CHAPTER 21

BIOCHEMISTRY

Introduction to Biochemistry

As the name indicates, biochemistry is a hybrid science: Biology is the science of living organisms and chemistry is the science of atoms and molecules, so biochemistry is the science of the atoms and molecules in living organisms.

Biochemistry:

"It is the branch of science concerned with studying the various molecules that occur in living cells and organisms, with their chemical reactions."

Biochemistry is concerned with the complete spectrum of all forms of life, from relatively simple viruses and bacteria to complex human beings.

It attempts to describe in molecular terms the structures, mechanisms, and chemical processes shared by all organisms.

Living organisms should be able to transform matter and energy into different forms, show response to changes in their environment and show growth and reproduction. All living organisms undergo changes due to large organic compounds called macromolecules. Four main types of macromolecules control all activities. They are carbohydrates, proteins, lipids and nucleic acids.

CARBOHYDRATES

Modern definition:

"The polyhydroxy compounds of aldehydes or ketones are called carbohydrates"

Carbohydrates are called carbohydrates because they contain carbon, oxygen and hydrogen and these are generally in proportion to form water with the general formula $C_n(H_2O)_n$. Carbohydrates or saccharides are the most abundant of the four types of macromolecules. These are sugars or starches.

Importance of carbohydrates:

They have several roles in living organisms, including energy transportation, as well as being structural components of plants and arthropods.

Carbohydrate derivatives are actively involved in fertilization, immune systems, development of disease, blood clotting and growth.

Most organic matter on earth is made up of carbohydrates because they are involved in so many aspects of life, including:

(i) Energy stores, fuels, and metabolic intermediates.

(ii) Ribose and deoxyribose sugars are part of the structural framework of RNA and DNA.

(iii) The cell walls of bacteria are mainly made up of polysaccharides (types of carbohydrate).

(iv) Cellulose (a type of carbohydrate) makes up most of plant cell walls.

(v) Carbohydrates are linked to many proteins and lipids (fats), where they are vitally involved in cell interactions.

Do you know?

All the organic compounds containing hydrogen and oxygen in the proportion of 2:1 are not carbohydrates. For examples:

(i) Formaldehyde $-HCHO = C(H_2O)$

(ii) Acetic acid $-CH_3COOH = C_2(H_2O)_2$

(iii) Lactic acid $-CH_3CH(OH)COOH = C_3(H_2O)_3$

Anyhow, Rhaminose $C_6H_{12}O_5$ does not have the ratio of hydrogen to oxygen as in H_2O, but it is a carbohydrate.

Classification of Carbohydrates

The commonly described classification is given below.

Carbohydrates

Sugars

- Crystalline solids
- Soluble in water
- Sweet in taste
- Micromolecules

Monosaccharides

- Simplest suger
- Cannot be hydrolize
- Aldoses or Ketoses

e.g. Glucose, fructose etc.

Oligosaccharides

- Contain 2 - 9 monosaccharides
- can be hydrolize
- di, tri, tetra saccharides

e.g. sucrose, lactose etc.

Non - sugars

- Amorphous solids
- Insoluble in water
- Tasteless
- Macromolecules

↓

Polysaccharides

- Contain more than 9 monosaccharides
- can be hydrolize
- Have structural and storage function

e.g. Starch, Cellulose, Glycogen etc.

Exercise: Q.3(i) Describe different classes of Carbohydrates.

(a) Monosaccharides

The carbohydrates which do not hydrolyze to simpler units are called monosaccharides.

They have an empirical formula $(CH_2O)_n$ where n = 3 or some large number.

There are 20 monosaccharides which occur in nature.

When monosaccharides merge together in linked groups, they are called polysaccharides.

Classification of Monosaccharides

Based on number of Carbon Atoms		Based on Functional Group
3 C	Trioses	**Having aldehydic group = Aldoses** Aldotriose = Glyceraldehyde Aldopentoses = Ribose, Xylose Aldohexoses = Glucose, Mannose, Galactose
4 C	Tetroses	
5 C	Pentoses	
6 C	Hexoses	
7 C	Heptoses	**Having ketonic group = Ketoses** Ketotriose = Dihydroxy acetone Ketopentose = Ribulose Ketohexoses = Fructose, Sorbose
8 C	Octoses	
9 C	Nonoses	

(i) Glucose

Glucose also called:

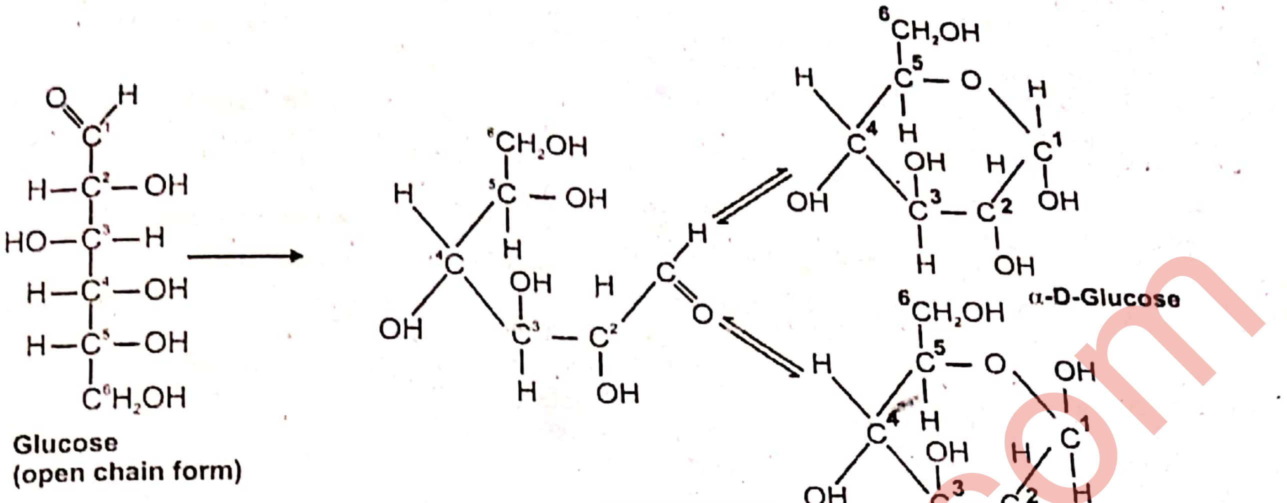
Dextrose because it occurs in nature as the optically active dextrorotatory isomer.

Grape sugar because it is present in most sweet fruits specially grapes and in honey.

Blood sugar because small quantities of glucose are also present in human blood and urine. The blood normally contains 65 to 110 mg of glucose per 100 mL.

In the combined state, it forms a major component of many disaccharides and polysaccharides.

It is the source of energy in our body.



Glucose (open chain form)

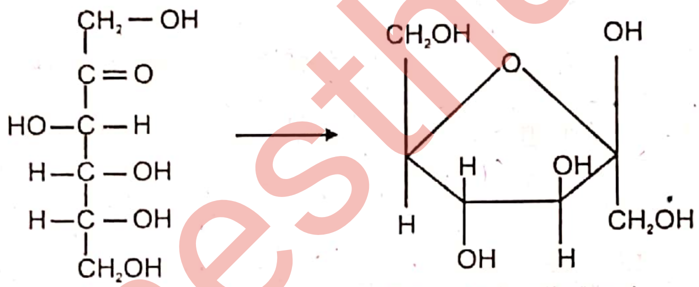
α-D-Glucose

β-D-Glucose (Glucose (cyclic form))

α-D-Glucose	⇌	Open chain form	⇌	β-D-Glucose
36%		0.02%		64%

(ii) Fructose

- Fructose is also found in combined and free states.
- Fructose is found mostly in vegetables and fruits grapes.



Fructose (open chain form) Fructose (cyclic form)

(iii) Galactose

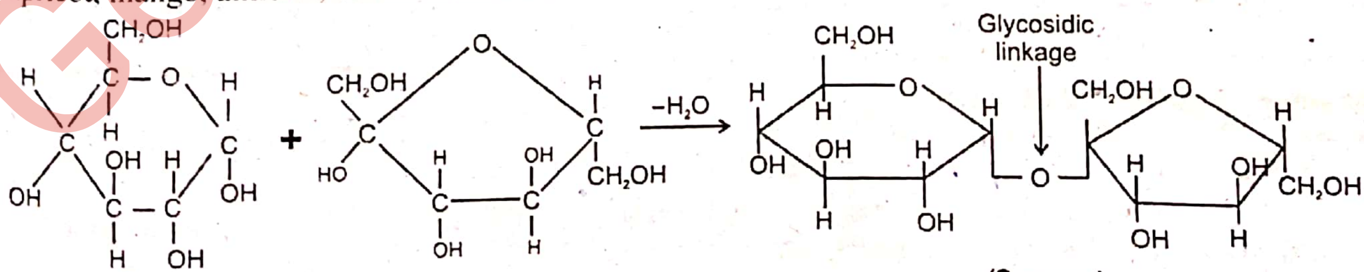
In human nutrition galactose can be found most readily in milk and dairy products.

(b) Disaccharides

"Two monosaccharide molecules are bonded together to form disaccharides. Disaccharides are polysaccharides; "poly" specifies any number higher than one, while "di" specifies exactly two."

Examples:

(i) Sucrose: It is a common table sugar and is a disaccharide of glucose and fructose. It occurs in sugar cane, sugar bo pineapple, apricot, mango, almond, coffee and honey.



α-D-Glucose Fructose (Sucrose)

(ii) Lactose (milk sugar): It is a disaccharide of glucose and galactose. It occurs in the milk of all animals. It does not occur in plants.

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Galactose}}{C_6H_{12}O_6}$$

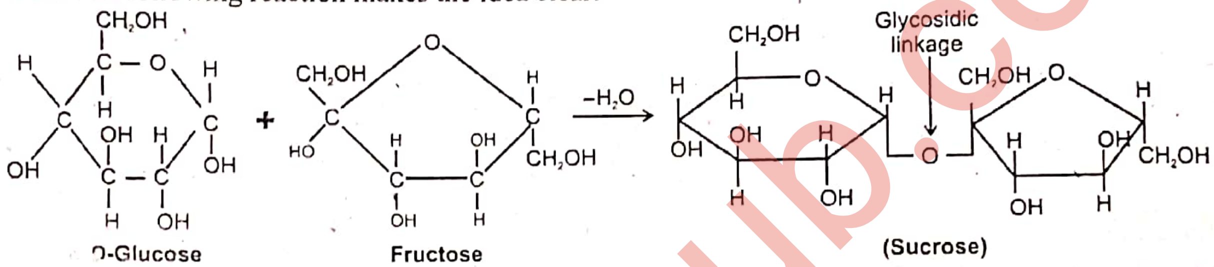
Maltose $\xrightarrow{H_2O}$ Glucose + Glucose
Lactose $\xrightarrow{H_2O}$ Glucose + Galactose
Sucrose $\xrightarrow{H_2O}$ Glucose + Fructose

(iii) Maltose: It is a disaccharide of two glucose molecules.

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{(Enzyme maltase)}]{H^+} \underset{\text{Glucose}}{2C_6H_{12}O_6}$$

Q: How the monosaccharides combine with each other?

Ans. Disaccharides are the acetals which are formed from two monosaccharides by the elimination of one molecule of H_2O. The OH group of one monosaccharide molecule acts as alcohol. It forms a glycosidic linkage with the hemiacetal group of second monosaccharide molecule. In this way, glucoside is produced which is called disaccharide. The following reaction makes the idea clear.



If we bond one glucose molecule with a galactose molecule we get lactose, which is commonly found in milk.

(c) Polysaccharides

"The carbohydrates producing large number of mono-saccharides on hydrolysis are called polysaccharides."

Polysaccharides are polymers. A simple compound is a monomer, while a complex compound is a polymer which is made of two or more monomers.

Examples: Starch, cellulose, glycogen etc.

These are chains of two or more monosaccharides.

The chain may be branched (molecule is like a tree with branches and twigs) or unbranched (molecule is a straight line with no twigs).

Polysaccharide molecule chains may be made up of hundreds or thousands of monosaccharides.

Monosaccharides	Disaccharides	Polysaccharides
Glucose, Galactose, Fructose, Ribose, Glyceraldehyde	Sucrose, Maltose, Lactose	Starch, Glycogen, Cellulose

Interesting Information

Glycemic Index:

A new system for classifying carbohydrates is the glycemic index. The glycemic index ranks foods on how they affect blood sugar level by measuring how much the blood sugar increases after one eats.

Functions of Carbohydrates

The main functions of carbohydrates are given below:

(i) They spare protein so that protein can concentrate on building, repairing, and maintaining body tissues instead of being used up as an energy source.

(ii) For fat to be metabolized properly, carbohydrates must be present. If there are not enough carbohydrates, then large amounts of fat are used for energy. The body is not able to handle this large amount so quickly, so it accumulates ketone bodies, which make the body acidic. This causes a condition called ketosis.

(iii) Carbohydrate is necessary for the regulation of nerve tissue and is the only source of energy for the brain.

(iv) Certain types of carbohydrates support the growth of healthy bacteria in the intestines for digestion.

(v) Some carbohydrates are high in fibre, which helps prevent constipation and lowers the risk for certain diseases such as cancer, heart disease and diabetes.

(vi) Polysaccharides act as food stores in plants in the form of starch, or in humans and other animals in the form of glycogen.

(vii) Polysaccharides also have structural roles in the plant cell wall in the form of cellulose or pectin, and the tough outer skeleton of insects in the form of chitin.

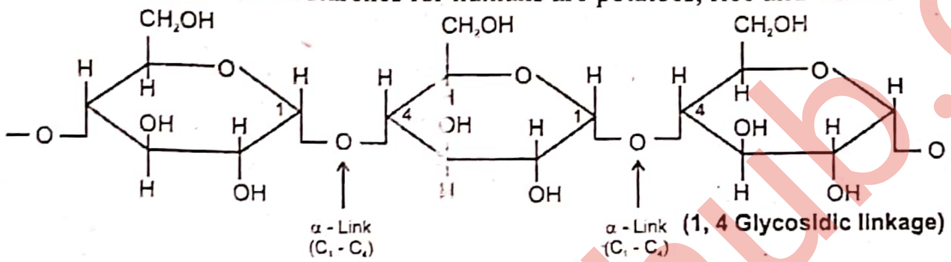
Q: Describe the major functions of polysaccharides.

