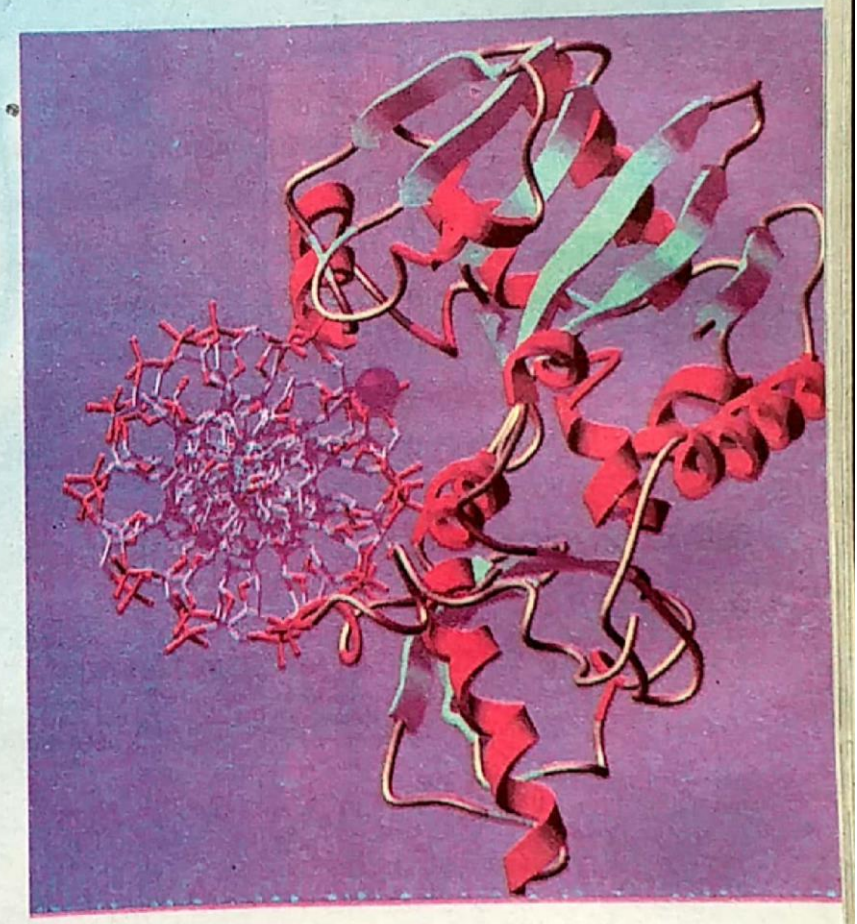
Chapter

13

Biochemistry

In this chapter you will be able to:

- Distinguish between mono-, di- and trisaccharides.
- Describe the bonding in a protein molecule.
- Explain the sources and uses of carbohydrates, proteins and lipids.
- Differentiate between fats and oil.
- Describe the importance of nucleic acids.
- Define and explain vitamins and their importance.



Introduction

The bodies of living organism are made up of chemical elements. The most common elements in the bodies of living organisms are carbon, hydrogen, nitrogen, oxygen, phosphorous and sulphur. The chemical analysis of protoplasm shows that it is composed of two types of compounds, i.e. organic compounds and inorganic compounds. These compounds are present in somewhat different proportions in different organisms and even in different types of cells of the same organism. Organic compounds consists of carbohydrates, proteins, lipids or fats, and nucleic acids. These are also called biological molecules.

13.1 Carbohydrates

The name carbohydrate (hydrates of carbon) is derived from the fact that the first compound of this group which was studied had a general formula of $C_n(H_2O)_n$, here "n" will take a value of either 3 or greater than 3.

They are commonly known as "Sugars" and can be defined as polyhydroxy derivatives of "aldehydes and ketones".

Thus these are poly functional (Alcohol + Aldehyde or ketone) organic compounds containing mainly carbon, hydrogen and oxygen, some times along with nitrogen (chitin) and sulphur (keratin sulfates).

Main function of carbohydrates is to support plant structure (cellulose) and to store chemical energy in the form of glycogen and starch.

