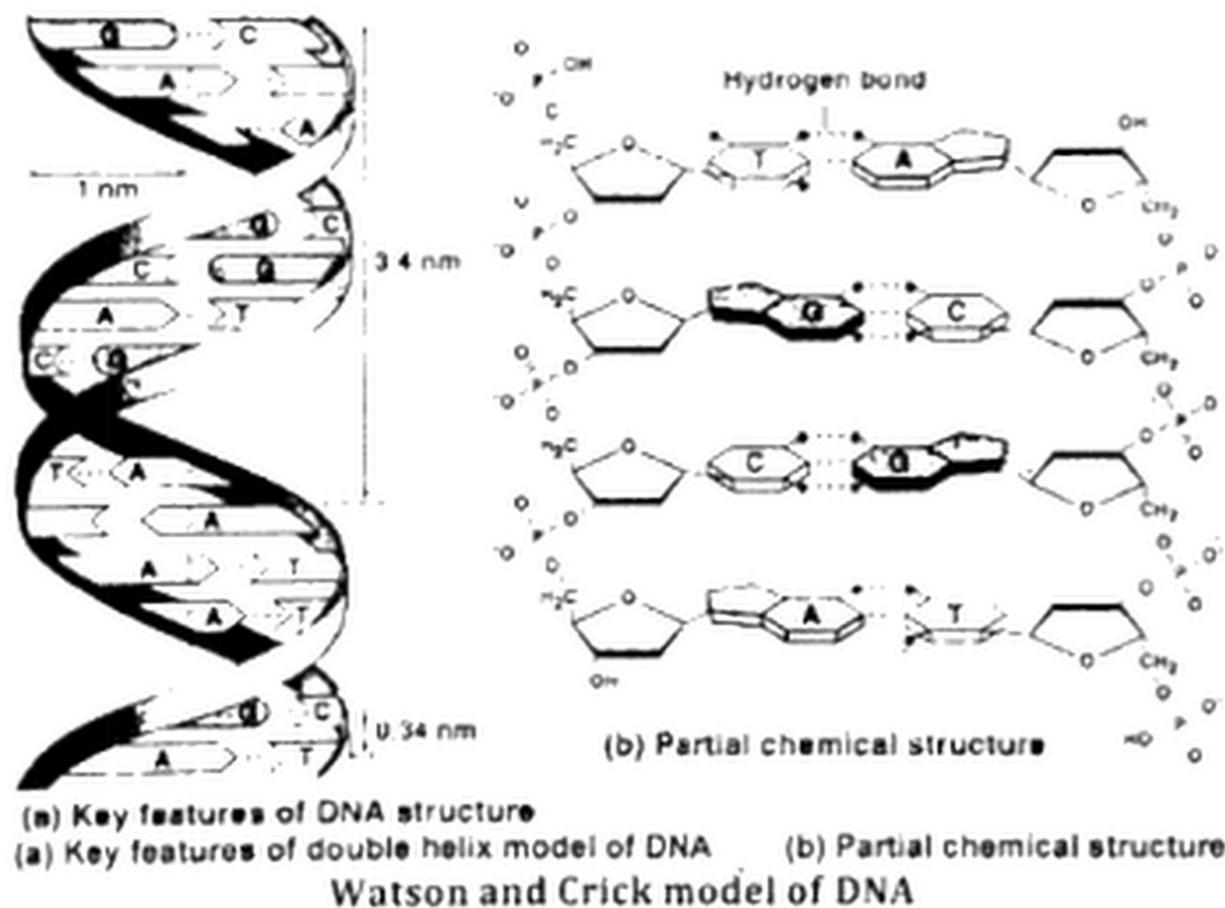
Ans: Watson and Crick Model of DNA:

In 1951, Erwin Chargaff found that the nitrogenous bases in a DNA show specific ratios. He observed that the amount of adenine is always equal to the amount of thymine and the amount of guanine is always equal to the amount of cytosine in DNA. This implies that the total purines and total pyrimidines are in a 1:1 ratio in any DNA. This conclusion is known as Chargaff's rule. In those days, the X-ray diffraction analysis of DNA by Maurice Wilkins and Rosalind Franklin was

published, They first time claimed that DNA is a duplex (double helix) molecule. The width of duplex is 2nm while the length of each turn is 3.4nm. In 1953, on the basis of these observations a graduate student Francis Crick and a research fellow James Watson of Cambridge University proposed a physical model of DNA which is now called Watson and Crick Model of DNA.