Ans. Following are three major functions of carbohydrates:

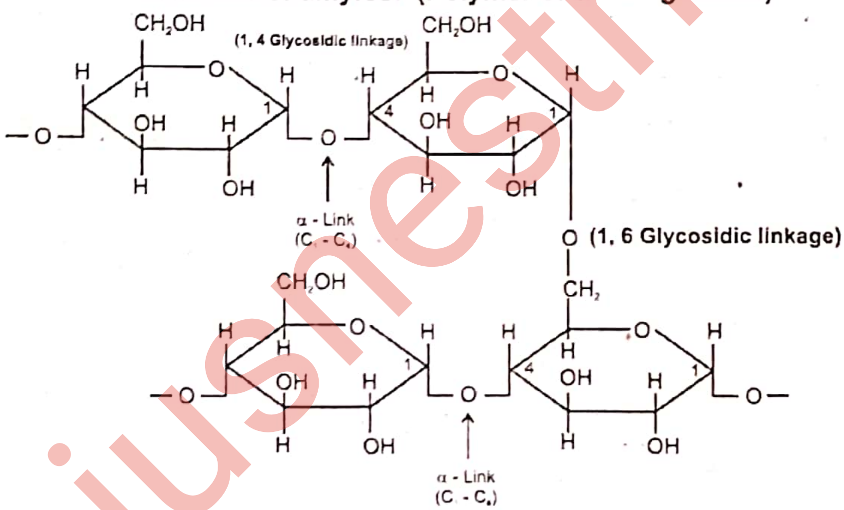
(a) Storage Polysaccharides

Glycogen - a polysaccharide that humans and animals store in the liver and muscles.

Starch - these are glucose polymers made up of Amylose (10-20%) and Amylopectin (80-90%). Starches are water insoluble. Humans and animals digest them by hydrolysis; our bodies have enzymes (amylases) which break them down. Rich sources of starches for humans are potatoes, rice and wheat.



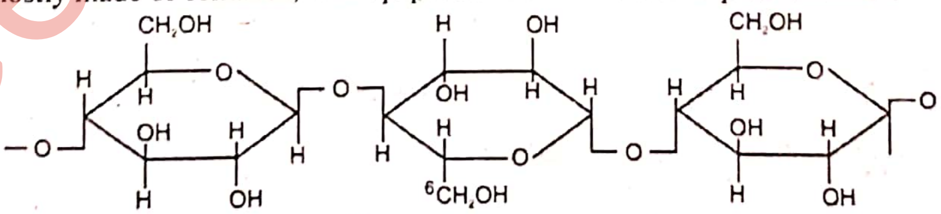
Structure of amylose (Polymer of α - D - glucose)



Structure of amylopectin (Polymer of α - D - glucose)

(b) Structural Polysaccharides

Cellulose - the structural constituents of plants are made mainly from cellulose - a type of polysaccharide. Wood is mostly made of cellulose, while paper and cotton are almost pure cellulose.



Cellulose (Polymer of β-D-Glucose)

Chitin - a polysaccharide, is one of the most abundant natural materials in the world. Microorganisms, such as bacteria and fungi secrete chitinases, which over time can break down chitin.

Chitin is the main component of fungi cell walls, the exoskeletons (hard outer shell/skin) of arthropods, such as crabs, lobsters, ants, beetles, and butterflies.

(c) Bacterial Polysaccharides

They are found in bacteria, especially in bacterial capsules. Pathogenic bacteria often produce a thick layer of mucous-like polysaccharide which protects the bacteria from the host's immune system. In other words, if the bacteria were in a human, that human's immune system would less likely attack the bacteria because the polysaccharide layer covers its pathogenic properties.

Nutritional Importance of Carbohydrates

Scientific research has shown the diverse functions of carbohydrates in the body and their importance for good health. Bread, pasta, beans, potatoes, bran, rice and cereals are carbohydrate-rich foods.

Their main functions are given by:

(a) Body Weight Regulation

People eating a diet high in carbohydrates are less likely to accumulate body fat compared with those who follow a low carbohydrate/high-fat diet. The reasons for this observation are threefold:

(i) It could be due to the lower energy density of high carbohydrate diets, as carbohydrates have fewer calories than fats.

(ii) Fiber-rich foods also tend to be bulky and physically filling, so fewer calories may be consumed.

(iii) Studies show that carbohydrates, both in the form of starch and sugars, work quickly to aid satiety and that those consuming high carbohydrate diets are therefore less likely to overeat. It is evident that diets high in carbohydrate, as compared with those high in fat, reduce the likelihood of developing obesity (موٹاپا).

Do you know?

1 gram of carbohydrate contains approximately 4 kilocalories (kcal)

1 gram of protein contains approximately 4 kcal.

1 gram of fat contains approximately 9 kcal.

Interesting Information

In several studies, high sugar consumers have been found to be slimmer than low sugar consumers.

(b) Diabetes

There is no evidence that sugar consumption is linked to the development of any type of diabetes. However there is now good evidence that obesity and physical inactivity increase the likelihood of developing non-insulin dependent diabetes, which usually occurs in middle age.

Weight reduction is usually necessary and is the primary dietary aim for people with non-insulin dependent (Type II) diabetes. Consuming a wide range of carbohydrate foods is an acceptable part of the diet of all diabetics, and the inclusion of low glycaemic index foods is beneficial as they help to regulate blood glucose control. Most recommendations for the dietary management of diabetes allow a modest amount of ordinary sugar as the inclusion of sugar with a meal has little impact on either blood glucose or insulin concentrations in people with diabetes.

(c) Dental Health

The incidence of tooth decay is influenced by a number of factors. These include:

- degree of oral hygiene and plaque removal carried out
- availability of fluoride
- type of food eaten
- frequency of consumption of any fermentable carbohydrate
- genetic factors

Foods containing sugars or starch can be broken down by the enzymes and bacteria in the mouth to produce acid which attacks the enamel of the teeth. However it is not the amount of sugar or other carbohydrate that is important but how often they are consumed. After an acid challenge, saliva provides a natural repair process which rebuilds the enamel. When carbohydrate-containing foods are consumed too frequently, or nibbled over time, this natural repair process is overwhelmed and the risk of tooth decay is increased.

(d) Getting Active

There is now substantial evidence that carbohydrates can improve the performance of athletes. During high intensity exercise, carbohydrates are the main fuel for the muscles. By consuming high levels of carbohydrate before, during and after training or an event, glycogen stores are kept well stocked. These stocks help the athlete to perform for longer and help their bodies sustain the effort.

The vital role of physical activity in maintaining health and fitness in the general population is now recognized. There is no doubt that many people would benefit from increasing their activity level as it helps in the regulation of body weight. It also reduces the risk of developing diseases such as heart disease and diabetes. For those who want to keep fit and active, a well-balanced high-carbohydrate diet is recommended.

QUICK QUIZ

1. What are carbohydrates? Give its general formula.

Ans. Carbohydrates are the organic compounds of carbon, hydrogen and oxygen. They are polyhydroxy compounds of aldehyde and ketone. They are widely distributed in plants and animals.

General Formula:

The general formula of carbohydrates are $C_n(H_2O)_n$. Therefore they were for the first time defined as hydrates of carbon. e.g. glucose ($C_6H_{12}O_6$), sucrose ($C_{12}H_{22}O_{11}$) etc.

2. Quote one example of each type of carbohydrates.

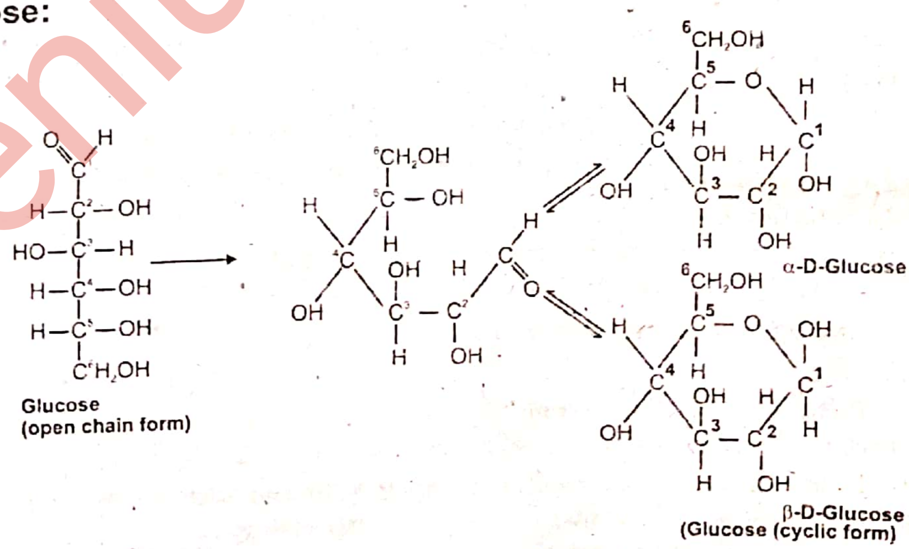
Ans. Type of carbohydrates with examples:

Carbohydrate	Example
(i) Monosaccharides	Glucose
(ii) Disaccharides	Sucrose
(iii) Polysaccharides	Starch

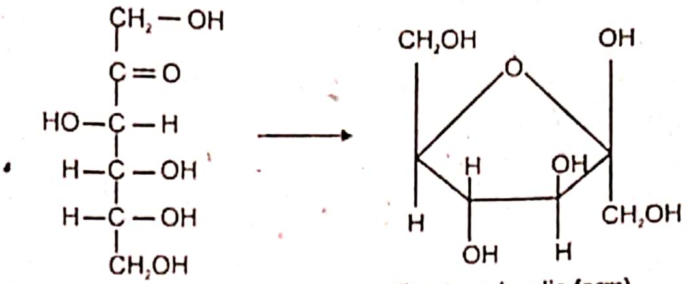
3. Write structural formulae of Glucose and Fructose.

Ans. Glucose and fructose both are monosaccharides. The only difference is that glucose contain aldehydic group while fructose contains ketonic group.

Structure of glucose:



Structure of fructose:



Fructose (open chain form) Fructose (cyclic form)

4. What do you understand by glycemic index?

Ans. Glycaemic index (GI) is a measurement carried out on carbohydrates containing food and their impact on our blood sugar. So it is a relatively new way of analyzing foods. Foods are ranked according to their immediate effect on blood sugar level. The higher affect raises the blood sugar level and higher its glycemic index.

5. How much calories do 1gm of carbohydrate have?

Ans. 1 gram of carbohydrates contain 4k calories or 4000 calories.

6. On what factors tooth decay depend?

Ans. The tooth decay is influenced by a number of factors which are:

- (i) Availability of fluoride.
- (ii) Type of food eaten.
- (iii) Degree of oral hygiene and plaque removal carried out.
- (iv) Frequency of consumption of any fermentable carbohydrates.
- (v) Genetic factor.

PROTEINS

"The molecules which yield amino acids on complete hydrolysis are called Proteins."

Proteins are probably the most important class of biochemical molecules, although, of course, lipids and carbohydrates are also essential for life.

Proteins are the basis for the major structural components of animal and human tissue.

Proteins are natural polymer molecules consisting of amino acid units. The number of amino acids in proteins may range from two to several thousands.

Elements of proteins:

Major elements present in proteins are carbon, hydrogen, oxygen, nitrogen, and phosphorus.

Trace elements which are present in protein are iron, copper, iodine, manganese, sulphur and zinc.

Role of protein in living organisms:

They act as biological catalysts (enzymes), form structural parts of organisms, participate in cell signal and recognition factors, and act as molecules of immunity. Proteins can also be a source of fuel.

Classification of Proteins

Based on the physico – chemical properties, proteins may be classified into three types.

(A) Simple Proteins

These give one amino acid only, upon hydrolysis.

Examples:

Albumins: blood (serumbumin); milk (lactalbumin); egg white (ovolbumin); lentils (legumelin); kidney beans (phaseolin); wheat (leucosin).

It is soluble in water and dilute salt solution; it is precipitated by saturation with ammonium sulfate solution; coagulated by heat; usually found in plant and animal tissues.

Globulins: blood (serum globulins); muscle (myosin); potato (tuberin); Brazil nuts (excelsin); hemp (edestin); lentils (legumin).

Globular protein is sparingly soluble in water and soluble in neutral solutions; precipitated by dilute ammonium sulfate and coagulated by heat; distributed in both plant and animal tissues.

Glutelins: wheat (glutenin); rice (oryzenin).

It is insoluble in water and dilute salt solutions; soluble in dilute acids; found in grains and cereals.

Histones: thymus gland, pancreas and nucleoproteins (nucleohistone).

It is soluble in water, salt solutions and dilute acids; insoluble in ammonium hydroxide; yields large amounts of lysine and arginine; combined with nucleic acids within cells.

Scleroproteins: connective tissues and hard tissues.

Fibrous protein is insoluble in all solvents and resistant to digestion.

(B) Conjugated Proteins

These give an animo acid and non-protein group upon hydrolysis.

Examples:

Nucleoproteins: cytoplasm of cells (ribonucleoprotein), nucleus of chromosomes (deoxyribonucleoprotein), viruses and bacteriophages. It contains nucleic acids, nitrogen and phosphorus. It is present in chromosomes and in all living forms as a combination of protein with either DNA or RNA.

Mucoprotein: saliva (mucin) and egg white (ovomucoid). Proteins combined with amino sugars, sugar acids and sulfates.

Glycoprotein: bone (osseomucoid), tendons (tendomucoid) and cartilage (chondromucoid). Containing more than 4% hexosamine, mucoproteins; if less than 4%, then glycoproteins.

Phosphoprotein: milk (casein) and egg yolk (ovovitellin). Phosphoric acid joined in ester linkage to protein.

(C) Derived Proteins

These are derived from simple and conjugated proteins.

Examples:

Proteans: Edestan (from elastin) and myosin (myosin). It results from short action of acids or enzymes; insoluble in water.

Proteases; intermediate products of protein digestion. It is soluble in water; not coagulated by heat; and precipitated by saturated ammonium sulfate; result from partial digestion of protein by pepsin or trypsin.

Peptones; intermediate products of protein digestion. It has the same properties as proteases except that they can not be salted out; of smaller molecular weight than proteases.

Peptides; intermediate products of protein digestion. Two or more amino acids joined by a peptide linkage; hydrolyzed to individual amino acids.

Exercise: Q.3(ii) Explain the structure of Proteins.

Structure of Proteins

The structure of a protein depends upon the spatial arrangement of polypeptide chains present in proteins. Since four spatial arrangements are possible, proteins have the following four structures:

(i) Primary Structure

The sequence of amino acids in a peptide chain is called primary structure. Amino acids are linked with one another through peptide bond. The arrangement of these acids is called primary structure.

(ii) Secondary Structure

Peptide chains may acquire spiral shape or may be present in a zig-zag manner. This coiling or zig-zagging of polypeptide is called secondary structure of protein. It is due to H-Bond.

