

# Chapter # 14 Macromolecules

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## MACROMOLECULES

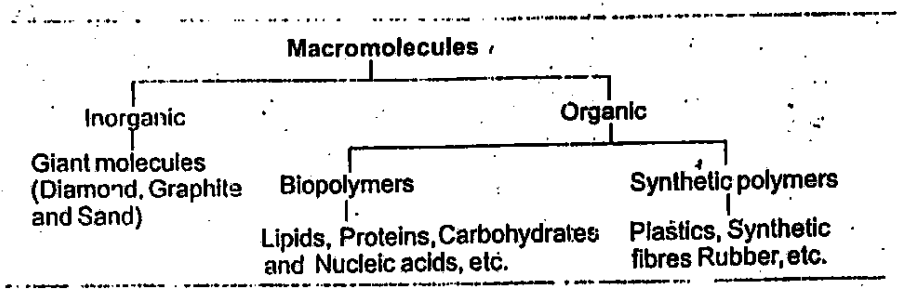
Very big molecules are called macromolecules.

### History

Concept of macromolecules was introduced by Staudinger. His idea was accepted in 1920s. Staudinger proposed long chain formulas for polystyrene, rubber and polyoxymethylene.

### CLASSIFICATION OF MACROMOLECULES

A brief classification of macromolecules is given below



## POLYMERS

These are macromolecules built up from small repeating units called monomers.

### Importance

Natural polymers such as Lipids, Proteins, Carbohydrates etc are important part of our daily life.

Synthetic polymers such as artificial fibers, plastics etc. have replaced natural material such as wood, cotton etc.

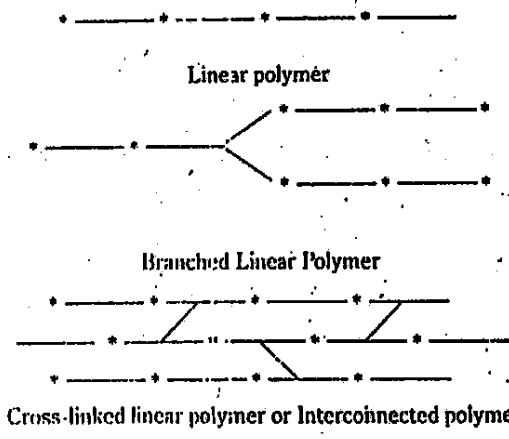
The synthetic polymers are so much that it can be said that we are living in a 'Plastic society'.

Development of process of polymerization has changed our daily life.

### CLASSIFICATION OF POLYMERS

Polymers may be of following types

- Linear polymers
- Branched linear polymers
- Cross-linked linear polymers or Interconnected polymers.



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**DEGREE OF POLYMERIZATION (DP) AND MOLECULAR MASS OF POLYMERS**

The number of repeating units in a polymer is called degree of polymerization (DP).

Length of polymer chain depends upon the number of repeating units.

e.g; Linear polyethene is

It's repeating units is  $(-CH_2-CH_2-)_n$  where n is a large number.

Molecular mass of polymer is the product of the molecular mass of the repeating unit and the D.P.

e.g. Polyvinyl chloride (PVC), has a DP of 1000.

It's molecular mass is

$$\begin{aligned} \text{Molecular Mass} &= \text{Molecular mass of repeating unit} \times \text{DP} \\ &= 63 \times 1000 = 63000 \end{aligned}$$

Repeating unit of PVC is  $(-CH_2-CH-)_n$ .

- Most high molecular mass polymers are useful for making plastics, rubbers or fibers etc. These have molecular masses between 10,000 to 1,000,000.
- Properties of polymeric materials depend upon chemical composition and structure of the macromolecules.

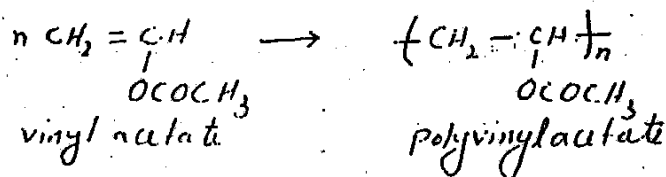
**TYPES OF POLYMERS**

There are following type of polymers

**1. Homopolymer**

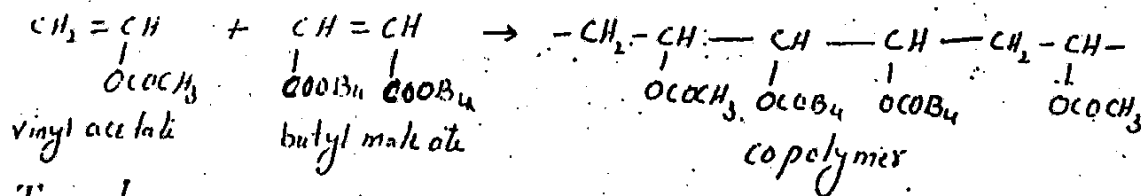
It is formed by polymerization of single type of monomer.

