Unit	Teaching (Periods)	Assessment (Periods)	Weightage %
13 Biochemistry	15	3	12

Introduction

The bodies of living organisms are made up of chemical elements. The most common elements in the living organisms are carbon, hydrogen, nitrogen, oxygen, phosphorus 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 consist of carbohydrates, proteins, lipids, nucleic acids and vitamins. These molecules are called biological molecules. Biochemistry is the study of the organic compounds and reactions that occur in living organisms. By using chemical knowledge and techniques, biochemists understand and solve biological problems. Biochemistry focuses on processes happening at a molecular level.

The study of this unit will enable you to recognize and know the structure, sources and importance of these biological molecules.

Real world link

Large biological molecules perform a wide range of jobs in an organism. Some carbohydrates store fuel for future energy needs, some lipids are key structural components of cell membranes. Whereas, proteins provide structural support and catalyze metabolic reactions and nucleic acids store and transfer hereditary information to next generation.

13.1 Carbohydrates

Carbohydrates are important class of naturally occurring organic compounds. It consists of glucose (grape sugar), fructose (honey), sucrose (cane sugar), starch (potatoes) and cellulose (wood).

Fig.13.1 Carbohydrates

These are organic compounds composed of carbon, hydrogen and oxygen in the ratio 1:2:1 respectively. Sometime also contains nitrogen (e.g. chitin) and sulphur (e.g. keratin), sulphate). They have general formula of $C_n(H_2O)_n$, Here 'n' will take a value of either 3 or greater than 3. According to modern definition, carbohydrates are macromolecules of polyhydroxy aldehydes or ketones. These substances have hydroxy (OH) and aldehyde (CHO) or ketone $(-\overset{\overset{\displaystyle O}{\|}}{C}-)$ functional groups.

Carbohydrates are usually referred as saccharide (Latin saccharum means sugar) because of the sweet taste of the simpler members of the class commonly known as, the "sugars".

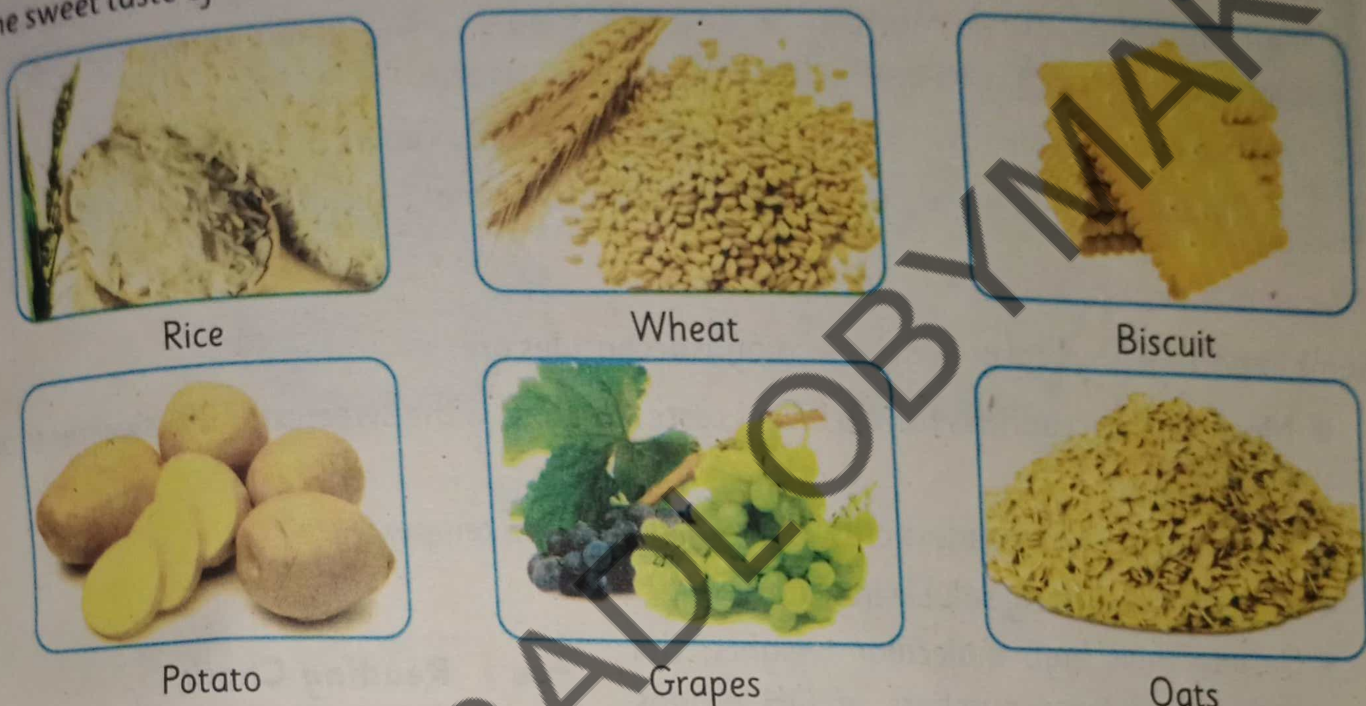


Fig. 13.2 Sources of Carbohydrates

Classification of Carbohydrates

Carbohydrates are divided into three main classes. This division of carbohydrates is based on the number of simple sugar units present per molecule.

13.1.1 Monosaccharides

Monosaccharides are the simplest sugar and the most basic units of carbohydrates. They cannot be further hydrolyzed to simple components. The general formula is the $C_n(H_2O)_n$ where, n=3,4,5 and so on. A Monosaccharide consists of three (3) to nine (9) carbon atoms. Monosaccharides are further classified according to the number of carbon atoms present in the molecules as trioses ($C_3H_6O_3$), tetroses ($C_4H_8O_4$), pentoses ($C_5H_{10}O_5$), hexoses ($C_6H_{12}O_6$), etc.

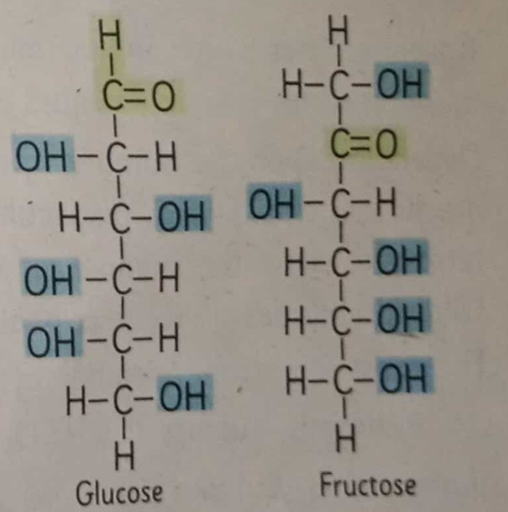


Fig.13.3 Structure of Glucose and Fructose

The two most important monosaccharides are glucose and fructose. Glucose and fructose are hexoses and have same molecular formula $C_6H_{12}O_6$. In these monosaccharides, glucose is pentahydroxy aldehyde (having aldehydic functional group), while fructose is pentahydroxy ketone (having ketonic functional group). Their open chain structural formulas are given in figure 13.3.

Tidbit

Monosaccharide molecules can rotate the plane polarized light to right (clockwise). They are called dextro-rotatory or dextrose sugars, while others rotate the plane polarized light to left (anti-clockwise), called levo-rotatory.

- Monosaccharides are reducing in nature, commonly known as reducing sugars.
- Glucose can dissolve in small amounts of water to make syrup ($1g / 1cm^3$ of H_2O).

Physical Properties of Monosaccharides

Some important physical properties of monosaccharides are,

- Most monosaccharides have a sweet taste (fructose is the sweetest; 73% sweeter than sucrose).
- They are usually colourless crystalline solids at room temperature.
- They are completely soluble in water.
- Despite their high molecular weights, the presence of large numbers of OH groups make the monosaccharides much more water soluble than most molecules of similar molecular mass.

Reading Check

Define carbohydrates. On what basis they are classified?

13.1.2 Oligosaccharides

Carbohydrates which on hydrolysis (reaction with water) give two (2) to nine (9) molecules of monosccarides or simple sugars are called Oligosaccharides.