(iii) Tertiary Structure

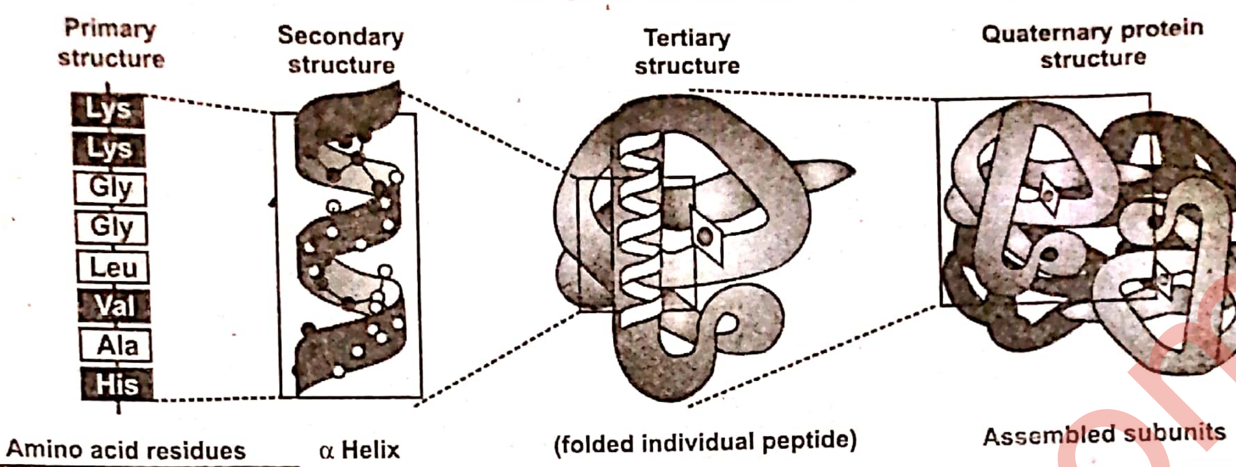
Twisting or folding of polypeptide chains represents tertiary structure of proteins.

(iv) Quaternary Proteins

Quaternary means four. This is the fourth phase in the creation of a protein.

Quaternary protein is the arrangement of multiple folded protein or coiling protein molecules in a multi-subunit complex.

A variety of bonding interactions including hydrogen bonding, salt bridges, and disulfide bonds hold the various chain into a particular geometry.



Properties of Proteins

Complete Hydrolytic Decomposition
Protein → Proteose → Peptone → peptides → Amino acids

Proteins are one of the four major groups of macromolecules that are found in all living organisms. These giant molecules carry out many of the vital functions needed by cells.

Proteins are involved in such processes as food digestion, cell structure, catalysis, movement, energy manipulation and much more. They are complex, huge associations of molecular subunits that appear impossibly difficult to understand. Fortunately they are all built using the same construction principle. As with all macromolecules, proteins are polymers, composed of smaller subunits - the amino acids - joined together in long chains.

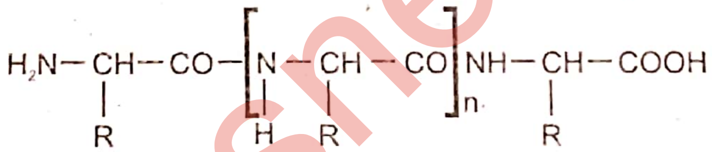
Amino acids-basic unit of proteins:

There are about 20-22 common amino acids found in most proteins. All but one of these small molecules has the same common structure, but varies in the nature of one chemical group - termed the "R-group". It is the varying structure and properties of these R-groups that make amino acids different from one another.

Polypeptides:

Amino acids are joined together in long chains called "polypeptides", a name which comes from the type of bond holding the chains of amino acids together.

Peptide	Composition
Dipeptide	Which are made up of two amino acids.
Oligopeptide	Which are made up of two to nine amino acids.
Polypeptide	Having molecular mass up to 10 000
Proteins	Having molecular mass from 10,000 to 40000000.



A bond formed between carbon and nitrogen atom in a peptide or polyamide is called peptide bond.

The order or sequence of amino acids along a polypeptide chain establishes the first critical property of proteins, its primary structure.

Importance of Proteins

Biological importance

(i) Proteins play an important role in the formation of protoplasm. Protoplasm is the essence of all forms of life.

(ii) Nucleoproteins are complex proteins and act as the carrier of heredity from one generation to the other.

(iii) Enzymes are the biological catalysts and they are also proteins. Without enzymes life is not possible.

(iv) Hemoglobin is a blood protein. It acts as carrier of oxygen.

(v) Some of the proteins act as hormones. They carry out the regulatory function of the body.

Industrial importance

(i) Proteins have great importance in industry. The tanning of hides is an industrial process. This process is the precipitation of protein by tannic acid.

(ii) Gelatin is obtained by heating bones, skins and tendons in water. It is used in bakery goods.

(iii) Casein is another protein used in the manufacture of buttons and buckles.

(iv) Proteins obtained from the soyabean are used for the manufacture of plastics.

Protein	Function	Examples
Enzymes	Biological catalysts, vital to all living systems.	Trypsin, pepsin
Structural proteins	Proteins that hold living systems together.	Collagen
Hormones	Act as messengers.	Insulin
Transport proteins	Transport oxygen from lungs to tissues.	Haemoglobin
Protective proteins	Destroy any foreign substance released into the living system.	Gamma globulin
Toxins	Poisonous in nature.	Snake venom

QUICK QUIZ

1. What are proteins? Give its simple classifications.

Ans. Proteins:

The extremely complicated high molecular weight organic materials, which upon complete hydrolysis, yield amino acids, are called proteins. e.g. albumins, histones, glycoprotein etc.

Classification:

Based on the physico – chemical properties, proteins may be classified into three types.

1. Simple proteins **2.** Compound or conjugated proteins **3.** Derived proteins

2. Differentiate primary, secondary and tertiary structure of Proteins.

Ans. The structure of proteins depends upon the special arrangement of polypeptide chains present in proteins. Proteins have the following four structures:

(i) **Primary structure**

The sequence of the amino acids combined in a peptide chain is called as the primary structure.

(ii) **Secondary structure**

Peptide chains may acquire spiral shape or may be present in a zig-zag manner. This coiling or zig-zagging of polypeptide is called secondary structure of protein. It is due to H-Bond.

(iii) **Tertiary structure**

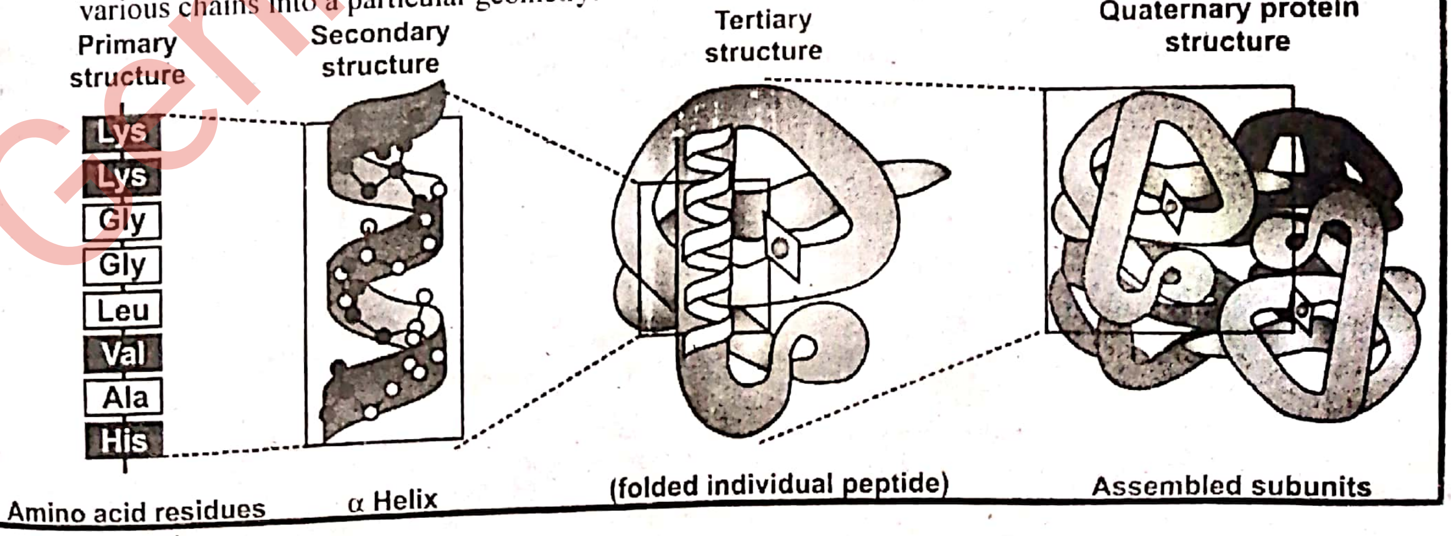
Twisting or folding of polypeptide chains represents tertiary structure of proteins.

(iv) **Quaternary Structure:**

Quaternary means four. This is the fourth phase in the creation of a protein.

Quaternary protein is the arrangement of multiple folded protein or coiling protein molecules in a multi-subunit complex.

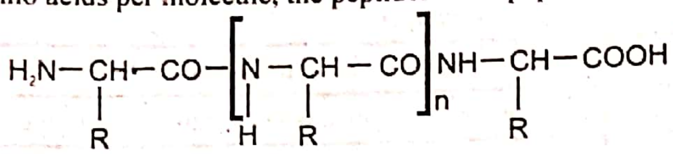
A variety of bonding interactions including hydrogen bonding, salt bridges, and disulfide bonds hold the various chains into a particular geometry.



3. What are polypeptides?

Ans. If a large number of amino acids (hundreds to thousands) are joined by peptide bonds, the resulting polyamide is called a polypeptide.

Depending upon the number of amino acids per molecule, the peptides are dipeptides, tripeptides, polypeptides etc.



The molecular mass of polypeptides is upto 10,000.

ENZYMES

"Enzymes are biocatalysts which alter the speed of metabolic activities in the living bodies."

Meanings: Greek word En means 'in' and Zyme means 'yeast'.

Enzymes are complex protein molecules which are quite specific in action and sensitive to temperature and pH.

Role of Enzymes as a Biocatalyst

The life of living organisms is a reflection of what is going on in their bodies.

Metabolism is the set of biochemical reactions that occur in living organisms in order to maintain life. These processes allow organisms to grow and reproduce, maintain their structures, and respond to their environments.

Anabolism includes the biochemical reactions in which larger molecules are synthesized.

Catabolism includes the biochemical reactions in which larger molecules are broken down.

Usually, energy is released in catabolism and it is utilized in anabolism. In this way the biochemical reactions are actually energy transfers.

During metabolism, chemicals are transformed from one form to the other by enzymes. Enzymes are crucial to metabolism because they act as **biocatalysts** and speed up and regulate metabolic pathways.

Enzymes are proteins that catalyze (i.e. speed up) biochemical reactions and are not changed during the reaction. The molecules at which enzymes act are called **substrates**, and enzymes convert them into different molecules, called **products**.

Q. How does Enzyme work?

Ans. **Enzyme Action**

When an enzyme attaches with substrate, a temporary enzyme-substrate (ES) complex is formed. After it, the ES complex breaks enzyme product. It means enzyme catalyzes the reactions and substrate is transformed into product.

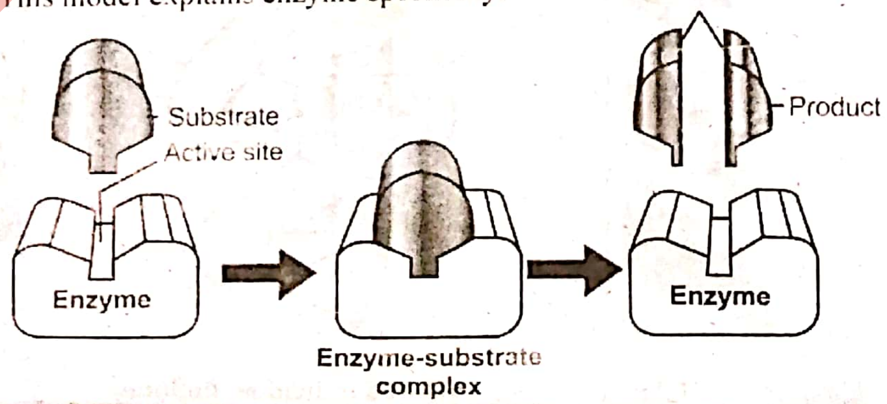
$$E + S \longrightarrow ES\ Complex \longrightarrow E + P$$

Following models were purposed to explain enzyme action:

Models to explain Enzyme Action:

(A) Lock and Key model

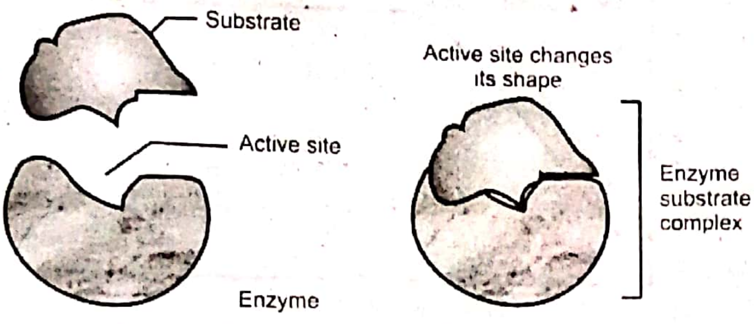
In order to explain the mechanism of enzyme action, a German chemist Emil Fischer in 1894, proposed lock and key model. According to this model, both enzyme and substrate possess specific shapes that fit exactly into one another. This model explains enzyme specificity.



Lock and Key Model

(B) Induced-Fit Model

In 1958, an American biologist **Daniel Koshland** suggested a modification to lock and key model and proposed **induced-fit model**. According to this model, active site is not a rigid structure rather is molded into the required shape to perform its function. "Induced fit model" is more acceptable than "lock and key" model of enzyme action.



Induced Fit Model

Interesting information:

(1) Winhelm Kuhne (1978) first time used the term enzyme
(2) There are over 2000 known enzymes, each of which is involved in one specific chemical reaction.
(3) Enzymes are substrate specific.
(i) The enzyme protease (which breaks peptide bonds in proteins) will not work on starch (which is broken down by an enzyme amylase).
(ii) Similarly lipase enzyme acts on lipids and digests them into fatty acids and glycerol.

Exercise: Q.3(iii) Briefly describe the factors that affect the Activity of enzymes.

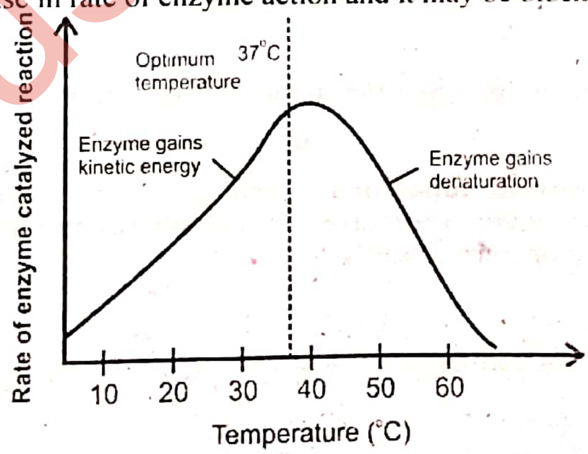
Factors Affecting Enzyme Activity

Enzymes are very sensitive to the environment in which they work. Any factor that can change the chemistry or shape of enzyme molecule, can affect its activity. Some of the factors that can affect the rate of enzyme action are being discussed here.