e.g; Polyvinyl acetate

**2. Co polymer**

It is formed by polymerization of two monomers

e.g; vinylacetate and butylmaleate combine to give a copolymer

**3. Ter polymer**

It is formed by polymerization of three monomers under controlled conditions.

e.g; Butyl acrylate, methacrylate and acrylic acid are polymerized together to give a high tough polymer.

This polymer is used in weather resistant paint.

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**CLASSIFICATION OF POLYMERS ON THE BASIS OF THERMAL PROPERTIES**

There are two types of polymers on the basis of thermal properties.

**1. Thermoplastic Polymer**

The polymer which is softened repeatedly on heating and hardened on cooling with a little change in properties is called thermoplastic polymer.

Examples

PVC pipes, plastic toys etc.

**2. Thermosetting Polymer**

The polymers which become hard on heating and cannot be softened again are called thermosetting polymers.

A thermosetting polymer decomposes on heating instead of melting.

Examples

Synthetic Varnish, Epoxy Resins etc.

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**POLYMERIZATION PROCESS**

In 1929, W.H. Carothers described two types of polymerization process.

1. Addition polymerization
2. Condensation polymerization

**1. Addition Polymerization**

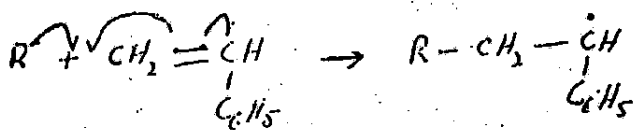
The polymerization in which monomers simply add together without elimination of small molecule is called addition polymerization.

It is a free radical type polymerization. It involves initiation, propagation and termination steps.

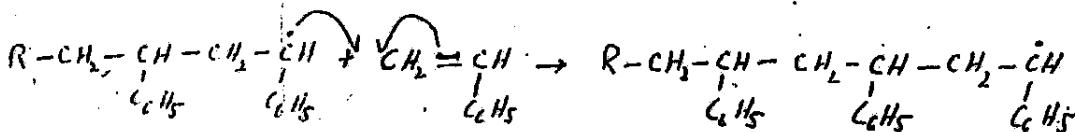
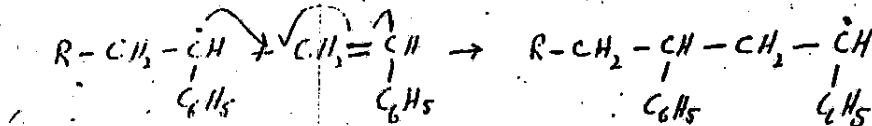
Example

Polymerization of styrene

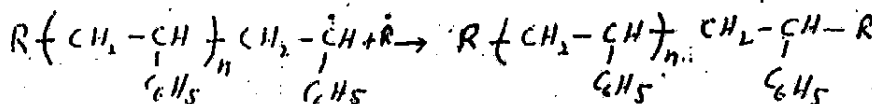
(i) Initiation



(ii) Propagation



(iii) Termination



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## 2. Condensation polymerization

The polymerization in which monomers unite together with the elimination of a small molecule is called condensation polymerization.

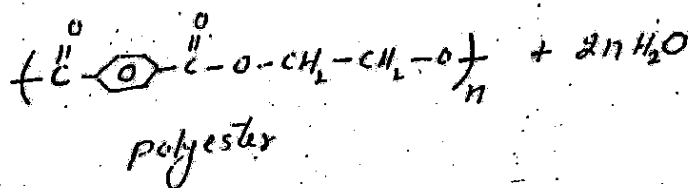
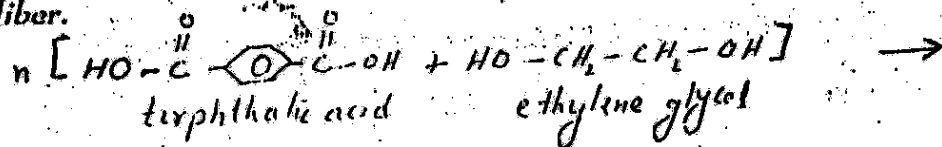
In this process two functional group are united together.

Usually water or methanol molecule is removed. Removal of molecule occurs at both ends of growing chain.

Such polymerization is ionic in nature.