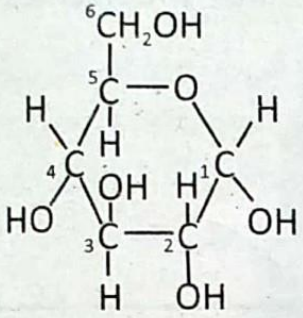
13.1.1 Classification of Carbohydrates:

Carbohydrates are classified into the following three categories.

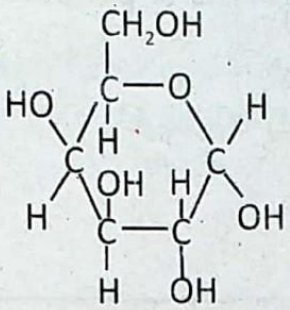
13.1.1.1 Monosaccharides:

These are simplest sugars /carbohydrates which can not be hydrolysed further. They are colourless, water soluble organic compounds, having sweet taste and general formula $C_n(H_2O)_n$ where $n = 3, 4, 5$ and so on.

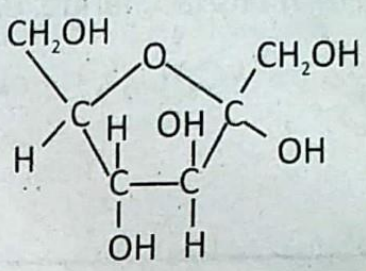
Monosaccharide are either aldoses e.g glucose having aldehydic functional group or ketoses (having ketonic functional group) e.g fructose. These may be trioses $(C_3H_6O_3)$, tetroses $(C_4H_8O_4)$, pentoses $(C_5H_{10}O_5)$, Hexoses $(C_6H_{12}O_6)$ etc



Glucose



Galactose



Fructose

13.1.1.2 Oligosaccharides:

Oligosaccharides are formed when two to nine monosaccharide units combine with each other by the loss of water molecules, resulting in the formation of glycosidic linkage.

Conversely hydrolysis of an oligosaccharide in water in the presence of an acid or enzyme yields two to nine monosaccharide units.

Those oligosaccharides which consist of two monosaccharide units are called as disaccharides e.g.

Disaccharides	**Monosaccharides**
Maltose	⟶ Glucose + Glucose
Lactose	⟶ Glucose + Galactose.
Sucrose	⟶ Glucose + Fructose

Those oligosaccharides containing three monosaccharide units are known as trisaccharides e.g. Raffinose $(C_{18}H_{32}O_{16})$ etc.

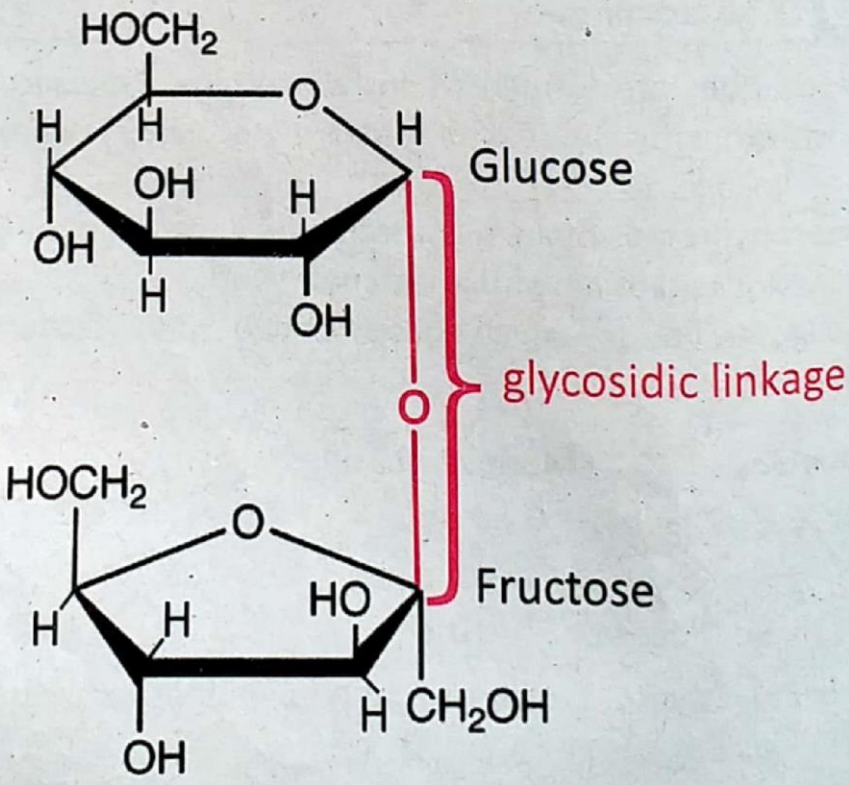
In general monosaccharides and disaccharides are crystalline solids, soluble in water, sweet in taste and are collectively known as "Sugars".