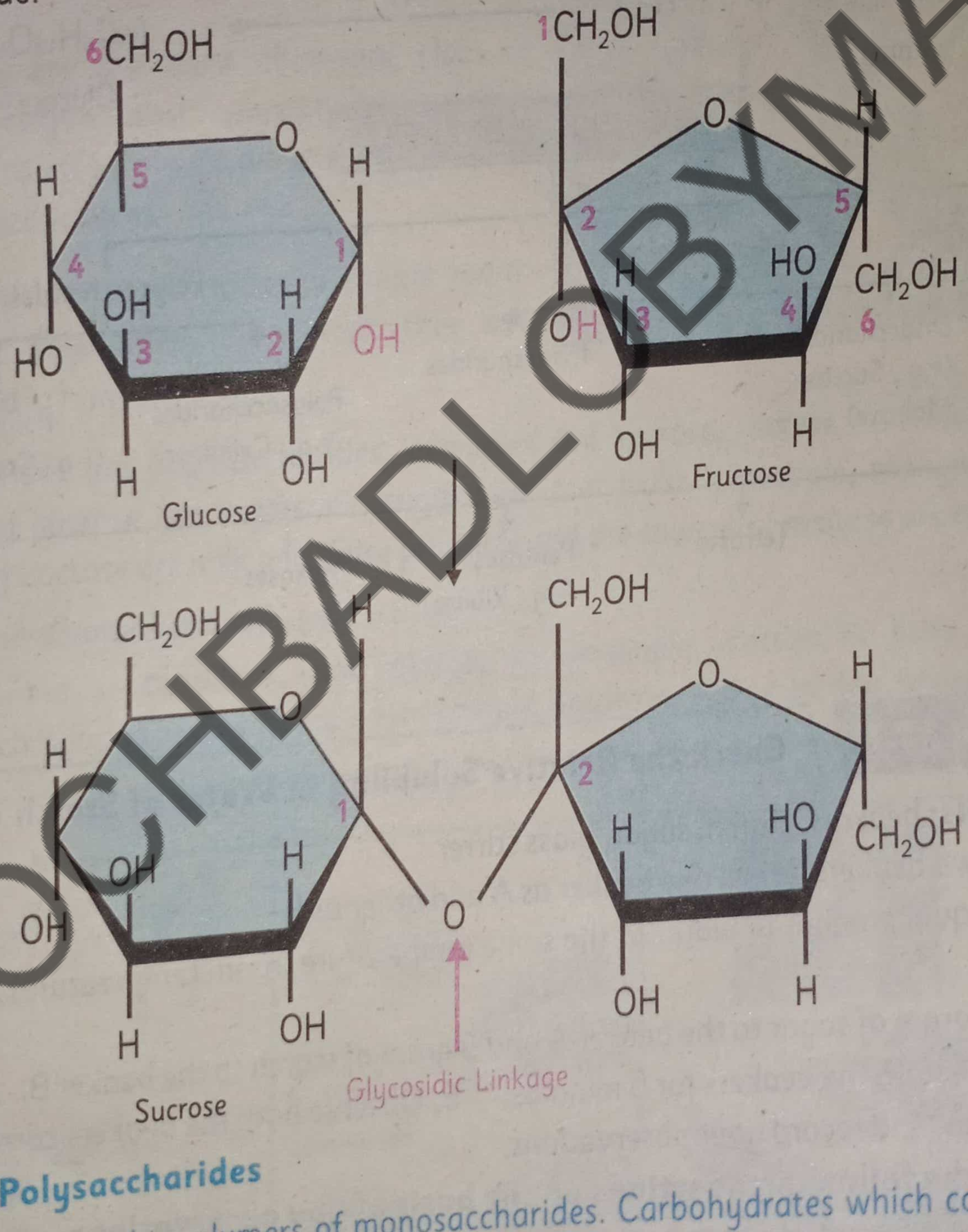
Depending upon the number of monosccarides molecules they produce on hydrolysis, they are further classified as disaccaharides, trisaccarides, tetrasaccahrides etc. prefixes di, tri, tetra etc, show the number of monosaccharide units that they produce on hydrolysis. Oligosaccharides are white crystalline solids easily soluble in water. They are sweet in taste.

The most important member of oligosaccharides is disaccharides, for example, sucrose. On hydrolysis, sucrose ($C_{12}H_{22}O_{11}$) produces two molecules, in which one molecule is of glucose ($C_6H_{12}O_6$) and one molecule is of fructose ($C_6H_{12}O_6$). Lactose produces glucose and galactose.

	Disaccharides		Monosaccharides
i.	Sucrose	$\xrightarrow{H_2O}$	Glucose + Fructose
ii.	Lactose	$\xrightarrow{H_2O}$	Glucose + Galactose
iii.	Maltose	$\xrightarrow{H_2O}$	Glucose + Glucose

Glycosidic Linkage

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



13.1.3 Polysaccharides

Polysaccharides are biopolymers of monosaccharides. Carbohydrates which consist of long chains of monosaccharide units or simple sugars bound together by glycosidic linkages are called Polysaccharides. They are also known as macromolecules. For example, starch, glycogen and cellulose are polysaccharides. They are amorphous solids. They are tasteless and insoluble in water and are called "non-sugars".

Tidbit

Studies have shown that honey has the same quick absorption and long-lasting energy-burst effect that many sports drinks do. This is because honey is high in fructose, a simple fruit sugar that has been found to be the best sugar for athletes. Unpasteurized honey also contains hydrogen peroxide and enzymes, which aid in digestion.

They have high molecular mass and consist of 100 or more monosaccharides units joined together through glycosidic linkages. Hydrolysis of polysaccharides gives many molecules of monosaccharides e.g.

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

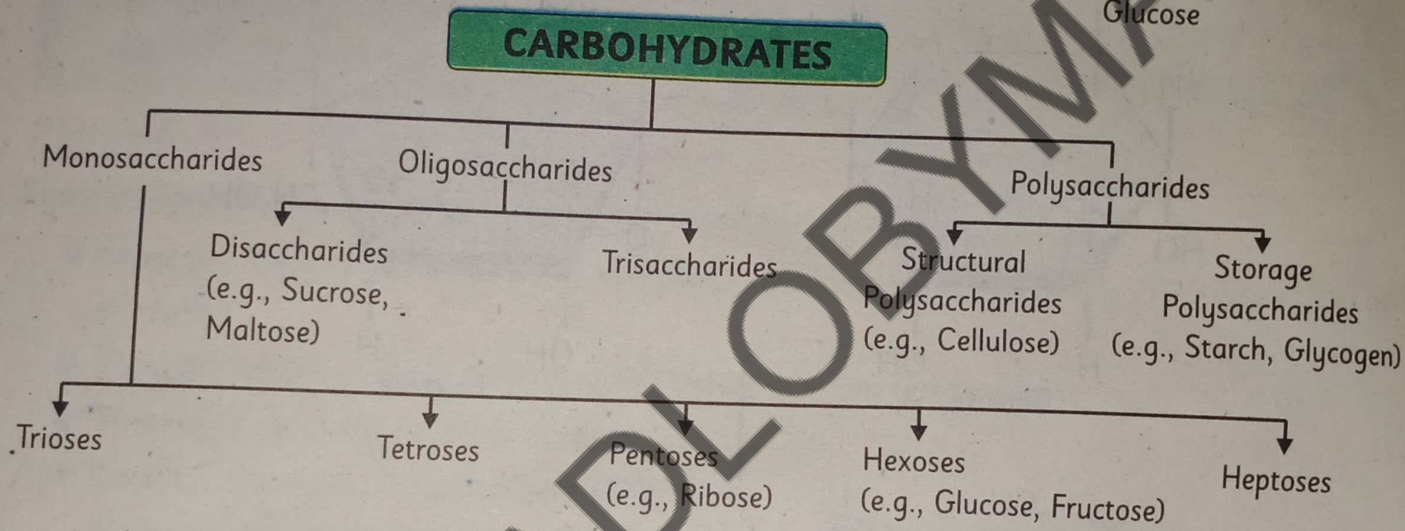


Fig. 13.4 Classification of carbohydrates

Activity 13.1 Check the Relative Solubility in Water of Starch and Sugar

Materials: beakers, starch, sugar, glass stirrer

1. Take two beakers. Label one beaker as A and other as B.
2. Take equal amount of water at the same temperature (room temperature) in both the beakers.
3. Add 5 gram of sugar to the beaker A and 5 gram of starch to the beaker B.
4. Stir well both the beakers for 5 minutes. 5. Observe both the beakers carefully.
6. Compare and record your observations.