### Example

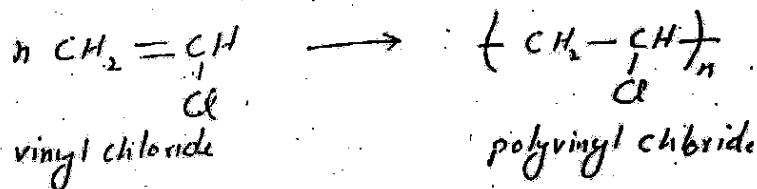
Di-carboxylic acid or esters combine with diols to give nylon and polyester fiber.



## EXAMPLES OF SYNTHETIC POLYMERS

### I. POLYVINYL CHLORIDE (PVC)

It is an addition polymer. It is obtained by heating vinyl chloride at  $52^\circ\text{C}$  and 9 atm pressure.



Addition of a plasticizer improves the flexibility of polymer

### Uses

It is used

- In making floor coverings
- In pipes
- In gramophone recorders etc.

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2. POLYSTYRENE

It is a polymer of styrene

Preparation

It is prepared by the polymerization of styrene in the presence of catalyst,



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Uses

It is used

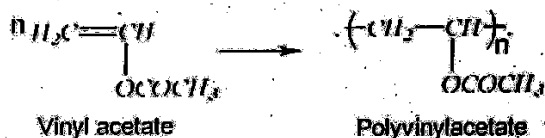
- For manufacture of food containers
- For manufacture of cosmetic bottles
- For manufacture of toys and packing material
- For manufacture of plastic cups

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3. POLYVINYL ACETATE (PVA)

It is a polymer of vinyl acetate

Preparation



Properties:

- It is a colorless, non-toxic resin
- It has different grades due to different degree of polymerization
- It has characteristic odour

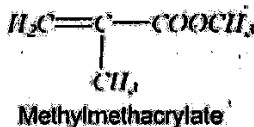
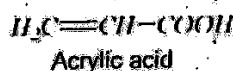
Uses

- It is used as an adhesive material
- It is used as a binder for emulsion paints

4. ACRYLIC RESINS

These are closely related to vinyl resins. Various types of monomers are used to prepare acrylic resins.

Some important monomers are



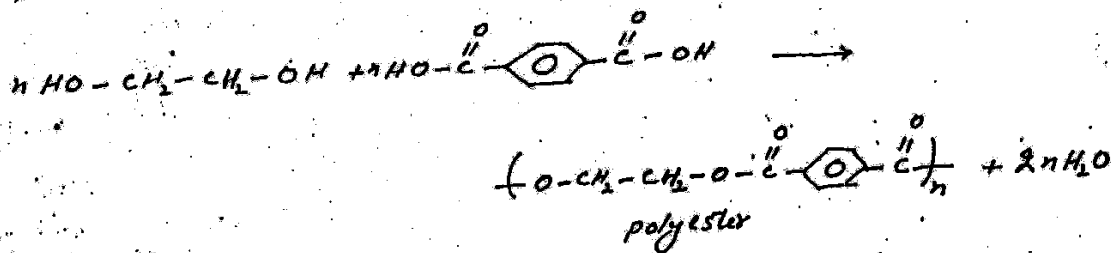
Uses

These are used

- For making plastics,
- For making paints for car industry
- For making water based weather resistant paints

**5. POLYESTER RESINS**

These are condensation polymers. These are prepared by reaction of an alcohol (ethane-1,2-diol) with aromatic bifunctional acids (benzene-1,4-dicarboxylic acid).



Uses

These are used

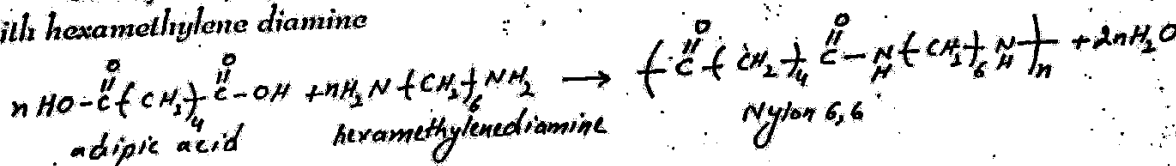
- In clothing
- For making cloth along with cotton or wool
- For making water tanks

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**6. POLYARIDE RESINS**

These are prepared by condensation of polyamine with aliphatic dicarboxylic acids.