(i) Temperature

Increase in temperature speeds up the rate of enzyme catalyzed reactions, but only to a point. Every enzyme works at its maximum rate at a specific temperature called as the optimum temperature for that enzyme.

When temperature rises to a certain limit, heat adds in the activation energy and also provides kinetic energy for the reaction. So reactions are accelerated. But when temperature is raised well above the optimum temperature, heat energy increases the vibrations of atoms of enzyme and the globular structure of enzyme is lost. This is known as the **denaturation** of enzyme. It results in a rapid decrease in rate of enzyme action and it may be blocked completely.



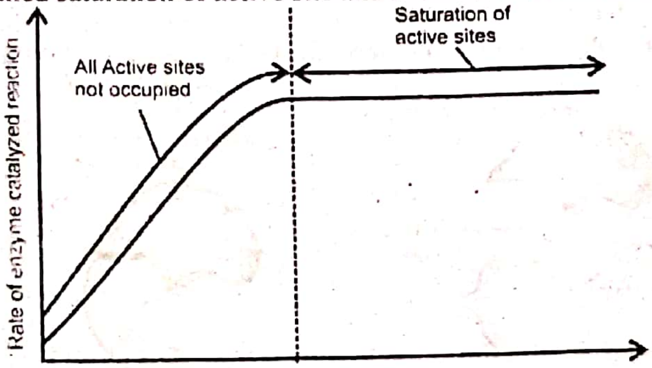
Effects of Temperature on Enzyme Activity

(ii) Substrate Concentration

In enzymatic reaction, if we increase the concentration of substrate the rate of reaction also increases.

If enzyme concentration is kept constant and amount of substrate in increased, a point is reached where any further increase in substrate concentration does not increase the rate of reaction any more.

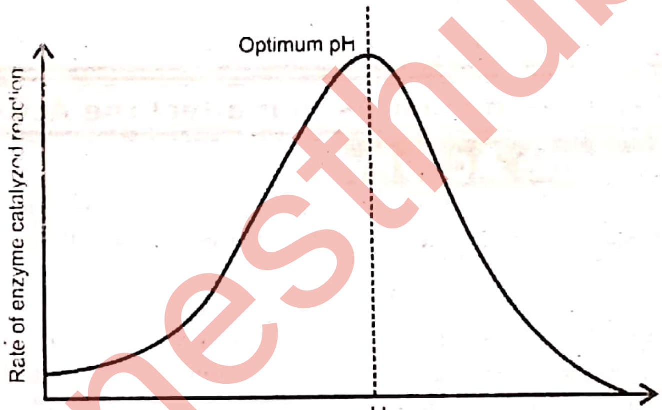
When the active sites of all enzymes are occupied (at high substrate concentration), any more substrate molecules do not find free active site. This state is called saturation of active site and reaction rate does not increase.



Effect of Substrate Concentration on Enzyme Activity

(iii) pH

All enzymes work at their maximum rate at a narrow range of pH, called as the optimum pH. A slight change in this pH causes retardation in enzyme activity or blocks it completely. Every enzyme has its specific optimum pH value. For example, pepsin (working in stomach) is active in acidic medium (low pH) while trypsin (working in small intestine) shows its activity in alkaline medium (high pH). Change in pH can affect the ionization of the amino acids at the active site.



Effect of pH on Enzyme Activity

Role of Inhibitors in Enzyme Catalyzed Reactions

Inhibitors:

"Substances that tend to decrease the activity of enzymes are called inhibitors."

or

"An inhibitor is a chemical substance which can react (in place of substance) with the enzyme but is never transferred into products by blocking the active site of enzyme temporarily or permanently."

Examples:

Poisons like cyanide, antibodies, anti-metabolic and some drugs.

Types of Inhibitors

Inhibitors can be divided into two types:

(a) Irreversible Inhibitors:

They occupy the active sites by forming covalent bond or they may physically block the active sites. They decrease the reaction rate by occupying the active sites or destroying the globular structure of enzymes. e.g. suicide inactivators.

(b) Reversible Inhibitors:

They form weak linkages with the enzyme. Their effect can be neutralized completely or partly by an increase in the concentration of the substrate. Reversible inhibitors can be competitive, uncompetitive or mixed.

Role of inhibitor

In an enzyme catalyzed reaction, the inhibitors may decrease the activity of enzymes and thus the rate of the reaction either by combining directly with the enzyme or by reacting with the activator, so that the activator does not remain available to enzyme for activation.

Examples:

(i) Competitive inhibitor

Succinic acid (substrate) is converted into Fumaric acid (product) by the enzyme succinic dehydrogenase.

Succinic dehydrogenase + succinic acid ⟶ Fumaric acid + succinic dehydrogenase
(Enzyme) (Substrate) (Product) (Enzyme)

But in the presence of malonic acid (competitive inhibitor) having structural similarity with succinic acid (substrate), the binding sites are occupied by the malonic acid but no catalysis takes place at the active or catalytic site, hence no product is formed

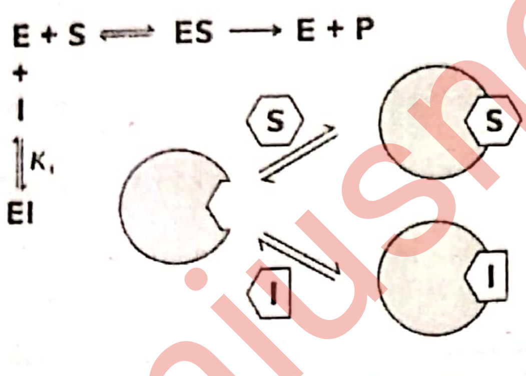
Succinic dehydrogenase + Malonic acid ⟶ No reaction possible
(Enzyme) (Competitive inhibitor) (Enzyme blocked)

(ii) Non-competitive inhibitor

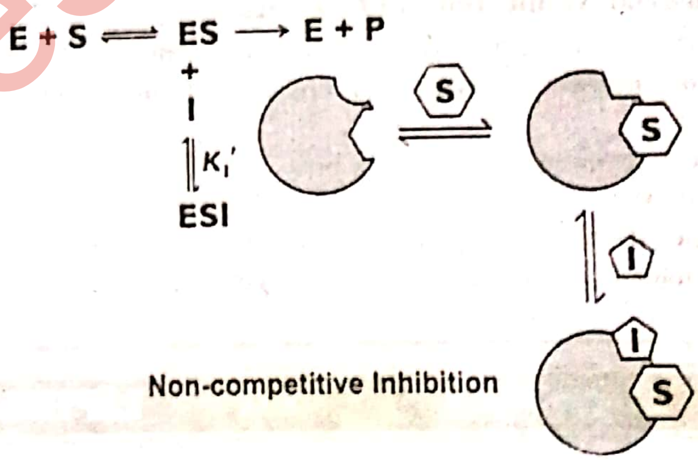
Another type of inhibitors, called non-competitive inhibitors cause "non-competitive inhibition". Here, the inhibitor is not bound to the catalytic or active site but to some other site of enzyme. This binding distorts the enzyme's structure also affecting the catalytic site of the enzyme in such a way that even if genuine substrate binds the active sites, catalysis fails to take place.

In the reactions catalyzed by enzymes irreversible inhibitors cause irreversible inhibition either by physically blocking the active sites of enzymes or by occupying the active sites and forming covalent bonds. So the rate of reaction is retarded due to the occupation of active sites of enzymes by irreversible inhibitors or due to the destruction of the globular structure of enzymes.

Note: **Competitive and non-competitive inhibitors are the two major types of reversible inhibitors.**



Competitive Inhibition



Non-competitive Inhibition

Industrial Applications of Enzymes

Enzymes are extensively used in different industries for fast chemical reactions. For examples:

(i) **Food industry:** Enzymes that break starch into simple sugars are used in the production of white bread, buns etc.

(ii) **Brewing industry:** Enzymes break starch and proteins. The products are used by yeast for fermentation (to produce alcohol).

(iii) **Paper industry:** Enzymes break starch to lower its viscosity that aids in making paper.

(iv) **Biological detergent:** Protease enzymes are used for the removal of protein stains from clothes. Amylase enzymes are used in dish washing to remove resistant starch residues.

1. What are enzymes? Why are they called biocatalysts?

Ans. The reaction catalysts of biological systems produced by living cells and are capable of catalyzing chemical reactions are called enzymes.

Role of enzymes as bio-catalysts:

Enzymes are crucial to metabolism because they act as biocatalysts and speed up and regulate metabolic pathways. Metabolism includes both anabolism and catabolism.

2. How does enzyme work?

Ans. When an enzyme attaches with substrate, a temporary enzyme-substrate (ES) complex is formed. After it, the ES complex breaks enzyme product. It means enzyme catalyzes the reactions and substrate is transformed into product.

$$E + S \longrightarrow ES\ Complex \longrightarrow E + P$$

3. Who has used the term Enzyme first time?

Ans. Winhelm Kuhne in 1978 used the term enzyme first time.

4. Why are following scientists famous for? (i) Emil Fischer (ii) Daniel Koshland

Ans. (i) Emil Fischer

He was a German chemist. In 1894, he proposed lock and key model. According to this model, both enzyme and substrate possess specific shapes that fit exactly into one another. This model explains enzyme specificity.

(ii) Daniel Koshland

He was an American biologist. In 1958, he suggested a modification to lock and key model and proposed **induced-fit model**. According to this model, active site is not a rigid structure rather is molded into the required shape to perform its function. "Induced fit model" is more acceptable than "lock and key" model of enzyme action.

5. "Enzymes are extensively used in different industries". Comment on this statement.

Ans. Industrial Applications of Enzymes:

Enzymes are extensively used in different industries for fast chemical reactions. For examples;

(i) Food industry: Enzymes that break starch into simple sugars are used in the production of white bread, buns etc.

(ii) Brewing industry: Enzymes break starch and proteins. The products are used by yeast for fermentation (to produce alcohol).

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(iv) Biological detergent: Protease enzymes are used for the removal of protein stains from clothes. Amylase enzymes are used in dish washing to remove resistant starch residues.

LIPIDS

(Greek, lipos means fat)

"Naturally occurring organic compounds of animals and plants origin, which are soluble in organic solvents are called lipids."

These molecules consist of carbon, hydrogen, and oxygen atoms.

The main constituents of all membranes in all cells (cell walls), food storage molecules, intermediaries in signaling pathways, Vitamins A, D, E and K, cholesterol.

All lipids are hydrophobic: that's the one property they have in common.

This group of molecules includes fats and oils, waxes, phospholipids, steroids (like cholesterol), and some other related compounds.

Fats and Oils

Fats and oils are made from two kinds of molecules: glycerol (a type of alcohol with a hydroxyl group on each of its three carbons) and three fatty acids joined by dehydration synthesis. Since there are three fatty acids attached, these are known as triglycerides.

Classification of Lipids

There are following three broad classes of lipids:

(a) Simple Lipids:

These are the ester of fatty acids with glycerol.

Examples:

Triglycerides, neutral fats: Found in adipose tissue, butterfat, fish oils, olive oil, and corn oil.
Waxes: beeswax, head oil of sperm whale, carnauba oil, and lanolin of industrial and medicinal importance.

(b) Compound Lipids:

These contain radicals in addition to fatty acids and alcohols.

Examples:

Phospholipids (phosphatides): Found chiefly in animal tissues.
Plasmalogen: Found in brain, heart, and muscle.
Lipositol: Found in brain, heart, kidneys, and plant tissues together with phytic acid. Phosphatidyl inositol; phosphatide linked to inositol; rapid synthesis and degradation in brain; evidence for role in cell transport processes.
Sphingomyelin: Found in nervous tissue, brain, and red blood cells. Source of phosphoric acid in body tissue.

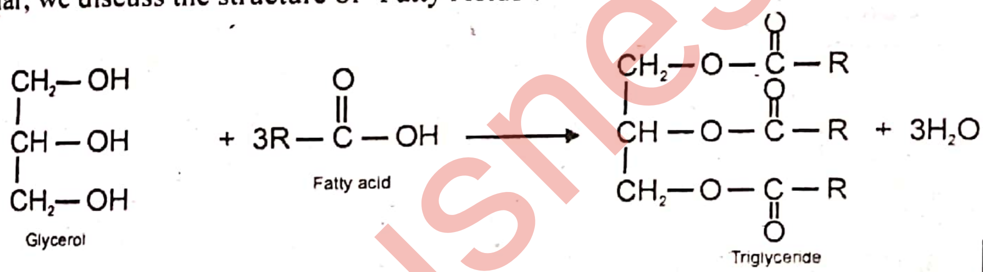
(c) Derived Lipids

These are hydrolytic product of compound lipids. e.g. sterols, vitamins D, terpens etc.

Fatty acids: occur in plant and animal foods; also exhibit in complex forms with other substances. Obtained from hydrolysis of fats; usually contains an even number of carbon atoms and are straight chain derivatives.

Structure of Lipids

Lipids are generally defined in terms of solubility, and not in terms of particular structures, as in the cases of proteins and nucleic acids. Lipids associate with one another via van der Waals forces and the hydrophobic effect. In particular, we discuss the structure of 'Fatty Acids'.



- Glycerol is commonly called as glycerine. It is trihydric alcohol.
- It is colorless oily fluid with sweetish taste.

Structure of fatty acids:

The "tail" of a fatty acid is a long hydrocarbon chain, making it hydrophobic.

The "head" of the molecule is a carboxyl group which is hydrophilic.

Do you know?
The unsaturated fats are "healthier" than the saturated ones.

Fatty acids are the main component of soap, where their tails are soluble in oily dirt and their heads are soluble in water to emulsify and wash away the oily dirt.

However, when the head end is attached to glycerol to form a fat, that whole molecule is hydrophobic.

Properties of Lipids

(1) Physical Properties

1. Oils and fats may be either liquids or non-crystalline solids at room temperature
2. Fats and oils in the pure states are colorless, odorless and tasteless.
3. The color fats arise due to foreign substances, for example yellow color of the butter is due to the presence of keratin.
4. They are lighter than water.

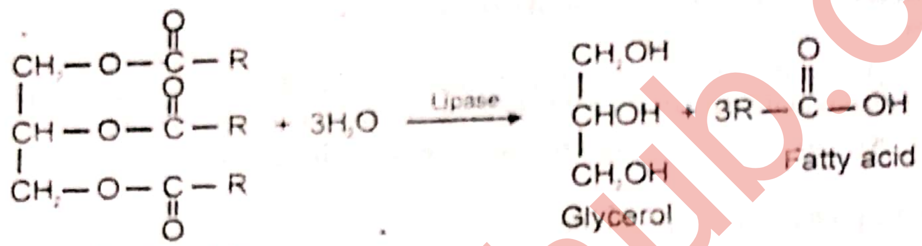
5. They are insoluble in water.
6. They are readily soluble in organic solvents like diethyl ether, carbon disulphide, acetone, benzene, chloroform and carbon tetrachloride.
7. They form emulsions when they are agitated with water in the presence of soap or other emulsifier.
8. Fats and oils are poor conductor of heat and electricity and serve as excellent insulator for the animal body.

