CHAPTER 10 BIOCHEMISTRY

"Biochemistry is the branch of science that deals with the chemical process taking place in the organisms."

CARBOHYDRATES

"Polyhydroxy aldehydes and ketones are called carbohydrates."

Carbohydrate is a nutrient for human beings and animals.

DO YOU KNOW?

- 1 gram of carbohydrate provides approximately 4 calories.
- 1 gram of protein provides approximately 4 calories.
- 1 gram of fat (lipid) provides approximately 9 calories.

Classification based on structure

On the basis of structures, carbohydrates can be classified into four categories:

1) Monosaccharides
2) Disaccharides
3) Oligosaccharides
4) Polysaccharides

1) Monosaccharides

Monosaccharides contain a single sugar unit.

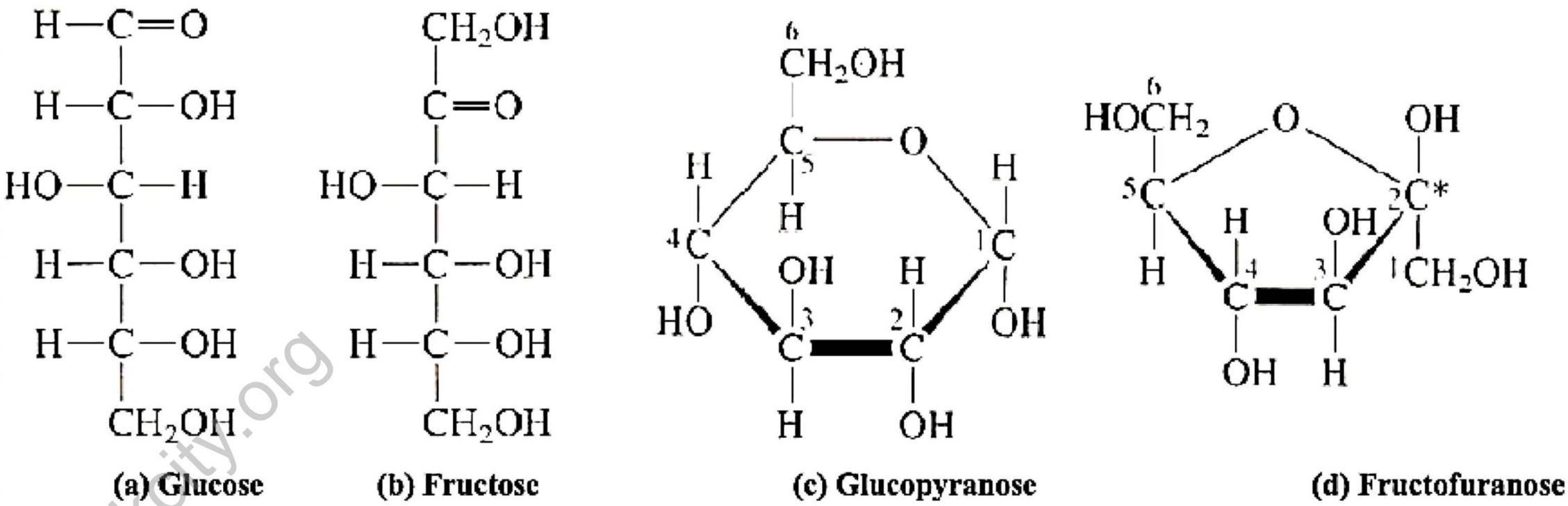
For example: glucose, fructose, galactose etc.

Monosaccharides are further classified on the basis of number of carbon atoms.

Class of Monosaccharide	Formula	Examples
Triose	$C_3H_6O_3$	Glyceraldehyde
Tetrose	$C_4H_8O_4$	Erythrose
Pentose	$C_5H_{10}O_5$	Ribose
Hexose	$C_6H_{12}O_6$	Glucose

Hexose sugars are classified into **aldohexose** and **ketohexose**. Glucose is an example of aldohexose because it contains aldehyde group while fructose is an example of ketohexose because it contains ketone group.