One of the polyamide resin is Nylon 6,6. It is obtained by heating adipic acid with hexamethylene diamine

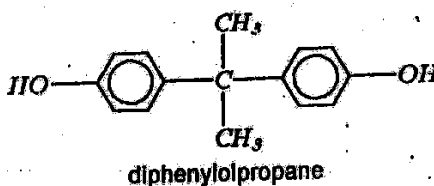
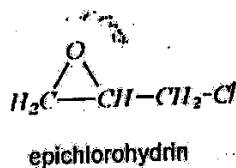


Both adipic acid and hexamethylenediamine have six carbon each. Thus product formed is called Nylon 6,6.

**7. EPOXY RESINS**

These are actually polyethers. Their name is due to their starting material and presence of epoxide ring in the polymer.

Epoxy resin is prepared by condensation of epichlorohydrin with diphenyl propane.



Uses

- These are used as adhesive
- These are used for making flexible, hard protective coatings.
- These are used for painting dams, bridges and floors
- These are used for coating of industrial materials, thermal power stations and patching materials.
- These are used for making chemical resistant coating.

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**BIOPOLYMERS**

These are biological molecules. They are made up of long chains of carbon. They perform various functions in living organisms. Major classes of biopolymers are

- Carbohydrates
- Lipids
- Proteins
- Nucleic acids

**CARBOHYDRATES**

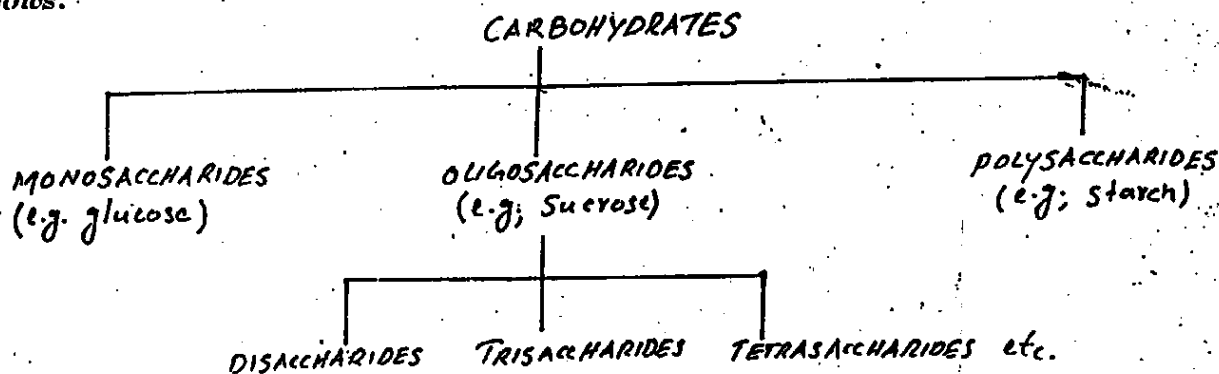
Polyhydroxy compounds of aldehyde or ketone are called carbohydrates. It is a class of heterogeneous compounds.

Word carbohydrate means hydrates of carbon. It is because first members of this class, which were studied had an empirical formula of  $C_n (H_2O)_n$ .

These are also commonly called as sugars

**CLASSIFICATION OF CARBOHYDRATES**

On the basis of hydrolysis behaviour, carbohydrates can be classified as follows.



**MONOSACCHARIDES**

Carbohydrates which can not be hydrolyzed into simpler carbohydrates are called monosaccharides.

Their general formula is  $(CH_2O)_n$ , where  $n=3$  or higher

On the basis of number of carbon atoms, these are further classified as trioses (3 carbon), tetroses (4 carbon), pentoses (5 carbon) and hexoses (6 carbon).

Further, monosaccharides containing aldehyde group are called aldoses while those containing ketone group are called ketoses.

**Examples**

Glyceraldehyde	(3 carbon)	aldotriose
Glucose	(6 carbon)	aldohexose
Fructose	(6 carbon)	ketohexose etc.

Monosaccharides containing five or six carbons are more stable in cyclic form.

**GLUCOSE**

It is an aldohexose. It is also called dextrose.

**Occurrence**

It occurs both in free and combined state

In free state it occurs in fruits, honey, human blood and urine etc.