13.1.1.3 Polysaccharides:

Polysaccharides are biopolymers of monosaccharides. They have high molecular mass and consists of 100 or more monosaccharide units joined together, through glycosidic linkages. Hydrolysis of polysaccharides gives many molecules of monosaccharide. e.g.

$$\underset{\text{Starch}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow{H^+} \left(\underset{\text{Glucose}}{nC_6H_{12}O_6} \right)$$

A glycosidic linkage or glycosidic bond, is the two-bond link between the rings in an oligosaccharide or polysaccharide.



Examples:
Starch, dextrine, Glycogen and cellulose etc.
Polysaccharides are amorphous solids, insoluble in water, tastless and are called **"non sugars".**

Polysaccharides perform two main functions in animals and plants i.e. They are used as a energy storage and structural Units of cell e.g. glycogen (animal) and starch (plant).

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Dextrose drips are administered to the dehydrated and weak patients in clinics and hospitals. In this process oxidation of dextrose takes place in the blood and are converted into water and carbon dioxide with release of energy. That is why, it is not only the instant source of energy but also compensate the loss of water during dehydration.

13.1.2 Sources and uses of Carbohydrates:

Sources: Main sources of carbohydrates are:

- Sugarcane
- Sugarbeet
- Pineapple
- Apricot
- Mango
- Honey
- Wheat
- Rice
- Maize
- Potatoes etc.

Uses of Carbohydrates:
The following are various uses of carbohydrates.

1) Textile Industry: Carbohydrates like cotton are used in Manufacturing of cloths.

2) **Paper Industry:** Cellulose is the basic component of paper.

3) **Medical Uses:** Cardiac glycosides are used to normalize heartbeat. Constipation and diarrhea are mainly controlled by the use of carbohydrate fibres. Carbohydrates also act as a chief source of energy and structural components in living organisms.

Do you know!

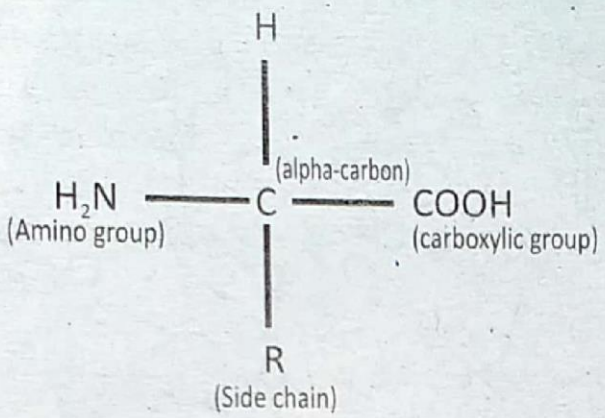
All the carbohydrates are of plant origin except lactose which is of animal origin. Sugars (mono and oligosaccharides) are soluble in water at normal conditions and give a solution but polysaccharides e.g starch are not soluble at normal conditions. Their solubility increases with heating but yet they do not give true solutions.

13.2 Proteins

The name protein is derived from Greek word "Proteios" meaning "of prime importance". Proteins are biopolymers of amino acids.

They are complex nitrogenous compounds present in living cells of plants and animals which are essential for growth and maintenance of life. Elements like carbon, nitrogen, oxygen, hydrogen and sulphur are present in proteins. Amino acids are the building blocks of proteins. All of amino acids are joined together by "peptide –linkage" in protein polymers.
Thus proteins are polyamides formed by condensation of Alpha –amino acids with a molecular weight greater than 10,000 .