Answer the following questions on the basis of you observations.

1. Can you differentiate both beakers based on solubility?
2. Can you identify the compound, which is more soluble in water at room temperature?
3. Can you give the reason that why there is a difference in their solubility, though both are carbohydrates?

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The Use Of Dextrose In Drips

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 for the loss of water during dehydration.

13.1.4 Sources and Uses of Carbohydrates

Sources of Carbohydrates

Carbohydrates are the most abundant class of carbon, hydrogen and oxygen containing compounds. It ranges from simple to complex units. They have varied sources.

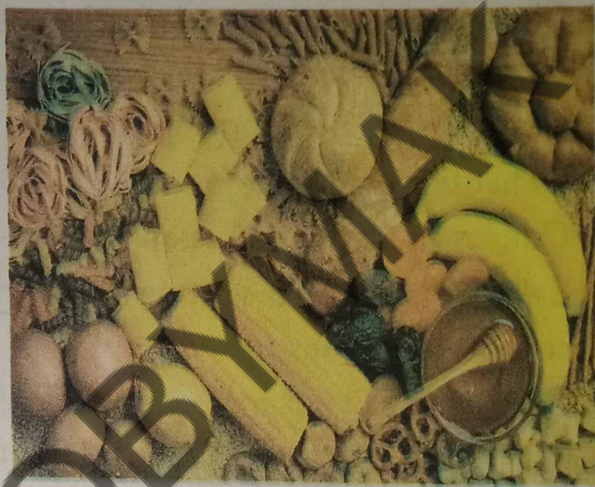


Fig.13.5 Different Sources of Carbohydrates

- Sources of Monosaccharides or simple sugar are fruits, vegetables, and cereals, they are also found in honey.
- Disaccharides are oligosaccharides, examples are sucrose, lactose and maltose. The sources of sucrose are sugarcane, sugar beet and fruits (pineapple, mango etc). The sources of Lactose are milk and dairy products and the sources of maltose are cereals etc.
- Polysaccharides are cellulose and starch.
  - Cellulose is obtained from plants, for example, cotton is pure cellulose.
  - Starch is found in cereal crops, for example, potatoes, wheat, barley, maize, rice, etc.

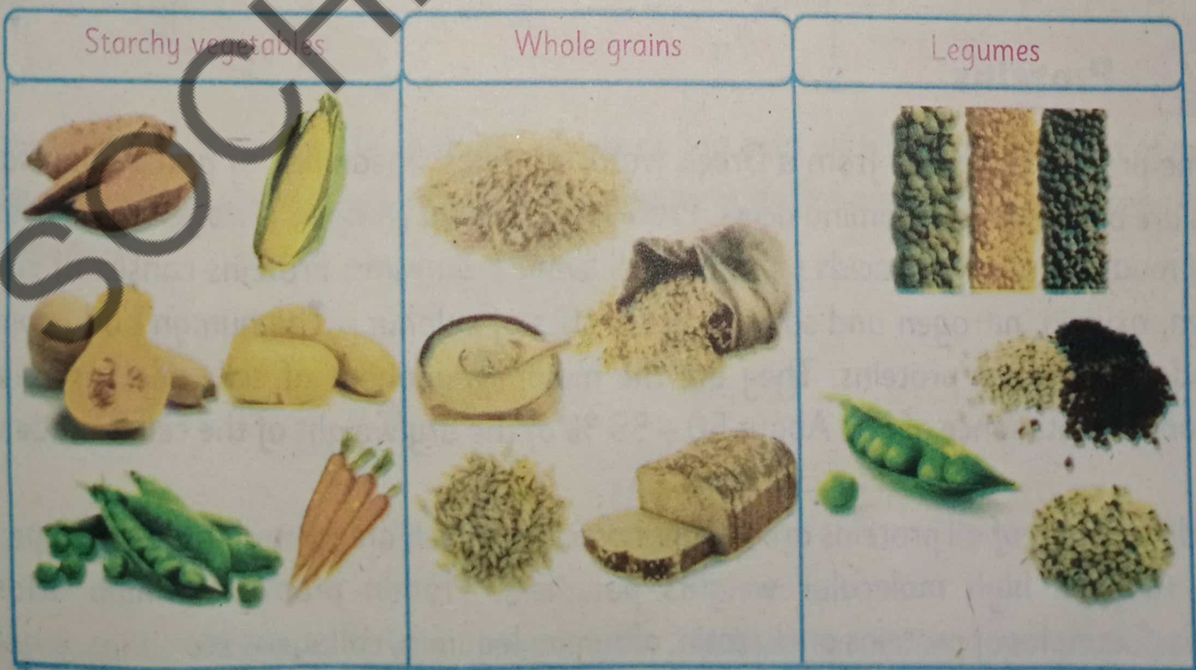


Fig.13.6 Sources of Complex Carbohydrates (Starches)

Uses of Carbohydrates

The following are various uses of carbohydrates.

- Carbohydrates are used by our body as a rich source of energy.
- Sugar is used as a common sweetener for food.
- Carbohydrates serve as a source of food.
- Carbohydrates serve as structural material for plants.
- Cellulose helps in lowering cholesterol and regulates blood pressure.
- Glucose is stored in animal muscles and liver cells in the form of glycogen. It serves as long-term energy reservoir in the body, converted back into glucose when needed. Plants store excess energy in the form of starch.
- Cellulose is used in the form of wood for housing, furniture and heating purposes.
- Cellulose is used to make paper and wood pulp (paper industry).
- Cellulose is used in the cotton industry for making cloths (textile industry).
- Constipation and diarrhoea are mainly controlled by the use of fibers which are carbohydrates.

Tidbit

All the carbohydrates are of plant origin except lactose which is of animal origin.

Self Assessment

1. Classify sucrose, galactose, glucose, fructose and maltose as mono, di and tri-saccharides.
2. Give the balanced equation of hydrolysis of sucrose.
3. Write down the five uses of carbohydrates.
4. Give the sources of mono, Oligosaccharides and Polysaccharides.

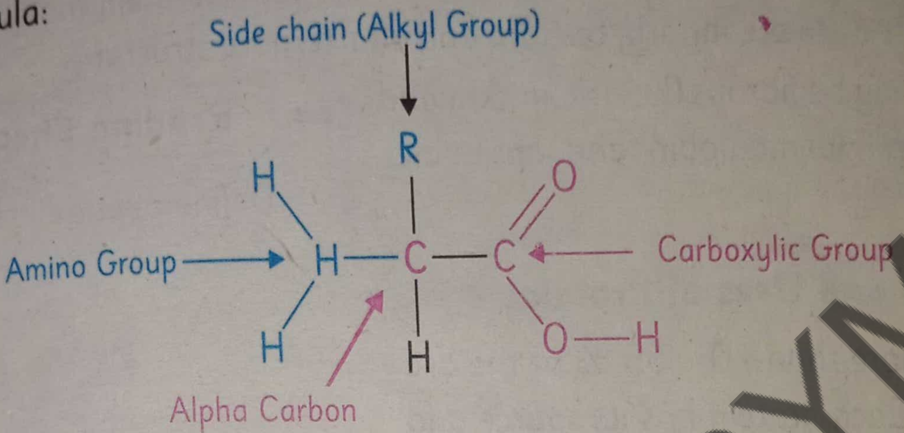
13.2 Proteins

The name protein is derived from a Greek word "proteios" meaning "of prime importance". Proteins are biopolymers of amino acids. Proteins are highly complex nitrogenous substances that are made up of amino acids present in all living organisms. Proteins consist of carbon, hydrogen, oxygen, nitrogen and some time consists of sulphur. The human body contains thousands of different proteins. They are the major component of cells and essential for growth and maintenance of life. About 50 – 55 % of the dry weight of the cell is made up of proteins.