(2) Chemical Properties

Fats and oils undergo various types of reactions but the most important are:

(i) Hydrolysis of fats and oils:

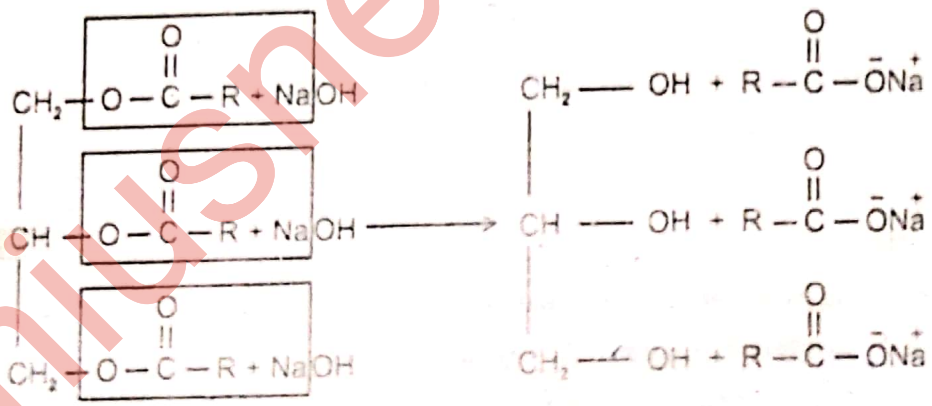
Fats and oils are triglycerides. They are triesters. They are hydrolyzed by enzymes which act as catalysts. These enzymes are called lipases.



Actually this hydrolysis takes place in the digestive tract of human beings and animals. Fatty acids are produced in animal body which play an important role in the metabolic pathways.

(ii) Saponification:

Saponification is the hydrolysis of triglycerides by alkalies. Glycerol is produced along with sodium or potassium salt of fatty acids. These Na and K salt are called soaps.

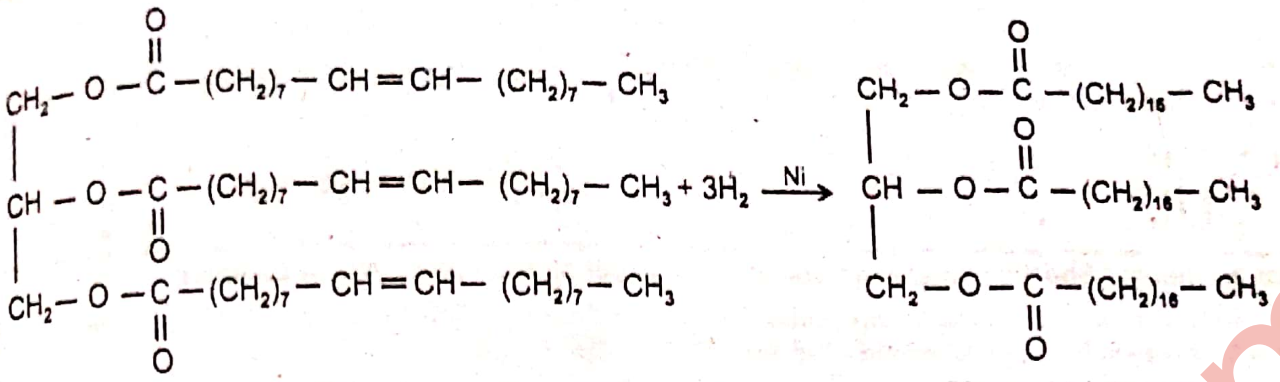


(iii) Hardening of Oils:

The unsaturated triglycerides are liquids at room temperature. They are called oils. They can be saturated by passing hydrogen in them in the presence of metal catalysts. In this way, liquid triglycerides are converted into a semisolid triglyceride.

This reaction is used commercially to harden the vegetable oil, for the production of vegetable ghee or margarine.

These hardened oils are also used extensively for making soaps and candles.



Glycerol trioleate (an oil) — Glyceryl tristearate (a fat)

Exercise: Q.3(iv) What is the nutritional importance of Lipids?

Nutritional Importance of Lipids

Lipids play three major biochemical roles:

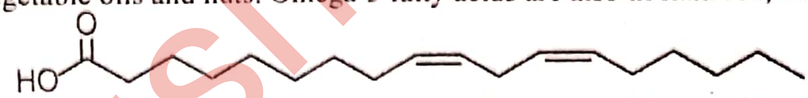
1. As a storage form for metabolic energy (triglycerides)
2. As components of membranes
3. As messengers (prostaglandins, steroid hormones)

> **Vitamins D, E, K & A are soluble in fats**

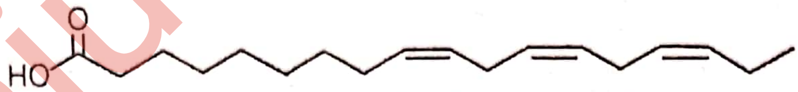
A major role of lipids in nutrition is to provide energy, since unsaturated, saturated and trans fats all provide about 9 calories per gram compared to carbohydrates or protein with 4 calories per gram. Even though it is high in calories, fat does not necessarily cause weight gain if you monitor your total intake. Our body also needs fat from our diet to be able to absorb and use fat-soluble essential nutrients such as vitamin A, vitamin D and vitamin E.

Essential Lipids

Some nutrients are essential in our diet because we need them for good health but our body cannot produce them. The essential lipids are polyunsaturated fats called omega-6 and omega-3 fats. We need these fats for hormone synthesis, cell membrane structure and healthy brain and vision, and they may help lower our blood cholesterol levels. We can get omega-6 fatty acids from vegetable oils and nuts. Omega-3 fatty acids are also in flaxseed, walnuts and fatty fish.



Linoleic acid - Omega-6 polyunsaturated fatty acid



α-Linoleic acid - Omega-3 polyunsaturated fatty acid

Non-Essential Lipids

Monounsaturated fatty acids are not essential in the diet because our body can synthesize them, but they may help reduce our risk for heart disease. They are in olive oil, peanuts and avocadoes. We do not need to get saturated fat, trans fat or cholesterol in our diet, and these lipids raise bad cholesterol levels in our blood.

> **Do you know?**
> Our bodies make about 2 g of cholesterol per day, and that makes up about 85% of blood cholesterol, while only about 15% comes from dietary sources.

(i) Saturated fat is in fatty meats and cheese, palm and coconut oil, and butter.

(ii) Trans fat is in partially hydrogenated oils in processed and fried foods.

(iii) Cholesterol is fatty animal foods.

More Functions of Lipids

(i) tissues reconstruction

(ii) nervous system organization

(iii) increases and assures a normal function of the skin

(iv) antibodies formation
(v) good function of endocrine glands(thyroid)
(vi) water metabolism

QUICK QUIZ

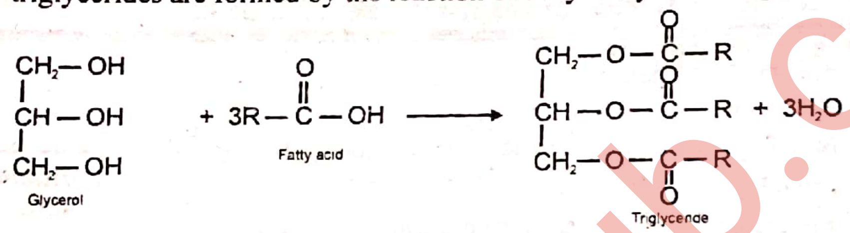
1. What are lipids? Shortly explain the only property that all the lipids have in common.

Ans. The naturally occurring organic compounds of animals and plants origin which are soluble in organic solvents and belong to a very heterogeneous group of substances are called lipids.

All lipids are hydrophobic: That's the one property they have in common.

2. What are triglycerides? Draw its structure.

Ans. Triacylglycerole or triglycerides are formed by the reaction of trihydroxyalcohol (glycerol) with fatty acids.



3. Explain briefly the structure of lipids.

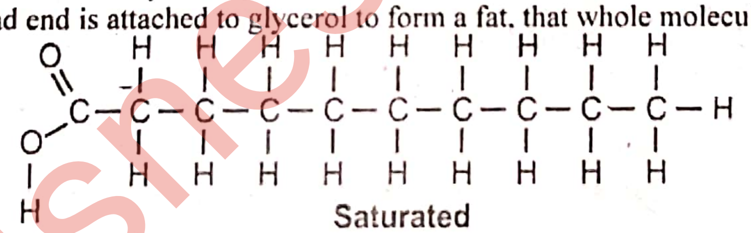
Ans. Lipids are heterogeneous class of organic compounds.

Lipids have no common structure. so lipids are generally explain in term of solubility not in term of common structure. Their primary building blocks are fatty acids, glycerol and sterols.

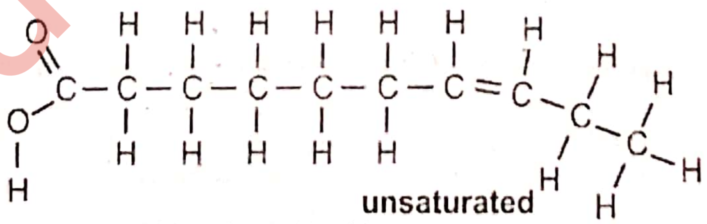
Fatty acids contain two parts; one is tail and the other is head. Tail of fatty acids consist of a long chain hydrocarbon which are hydrophobic. The head of fatty acids contain carboxyl group which is hydrophilic.

Fatty acids are the main component of soap, where their tails are soluble in oily dirt and their heads are soluble in water to emulsify and wash away the dry dirt.

However when the head end is attached to glycerol to form a fat, that whole molecule is hydrophobic.



Saturated



unsaturated

Fats are solid at room temperature while oil are liquid at room temperature.

Oils contain more unsaturation in the alkyl part of fatty acids than fats.

Note: Some other examples of lipid fatty acids are stearic acid, oleic acid, wax, phospholipids, cholesterol, β-carolene.

NUCLEIC ACIDS

Definition

The molecules that preserve hereditary information and that transcribe and translate that information in a way that allows the synthesis of all the varied enzymes of the cell are called the nucleic acid.

Discovery:

(i) Nucleic acids were first of all demonstrated in the nuclei of puss cells in 1868 by Friedrik Miescher.

(ii) They were found in sperm heads in 1872.

Types of Nucleic Acids:

There are two types of nucleic acids which have been discovered:

(i) Deoxyribonucleic acids (DNA) (ii) Ribonucleic acid (RNA)

Nucleic acids and proteins:

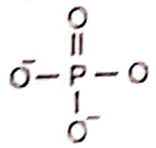
In the human body the nucleic acids occur as part of the conjugated proteins which are called nucleoproteins. The nucleic acids direct the synthesis of proteins.

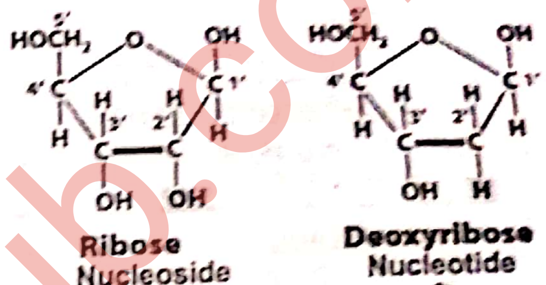
Exercise: Q.3(v) Explain the structures of Nucleic acids.

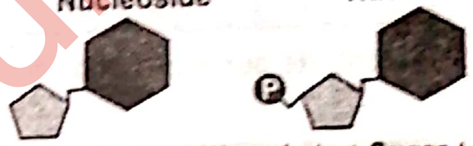
Structural Components of DNA and RNA

The basic structure of nucleic acids are determined by the biochemist P.A. Levene, who found that DNA contains three main components.

(i) Five carbon sugars
(ii) Nitrogen containing bases
(iii) Phosphate (PO_4) groups

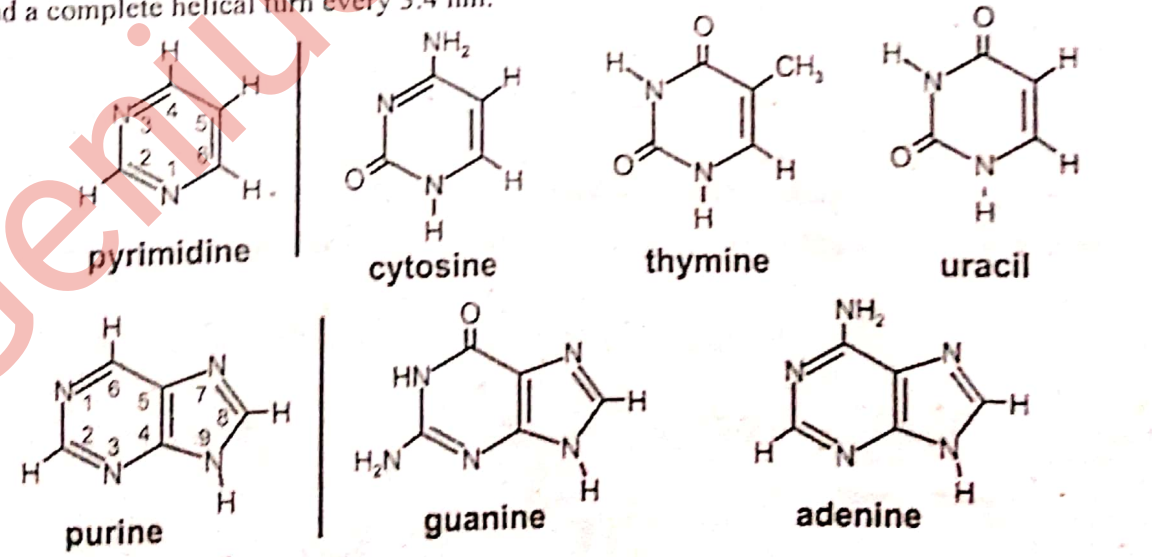






Levene concluded that DNA and RNA molecules are made of repeating units called nucleotides.

In a nucleotide nitrogen base is attached to carbon number 1 of a pentose sugar and phosphate group is attached to carbon number 5 of the sugar. In addition a free hydroxyl (–OH) group is attached to the 3′ carbon atom. The 5′ phosphate and 3′ hydroxyl groups allow DNA and RNA to form long chains of nucleotide because these two groups can react chemically with each other. The reaction between the phosphate group of one nucleotide and the hydroxyl group of another is a dehydration synthesis, eliminating a water molecule and forming a covalent bond that links the two groups. The linkage is called a phosphodiester bond because the phosphate group is now linked to the two sugars by means of a pair of ester (P–O–C) bonds. The two unit polymer resulting from this reaction still has a free 5′ phosphate group at one end and a free 3′ hydroxyl group at the other, so that it can link to other nucleotides. In this way, many thousands of nucleotides can join together in long chains. Linear strands of DNA or RNA no matter how long, will almost always have a free 5′ phosphate group at one end and a free 3′ hydroxyl group at the other. It is analysed that the amount of adenine in DNA always equals the amount of thymine, and the amount of guanine always equals the amount of cytosine. It also implies that there is always equal proportion of purine (A + G) and pyrimidine (C + T). The X-ray diffraction pattern suggested that the RNA molecule had a shape of a helix with a diameter of 2 nm and a complete helical turn every 3.4 nm.