Examples: Globulin , Keratin , Albumin etc.



Proteins, carbohydrates and lipids are the three important components of food stuff collectively called "Triumvirates".

13.2.1 Bonding in Protein Molecules (Amino acid as building block of protein):

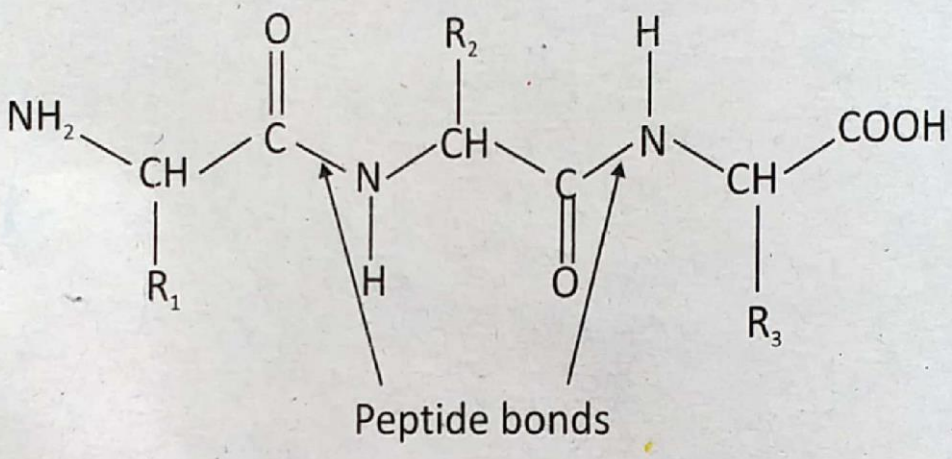
In protein molecules three types of bondings may occur i.e.

i. Peptide Bondings
ii. Hydrogen Bondings
iii. Disulfide Bridges.

Protein molecules are formed due to amino acid condensation (with the removal of water molecule) giving a linear sequence of a protein polymer.

Proteins are fundamental in both the structure and function of living materials. All proteins contain four essential elements: carbon, hydrogen, oxygen and nitrogen. Most proteins also contain some sulphur. These elements are bonded together to form compounds called amino acids, which contain the COOH (carboxyl) group and amino group (NH_2). Both the COOH and the NH_2 groups are attached to the same carbon atom (alpha) carbon. Finally, each amino acid has a

side chain designated as R (alkyl group). The various alpha amino acids differ in their side chains or R groups. R may be very simple, as in glycine, where it is only a hydrogen atom, or it may be very complex, as in tryptophan, where it includes two ring structures. Twenty different amino acids are commonly found in proteins.



Disulfide bridges are found only in sulfur containing protein molecules.
Due to the presence of Hydrogen bonding and sulphide bridges protein molecules get folded and refolded to give secondary, tertiary and quarternary structures.
Protein molecules may be fibrous e.g. keratin in skin & nails and globular e.g. haemoglobin and antibodies etc.

13.2.2 Sources of Proteins:

Plants and animals are the major sources of proteins e.g.
Eggs, pulses, meat, beans are the chief sources of proteins like albumins, Globulins, legumine and collagens etc.

13.2.3 Uses / Functions of Proteins:

The following are various uses of proteins e.g.

1) **Body Structures** like skin, nail, hair, hoofs, horns and feathers are composed of proteins.