According to this model,

- i. A DNA is made up of two polynucleotide chains which are attached together by base pairs.
- ii. In order to make base pairing the two polynucleotide chains are opposite in direction i.e., one chain runs from 5' to 3' downward and the other chain runs from 5' to 3' upward. Both chains show a constant width of 2 nm- Therefore, both chains are supposed to be antiparallel to each other.



- iii. The base pairing is very specific i.e., Adenine makes the pair with Thymine and Guanine with Cytosine. The base pairs are held together by the hydrogen bond.

- iv. There are three hydrogen bonds between Guanine and Cytosine and two hydrogen bonds between Adenine and Thymine. Therefore, the group of A:T and C:G is equal but the ratio of AT:CG is different.
- v. Each turn of the duplex consists of 10 base pairs. Both polynucleotide chains are complementary to each other. There is no restriction of the sequence of nucleotides along the length of a DNA strand. The sequence can vary in countless ways. The sequence is specific for different species, organisms and even individuals.

64. What is a gene? How does a gene code for the formation of a polypeptide?

Ans: Concept of Gene:

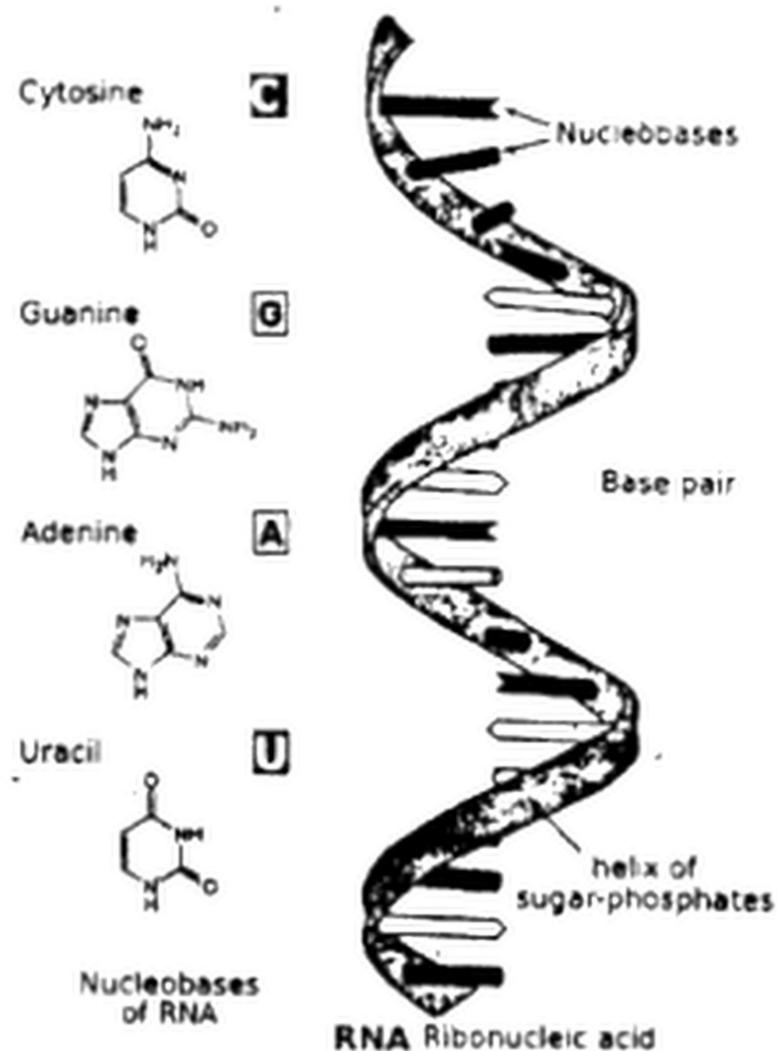
A gene is a region of DNA which is made up of nucleotides. It is the physical and functional unit of heredity. Each gene contains the information required to build specific proteins needed in an organism, such as they contain the instructions for our individual characteristics — like eye and hair color. In order to make proteins, the gene from the DNA is copied into messenger RNA. The mRNA moves out of the nucleus and uses ribosomes to form the polypeptide that finally folds and configures to form the protein. Genes possess the data to build and maintain cells and pass genetic information to offspring.