Difference between DNA and RNA

They differ in three ways:

1. The sugar in RNA is ribose while the sugar in DNA is 2-deoxyribose.
2. Four different bases are found in DNA cytosine (c) thiamine (T) adenine (A) and guanine (G). In RNA thiamine does not occur and its place is taken by uracil (U).
3. DNA is nearly always double stranded, while RNA is usually single strand.

QUICK QUIZ

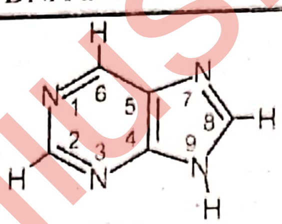
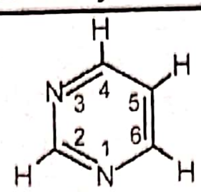
1. Write the names of structural components of DNA and RNA.

Ans. Structural components of:

DNA	RNA
(i) **Sugar** Deoxyribose sugar.	(i) **Sugar** Ribose sugar.
(ii) **Nitrogenous bases** Adenine, guanine, thymine and cytosine are found in DNA.	(ii) **Nitrogenous bases** Adenine, guanine, uracil and cytosine are found in RNA.
(iii) **Strand** DNA is nearly always double stranded.	(iii) **Strand** RNA is usually single stranded.

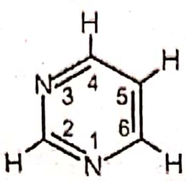
2. Differentiate purines and pyrimidines.

Ans.

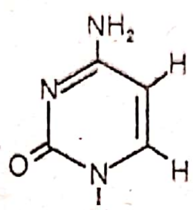
Purines	Pyrimidines
(iv) It contains two heterocyclic rings of carbon and nitrogen.	(v) It consists of a 6-membered ring containing both nitrogen and carbon atoms.
(vi) There are two purines adenine and guanine and both are presence in DNA and RNA.	(vii) Two pyrimidines, thymine and cytosine are found in DNA but RNA contains cytosine and uracil.
 purine	 pyrimidine

3. Which purines are present both in DNA and RNA?

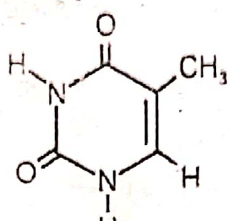
Ans. Adenine and Guanine are the derivatives of purines which are present in both DNA and RNA.



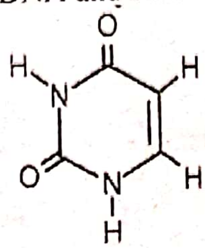
pyrimidine



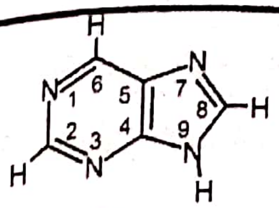
cytosine



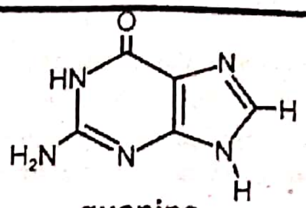
thymine



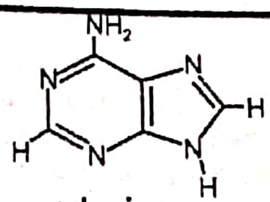
uracil



purine



guanine



adenine

MINERALS OF BIOLOGICAL SIGNIFICANCE

Minerals are the nutrients that exist in the body, and are as essential as our need for oxygen to sustain life. Minerals are also found in organic and inorganic combinations in food. In the body only 5% of the human body weight is mineral matter, vital to all mental & physical processes & for total wellbeing. They are most important factors in maintaining all physiological processes, are constituents of the teeth, bones, tissues, blood, muscle, and nerve cells.

Acting as catalysts for many biological reactions within the human body, they are necessary for transmission of messages through the nervous system, digestion, & metabolism or utilization of all nutrients in foods. Vitamins cannot be properly assimilated without the correct balance of minerals. For example; calcium is needed for vitamin "C" utilization, zinc for vitamin "A", magnesium for "B" complex vitamins, selenium for vitamin "E" absorption, etc.

Important minerals in human diet and their roles

Minerals	Role in body	
Major minerals		
Sodium	Fluid balance in the body Helps in absorption of other nutrients	Important for muscle contraction, nerve impulse transmission, heart function, and blood pressure
Potassium	Fluid balance in the body Acts as cofactor for enzymes	
Chloride	Fluid balance in the body Component of hydrochloric acid	
Calcium	Development and maintenance of bones and teeth and Blood clotting	
Magnesium & Phosphorus	Development and maintenance of bones and teeth	
Trace Minerals		
Iron	Oxygen transport and storage	Act as enzyme cofactors Support immune function
Zinc	Aids insulin action Helps in growth and reproduction	
Copper	Acts as enzyme cofactor	
Chromium	Helps in insulin action	
Fluoride	Stabilizes bone mineral and hardens tooth enamel	
Iodine	Essential for normal thyroid function	

Out of all above mentioned mineral only Calcium, phosphorus, Iron and Zinc are included in our syllabus.

Exercise: **Q.3(vi) Describe four important minerals and their sources.**

Sources of Important Minerals

Here is a list of good food sources for a number of important minerals that are an essential part of good nutrition.

Calcium

Calcium is important to bone growth and formation, blood clotting, nerve and muscle functioning.

(a) Sources: We get calcium from milk, cheese, egg yolk, beans, nuts, cabbage etc.

(b) Deficiency: A deficiency may result in arm and leg muscles spasms, softening of bones, back and leg cramps, brittle bones, rickets, poor growth, osteoporosis, tooth decay and mental depression.

Iron

Iron is an essential mineral. Its major function is to combine with protein and copper in making hemoglobin, the component of the blood that carries oxygen from the lungs to the tissues throughout the body.

(a) Sources: We get Iron from red meat, egg yolk, whole wheat, fish, spinach and mustard etc.

(b) Deficiency: A deficiency may result in weakness, fatigue, paleness of the skin, constipation and anemia.

Phosphorus

Phosphorus is after calcium the second most abundant mineral in the body. It is a principal mineral of bones and teeth. Phosphorus is involved in most metabolic actions in the body, including kidney functioning, cell growth and the contraction of the heart muscle.

(a) Sources: We get phosphorus from egg yolk, cheese, milk, cabbage etc.

(b) Deficiency: A deficiency is unusual, but may have symptoms varying from painful bones, irregular breathing, fatigue, anxiety, numbness, skin sensitivity and changes in body weight.

Zinc

Zinc is vital to immune resistance, wound healing, digestion, reproduction, physical growth, diabetes control, taste and smell and maintaining normal Vitamin A levels and usage. Zinc can be found in almost every cell of the body and serves as part of more than 70 enzymes that control body processes.

(a) Sources: We get zinc from Oyster, red meat, chicken, beans, nuts, dairy products and some sea foods.

(b) Deficiency: A deficiency may result in poor growth, acne-like rash, hair loss, diarrhea, delayed sexual maturation, impotence, sterility, eye lesions, loss of appetite, reduced sense of taste and smell, skin lesions and inflammation, poor wound healing, reduced resistance to infections, mental confusion, poor learning ability, changes in hair and nails and anemia.

Biological Significance of Minerals

(a) Importance/Significance of Iron

The primary role of iron relates to the ability of red blood cells to adequately carry oxygen for use throughout the entire body. Some functions of iron are mentioned below.

- **Fatigue**

  To prevent fatigue, iron is needed by the body to make hemoglobin rich blood, which transports oxygen to the cells. It is also needed for adenosine triphosphate production (ATP), which is essential for cellular energy and proper cell function.

- **Exercise**

  Iron is lost through sweat and through bleeding of the digestive tract from the harsh motion of exercise. Studies indicate that 34% of female runners and 8% male runners are iron deficient.

- **Pregnancy**

  Iron is needed for proper placenta development and also for the prevention of pre-term and low birth weight babies. Studies estimate that up to 58% of pregnant women are iron deficient.

- **Pediatric**

  Iron is essential during the first eight months for brain growth and the effects of anemia may be associated with developmental delays in both motor and cognitive abilities.

- **Treatment Duration**

  Up to six months to restore low iron stores, its sufficient quantity must be used. When iron deficiency is left untreated, it can lead to conditions that are more serious.

- **Metabolic Processes**

  Iron plays an important part in the metabolic processes of the animals. The function of iron in the body is limited almost exclusively to the oxygen transport in the blood, through hemoglobin. It is present in some enzymes that catalyze reactions of cellular oxidation. In human body, the richest organs in iron are liver and spleen. In smaller amount, it is also present in bones, medulla, kidneys and intestines.

(b) Importance/Significance of Calcium

Calcium is the most common mineral in the human body, where it is present in almost the same relative abundance as in the earth's crust. There are six stable isotopes of calcium: calcium40 is the most common (97 %), and calcium 46 the least abundant (0.003 %).

- The integrity of the system depends critically on vitamin D status; if there is a deficiency of vitamin D, the loss of its calcaemic action leads to a decrease in the ionised calcium and secondary hyperparathyroidism and hypophosphataemia. This is why experimental vitamin D deficiency results in rickets and osteomalacia whereas calcium deficiency gives rise to osteoporosis.
- Approximately 99% of total body calcium is in the skeleton and teeth and 1% in blood and soft tissues. Calcium has four major biological functions:

(a) Structural as stores in the skeleton

(b) Electrophysiological-carries charge during an action potential across membranes

(c) Intracellular regulator, and

(d) As a cofactor for extracellular enzymes and regulatory proteins.

(c) Importance/Significance of Phosphorus

Phosphorus is present in plants and animals. There is over 1 lb (454 grams) of phosphorus in the human body. It is a component of **adenosine triphosphate** (ATP), a fundamental energy source in living things. It is found in complex organic compounds in the blood, muscles, and nerves, and in calcium phosphate, the principal material in bones and teeth. Phosphorus compounds are essential in the diet. Organic phosphates, ferric phosphate, and tricalcium phosphate are added to foods. Dicalcium phosphate is added to animal feeds.

1. The main function of phosphorus is in the formation of bones and teeth.
2. It plays an important role in the body's utilization of carbohydrates and fats and in the synthesis of protein for the growth, maintenance, and repair of cells and tissues.
3. It is also crucial for the production of ATP, a molecule the body uses to store energy.
4. Phosphorus works with the B vitamins.
5. It also assists in the contraction of muscles, in the functioning of kidneys,
6. In maintaining the regularity of the heartbeat, and
7. In nerve conduction.

(d) Importance/Significance of Zinc

Zinc is the most important of all trace elements involved in human metabolism. More than a hundred specific enzymes require zinc for their catalytic function. If zinc is removed from the catalytic site, Activity is lost; replacement of zinc restores activity. Studies in individuals with acrodermatitis enteropathica, a genetic disorder with zinc malabsorption resulting in severe deficiency, have provided much insight into the functional outcomes of zinc deficiency. These include impairments of dermal, gastrointestinal, neurologic and immunologic systems.

Loss of zinc through gastrointestinal tract accounts for approximately half of all zinc eliminated from the body. Considerable amount of zinc is secreted through the biliary and intestinal secretions, but most of it is reabsorbed and this process is an important point of regulation of zinc balance. Other routes of zinc excretion include the urine and surface losses (desquamated skin, hair, sweat).

QUICK QUIZ

1. What is biological significance of mineral?

Ans.

Minerals	Role in body	
Major minerals		
Sodium	Fluid balance in the body Helps in absorption of other nutrients	Important for muscle contraction, nerve impulse transmission, heart function, and blood pressure
Potassium	Fluid balance in the body Acts as cofactor for enzymes	
Chloride	Fluid balance in the body Component of hydrochloric acid	
Calcium	Development and maintenance of bones and teeth and Blood clotting	
Magnesium & Phosphorus	Development and maintenance of bones and teeth	
Trace Minerals		
Iron	Oxygen transport and storage	Act as enzyme cofactors Support immune function
Zinc	Aids insulin action Helps in growth and reproduction	
Copper	Acts as enzyme cofactor	
Chromium	Helps in insulin action	
Fluoride	Stabilizes bone mineral and hardens tooth enamel	
Iodine	Essential for normal thyroid function	

2. Define mineral. Give its percentage present in human body.

Ans. Minerals are the nutrients that exist in the body, and are as essential as our need for oxygen to sustain life. Minerals are also found in organic and inorganic combinations in food. In the body only 5% of the human body weight is mineral matter, vital to all mental & physical processes & for total wellbeing.

3. Minerals of which metals are required for assimilation of vitamins B, C and E.

Ans. Calcium is needed for vitamin "C" utilization, magnesium for "B" complex vitamins, selenium for vitamin "E" absorption, etc.

4. What problems are caused by deficiency of calcium and phosphorus?

Ans. Problems caused by deficiency of calcium

A deficiency of calcium may result in arm and leg muscles spasms, softening of bones, back and leg cramps, brittle bones, rickets, poor growth, osteoporosis, tooth decay and mental depression.

Problems caused by deficiency of phosphorus

A deficiency of phosphorus is unusual, but may have symptoms varying from painful bones, irregular breathing, fatigue, anxiety, numbness, skin sensitivity and changes in body weight.

5. **Give importance of zinc mineral.**

Ans. **Importance of zinc mineral**

(i) Aids insulin action
(ii) Helps in growth and reproduction
(iii) Act as enzyme cofactors
(iv) Support immune function

6. **Give significance of (i) Keralin (ii) Myosin and fibrin fibrous protein.**

Ans. **(i) Keralin**

Keralin Ointment is used in the treatment skin diseases, pain, swelling and inflammation of skin, blood diseases, breathing problems, cancer, eye diseases

(ii) Myosin and fibrin fibrous protein

Fibrous proteins consist of elongated molecules having one or more polypeptide chains in the form of fibrils. Secondary structure is most important in them. They are insoluble in aqueous media, a property conferred by a high concentration of hydrophobic amino acid residues both in interior of the proteins and or its surface. They are non-crystalline and are elastic in nature. Their characteristic feature is regular repeating pattern. They play structural or supporting role in the body. Examples are silk fiber, keratin (of nails, and hair), myosin (in muscle cells), fibrin of blood clot.

7. **How much intake of manganese should be per day?**

Ans. **Intake of Manganese per day**

The adequate intake of manganese is 2 to 5 mg/day.

8. **How hibernating animals obtain energy during hibernation?**

Ans. Large amount of fat is stored in the body of hibernating animals. In winter the metabolic activities slow down. They use this fat as reserved food material that produces ATP during oxidation.

9. **Give few macro and micro minerals.**

Ans.