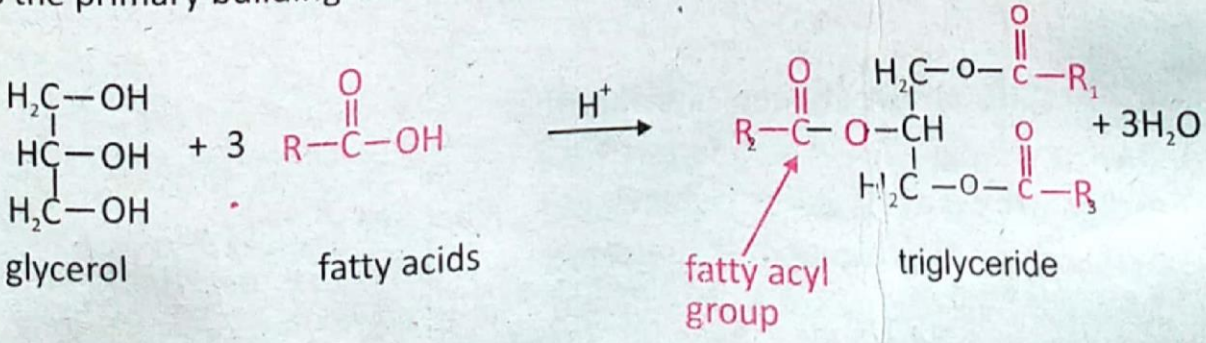
2) **As oxygen Carrier:** Haemoglobin which is a blood protein is a main carrier of oxygen to all parts of the body.
3) **As Body Regulators:** Hormones and enzymes are protienaceous in nature which are chemical regulators in the body.
4) **Commercial uses of Enzymes:** Enzymes are proteins with catalytic function. It turns the starch into sugar which is less expensive than cane sugar . It also helps in improving the quality of products such as textile, detergents, foods, and beverages. Vinegar, cheese is also produced due to utilization of enzymes in bacteria and yeast.
5) **Body Defence System:** Antibodies which increase the body immune power are also of protein nature.

Activity 1

(1) Take an egg.
(2) Boil it in water and see what happens.
(3) Compare and record the observation about the denaturing of protein.

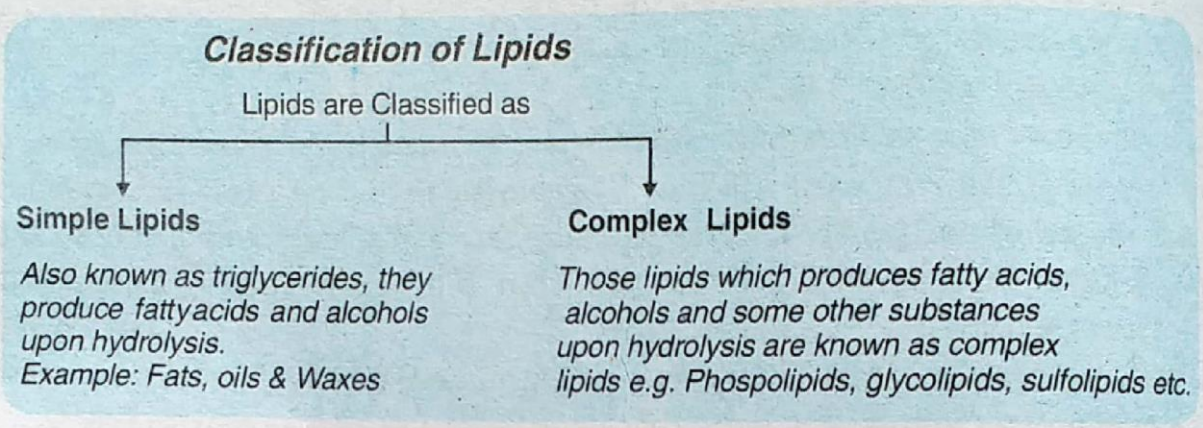
13.3 Lipids

The term lipid is derived from Greek word "lipose" which means "fat". These are naturally occurring organic compounds of animal and plant origin which are insoluble in water but soluble in organic solvents like ether, chloroform, alcohol etc and belong to a very heterogeneous group of substances.
Generally "lipids are esters of long chain fatty acids and alcohols.
Thus the primary building block of lipids, are fatty acids and alcohols (glycerol).



Fats and oils are the most important lipids found in nature.

13.3.1 Classification of Lipids:



13.3.2 Sources of Lipids:

Lipids (fats & oils) comes from a variety of natural sources like animals, plants and marine organisms. Animal fats are located particularly in adipose tissue. Butter & ghee are special type of animal fats which are obtained from milk. Vegetable oils are chiefly present in seeds and nuts of plants. Marine oils are obtained from sea animals like salmon and whales.