Glucose and fructose exist in both open chain and closed chain form. However, the open chain form is relatively unstable. The close chain form of glucose is called pyranose (6 membered ring) whereas the close chain form of fructose is called furanose (5 membered ring).



(a) Glucose (b) Fructose (c) Glucopyranose (d) Fructofuranose

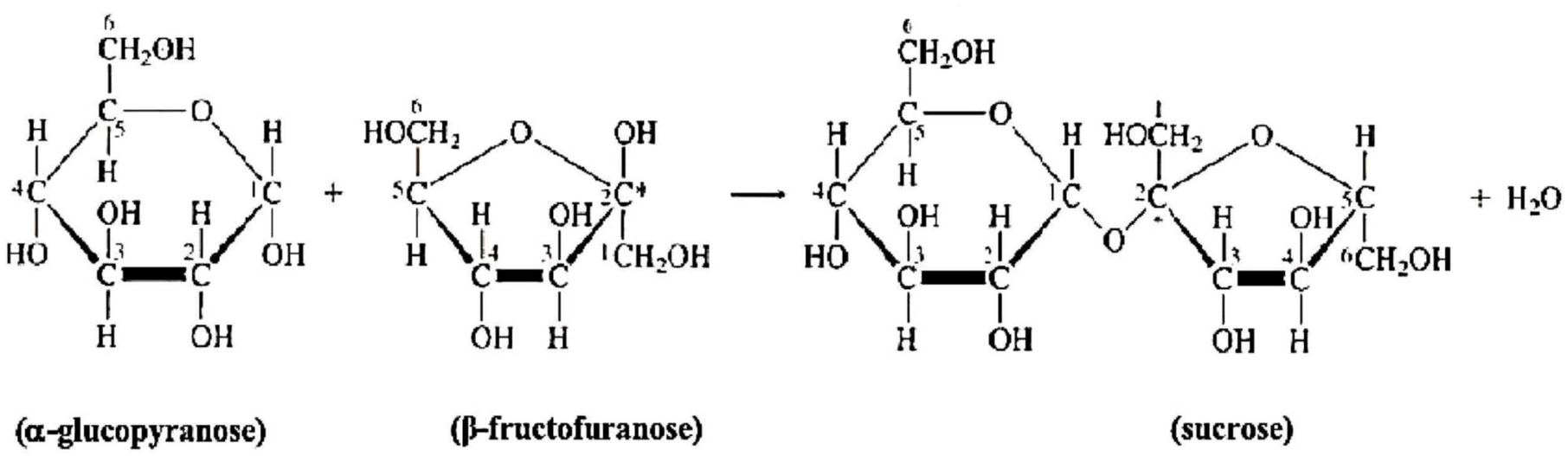
2) Disaccharides:-

Disaccharides contain two sugar units.

For example: sucrose lactose, maltose etc.

Monosaccharides are joined together though 'glycosidic bond' to form disaccharide. (O-C-O) bond is called glycosidic bond. It's formed through a condensation reaction by the elimination of water molecule.

Disaccharides are water soluble crystalline solids and represented by molecular formula $C_{12}H_{22}O_{11}$.



(α-glucopyranose) (β-fructofuranose) (sucrose)

3) Oligosaccharides (Oligo = Few)

Oligosaccharides contain 3 to 10 sugar units.

For example: kestose (glucose+fructose+fructose), melezitose (glucose+fructose+glucose)

4) Polysaccharides

Polysaccharides contain more than 10 sugar units.

For example: cellulose, starch, glycogen etc.

Polysaccharides are macromolecules or polymers of monosaccharides. They are amorphous, water insoluble and made up of more than 10 hexose sugars.

Hexose units are joined together by glycosidic bond.

Polysaccharides are further classified into animal polysaccharides and plant polysaccharides.