65. Explain the general structure of RNA.

Ans: Ribonucleic Acid (RNA):

RNA is also a polymer of nucleotides. Its detailed chemical nature has already been discussed in previous topics. Unlike DNA, the RNA is generally single stranded and does not form a double helix like DNA. However, some RNA shows a secondary double stranded structure in their complementary

regions. There are three major classes of RNA each with a special function in protein synthesis. This RNA is transcribed from DNA template.



66. Explain the structure and role of three types of RNA.

Ans: Ribonucleic Acid (RNA):

RNA is also a polymer of nucleotides its detailed chemical nature has already been discussed in previous topics Unlike DNA, the RNA is generally single stranded and does not form a double helix like DNA However, some RNA shows a secondary double stranded structure in their complementary regions.

Types of RNA:

There are three major classes of RNA each with a special function in protein synthesis. These RNA are transcribed from DNA template.

- i. Messenger RNA (mRNA)

ii. Ribosomal RNA (rRNA)

iii. Transfer RNA (tRNA)

i. **Messenger RNA (mRNA):**

mRNA consists of a single strand of variable length. Its length depends upon the size of the gene as well as the protein for which it is taking message for example, for a protein molecule consisting of 100 amino acids, the mRNA will have the length of 300 nucleotides.

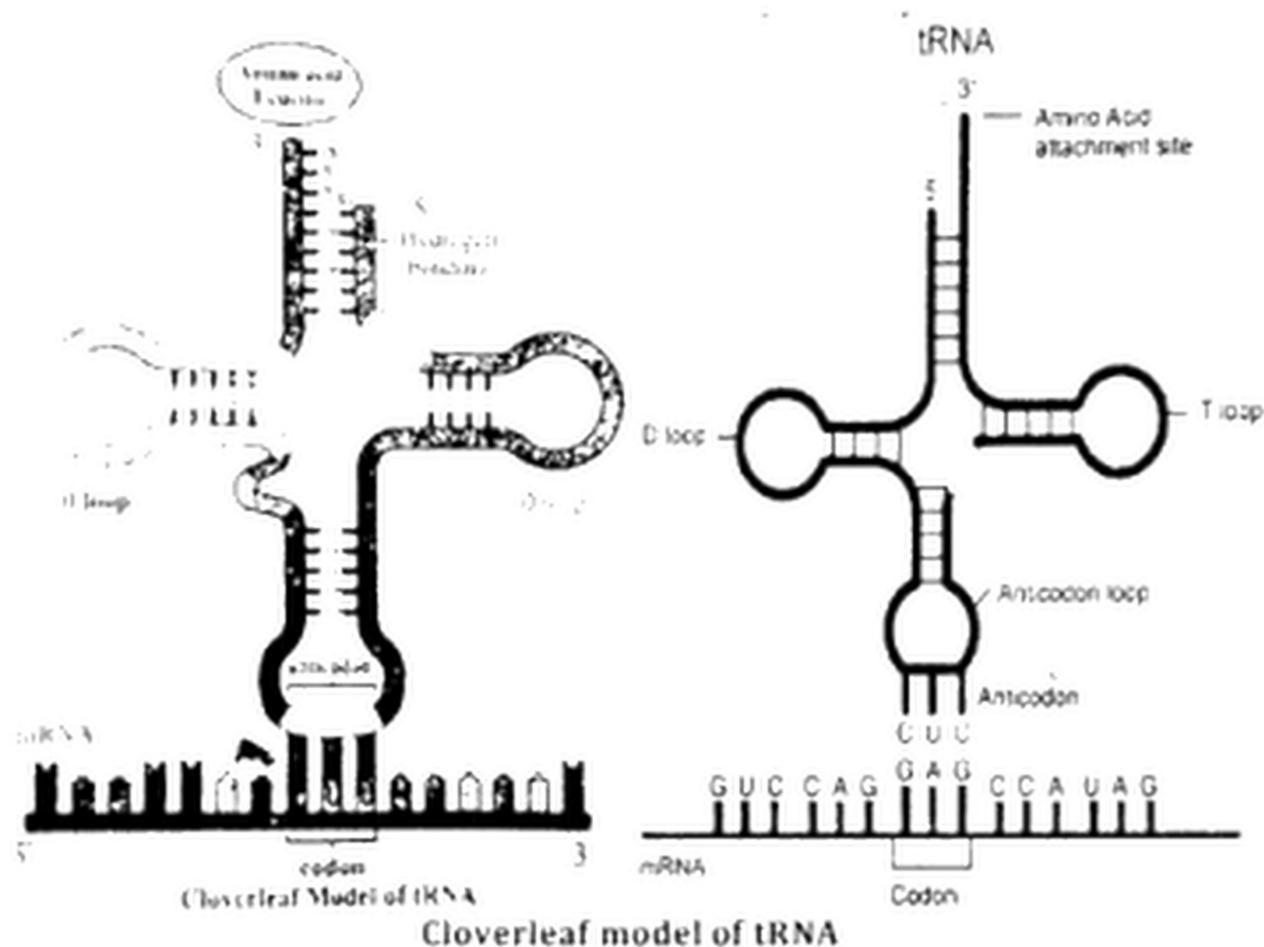
Actually every three nucleotides in mRNA encode a specific amino acid, such triplets of nucleotides along the length of mRNA are called codons of genetic codes mRNA is about 3 to 4% of the total RNA in the cell mRNA takes the genetic message from the nucleus to the ribosome in the cytoplasm to form particular protein It is transcribed from DNA template i.e., the base of sequence of mRNA is according to the base sequence of DNA It becomes attached to the ribosome. At ribosome, amino acids are attached one by one to form a polypeptide chain as per base sequence of mRNA. This process is known as translation.