The building blocks of all proteins are the amino acids. Which are jointed together by peptide linkages to form high molecular weights polymers. Protein produces amino acids on hydrolysis. Examples of proteins are keratin, albumin, legumin, collagens etc.

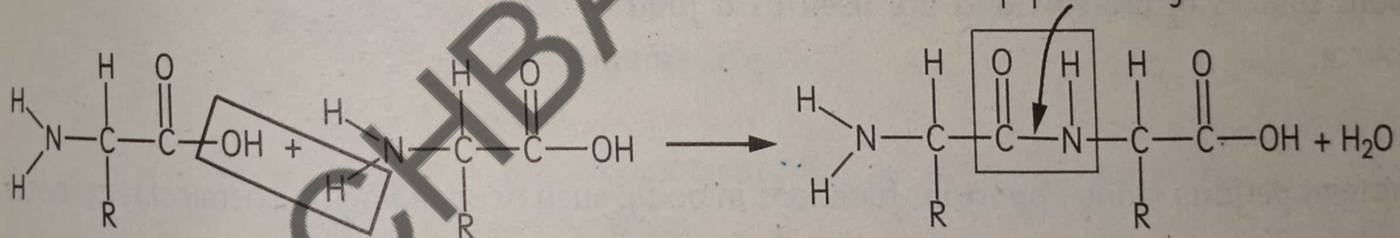
13.2.1 Amino Acids as Building Blocks of Proteins

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. Amino acids are the building blocks of protein. Amino acids are organic compounds consisting of both amino group (NH_2) and carboxyl group (COOH). Both the COOH and the NH_2 groups are attached to the same carbon atom (alpha carbon). They have the general formula:

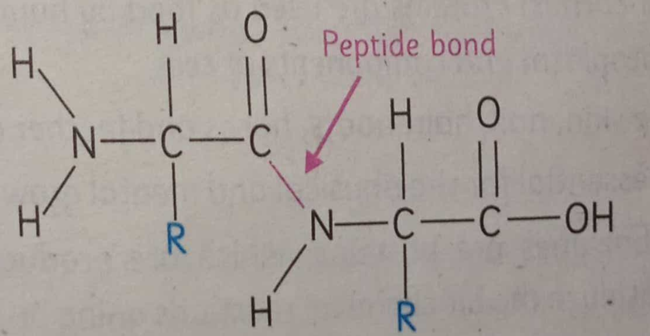


Twenty different types of amino acids (each with a different alkyl group in the formula) are involved in protein synthesis. Out of twenty amino acids, our body can prepare ten amino acids. These amino acids are called non-essential amino acids. The remaining ten are called essential amino acids, which are required by our bodies and must be supplied through diet.

All of the amino acids are joined together by "peptide linkage" in protein polymer. The protein polymer is built by condensation reactions between amino acids, along with removal of H_2O molecule. For example,



The linkage, which joins carboxyl carbon of one amino acid with an amino group of another amino acid, forming the sequence CONH, is called peptide linkage. The resultant molecule is called dipeptide.



Additional condensation reactions lengthen the chain to produce a polypeptide, finally producing a giant molecule of protein.

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

i. Peptide bonding ii. Hydrogen bonding iii. Disulphide bridges

Each amino acid has a side chain designated as R (alkyl group). The various amino acids differ in their side chains or alkyl groups (R).

Disulphide bridges are found only in sulphur containing protein molecules.

The presence of hydrogen bonding and disulphide bridges in protein molecules cause it to fold and refold to produce secondary, tertiary and quarternary structures.

Protein molecules may be fibrous (keratin in skin and nails) and globular (Haemoglobin and antibodies etc.)

Reading Check

Define peptide linkage.

13.2.2 Sources and Uses of Proteins

Proteins make up more than 50 – 55 % of the dry weight of the cells. Each protein has its source and performs a specific function. Most proteins obtained from animal sources contain all the necessary amino acids in enough amounts.

Animal Sources of proteins: Animal sources of proteins are fish, meat, eggs, milk, cheese etc.

Plant Sources of Proteins: Pulses, beans etc are plant sources of proteins and are used as a food source.

Fig13.7 Sources of Proteins

Uses of Proteins

Proteins perform many important functions in body, such as speeding up chemical reactions (enzymes), transporting oxygen in blood (haemoglobin), and regulating body responses (hormones).

- **As Oxygen carrier:** Proteins (haemoglobin) perform the functions of oxygen transportation in blood (act as oxygen carrier) Proteins are used as food by human beings, as it is essential for the formation of protoplasm and components of cells.
- **Body structures:** Like skin, nail, hair, hoofs, horns and feather are composed of proteins.
- **Growth:** Proteins are essential for the physical and mental growth especially in children.
- **Enzymatic action:** Enzymes are proteins, which are produced by the cells of living organisms. Enzymes catalyze the biochemical reactions going on in our bodies.
- **As Body Regulators:** Hormones and enzymes are the chemical regulators of the body.

- **Commercial Uses of Enzymes:** Enzymes help in improving the quality of products such as textile, detergents, foods and beverages. Vinegar and cheese are also produced due to the utilization of enzymes in bacteria and yeast.
- **Body Defence System:** The antibodies that help us to fight against diseases are large protein molecules.
- **Other Uses of Protein:**
  - A protein called gelatine is used as bakery items.
  - Animal Hides are also made up of proteins. Which are used to make leather and leather is used for making shoes, jackets, sports items etc.

Self Assessment

1. What are the functional groups of amino acids?
2. What are the different sources of proteins?
3. Write down the fives uses of proteins.
4. Differentiate between protein and amino acids.

Activity 13.2 **Observe and Explain the Denaturing of Proteins**

Materials: eggs, beakers, water, Bunsen burner

1. Take an egg.
2. Carefully break the egg and pour the contents of the egg in a beaker.
3. Observe the colour, fluidity, concentration, pH with pH paper.
4. Take another egg and boil it in water.
5. Remove the covering shell of egg carefully.
6. Divide the egg into half slices.
7. Now observe the colour, fluidity, concentration, pH with pH paper again.
8. Compare and record the observation.

Answer the following questions on the basis of your observations.

1. Can you differentiate the normal and denatured protein?
2. Can you explain what happened during the denaturing of protein?
3. Can you give the reason that why such physical change occurs in the egg protein?

13.3 Lipids

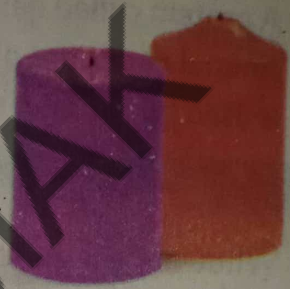
The term lipid is derived from a Greek word "lipose" which means "fats". Lipids are defined as biological molecules obtained from plant and animal tissues. They are not soluble in water, but are soluble in non-polar organic solvents, such as alcohol, chloroform, ether etc.

Lipids contain large hydrocarbon chains. Several types of lipids may be,

(a) Fats and oils,
(b) Steroids such as cholesterol,
(c) Turpentine oil,
(d) Sex hormones,
(e) Components of cell membrane known as phospholipids,
(f) Vitamins such as (A, D, E and K) and
(g) Waxes

Animal fat

Plant oils



Waxes

Fig.13.8 Lipids

Classification of Lipids

Lipids are classified as

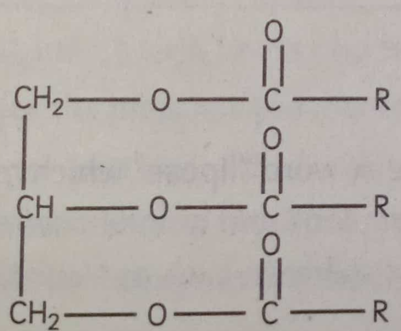
i. Simple Lipids: These lipids are also known as triglycerides. They produce fatty acids and alcohols upon hydrolysis, e.g. Fats, Oils and Waxes.

ii. Complex Lipids: Those lipids which produce fatty acids, alcohols and some other substances upon hydrolysis are known as complex lipids, e.g. Phospholipids, Glycolipids, Sulpholipids etc.