An example of animal polysaccharide is glycogen, which is found in the liver of animals. It's a storage of carbohydrate and commonly known as anima starch.

Examples of plant polysaccharide are starch and cellulose. Starch is found in potato, wheat, barley etc. Cellulose is found in the cell wall of plant.

Role of Common Carbohydrates in Health and Disease

Glucose

It's a vital component of our blood. The normal range of glucose in blood ranges between 70 to 110 mg per 100 dl. However, if glucose level exceeds this range, it can lead to Diabetes.

Fructose

It is found in fruits and honey. It's the sweetest sugar.

Lactose

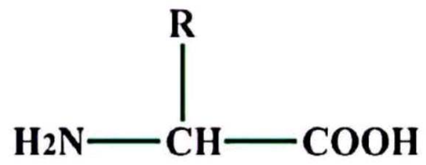
It's a disaccharide. It's found in milk so it's also known as milk sugar. It's broken down into glucose and galactose in the alimentary canal by the enzymic activity.

Sucrose

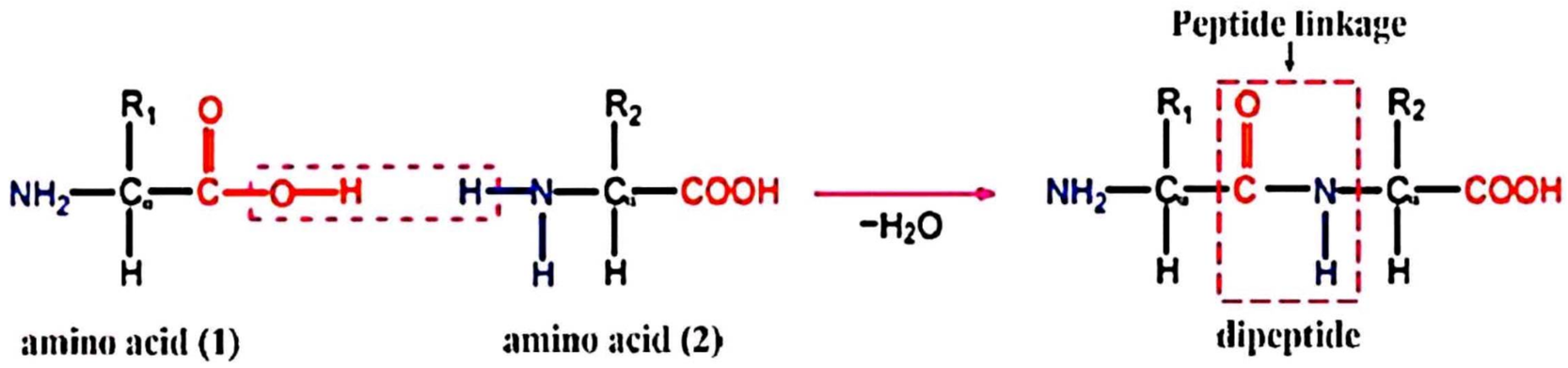
It's also a disaccharide and made up of a glucose and a fructose sugar. It's known as table sugar or cane sugar. An excess amount of sucrose in our diet can cause the development of gum disease such as plaque formation in the teeth and even tooth decay.

PROTEINS

Proteins are naturally occurring macromolecules made up of long chain of amino acids.



There are 22 types of α amino acids that can be used to build proteins. Each amino acid consists of an amino group as well as a carboxyl group. These amino acids are associated with each other through poly peptide linkage (CONH).



Classification of proteins

Proteins may be classified on the basis of their functions and structures.

CLASSIFICATION OF PROTEINS ON THE BASIS OF FUNCTION:

Based on functions, proteins are classified into following types.