Macro Minerals	Micro Minerals
Calcium, chloride, Phosphorous, Sodium, Potassium, Sulfur, Magnesium.	Iron, Boron, Chromium, Iodine, manganese, molybdenum, Selenium, Silicon.

10. **How much sodium and potassium should be taken per day?**

Ans. **Intake of Sodium per day**

The adequate intake of sodium is 1.5 grams per day with an upper limit of 2.3 grams per day for individuals 8 years or older.

Intake of Potassium per day

The adequate intake of potassium is 4.5 grams per day for children 9 to 13 years old and 4.7 grams per day for older person.

11. **What is insulin?**

Ans.
- Insulin is a 51 amino acid peptide hormone that is produced exclusively by pancreatic beta cells.
- These amino acids are arranged in two chains, one alpha chain and one beta chain. The alpha chain contains 21 amino acids and the beta chain contains 30 amino acids. Both chains are held together by disulphide bridges. The molecular weight of insulin is 5808.
- Insulin hormone is central in regulating carbohydrate and fat metabolism in the body.
- It causes the cells in liver, muscles and fat tissue to take up glucose from the blood. In the liver and skeletal muscles, glucose is stored as glycogen, while in adepocytes, it is stored as triglycerides.
- Insulin stops the use of fat as energy source. As a central metabolic control mechanism its status is also used as a control signal to other body systems (such as amino acids uptake by body cells.).
- Insulin is used medically to treat some forms of diabetes patients.

Society Science Technology

Glycogen – A store house

Glycogen is reserved food material that is stored in muscles and liver in animals and human. When body requires energy due to lack of glucose, the glycogen reconverted into glucose and provide energy to the body in the form of ATP.

Hibernating Animals and Reserve Food

Large amount of fat is stored in the boy of some animals that hibernate during winter. In winter the metabolic activities slow down. They use this fat as reserved food material that produces ATP during oxidation.

❖ **Complex carbohydrates which Provide Lubrication to the Elbow and Knee:**

Glucosamine, glucosaminoglycons or proteoglycan are the complex carbohydrates which provide lubrication to elbow and knee.

Glucosamine ($C_6H_{13}NO_5$) is an amino sugar. It is produced naturally in the body and plays a key role in building cartilage and lubricating joints. It is found in the fluid that is around joints. It is a prominent procurer for glycosaminoglycans and for glyeosaylated proteins and lipids.

Gluasamine has been shown to help keep our joints resilient and healthy by lubricationg and resting the connective tissue. It is a naturally occurring nutrient and is a glutamine derivative that retains an amine group and a sugar molecule (glucose).

Over time, every day wear and tear, less than perfect nutrition, injuries and aging can result in dry, brittle cartilage which is vulnerable to damage and stiffening. Research has shown that glucosamine may repair damaged or strained connective tissue.

Our joints are made up of two third of water yet are into able to attract and retain it. Glucosamine has shown to help keep cartilage resilient and healthy by attracting and holding water and nutrients within this matrix. Studies have even shown glucosamine may even help to regenerate new cartilage once it becomes damaged, thereby restoring joint function and mobility. Because of its ability to help to lubricate and restore elbow and knee joints, it is quite popular with weight trainers, sports enthusiasts etc.

Glucosaminoglycans (CAGs) are the most abundant hetropolysaccharides in the body. They are long unbranched molecules containing a repeating disaccharide unit. Usually one sugar is uronic acid and the other is either GlcNAc or CalNAc. GAGs have negative charge on them. GAGs are a major component of joint cartilage.

Chondroitin sulphate (D. glucuronate + CalNSc sulphate) is the most abundant GAG found in cartilage. Keratan sulphate (Gal + GlcNAc sulphate) is often aggregated with chondroitin sulphate.

GAGs have unique properties i.e. the ability to fill space, bind and retain water and repel negatively charged molecules. Because of high viscosity and low compressibility, they are ideal for a lubricating fluid in the joints especially in knee and elbow. On the other hand, their rigidity provides structural integrity to the cells.

Proteoglycans (mucoportiens) are formed of glycosamineglycaosn (GAGs) and core proteins, covalently bonded to each other. These are found in all connective tissues.

Proteoglycans can also be called joint grease. Proteoglycan appears to be a mecessary compound in synovial fluid for normal joint lubrication and function. (Synovial fluid is a clear pale yellow fluid, the main function of which is to serve as a lubricant in joints or tendon sheath.)

Aggrecan is one of the most important extra cellular proteoglycan. To each aggrecaon core protein, multiple chains of chondroitin sulphate and keratin sulphate are covalently attached through the trisaccharade linker. They play an important role in hydration of cartilage of joints. They give cartilage its gel like properties i.e. lubricate it and provide resistance to deformation.

❖ **Fibrous Proteins from hair and Silk:**

Fibrous proteins consist of elongated molecules having one or more polypeptide chains in the form of fibrils. Secondary structure is most important in them. They are insoluble in aqueous media, a property conferred by a high concentration of hydrophobic amino acid residues both in interior of the proteins and or its surface. They are non-crystalline and are elastic in nature. Their characteristic feature is regular repeating pattern. They play structural or supporting role in the body. Examples are silk fiber, keratin (of nails, and hair), myosin (in muscle cells), fibrin of blood clot.

Insulin – A protein hormone whose deficiency leads to diabetes mellitus

Insulin is a 51 amino acid peptide hormone that is produced exclusively by pancreatic beta cells. F. Sanger was the first scientist who determined the sequence of amino acids in insulin. After 10 years of careful work, he concluded that insulin is composed up of 51 amino acids in two chains, one alpha chain and one beta chain. The alpha chain contains 21 amino acids and the beta chain contains 30 amino acids. Both chains are held together by disulphide bridges. The molecule weight of insulin is 5808.

Insulin hormone is central in regulating carbohydrate and fat metabolism in the body. It causes the cells in liver, muscles and fat tissue to take up glucose from the blood. In the liver and skeletal muscles, glucose is stored as glycogen, while in adepocytes, it is stored as triglycerides.

Insulin stops the use of fat as energy source. When blood glucose level falls below a certain limit, the body begins to use stored sugar as an energy source through glycogenolysis. As a central metabolic control mechanism its status is also used as a control signal to other body systems (such as amino acids uptake by body cells.). In addition, it has several other anabolic effects throughout the body. Insulin is used medically to treat some forms of diabetes patients.

Role of Minerals in the Body

Minerals act as cofactors for the enzyme reactions. Enzymes don't work without minerals. All cells require enzymes to work and function. They give us our vitality.
They maintain the pH balance with in the body.
Minerals actually facilitate the transfer of nutrients across cell membranes.
They maintain proper nerve conduction.
Mineral help to contract and relax muscles.
They help to regulate our bodies' tissue growth.
Minerals provide structural support for the body.

These are two categories of mineral essential with in body, macro-minerals and micro-minerals. There is no one mineral deficiency; they all must be maintained in balance within body.

Macro-minerals

- Calcium
- Chloride
- Phosphorous
- Sodium
- Potassium
- Sulfur
- Magnesium

Micro-minerals (or Trace Minerals)

- Iron
- Boron
- Chromium
- Iodine
- Manganese
- Molybdenum
- Selenium
- Silicon
- Copper
- Cobalt
- Rubidium
- Germanium
- Lithium
- Zinc
- Vanadium

Structure and Function of Minerals

The term mineral is applied to chemical elements present in the ash of calcined tissue. Dietary minerals Amy are present in inorganic salts, or as part of carbon containing organic compounds. For example, magnesium is present in chlorophyll, the pigment that makes plants green. Six minerals are required by people in gram amount: sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), Phosphorous (P), and chlorine (Cl). Daily requirements range from 0.3 to 2.0 grams per day. Nine trace mineral are required by people in minute amounts: chromium (Cr), copper (Cu), iodine (I), iron (Fe), fluorine (F), manganese (Mn), molybdenum (Mo), selenium (Se), and zinc (Zn). There are additional requirements for cobalt (Co) but these are generally expressed in terms of the cobalt containing vitamin B12. All trace minerals are toxic at high levels.

Calcium

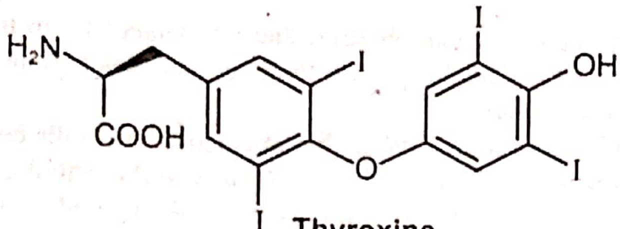
Calcium is the most abundant mineral in the human body. More than 99% of total body calcium is sorted in the bones and teeth. Calcium is also found in body fluid where its function is to regulate contractions of blood vessels and muscles. The requirement for calcium is greatest form puberty to maturity, when the body grows very quickly. Milk and dairy products are good sources of calcium.

Fluorine

Most of the body's fluorine (F) is contained in bones and teeth. The main source of fluoride is drinking water. Fluorine hardens tooth enamel and effectively prevents dental caries. Excessive fluorine in drinking water can accumulate in teeth and bones, causing fluorosis. Permanent teeth that develop during high fluorine intake have irregularly distributed chalky patches on the surface of the enamel which become stained yellow or brown, producing a characteristics mottled appearance.

Iodine

Iodine (I) is primarily involved in the synthesis of two thyroid hormones, thyroxine and triiodothyronine. In adults about 80% of the iodide absorbed is trapped by the thyroid gland.

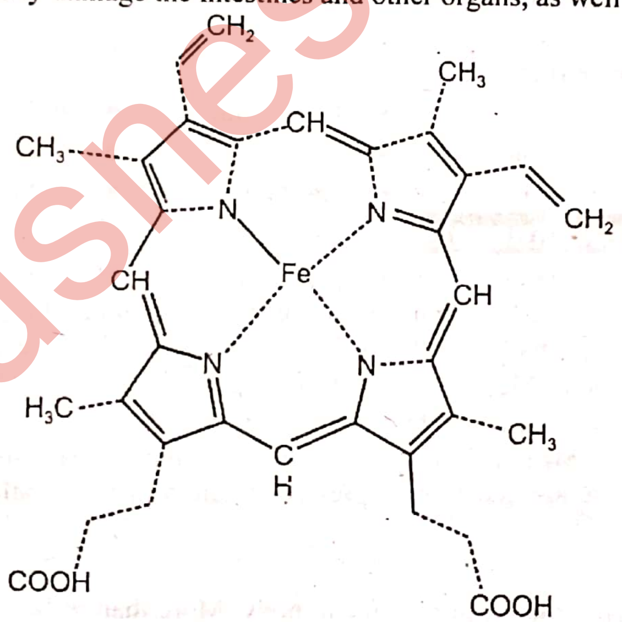


Thyroxine

Most environmental iodine occurs in seawater. People living far from the sea are at particular risk of deficiency. Salt fortified with iodide (typically 70ug/g) helps ensure adequate intake (100ug/day). Deficiency is rare in areas where iodized salt is used but common worldwide. Iodine deficiency develops when iodide intake is less than 20ug/day. In mild or moderate deficiency the thyroid gland hypertrophies to concentrate iodine in itself, resulting goiter which is an enlargement of the thyroid gland visible as a swelling of front the of neck. Excessive iodine consumption can lead to thyrotoxicosis, a condition resulting from high concentrations of thyroid hormones in the body which can result from eating foods that have high amounts of iodine, such as kombu-type kelp or seaweed.

Iron

Iron (Fe) is a component of hemoglobin, myoglobin, and many enzymes in the body. Heme iron, contained mainly in animal products is absorbed much better than nonheme iron, which accounts for over 85% of iron in the average diet. However, absorption of nonheme iron is increased when it is consumed with animal protein and vitamin C. the Recommended Daily Allowance (RDA) of iron is 8 milligrams for men and postmenopausal women. Iron deficiency, which may be caused by improper vegan or ovo-lacto vegetarian diets. Chronic bleeding may also cause iron deficiency, iron may accumulate in the body when a person is given repeated blood transfusions or takes an overdose of iron supplements. Excess iron is toxic, may damage the intestines and other organs, as well as cause vomiting and diarrhea.



Magnesium

Magnesium (Mg) has several important metabolic functions in the production and transport of energy. It is also important for the contraction and relaxation of muscles. Magnesium is involved in the synthesis of protein, and it assists in the functioning of some enzymes. Most dietary magnesium comes from nuts, cereals, and dark green, leafy vegetable which are rich in chlorophyll.

Manganese

Manganese (Mn) is necessary for healthy bone structure.and is a component of several enzyme systems including manganese-specific glycosyltransferases and phosphoenolpyruvate carboxykinase. Manganese is found in cereal and nuts. The adequate intake of manganese is 2 to 5 mg/day.

Molybdenum

Molybdenum (Mo) is a component of coenzymes necessary for the activity of xanthine oxidase, sulfite oxidase, and aldehyde oxidase. Sulfite oxidase catalyses the transformation of sulfite to sulfate which is necessary for the metabolism of sulfur containing amino acids, such as cysteine. Legumes such lentils, beans, and peas are good sources of molybdenum.

Potassium

Potassium (K) maintains fluid volume inside and outside of cells, and acts to blunt the rise of blood pressure in response to excess sodium intake. The adequate intake of potassium is 4.5 grams per day for children 9 to 13 years old and 4.7 grams per day for older person. Potassium is generally found in fruits and vegetables, dried peas, dairy products, meats and nuts. Potassium from supplements or slat subtitles can result in hyperkalemia and possibly sudden death if excess is consumed by individuals with chromic renal insufficiency (kidney disease) or diabetes.

Selenium

Selenium (Se) is a part of the enzyme glutathione peroxides, which metabolizes hydro-peroxides formed from polyunsaturated fatty acids. Selenium is also a part of the enzyme that deiodinate thyroid hormones. Generally, selenium acts as an antioxidant that works with vitamin E. deficiency of selenium causes Keshan disease which is a form of congestive chardiomyopathy. The RDA for selenium is 70 micrograms (mcg). The tolerable upper level of selenium is 400 mcg/day for adults based on the prevention of hair and nail brittleness and early signs of chronic selenium toxicity.

Sodium

Sodium (Na) is usually consumed as table salt (Sodium Chloride, NaCl). The adequate intake of 1.5 grams per day with an upper limit of 2.3 grams per day is calculated to meet the needs for sweet losses for individuals 8 years or older engaged in recommended levels of physical activity. Active people in humid climates who sweat excessively may need more than the adequate intake.

Zinc

Zinc (Zn) is contained mainly in bones, teeth, skin, hair, liver, muscle, leukocytes, and testes. Zinc is a component of several hundred enzymes, including many nicotinamide adenine dinucleoptide (NADH) dehydrogenases, RNA and DNA polymerases, and DNA tanscripition, factors as well as alkaline phosphatase, super oxide disumatse, and carbonic anhydrase. Good dietary sources of zinc include molluscs, such as oysters, and cereals.