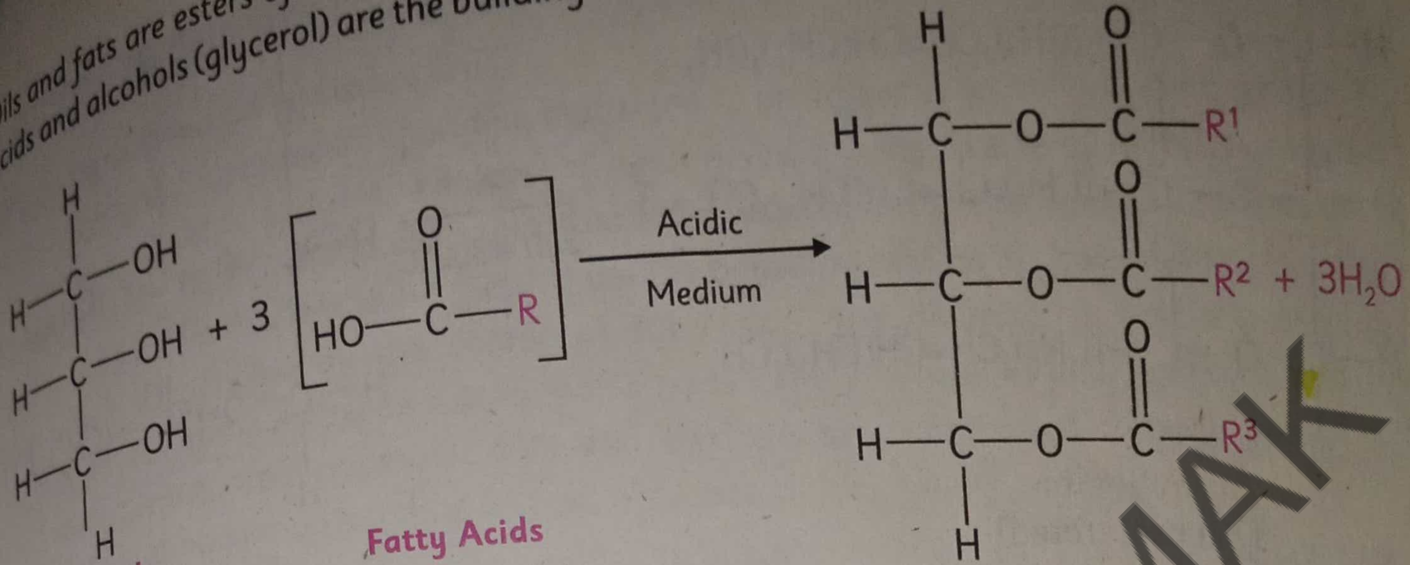
Classification of Lipids

- **Simple Lipids**
  e.g. Fats, Oils ans Waxes
- **Complex Lipids**
  e.g. Phospholipids, Glycolipids
  Sulpholipids wtc.

Generally lipids are esters of long chain fatty acids and alcohols. These esters are made up of three fatty acids; therefore, they are called triglycerides. General formula of triglycerides is as under.



Oils and fats are esters of long chain carboxylic acids (fatty acids) with glycerol. Thus, Fatty acids and alcohols (glycerol) are the building blocks of lipids.



Glycerol

(1 Molecule)

Fatty Acids

(3 Molecules)

Fat(triglyceride)

(1 Molecule)

13.3.1 Fatty Acids

Oils and fats are simple lipids. Fatty acids are carboxylic acids (or organic acid), often with long aliphatic tails (long chains), either saturated or unsaturated. Saturated fatty acid has carbon–carbon single bonds whereas, unsaturated fatty acid has at least one carbon–carbon double bond. If a fatty acid has more than one double bond then it is called a polyunsaturated fatty acid. For example, stearic acid ($C_{17}H_{35}COOH$), found in animals fat, Butyric acid (C_3H_7COOH) and Caproic acid ($C_5H_{11}COOH$) present in butter etc.

Difference between Fats and Oils

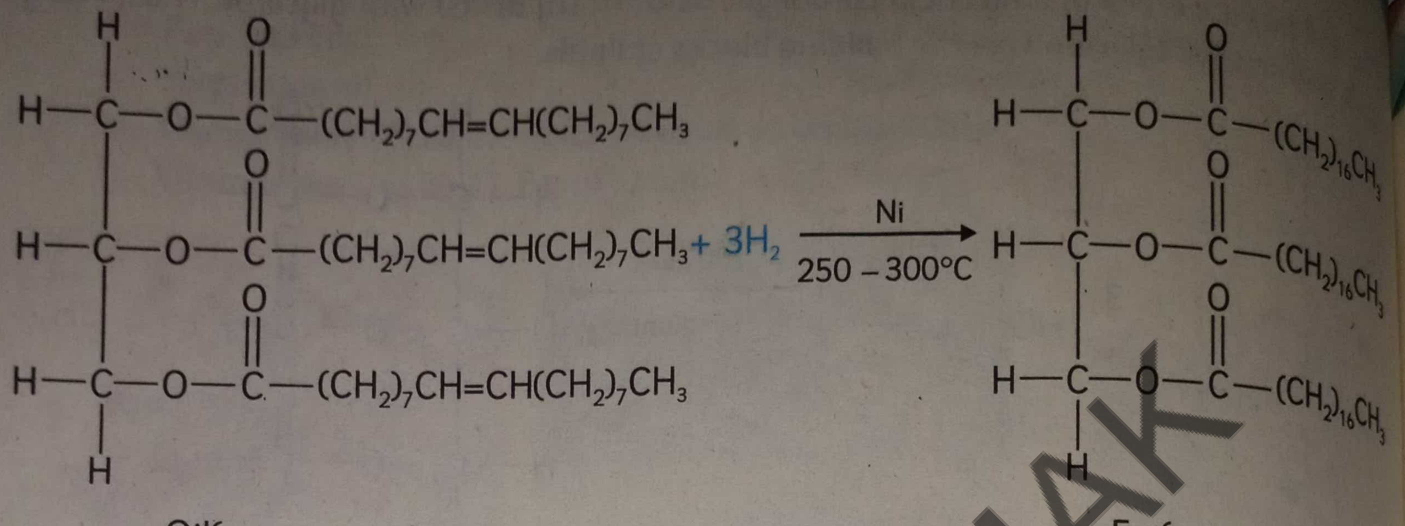
Fats and oils have similar chemical structures. They are triesters formed from glycerol and long chain organic acids called fatty acids. The degree of unsaturation of the fatty acids determines whether a triglyceride will be a solid or a liquid.

Fats: Those triglycerides in which long chain saturated fatty acid components predominate, tend to be solid or semisolid at room temperature e.g. palmitic acid. Fats are mainly present in animals.

Oils: These are glycerol esters which contain higher proportion of unsaturated fatty acid components which make them liquids at room temperature e.g. oleic acid. Oils are mainly present in plants and in fish.

The melting point of mixed glycerides mainly depends upon the number 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 a solid state.

By catalytic hydrogenation, polyunsaturated oils can be reduced to saturated solid fat (ghee), which make them solids at room temperature.



Oil(unsaturated) Fat(saturated)

Reading Check

What are the triglycerides?

Daily life link

Unsaturated mustard oil remains liquid and saturated bee wax is in solid state at room temperature.

Fig.13.9 Fats and Oil

13.3.2 Sources and Uses of Lipids

Sources of Lipids

Lipids come from a variety of natural sources like animals, plants and marine organisms for example, salmon and whales are rich sources of lipids (cod liver oil).

- Milk is a rich source of animal fat from which butter, ghee, cheese etc are obtained.
- Seeds of many plants such as sunflower, corn, cotton, peanut; groundnut, walnut, coconut etc are good sources of vegetable oils (lipids).

Tidbit

Animal fats are located particularly in adipose tissues.

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Hydrogenation of Vegetable Oil

Hydrogenation is the process of adding hydrogen to an edible vegetable oil using a catalyst to produce semi-solid fats. In the process of hydrogenation, the powdered nickel is used as a catalyst. In the hydrogenation, the unsaturated vegetable oils are converted into saturated semi solid fats (Ghee). This elimination of double bonds by adding hydrogen atoms is called saturation. Depending on the degree of saturation, the oil may be partially or fully hydrogenated. If the degree of saturation increases, the oil becomes fully hydrogenated. In this way, unsaturated vegetable fats and oils can be transformed through partial or complete hydrogenation into fats and oils of higher melting points and thickness.