In combined state it occurs as disaccharides, polysaccharides

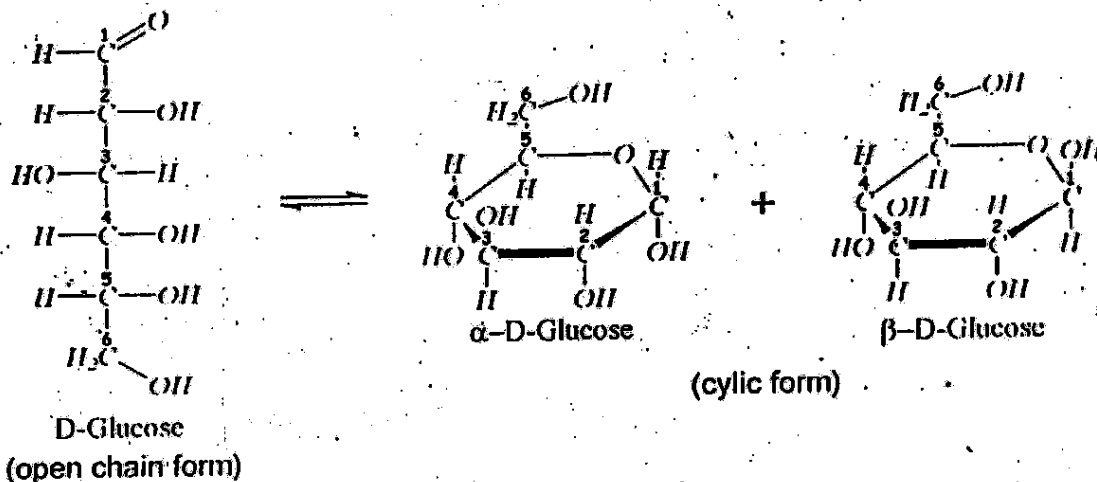
**Properties**

- It is colourless, odourless, crystalline solid
- It's m.p. is 140°C
- It is highly soluble in water
- It is a source of energy

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**Structure Of Glucose**

Naturally occurring glucose exists as D-glucose. Interconversion of open chain structure to cyclic structure occurs as follows.



**FRUCTOSE**

It is a ketohexose

**Occurrence**

It occurs both in free and combined states

In free state it occurs in fruits

In combined state it exists as disaccharides, polysaccharides

**Properties**

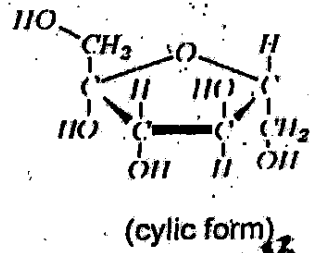
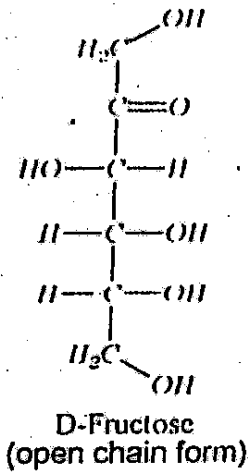
- It is a colourless, crystalline solid
- It's m.p. is 102.4°C
- It is highly soluble in water
- It is used as a sweetening agent in confectionery as a substitute for cane sugar

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Structure Of Fructose

Interconversion of open chain and cyclic structure occurs as follows.



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OLIGOSACCHARIDES

The carbohydrates which produce two to nine monosaccharides unit upon hydrolysis by acid or enzyme are called oligosaccharides.

These are formed by condensation of two or more monosaccharides unit with the loss of water. The monosaccharide units are interconnected by glycosidic linkage.

DISACCHARIDES

Oligosaccharides which produce two monosaccharides unit upon hydrolysis are called disaccharides.

Examples

Sucrose, Lactose, Maltose etc.