(i) Catalytic Proteins (Enzymes)

Enzymes are biological catalysts. They increase the rate of the biological reaction multiple fold as compared to a chemical catalyst. Our bodies contain numerous catalytic proteins which facilitate the chemical reactions inside the body. For example, lipase catalysis the decomposition of lipids into fatty acids in our alimentary canal.

$$\text{Starch} + H_2O \xrightarrow{\text{Amalyase}} \text{Glucose}$$

$$\text{Protein} + H_2O \xrightarrow{\text{Protease}} \text{Amino acid}$$

$$\text{Lipid} + H_2O \xrightarrow{\text{Lipase}} \text{Fatty acid}$$

(ii) Storage Proteins:

These proteins store nutrients or metal ions in a particular part of plants or animals. For example, Albumin, Globulin and Casein etc.

(iii) Transport Proteins:

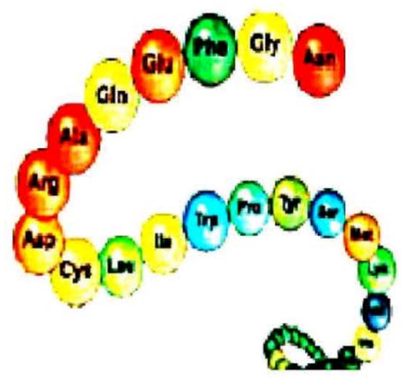
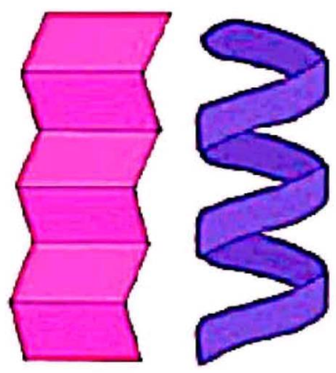
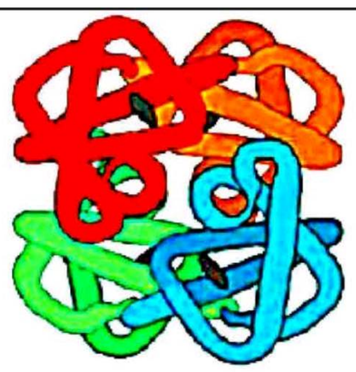
These proteins facilitate the movement of molecules, ions and other substances across cellular membrane and in the blood stream. For example: hemoglobin.

(iv) Hormonal Proteins:

These proteins play a critical role in regulating the function of body by transmitting signals between the cells.

CLASSIFICATION OF PROTEINS ON THE BASIS OF STRUCTURE:

Proteins are classified into four main types based on their structures.

Primary	➢ It is a linear sequence of amino acids in the protein chain. ➢ This sequence plays a crucial role in determining the overall shape and function of the protein.	
Secondary	➢ It refers to the folding patterns in polypeptide chains due to interactions between nearby amino acids. ➢ The two secondary common structures are alpha helix and beta sheets. ➢ The Stabilization of secondary structure is due formation of hydrogen bonds between N-H and C=O groups of amino acids	
Tertiary	➢ It refers to three-dimensional arrangement of a protein molecule having folded and refolded polypeptide chain. ➢ The stability of molecule is due to the presence of following types of forces among polypeptide chain; • Salt bridge (ionic bond) • Disulfide bridge (covalent bond) • Van der Waals forces • Hydrogen bond ➢ Example: Myoglobin exhibits a tertiary structure.	
Quaternary	➢ It is a large complex protein molecule and formed by the interaction of multiple protein subunits. Example: Hemoglobin, which consists of four subunits and illustrates the quaternary structure.	

Properties of proteins

(i) Proteins are water soluble due to the di polar terminal of amino acids in the polypeptide chain.
(ii) Proteins are amphoteric in nature because of the presence of–COOH as well as $–NH_2$ group in their structure of amino acid sequences.
(iii) Proteins exhibit flexibility due to the ability of amino acid chain rotation.
(iv) Certain proteins exist in various colours i.e. haemoglobin.
(v) Proteins are thermally stable, however the structure of proteins are disrupted by heating, at elevated temperature or by a sharp change in the pH.