ii. **Ribosomal RNA (rRNA):**

Ribosome consists of rRNA and protein. rRNA is transcribed by the genes present on the DNA of the several chromosomes. It is called rRNA because it eventually becomes part of ribosome. The rRNA is packaged with a variety of proteins into ribosomal subunits. The base sequence of rRNA is similar from bacteria to higher plants and animals. rRNA have largest size among the RNA. Approximately, 80% of total RNA contents of a cell are rRNA. It is a part of ribosome where protein synthesis takes place in other words rRNA provides a platform for protein synthesis.

iii. **Transfer RNA (tRNA):**

It is the smallest of the RNA molecules that. It consists of 75 to 90 nucleotides. A tRNA is a single stranded molecule but it shows a duplex appearance at its some regions where complementary bases are bonded to one another. It shows a flat cloverleaf shape in two dimensional views. Its 5' end always terminates in Guanine base while the 3' end always is the base sequence of ACC. Amino acid is attached to tRNA at this end. The nucleotide sequence of the rest of the molecule is variable, tRNA has three loops, The middle loop in all the tRNA is composed of 7 bases, the middle three of which form the anticodon, it is complementary to specific codon of mRNA. For example, a tRNA that has anticodon GAA binds to the codon CUU and carries amino acid Leucine. The D loop recognizes the activation enzyme Theta (θ) loop recognizes the specific place on the ribosome for binding during protein synthesis. There is at least one tRNA molecule for each of the 20 amino acids found in proteins. Sixty tRNA have been identified. However, human cells contain about 45 different kinds of tRNA molecules each transports a specific amino acid from cytoplasm to the surface of ribosome for protein synthesis.



67. Describe the roles of the following conjugated molecules:

(a) glycolipids (b) glycoproteins

(c) lipoproteins (d) nucleoproteins

Ans: (a) glycolipids:

Glycolipids are complex lipids containing one or more simple sugars in connection with long fatty acids or alcohol the carbohydrates form the polar head to the molecule Glycolipids are present in white matter of brain and myelin sheath of nerve fibers and chloroplast membrane.

(b) Glycoproteins:

Glycoproteins are formed when proteins are covalently attached to carbohydrates. Glycoproteins are widely distributed in the cells. They function as hormones, transport proteins, structured proteins and receptors. The blood group antigens contain glycoproteins, which also play an important role in blood grouping.

(c) lipoproteins:

Lipoproteins are formed by the combination of protein with phospholipids. Phospholipid protein complexes are widely distributed in plant and animal material. They occur in milk, blood, cell nucleus, egg yolk membrane and chloroplasts of plants.

(d) nucleoproteins:

Nucleoproteins consist of simple basic protein and nucleic acid. They are found in chromosomes and ribosomes.