SUCROSE

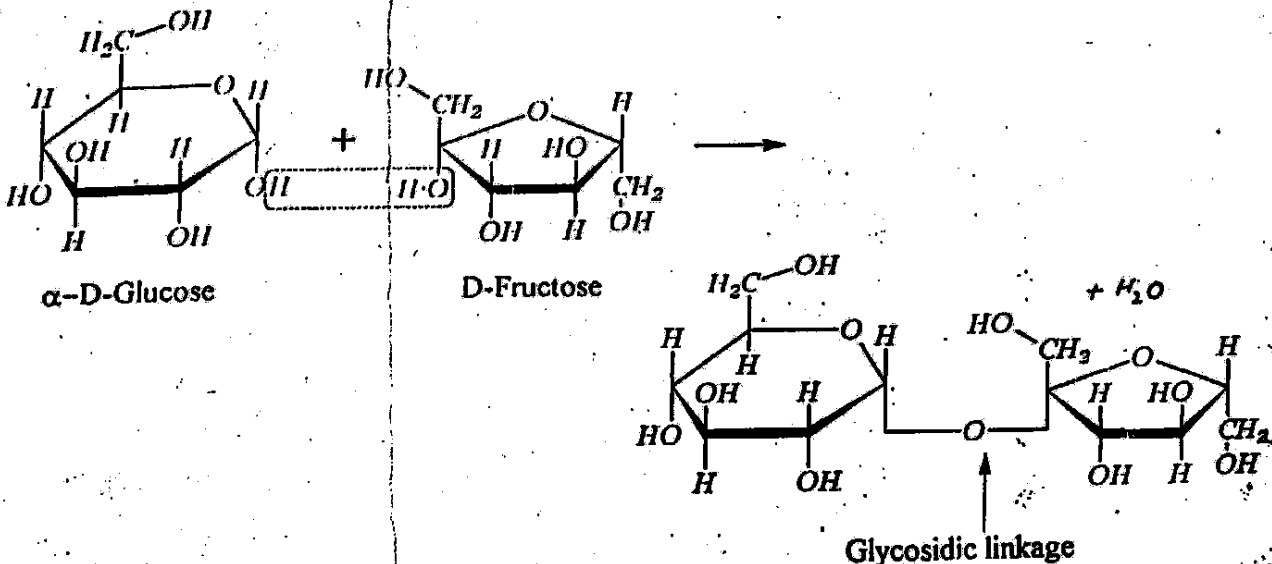
It is also called table sugar

Occurrence

It occurs in sugar cane, sugar beet, pineapple, apricot, mango, almond, coffee, honey etc.

Formation

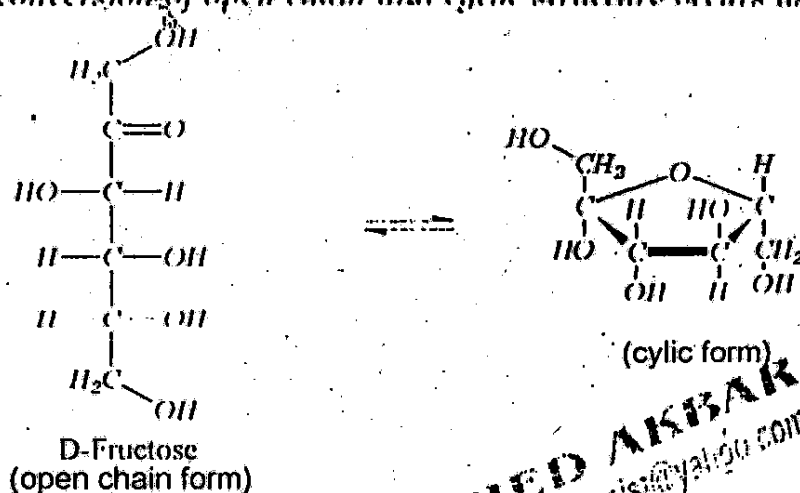
It is formed by condensation of glucose and fructose



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Structure Of Fructose

Interconversion of open chain and cyclic structure occurs as follows.

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SUCROSE

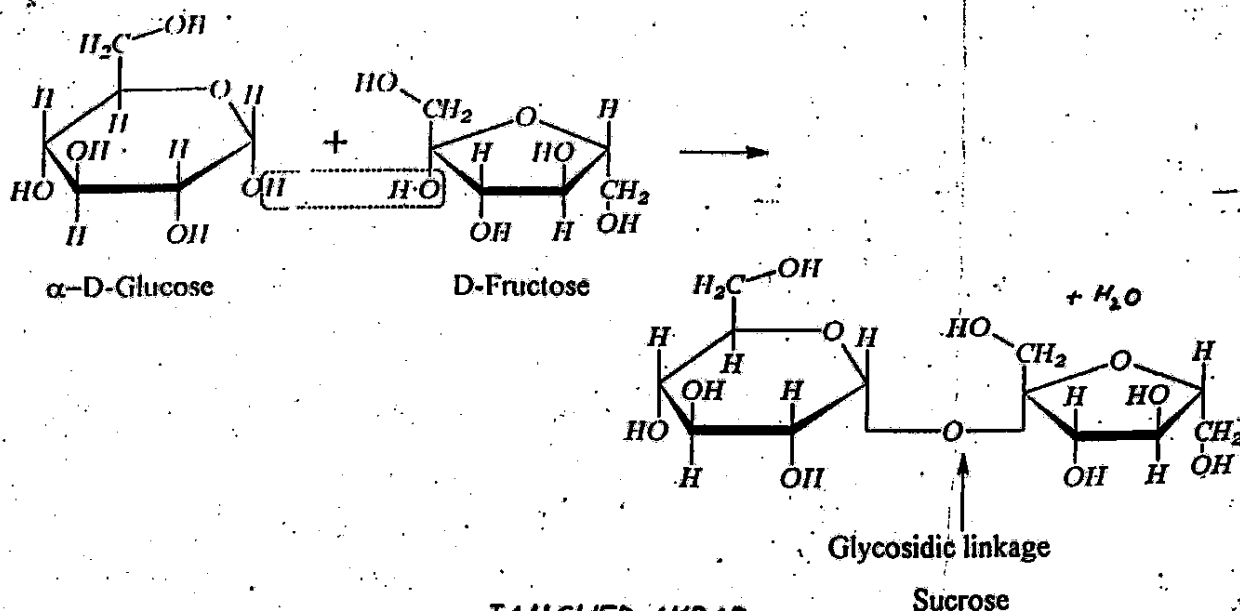
It is also called table sugar

Occurrence

It occurs in sugar cane, sugar beet, pineapple, apricot, mango, almond, coffee, honey etc.