Importance of proteins

(i) Proteins provide energy for the body and in a rough estimation, 1g of protein provides four calories.
(ii) Haemoglobin is a protein, it transports oxygen from the lungs to every tissue of the body.
(iii) Harmones are proteins which regulate various physiological functions in the body.
(iv) Antibodies are proteins which play a very important role in the immune system of the body.

LIPIDS

"Lipids are naturally occurring heterogenous organic compounds that are insoluble in water but soluble in Bloor's reagent."

Bloor's reagent is a mixture of diethyl ether and ethyl alcohol.

Classification of lipids

Lipids are classified into three main groups.

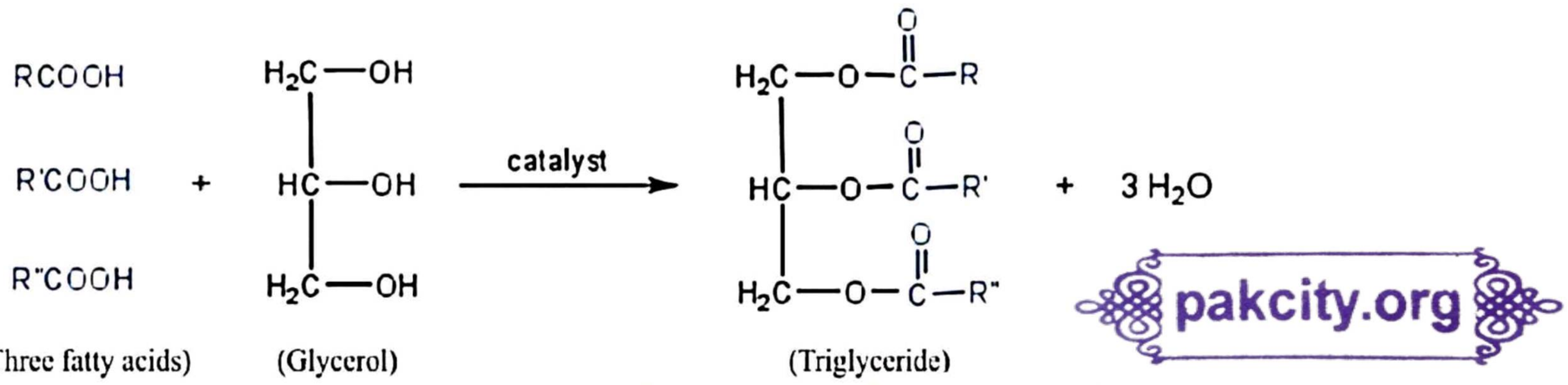
a) Simple lipids b) Compound lipids c) Steroids

a) Simple Lipids

These lipids are chemically esters, made up of fatty acids and alcohols.

Such lipids are further classified into fat, oil and waxes.

Fats and Oils: They are also known as triglycerides or triesters. They are formed by the condensation of three fatty acid and a glycerol molecule.



Fatty acids are carboxylic acids with contains 12 to 24 carbon atoms which may be saturated or unsaturated. Oils are made up of unsaturated fatty acids and they are liquids at room temperature. Fats are made up of saturated fatty acids.

Type of Fatty Acid	Description	Examples
Saturated Fatty Acid	Contains only single bonds between carbon atoms	Stearic Acid, Palmitic Acid
Unsaturated Fatty Acid	Contains at least one double bond between carbon atoms	Oleic Acid, Linoleic Acid.

Waxes: Waxes are naturally occurring esters of long-chain fatty acids and long chain alcohols.

For example:

$$C_{15}H_{31} - COO - C_{16}H_{33}$$
(Bees wax)

b) Compound Lipids

These are esters of glycerol with two fatty acids and some other compounds sch as carbohydrates, amino acids, phosphoric acid etc.

c) Steroids

Non-saponifiable lipids are called steroids. It contains a polycyclic structure.

Examples of steroids are cholesterol and cholic acid.