In this process a hydrogen molecule is added to unsaturated molecules of oil, in the presence of finely divided nickel catalyst. Oil that is completely hydrogenated becomes solid at room temperature. Vegetable oils are triester of glycrol and fatty acids or unsaturated long chain. These oils are hydrogenated in the presence of nickel catalyst at 250 – 300°C to form vegetable ghee.

$$\underset{\text{(Unsaturated Triester)}}{\text{Vegetable Oil}} + H_{2(g)} \xleftarrow[250-300^{\circ}C]{Ni} \underset{\text{(Saturated Triester)}}{\text{Vegetable Ghee}}$$

Uses of Lipids

- Lipids perform many important functions in the body. Their most important function is the long-term storage of energy. One gram of fat contains approximately twice more energy than a gram of carbohydrate or protein.
- Butter, oil and ghee are used for cooking and frying of food items, for preparing bakery products and making the food more palatable.
- In mammals, a layer of fat is present under the skin. This layer acts as a thermal insulator. They insulate the body from excessive heat or cold.
- The fatty tissues in our body are made from lipids. A protective layer of fat around our heart, kidneys etc. reduces the impact of any external jerk or shock.
- Lipids act as a solvent for some vitamins like A,D and E.
- Lipids are an integral part of cell-protoplasm and plasma membrane.
- Lipids such as cholesterol etc act as hormones to regulate body functions.
- Fats and oils are used in the manufacture of soaps, lubricants, cosmetics, polishes, paints, greases etc.

Tidbit

Equal amount of different food items produce different amount of energy.

S.No	Food source	Energy
1	Carbohydrates	4kcal/g
2	Lipids	9kcal/g
3	Protein	4kcal/g

Fig.13.10 Different Sources of Fats and Oils

Self Assessment

1. Define fatty acids.
2. Write down the different sources of lipids.
3. Differentiate between oil and ghee.

13.4 Nucleic Acids

Friedrich Miescher

Nucleic acids were first discovered in the nuclei of white blood cells in 1868 and in sperm head in 1872 by Johannes Friedrich Miescher, a Swiss physician and biologist.

They are found in every living cell as well as in viruses and have been found to be the essential component of genes. Their structure contains the blueprints for normal growth and development of each and every living organism.

These are complex bio-molecules composed of units called nucleotides. Most of the nucleotides are bio-polymers of nucleosides and phosphate groups.

13.4.1 Types of Nucleic Acids

Naturally occurring nucleotides are of two types, which give two types of nucleic acids i.e.

i. Deoxyribonucleic acid (DNA) and ii. Ribonucleic acid (RNA)

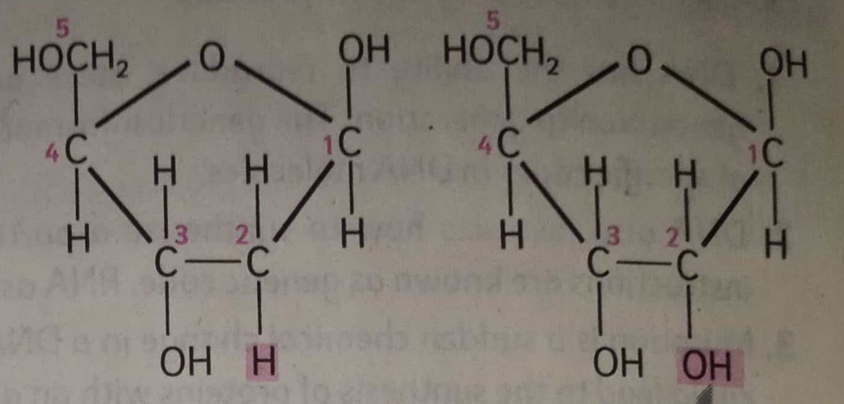
Real world link

DNA tests are now being widely used in medicine, forensic science, criminal investigations, track down blood relatives, identification of victims in disasters and to look for cures for diseases.

13.4.2 Composition of Nucleic Acids

The monomers of the nucleic acids are called **nucleotides. Nucleotides** are composed of three distinct parts:

1. A five-carbon sugar (deoxyribose in DNA or ribose in RNA).
2. A nitrogen-containing organic bases of the five types, uracil, cytosine, thymine, adenine and guanine.
3. A phosphate (PO_4) group.



(a) Deoxyribose (b) Ribose

The structure of the pentose (a) Deaxyribose and (b) Ribose

Deoxyribonucleic Acid (DNA)

Deoxyribonucleic acid (DNA) consists of deoxyribose sugar. Its structure was discovered by J. Watson and F. Crick in 1953. DNA exists in the form of two polynucleotide chains or strands twisted around each other in a spiral formation called a **double helix**.

The five carbon sugar and a phosphate group make the backbone of each chain and two chains are linked through bases. The strands are held together by hydrogen bonds. The order of the base pairs in a strand is a code that stores information, which is used to produce proteins.

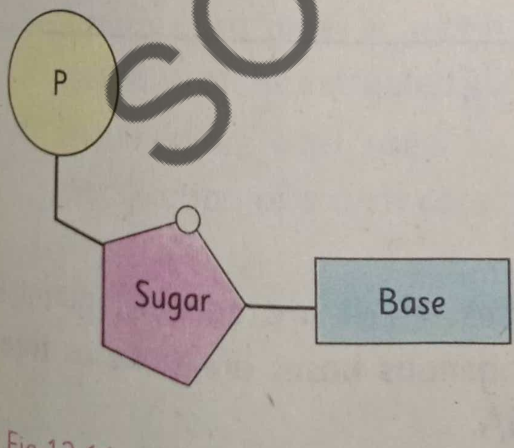


Fig.13.11 The Three Components that makes a Nucleotide

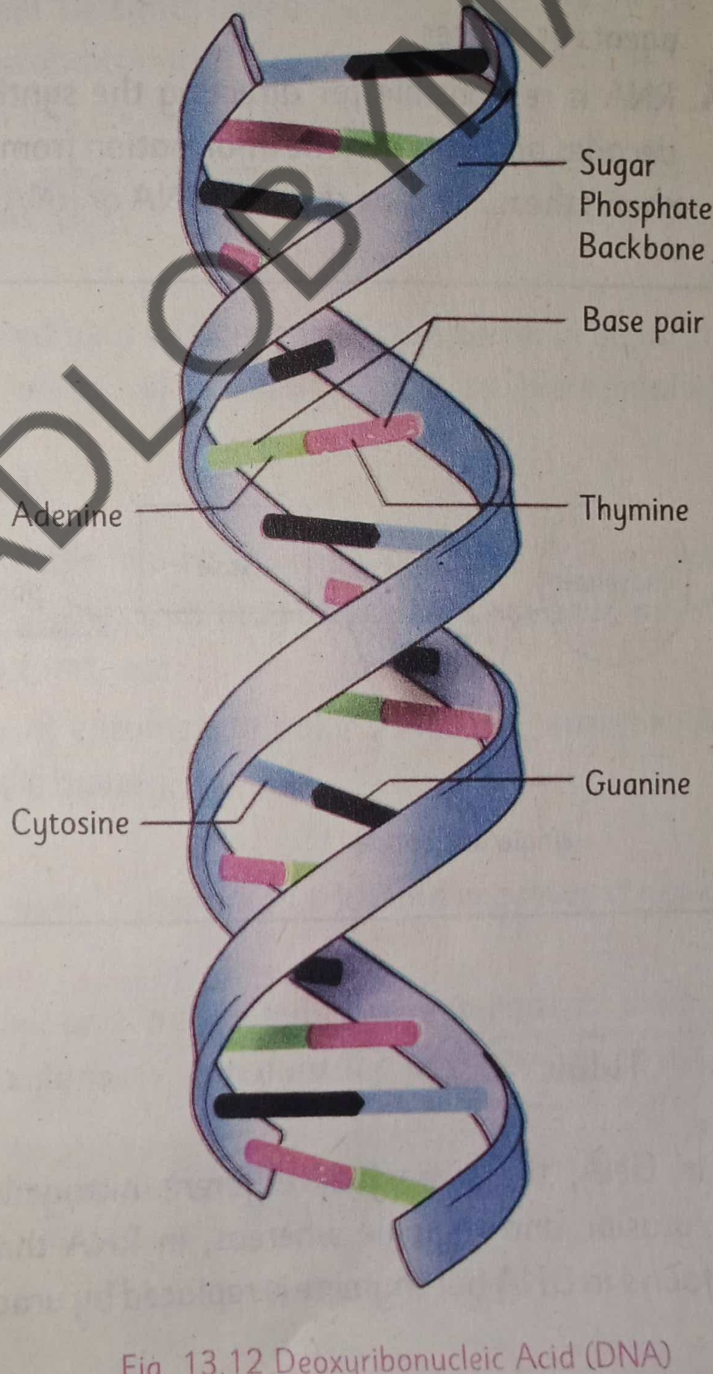


Fig. 13.12 Deoxyribonucleic Acid (DNA)