Formation

It is formed by condensation of glucose and fructose



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Uses

- It is used as food.
- It is used in confectionaries, condensed milk, jams, jellies etc.

LACTOSE (MILK SUGAR)

Occurrence

It is found in milk of all animals. It does not occur in plants

TRISACCHARIDES

Oligosaccharides which give three monosaccharide units on hydrolysis are called trisaccharides.

Their general formula is  $C_{18}H_{32}O_{16}$

Example

Raffinose

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Note

Monosaccharides and Oligosaccharides are water soluble crystalline solids, has sweet taste. Thus these are also called as sugars

POLYSACCHARIDES

Carbohydrate which give more than nine monosaccharide units upon hydrolysis are called polysaccharides.

These are natural polymers of high molecular mass.

In these monosaccharide units are linked together by glycosidic linkage

Examples

Starch, Cellulose, Glycogen, Dextrin etc

Both starch and cellulose have formula  $(C_6H_{10}O_5)_n$

Properties

- These are amorphous solids
- These are insoluble in water
- These are tasteless. Thus these are also called non-sugars
- These are storehouse of energy.
- These are structural element of cell
- Plants store their food as starch while Animals store their food as glycogen.
- Glycogen is highly branched polymers. It is present in liver and muscles.

STARCH

It is a polysaccharide. It is a polymer of  $\alpha$ -D-glucose. It's formula is  $(C_6H_{10}O_5)_n$ . Plants store their food as starch. It is an energy source in human diet.

Occurrence

It occurs in wheat, rice, maize, potatoes, barley etc

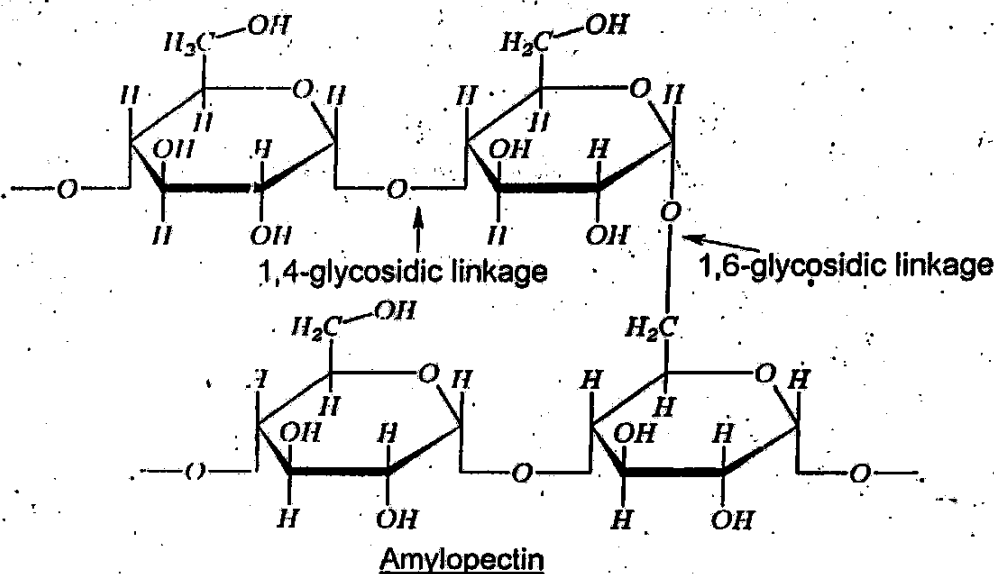
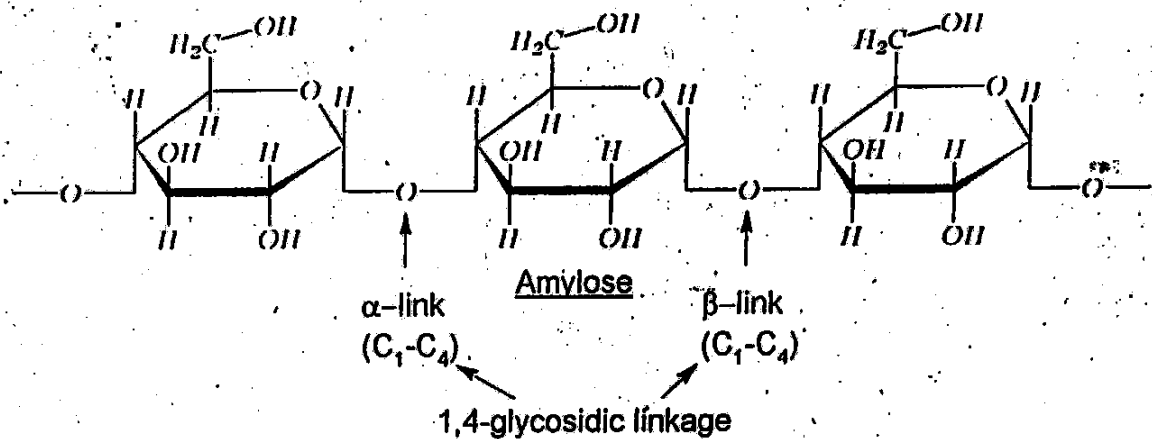
It is not a pure compound. It is a mixture of two polysaccharides. It contains 10 - 20% amylose and 80 - 90% amylopectin. These components can be separated.