13.3.3 Uses of lipids:

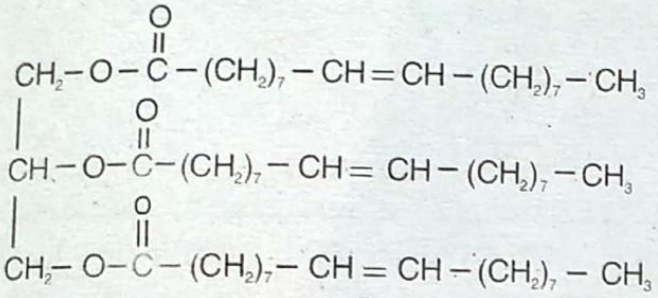
The following are various uses of lipids:

- They are good source of energy and make the food more palatable.
- They exert an insulating effect on the nervous system.
- They are good energy reservoirs in the body.
- Lipids are an integral part of cell protoplasm and plasma membrane.
- Some lipids act as precursors of very important physiological compounds. For example cholesterol is the precursor of steroid hormones.

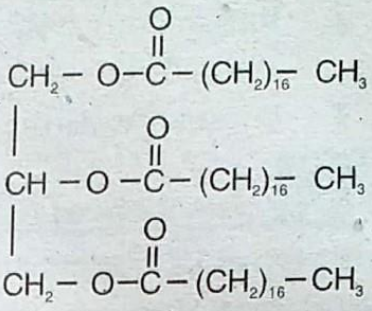
13.3.4 Difference between Fats and Oils

Animal and vegetable fats and oils have similar chemical structures. They are triesters formed from glycerol and long chain organic acids called fatty acids. The degree of unsaturation of the constituent fatty acids determine whether a triglyceride will be a solid or a liquid. Those glycerides in which long chain saturated fatty acid components predominate tend to be solid or semisolid and

are termed as fats e.g. palmitic acid. On the other hand, oils are glycerol esters which contain higher proportion of unsaturated fatty acid components e.g. (oleic acid). This difference can be illustrated by the structural formulas such as.



An oil (unsaturated)



A fat (saturated)

The melting point of mixed Glycerides mainly would depend on the number (ratio) of unsaturated fatty acid components in a molecule. It is a matter of common observation that unsaturated mustard oil (sarsoon) remains liquid while saturated bees wax is in solid state.

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Vegetable oils have unsaturated molecules. In industry these oils are converted into saturated solid fat (ghee) by a process called hydrogenation. In this process , hydrogen molecule is added at the double bond of unsaturated molecules of oils in the presence of finely divided nickel catalyst.

13.4 Nucleic Acids

Nucleic Acids were first discovered in the nuclei of pus cells in 1868 and in sperm heads in 1872 by Friedrik Miescher.They are found in every living cell as well as in viruses and have been found to be the essential components of genes. Their structure contain the blueprints for normal growth and development of each and every living organism.

These are complex biomolecules composed of units called nucleotides. Most of the nucleotides are biopolymers of nucleosides and phosphate group.

13.4.1 Types of Nucleic Acids

Naturally occurring nucleotides are of two types which gives two types of nucleic acids i.e. deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA).

13.4.2 Composition of Nucleic –Acids:

Each of nucleotides i.e DNA and RNA are composed of the following components i.e.

1. Sugar either (Ribose ⇒ in RNA) and (deoxyribose ⇒ in DNA)
2. Nitrogenous Base that is heterocyclic amine, which is either purine OR pyrimidine.
3. Phosphate –Group,

13.4.3 Functions of Nucleic Acids:

Both types of nucleic acids deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA) are formed of nucleotides which are joined together through phosphodiester linkages and performs two main functions i.e.

1. Their ability to reproduce, store and transmit genetic information.
   The genetic informations for the cell are contained in the form of specific codes in DNA molecules. These informations are translated and expressed by synthesis of specific proteins, that performs various functions in the cell according to the directions given by the codes in DNA.
   Thus protein synthesis in the cell is completed in two stages i.e. Transcription and Translation.
2. **Mutation:**
   Mutation is a sudden chemical change in a DNA (Deoxy Ribonucleic acid) molecule that could lead to the synthesis of proteins with an altered amino acid sequence.
   Changes in DNA molecules may be caused by mutagens like radiations, chemical agents or viruses.
   Majority of changes in DNA are repaired by special enzymes in the cell. Failure in repair by the enzyme system can cause a mutation.