Properties of lipids

A. Physical Properties

- Lipids exist in different physical states depending upon their chemical nature and temperature. For example, fat exists in solid state, wax is semisolid state and oil in liquid state at room temperature.
- Lipids are translucent or opaque in nature.
- Lipids are insoluble in water and soluble in the organic solvents; like Bloor's reagent.
- Lipids have low density which enables them to float on water.
- Melting point of saturated lipids is higher than unsaturated lipids.

B. Chemical Properties

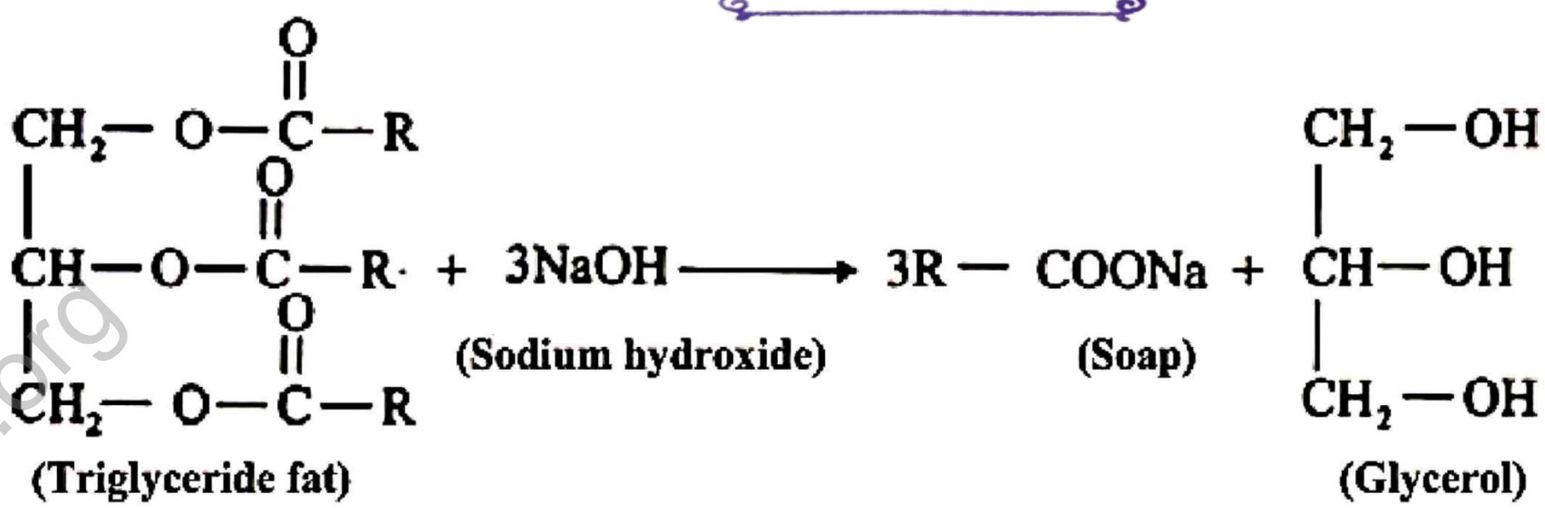
i) Addition Reactions:

Oils undergo addition reactions with hydrogen in the presence of nickel catalyst to produce fats.

$$R\text{-}CH{=}CH\text{-}COOH + H_2 \text{ ----------} R\text{-}CH_2\text{-}CH_2\text{-}COOH$$

ii) Saponification

Fats and oils are hydrolyzed when heated with an alkali to produce soap and glycerol, this process is known as saponification.



iii) Rancidity

When animal fats are exposed to moist air, they undergo oxidation and hydrolysis reactions simultaneously leading to the development of an unpleasant taste and odor. This process is called rancidity.

Importance of lipids

(i) They store chemical energy in the form of triglycerides in adipose tissues. They store more than twice energy as compared to carbohydrates and proteins. This stored energy is used during fasting.