KEY POINTS

- Carbohydrates are the most abundant macromolecules on earth. They are of three types i.e. Monosaccharides, oligosaccharides and polysaccharides.
- People eating a diet high in carbohydrates are less likely to accumulate body fat compared with those who follow a low carbohydrate / high-fat diet.
- Proteins are the most important class of biomolecules. They are major structural components of animals and human tissues. They are classified as a simple protein, conjugated proteins and derived proteins. They are actually the polymers of Amino acids.
- Nucleoproteins act as the carrier of heredity from one generation to the other.
- Hemoglobin is a protein and carrier of oxygen. Some of the proteins act as hormones.
- Enzymes are biocatalyst and catalyze chemical reactions in living organisms. They are quite specific in their function. Their Activity depends upon temperature, substrate concentration and pH. They are protein in nature and are used extensively in food, brewing, paper industries.
- All lipids are hydrophobic. Fats are solid while oils are liquid at room temperature. They are insoluble in water while soluble in organic solvents such as diethyl ether, acetone, benzene etc.
- Some lipids are essential for our diet and some are non-essential.
- Nucleic acids are present in every living cell as well as in viruses. They have ability to reproduce, store and transmit genetic information. They are of two types, DNA and RNA. Nucleotide is the structural unit of DNA and consists of one sugar, one nitrogenous base and at least one phosphate.

- Minerals are the nutrients and are as necessary as oxygen for life. They are constituents of teeth, bones, tissues, blood, muscles and nerve tissues.
- Minerals are classified as major and trace minerals i.e. those required in appreciable quantity are major and those required in low quantity are trace.

EXERCISE

Q1. Multiple Choice Questions. Encircle the correct answer:

- *Read the question carefully.*
- *Try to answer the question yourself before reading the answer choices.*
- *Guess only if you can eliminate one or more answer choices.*
- *Drawing a picture can help.*
- *Don't spend too much time on any one question.*
- *In-depth calculations are not necessary; approximate the answer by rounding.*

(i) Biochemistry covers the practical applications of:
(a) medicine (b) agriculture (c) nutrition (d) all of these

(ii) Macromolecules are of how many types?
(a) three (b) four (c) five (d) six

(iii) The general formula for carbohydrates is:
(a) $N_n(H_2O)_n$ (b) $P_n(H_2O)_n$ (c) $C_n(H_2O)_n$ (d) $H_n(CO_2)_n$

(iv) Most organic matter on earth is made up of:
(a) carbohydrates (b) lipids (c) olive oils (d) proteins

(v) The number of carbon atoms in hexose is:
(a) one (b) four (c) six (d) ten

(vi) The long chains of amino acids are called:
(a) oils (b) polypeptides (c) proteins (d) monopeptides

(vii) Proteins are used in both forms of:
(a) catabolism (b) anabolism (c) enzymes (d) metabolism

(viii) What is TRUE about enzymes?
(a) they make biochemical reaction to proceed spontaneously
(b) they lower the activation energy of a reaction
(c) they are not very specific in their choice of substrates
(d) they are needed in large quantities

(ix) To what category of molecules do enzymes belong?
(a) carbohadrates (b) lipids (c) nucleic acids (d) proteins

(x) What is TRUE about co factors?
(a) break hydrogen bonds in proteins
(b) help facilitate enzyme Activity
(c) increase activation energy
(d) are composed of proteins

(xi) Prosthetic groups are:
(a) required by all enzyme
(b) loosely attached with enzymes
(c) proteinsous nature
(d) tightly bound to enzyme

(xii) Lipids are generally defined in terms of:
(a) solubility (b) structure (c) molarity (d) all of these

(xiii) DNA and RNA are made up of:
(a) peptides (b) nucleotides (c) neurons (d) none of these

(xiv) ______ of the human body weight is mineral matter?
(a) 5 % (b) 10 % (c) 50 % (d) 100 %

(xv) ______ is needed for Vitamin C utilization.

(a) acid (b) iron (c) phosphorus (d) calcium

(xvi) **The component of blood that carries oxygen in the body is:**
(a) fats (b) myoglobin (c) hemoglobin (d) amino acids

(xvii) **Most RNA molecules are:**
(a) independent (b) double stranded (c) single stranded (d) multiple stranded

(xviii) _____ **are the major component of soap.**
(a) fatty acids (b) palm oils (c) proteins (d) saccharides

(xix) **The mineral, related with the formation of bones and teeth, is:**
(a) RNA (b) phosphorus (c) iron (d) sulphur

SOLVED EXERCISE MCQs

Q. No	Answer	Reason
(i)	(d) all of these	Because biochemistry covers nearly all aspects of life of living organism.
(ii)	(b) four	There are four main types of macromolecules called biopolymers. These includes carbohydrate, proteins, lipids and nucleic acids.
(iii)	(c) $C_n(H_2O)_n$	$C_n(H_2O)_n$ e.g. Glucose has formula $C_6H_{12}O_6$ $C_6(H_2O)_6 \Rightarrow C_6H_{12}O_6$ empirical formula glucose is CH_2O
(iv)	(a) carbohydrates	Because carbohydrates are involved in many aspect of life.
(v)	(c) six	The number of carbon atoms in hexoses is six e.g. glucose, fructose and galactose are hexoses because they contain six carbon atoms each.
(vi)	(b) polypeptides	When amino acids are linked together in long chain by peptide bonds called polypeptide.
(vii)	(d) metabolism	Metabolism which consists of anabolism and catabolism.
(viii)	(b) they lower the activation energy of a reaction	Enzymes are biocatalysts. They increase the rate of reaction by decreasing the energy of activation.
(ix)	(d) proteins	Mostly enzymes are protein in nature.
(x)	(b) help facilitate enzyme Activity	Co-enzymes are assistant of an enzyme therefore they facilitate the enzyme activity. They are non protein components.
(xi)	(d) tightly bound to enzyme	Prosthetic groups are bound tightly to enzymes (proteins) and may even be attached through a covalent bond but co-enzymes are loosely bound.
(xii)	(a) solubility	The naturally occurring organic compounds of animals and plants origin which are soluble in organic solvents and belong to a very heterogeneous group of substances are called lipids.
(xiii)	(b) nucleotides	It is because both DNA and RNA are polymer of nucleotides.
(xiv)	(a) 5 %	Only 5% of human body weight is mineral matter, vital to all mental and physical processes.
(xv)	(d) calcium	Calcium is necessary for utilization of vitamin C.
(xvi)	(c) hemoglobin	It is present in blood and acts as oxygen carries from lungs to all parts of the body.
(xvii)	(c) single stranded	RNA is a single while DNA is double stranded.
(xviii)	(a) fatty acids	Soap are the sodium or potassium salts of long chain fatty acids (saponification process)
(xix)	(b) phosphorus	Its main function is the formation of bones and teeth.

SHORT ANSWERS QUESTIONS

2. Give brief answers for the following questions.

(i) What do you understand by the word 'Biochemistry'?

Ans. Biochemistry is the branch of science which deals with the study of various molecules that occurs in living cells and organism, with their chemical reactions. So biochemistry is the science of atoms and molecules in living things because biochemistry is the combination of biology and chemistry. Biology is the study of living organisms and chemistry is the science of atoms and molecules.

(ii) Briefly state the functions of Carbohydrates.

Ans.
- Carbohydrates are source of energy. They are also known as "fuel of life" they produce energy by the process of oxidation.

$$\text{Carbohydrates} + O_2 \xrightarrow{\text{Oxidation}} CO_2 + H_2O + \text{Energy}$$

- These are necessary for proper fat metabolism. Some carbohydrates support the growth of healthy bacteria in the intestine for digestion.
- Some carbohydrates are used as s sweetening agent in confectionary and in medicinal syrup (fructose).
- They are storehouse of energy e.g. starch is the food stores in plants while glycogen in animals. Starch is also used as a stiffening agent in textile industry and in laundry. Cellulose is used for manufacturing of paper.
- Some carbohydrates high in fibre helps prevent constipation and lower the risk for cancer, heart disease and diabetes.

(iii) Name the classes and sub-classes of Proteins.

Ans. Proteins are classified into three classes:

Simple proteins	Conjugated proteins	Derived proteins
Albumins	Nucleoprotein	Proteans
Glubulins	Mucoprotein	Proteases
Glutelins	Glycoprotein	Peptones
Histones	Phosphoprotein	Peptides
Scleroproteins		

(iv) In a range of 0-35°C, the rate of reaction of an enzyme is proportional to temperature. Justify it.

Ans. The reactions are accelerated by rising the temperature upto 35°C because heat is added in the activation energy which provide kinetic energy for the reaction to accelerate it.

However, when temperature is raised above this temperature then heat energy increases the vibration of atoms of enzyme. So the globular structure of enzyme is lost which results in a rapid decrease in rate of enzyme action.

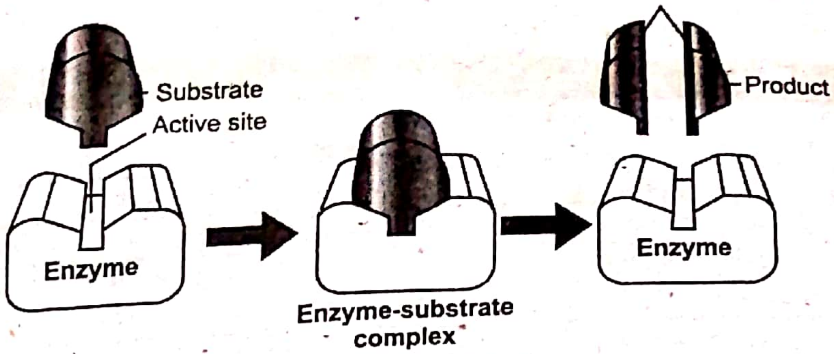
(v) How does pH affect enzyme Activity?

Ans. All the enzymes work at their maximum rate at a narrow range of pH which is known as optimum pH. Change in pH can effect the ionization of the amino acids at the active site thus enzyme activity is lost. Every enzyme has its specific optimum pH value e.g. pepsin is active in acidic medium which has low pH.

(vi) Describe lock and key mechanism of enzyme action.

Ans. Lock and key mechanism:

In order to explain the mechanism of enzyme action, a German chemist Emil Fischer in 1894, proposed lock and key model. According to this model, both enzyme and substrate possess specific shapes that fit exactly into one another. This model explains enzyme specificity.



Lock and Key Model

(vii) What is the main use of enzymes in paper industry?

Ans. The main use of enzymes in paper industry is, they break starch to lower its viscosity that aids in making paper.

(viii) Define cofactor and co-enzymes.

Ans. **Cofactor and co-enzymes:**

Cofactors	Coenzymes
• It is a non-protein chemical compounds that are bound tightly or loosely to an enzyme (protein).	• It is defined as small, organic, non-protein molecules, which carry chemical groups between enzymes.
• These are inorganic substances.	• These are organic substances.
• They assist in biological transformations.	• They aid or help the function of an enzyme.
• They are chemical compounds.	• They are chemical molecules.
• They are tightly bound to enzymes.	• They are loosely bound to enzymes.
• They act on catalyst to increase the speed of the reaction.	• They act as carries to the enzymes.
Examples: • Metal Ions like Zn^{++}, K^{+} and Mg^{++}, etc.	**Examples:** • Vitamins, Biotin, Coenzyme A, etc.

(ix) Shortly explain the only property that all the Lipids have in common.

Ans. All lipids are hydrophobic: That's the one property they have in common.

(x) Explain the structural components of DNA and RNA.

Ans. **Structural components of:**

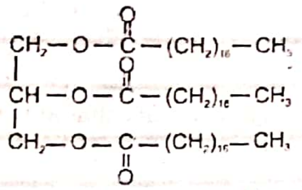
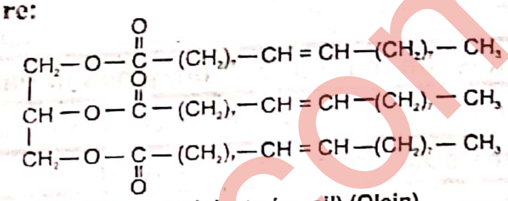
DNA	RNA
(i) Sugar Deoxyribose sugar.	**(i) Sugar** Ribose sugar.
(ii) Nitrogenous bases Adenine, guanine, thymine and cytosine are found in DNA.	**(ii) Nitrogenous bases** Adenine, guanine, uracil and cytosine are found in RNA.
(iii) Strand DNA is nearly always double stranded.	**(iii) Strand** RNA is usually single stranded.

(xi) Define Lipids and state the difference between fat and oil.

Ans. **Lipids:**

Lipids are naturally occurring organic compounds which are obtained from plants and animals. They are soluble in organic solvents like ether, benzene etc. but insoluble in water.

Differentiate between fats and oils

Fats	Oils
A glyceride in which the long chain saturated fatty acids predominate is called Fat.	A glyceride in which the long chain unsaturated fatty acids predominate is called Oil.
They are usually semi-solids or solids.	They are usually liquids.
They have high melting and boiling points.	They have low melting and boiling points.
Fats are generally obtained from animals.	Oils are generally obtained from plants and marine animals.
Structure:  Glyceryl tristearate (a fat) (Stearin)	**Structure:**  Glyceryl trioleate (an oil) (Olein)

(xii) Briefly state how Vitamin D is formed in human body?

Ans. The 7-dehydrocholestrol is converted into vitamin D when the ultraviolet radiation fall upon it. This molecule is naturally present in the skin of animals. When the skin is exposed to ultraviolet rays (UV rays), this 7-dehydrocholesterol is converted into vitamin D. The U.V rays present to some extent in sun rays.

(xiii) State the differences between the chemical structures of DNA and RNA.

Ans. Differences between DNA and RNA:

DNA	RNA
DNA stands for Deoxyribonucleic acid	RNA stands for Ribonucleic acid.
The sugar used in the structure of DNA is 2-deoxyribose.	The sugar used in the structure of RNA ribose.
It contains nitrogenous bases i.e. Cytosine, thyamine, adenine and guanine.	It contains nitrogenous bases i.e. Cytosine, and uracil, adenine and guanine.
It is double stranded.	Usually, RNA is single stranded.
It carries the genetic information in the cell.	It is involved in putting the genetic information to work in the cell.

(xiv) Briefly state why minerals are important for human life.

Ans. Minerals are the constituents of bones, tissues, teeth, muscle, blood and nerve cells.

Several minerals act as catalysts for many biological reactions within the human body.

They are necessary for transmission of messages through the nervous system, digestion and metabolism.

It is also noted that without the correct balance of minerals, vitamins are not properly assimilated. e.g. calcium is needed for vitamin "C" utilization.

(xv) Name different routes for the loss of Zinc from human body.

Ans. Loss of zinc will occur through gastrointestinal tract. It should be noted that it accounts for approximately half of all zinc eliminated from the body.

(i) Through biliary and intestinal secretion a considerable amount of zinc is secreted but most of them are reabsorbed.

(ii) Through urine and surface losses the secretion of zinc also occurs.

3. Give detailed answers for the following questions.

Note: Answers of all extensive questions are given with the related topics in the chapter.