13.4.3 Functions of Nucleic Acids

1. DNA has the ability to reproduce, store and transmit genetic information from generation to generation. The genetic information for the cell are contained in the form of specific codes in DNA molecules.
2. DNA also instructs how to synthesize a particular protein from amino acids. These instructions are known as genetic code. RNA assists in this process.
3. Mutation is a sudden chemical change in a DNA (Deoxyribonucleic acid) molecule that could lead to the synthesis of proteins with an altered amino acid sequence.
   Majority of changes in DNA are repaired by special enzymes in the cell. Failure in repair by the enzyme system can cause a mutation.
   Changes in DNA molecules may be caused by mutagens like radiations, chemical agents or viruses.
4. RNA is responsible for directing the synthesis of new proteins. RNA receives, reads, decodes and uses genetic information from DNA to synthesize new proteins. Fig. 13.13 shows the nucleotide chain of DNA or RNA.

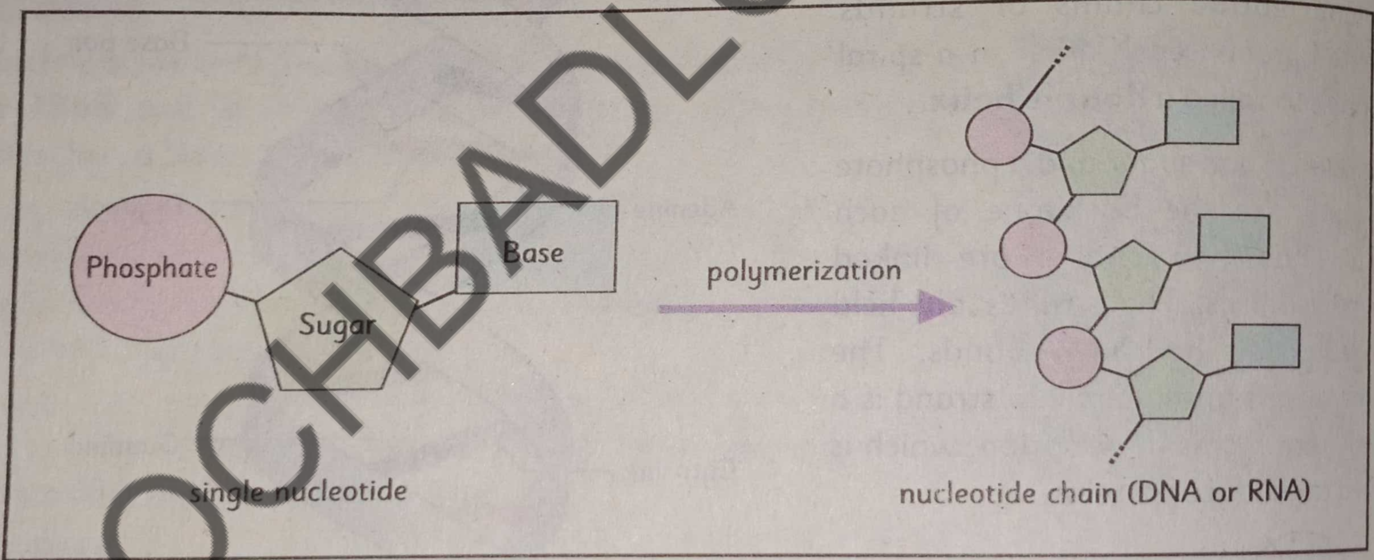


Fig.13.13 Structures of DNA and RNA

Tidbit

In DNA, there are four different nitrogenous bases which are adenine, guanine, cytosine and thymine whereas, in RNA three nitrogenous bases are same as those found in DNA but thymine is replaced by uracil in RNA.

Self Assessment

1. Name the sugar unit in DNA and RNA?
2. Define nucleotide.
3. What are the differences between DNA and RNA?

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 cannot 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 causes various diseases.

Society, Technology And Science

The Commercial Uses of Enzymes

Enzymes are biological catalysts that speed up a wide range of commercially important processes. They are used in several areas. of industry, such as biotechnology, agriculture, pharmaceuticals, etc.

Some of the commercial uses of enzymes are,

- Enzymes are widely used in the textile industry. They are used for increaing production and for fabric finishing. Enzymes that may be used in the textile industry are Amylase, Cellulase, Catalase, Pectinase etc.
- The food industry is the largest user of enzymes. In baking industry, enzymes (e.g. protease) are added to the dough while baking.
- Protease – used in biscuit production
- The use of enzymes in juice industry gives higher juice yields and improves the colour and smell of the extracted juices.
- Enzymes are also used in the pulp and paper industry. Amylase is used for modification of starch coating and xylanases to reduce the consumption of bleach chemicals.
- Enzymes are used in detergents and in personal care and hygiene.

13.5.1 Types of vitamins

There are two types of vitamins.

1. Fat soluble vitamins
2. Water soluble vitamins

1. Fat Soluble Vitamins

Vitamins which dissolve in fats are called fat soluble vitamins. These vitamins are A, D, E and K.

2. Water Soluble Vitamins

Vitamins which dissolve in water are called water soluble vitamins. These vitamins are B-complex (this include eight vitamins) and vitamin C (ascorbic acid).

- **Vitamins**
  - Water Soluble Vitamins
    - Vitamin C
    - Vitamin-B Complex
  - Fat Soluble Vitamins
    - Vitamin A
    - Vitamin D
    - Vitamin K
    - Vitamin E

Sources and deficiency symptoms/diseases of vitamins are given in the table 13.1.

Table 13.1 Sources and Deficiency Symptoms/Diseases of Vitamins

Vitamin	Sources	Necessary for	Deficiency Symptoms
A	Milk, butter, fish oils, eggs, fresh green vegetables and fruits	Eyes and skin	Night blindness, dry skin, burning/ irritation of eyes.
B (complex of eight vitamins) B_1,B_2,B_3, B_5,B_6, Biotin, Folic acid and B_{12}	Bread, rice, yeast, liver, milk, meat, fish, eggs, soybean oil, fresh green vegetables	Energy production in cells, nerves and skin	Skin diseases, tongue /lips inflammation, anaemia, bleeding gums, beriberi.

C (Ascorbic Acid)	Citrus fruits (Oranges, lemons) etc, tomatoes, fresh green vegetables	Blood vessels, gums, healing wounds, preventing cold.	Scurvy (Bleeding from gums), pain in joints.
D	Milk, butter, eggs, fish oils, vegetables.	Bones, teeth	Rickets, osteomalacia
E	Bread, rice, eggs, liver, butter, fresh green vegetables, corn and soybean oil.	Antioxidant	Haemolysis of red blood cells (Anaemia), sterility.
K	fresh green vegetables, liver, egg yolk, meat, cheese.	Clotting of blood	Hemorrhage, delayed blood clotting.

13.5.2 Importance of Vitamins

Each vitamin plays an important role in the healthy development and growth of our body. Our body needs a small amount of vitamins and minerals every day to remain healthy, function properly and prevent in future from health problems. They also play important roles in bodily functions such as metabolism,, immunity and digestion. Our body does not have the ability to synthesize or make vitamins.