(ii) They are fundamental building blocks of cell membranes. Due to their water insolubility, they protect the cell by forming a phospholipid layer which allows the movement of substances in and out of the cell.

(iii) Lipids in adipose tissues help maintaining the body temperature and serve as insulation of the body.

(iv) They help in the absorption and utilization of fat soluble vitamins such as vitamin A, D, E and K.

IMPORTANCE OF MINERALS IN OUR BODY:

1. IRON:

It involves in the oxygen transport, immune function and the production of red blood cells.

2. CALCIUM:

Calcium is used to build strong bones and teeth. It also helps in immune system.

3. PHOSPHORUS:

Being a part of DNA and RNA, it is important for protein synthesis and transferring genetic information.

4. Zinc:

It improves our immune system and enhances insulin activity. It also activates our sense of smell and taste. Deficiency of zinc causes loss of weight, appetite and taste.

Multiple Choice Questions

(i) Starch and Sucrose are examples of:
(a) Monosaccharides and Disaccharides
(b) Disaccharides and Oligosaccharides
(c) Polysaccharides and Disaccharides
(d) Monosaccharides and Polysaccharides

(ii) Amino acid units bonded in protein molecule through:
(a) Glycosidic linkage (b) Ether linkage
(c) Peptide linkage (d) Hydrogen bridge

(iii) Proteins are composed of:
(a) Amino acids (b) Carbohydrates
(c) Lipids (d) Nucleic acids

(iv) A condensation polymer of amino acid is:
(a) Protein (b) Lipids
(c) Starch (d) Glycogen

(v) Saponification is the formation of soap by the reaction of fat and oil with:
(a) An alkali (b) An acid
(c) Sugar (d) Glycerol

(vi) Which of the following mineral is considered to be essential for immune system:

(a) Iron (b) Zinc
(c) Magnesium (d) Calcium

(vii) Rancidity is a chemical process involving:

(a) Oxidation and hydrolysis (b) Condensation and reduction
(c) Polymerization (d) Decarboxylation

(viii) Lipid which is a major component of cell membrane is:

(a)Triglyceride (b) Phospholipid
(c) Glycolipid (d) Steroid

(ix) Total numbers of alpha amino acids are:

(a) 19 (b) 22
(c) 25 (d) 28

(x) Sugar molecules are classified as:

(a) Fats (b) Proteins
(c) Carbohydrates (d) Lipids

Short Questions

1. Mention the three main functions of lipids.

ALREADY DISCUSSED ABOVE

2. Comparing with other nutrients, why lipids are better source of energy?

Ans. Lipids are better source of energy because they can provide more energy in a little amount.

3. Carbohydrates are necessary component of our diet. Give two dietary importance of carbohydrates.

ALREADY DISCUSSED ABOVE

4. What is meant by saponification? Give the reaction.

ALREADY DISCUSSED ABOVE

5. What is rancidity which chemical reaction involves in this process?

ALREADY DISCUSSED ABOVE

6. Write three essential functions of protein in the body.

ALREADY DISCUSSED ABOVE

7. Write down the sources from which we intake fructose and lactose.

ALREADY DISCUSSED ABOVE

Descriptive Questions

1. What are Carbohydrates? Give their classification on the basis of structure.

ALREADY DISCUSSED ABOVE

2. Explain the role of glucose, fructose, sucrose and lactose in the health of human being.

ALREADY DISCUSSED ABOVE

3. What are Proteins? Classify various types of proteins on the basis of their function.

ALREADY DISCUSSED ABOVE

4. What are Lipids? Give their classification, properties and biological significance.

ALREADY DISCUSSED ABOVE

5. How can you explain primary, secondary and tertiary structure of proteins?

ALREADY DISCUSSED ABOVE

6. Describe physical properties of proteins.

ALREADY DISCUSSED ABOVE

7. Why minerals are essential for our health? Give the biological significance of Calcium, Iron, Zinc, and phosphorus.

ALREADY DISCUSSED ABOVE