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Resin is a natural or synthetic chemical which is in highly viscous state and hardens with treatments. It is soluble in alcohol but not in water.
Natrual resin is a hydrocarbon secretion of many plants specifically of coniferous plants e.g pine sap having specific sharp smell due to the presence of terpene compounds.
Resins have a number of types depending on its chemical composition and potential uses.
Resins have a number of applications especially of polymer production.

Types of Natural Resins:

- Epoxy Resins
- Gum Resins.
- Ion –exchange Resins
- Copals, dammars & mastics

Resins may be used in varnishes, adhesives and organic synthesises.

A chemical substance that has a smell or odour is called fragrance. It gives smell when two conditions meet. The chemical compound must be volatile and much concentrated so that it interacts sufficiently with the olfactory system of nose having olfactory receptors. These compounds can be found in food, wine, spices fragrance oils and perfumes etc.

Odorants / fragrances can be added to odourless dangereous gases e.g (CH_4) in order to detect the leakage of the gas . These also help to improve the flavour & value of food.

Some natural fragrances, their occurence & smell are given as.

Esters $\Rightarrow$ ethyl Acetate $\rightarrow$ sweet fragrance $\rightarrow$ comes from wine

Terpenes $\Rightarrow$ Citrolenellal $\Rightarrow$ lemon smell $\rightarrow$ comes from lemongrass

Aromatic $\Rightarrow$ vanilline $\longrightarrow$ vanilla $\longrightarrow$ comes from vanilla.

Ketones and lactones etc.

Flavours are sensory perception of a food or other chemical substances which are determined mainly by senses of taste and smell.

The flavours of a food can be altered with addition of some natural or synthetic flavours which are known as flavourants.

Flavourants can be defined as substances that give another substance flavour, altering the characteristics of the solutes, causing it either to become sweet, sour or tangy.

Flavourants either enhance the taste, smell or colour of the food. Flavourants can be classified such as.

Natural taste –Flavourants:

- Acetic acid $\Rightarrow$ comes from vinegar $\Rightarrow$ having sour taste to food.
- Citric acid $\Rightarrow$ found in citrus fruits.
- Tartaric acid $\Rightarrow$ found in grapes and wines and gives tart taste.

Natural Smell – Flavourants:

- Ethyl propionate → having fruity smell.
- Methyl anthranalite → comes from grape.
- Iso amyl acetate → comes from banana. etc.

Natural colour Flavourants:

Some flavourants increases the value of food by highlighting its colour e.g. colour of red beverages.

13.5 Vitamins

The name vitamin was originally vitamine because the first one that was found was an amine, hence the name vital amine or vitamine. Subsequent studies of other such substances showed that they were not all amine. So, the "e" was dropped.

Vitamins are organic compounds that can not be synthesized by an organism but are very essential for the maintenance of normal metabolism and therefore must be included in the diet.The absence or deficiency of vitamins in diet results in various diseases.

Carbohydrates, fats and proteins are the three major classes of foods. To remain healthy we must take in relatively large amount of these substances. They are not, however, the only nutrients we require. Some of our needs are satisfied only by vitamins and minerals.

13.5.1 Type of vitamins

Vitamins are of two main types	
Fat soluble vitamins.	Water soluble vitamins.
Vitamins A,D,E and K.	Vitamins B –Complex and C.

Fats soluble vitamins:

Vitamin A:

Vitamin A may be obtained from green vegetables and fruits, fish liver oil, eggs, butter, cheese etc.

Vitamin A is not found in plants as such. It is present in the form of pro vitamin such as β carotene. Vitamin A combines with a protein called opsin to produce a light absorbing compound called rhodopsine. Its deficiency causes night blindness which is inability of a person to see in dim light.

Vitamin D:

Vitamin D is also known as calciferol due to its role in calcium metabolism. The liver oils of fish, milk, vegetable and butter contain good amount of vitamin –D. Vitamin D helps in the absorption of calcium and phosphate from intestine and deposits it in skeleton. Its deficiency produces a disease called rackets.