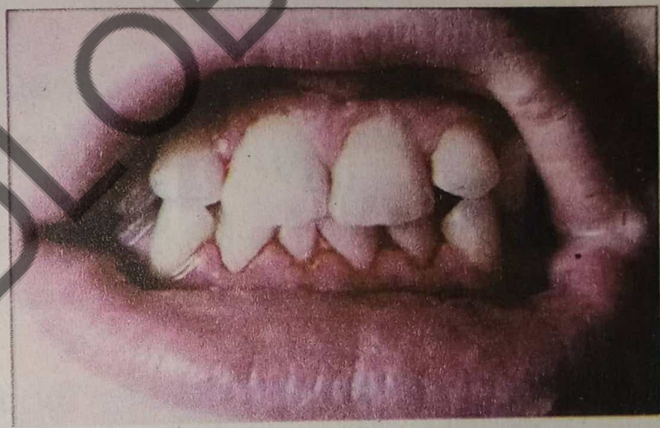


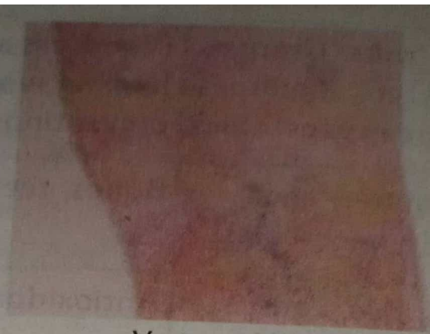
Fig.13.14 Deficiency of Vitamin C cause Scurvy (Bleeding from gums)

- Vitamin C is necessary for the formation of blood, improvement of the immune system and protection against illnesses, including the common cold.
- Vitamin A is important for vision. It also keeps the cornea moist.

Fig.13.15 Deficiency of Vitamin A

- Vitamin E has been considered responsible for youth preserving and a defender against the carcinogenic (cancer-causing) effects of certain chemicals.


Premature aging


Varicose Veins


Acne

Fig. 13.16 Deficiency of Vitamin B

- Vitamin B helps to regulate nerve impulse transmissions.
- Deficiency of vitamin B_{12} may result in the inflammation and irritation of the corner of the mouth and cracks in lips.
- Vitamin D regulates blood calcium, necessary for proper bones and tooth growth.

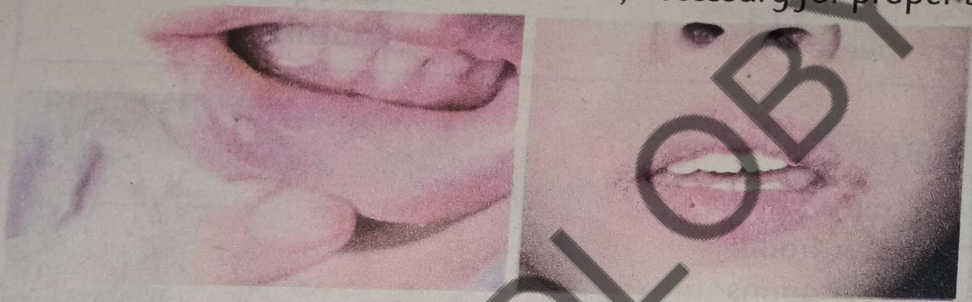


Fig. 13.17 Deficiency of Vitamin B_{12}


Fig. 13.18 Deficiency of Vitamin D cause Rickets

Self Assessment

1. What are the different types of vitamins? **2.** Write down the name of fat-soluble vitamins. **3.** What is mean by vitamin B complex? **4.** Explain the disadvantages of fat-soluble vitamins.

Activity 13.3 **The biochemistry of food. Complete the table accordingly**

Name of Macromolecule	Elements that Compose	Building block(s)	Function	Examples	Food Sources
Carbohydrate					
Proteins					
Lipids					
Nucleic acid					

Key Points

- Biochemistry is the study of the organic compounds and reactions that occur in living things.
- Carbohydrates, proteins, lipids, nucleic acids and vitamins are called macromolecules.
- Carbohydrates are composed of carbon, hydrogen and oxygen in the ratio 1:2:1 respectively.
- Carbohydrates have a general formula of $C_n(H_2O)_n$, here 'n' will take a value of either 3 or greater than 3.
- Carbohydrates are divided into three main classes, Monosaccharides, Oligosaccharides and Polysaccharides.
- A glycosidic linkage or glycosidic bond is the link between the rings in an oligosaccharide or polysaccharide.
- Proteins are highly complex nitrogenous substances that are made up of amino acids present in all living organisms.
- Out of the twenty amino acids, our body can prepare ten amino acids. These Amino acids are called non-essential amino acids. The remaining ten are called essential Amino acids.
- Lipids are biological molecules obtained from plants and animals tissues. They are not soluble in water but are soluble in non-polar solvents, such as alcohol, chloroform, ether, etc.
- Fatty acids are carboxylic acids (or organic acid), often with a long aliphatic tails (long chains), either saturated or unsaturated.
- Fats are glycerides in which long chain saturated fatty acid components predominate and tend to be solid or semisolid at room temperature e.g. palmitic acid
- Oils are glycerol esters which contain higher proportions of unsaturated fatty acids components which make them liquids at room temperature e.g. oleic acid.
- Nucleic acids are complex bio-molecules composed of units called nucleotides.
- DNA store genetic information in the nucleus of the cell.
- Vitamins are organic compounds that cannot be synthesized by an organism but are very essential for the maintenance of normal metabolism and therefore must be included in the diet.
- There are two types of vitamins i.e. fat soluble vitamins and water soluble vitamins.

Exercise

A. Choose the correct option.

1. Which one of the following is a disaccharide?
   a. Glucose b. Fructose c. Sucrose d. Starch
2. A large number of amino acids polymerizes into
   a. Vitamins b. Carbohydrates c. Protein d. Lipids
3. Glycogen is an example of
   a. Fats b. Nucleic acids c. Carbohydrates d. Protein
4. Deficiency of vitamin A causes
   a. Scurvy b. Rickets c. Night blindness d. Aging
5. The compound which is found in every living cell and serves as a centre of information and control is
   a. Protein b. Amino acids c. DNA d. Glucose
6. Triglycerides are the building blocks of
   a. Protein b. Carbohydrates c. Lipids d. Vitamins
7. Sugars are polyhydroxy derivative of
   a. Alkyl halides b. Aldehyde
   c. Ketone d. Aldehyde and Ketone
8. Peptide linkage is present in
   a. Carbohydrates b. Lipids c. Proteins d. Vitamins
9. Plants convert glucose into
   a. Amino acids b. Lipids c. Proteins d. Starch
10. All are present in DNA except
    a. Deoxyribose sugar b. Ribose sugar c. Nitrogen base d. Phosphate unit

B. Short questions.

1. Differentiate between glucose and fructose?
2. Write down four uses of lipids.
3. How would you differentiate between simple and complex lipids.
4. What is meant by denaturing of protein?
5. How would you classify vitamins?
6. Vitamins are vital for us, why?

7. Write down the products of sucrose hydrolysis.
8. Draw the general formula of amino acid. Identify the different parts and functional groups present in it.
9. Briefly describe the sources and deficiency symptoms of vitamin A.
10. Identify the different sources of proteins? Also, list the four uses of proteins.

C. Long questions.

1. What functions do carbohydrates perform in living organisms?
2. a. Distinguish between monosaccharides, disaccharides and polysaccharides and also give examples of each one.
   b. How are carbohydrates important to living organisms?
3. a. How are proteins important to living organisms?
   b. Describe the nature of bonding in protein?
4. a. Define the term lipid.
   b. Distinguish between fats and oils.
   c. List four foods you eat that contain lipids.
   d. How are lipids important to your body?
5. a. How would you justify DNA as genetic code of life?
   b. Distinguish between DNA and RNA
   c. Explain the functions of DNA.
6. a. Define the term Vitamin and classify it.
   b. Explain the important sources of vitamins.
   c. Write down the names of five vitamins and their importance.

Project

1. A healthy diet is a diet that helps to maintain or improve overall health. Prepare a healthy diet plan for a week for yourself and share with your classmates.
2. Explain why agricultural and nutritional sciences are vital.