Vitamin E:

Vitamin E also called "Tocopherols" which means fertility. The main sources of vitamin E are vegetable oil, corn oil, soyabean oil, egg yolk, liver etc. Vitamin -E has also different types. It is used as an antioxidant. It has a major role in reproduction. Its deficiency causes Anemia due to destruction of cell membrane of RBC by oxidation.

Vitamin K:

Vitamin K is a factor related to blood clotting. Its main sources are cabbage, cauliflower, spinach, tomatoes, cheese, meat, egg yolk. Some microorganism synthesize vitamin k in intestine. The defficiency of vitamin k causes hemorrhage in which the blood fails to clott and thus increases the bleeding time.

Water soluble vitamins:

Vitamin B:

Vitamin B is not a single vitamin but consist of vitamin $B_1, B_2, B_3, B_6, B_{12}$ etc. Therefore it is called vitamin B complex. Vitamin B_1 (thiamine) deficiency produces a disease called beriberi which results in loss of weight, nervous disorder. Vitamin B_2 (Riboflavin) is present in milk, meat, fish, eggs, and leafy vegetables. Its deficiency causes inflammation of lips, dryness and burning of eyes. Vitamin B_6 (pyridoxine) is important for fats and protein metabolism. Its deficiency causes anemia.

Vitamin C:

Vitamin C is also known as Ascorbic acid. Most of the animals can synthesize it but human being can not do so due to absence of enzyme.

The main source of vitamin C is citrus fruit such as lemon, orange, strawberries but cereals contain no vitamin C. Its deficiency causes scurvy disease which is characterized by pain in joints and bleeding from gums.

KEY POINTS

- Carbohydrates are polyhydroxy aldehydes and ketones.
- Carbohydrates are classified as monosaccharides, oligosaccharides and polysaccharides.
- Proteins are biopolymers of amino acids.
- Three types of bonding i.e peptide-bonding, hydrogen bonding and disulphide bridges are present in protein molecules.
- Lipids are esters of long chain fatty acids and alcohols.
- Fats and oils are the most important lipids found in nature.
- Deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA) are the two types of nucleic acid.
- Main source of vitamin C is citrus fruit.
- Vitamin A, D, E, K are fats soluble and vitamin B complex and vitamin C are water soluble.
- Deficiency of vitamin causes different diseases.

Q.1 Select correct answer from the given choices.

i. Polyhydroxy compounds of aldehyde and ketones are called.
   I. Carbohydrates
   II. Protein
   III. Lipids
   IV. Vitamin

ii. Wheat,Rice and honey are the sources of
   I. Vitamins
   II. Proteins
   III. Carbohydrates
   IV. Lipids

iii. ——Is a basic component of paper industry
   I. Cellulose
   II. Maltose
   III. Glucose
   IV. Lipids

iv. Polymers of Amino acid are _____.
   I. Vitamins
   II. Proteins
   III. Lipids
   IV. Carbohydrates

v. Nucleic acids are of _____ types
   I. Two
   II. Three
   III. Four
   IV. Five

vi. Vitamin _____ is called ascorbic acid
   I. A
   II. B
   III. C
   IV. E

vii. Fats and oils are called _____

I. Carbohydrates
II. Lipids
III. Proteins
IV. Vitamins

viii. _____ Is a factor related to blood clotting

i. Vitamin A
ii. Vitamin B
iii. Vitamin C
iv. Vitamin K

Q.2 Write short answers to the following questions.

i. Describe some of the sources and uses of carbohydrates.
ii. Explain Bonding in protein – molecules in your own words.
iii. What is meant by denaturing of proteins, explain.
iv. Describe difference between fats and oils.
v. Write brief composition of Nucleic acid.

Q.3 Comprehensive questions.

i. What are carbohydrates? Explain classification of carbohydrates.
ii. Describe proteins, the nature of bonding in protein and their uses.
iii. Explain lipids with the classification, sources and uses.
iv. What are Nucleic acids? Describe their types, composition and functions.
v. What are vitamins and how are they classified?