- Amylose is soluble in water. It gives deep blue color with iodine
- Amylopectine is insoluble in water. It does not give color with iodine.

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Structure

Structure of amylose and amylopectin are given below

Uses

- It is used in coating and sizing of paper to improve the writing qualities.
- It is used in laundering.
- It is used in the manufacture of glucose and ethyl alcohol.

CELLULOSE

It is a polymer of  $\beta$ -D-glucose

Occurrence

It is the most abundant natural polymer. About 100 billion tons of cellulose are produced each year.

e.g Cotton contain 99% cellulose

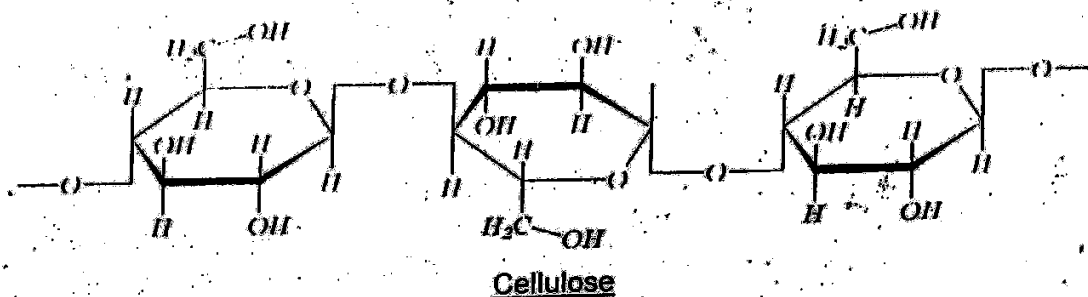
Woody part of Trees contain more than 50% of cellulose

It is mainly found in plant kingdom. However, it is also present in marine animals.

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Structure

Unbranched polymer of  $\beta$ -D-glucosa is given below



Properties

- It is a colourless amorphous solid
- It has low m.p.
- It decomposes on heating
- It is insoluble in water

Uses

- It is used to make fibres.
- It is used as food by living organisms.
- It stimulates intestinal peristalsis
- It is not digested by human being due to lack of cellulase enzyme

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GLYCOGEN

It is also called animal starch.

Occurrence

It is found in liver, muscles.  
It is also found in mushrooms, yeast

Structure

Its structure is close to amylopectin. It has 1-4 and 1-6 glycosidic linkages. However it is highly branched than amylopectin. Upon hydrolysis it gives glucose units.

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**PROTEINS**

**Proteins are high molecular weight organic material which upon complete hydrolysis give amino acids.**

**Explanation**

Word protein is derived from Greek word proteose meaning of "Prime Importance"

- Proteins are complicated molecule
- Proteins are present in all living organisms
- These are present in muscles, skin, hair and non bony structure of body.
- Human body contains at least 10,000 different kinds of proteins.

**CHEMICAL COMPOSITION**

Proteins are nitrogenous compounds made up of variable number of amino acids.

Almost all protein contains following elements

Carbon, hydrogen, oxygen, nitrogen and sulphur

They may also contain phosphorous. Traces of other elements e.g. iron, copper, iodine, manganese and zinc may also present.

Proteins have high molecular mass

**CLASSIFICATION OF PROTEINS**

On the basis of physico-chemical properties, proteins are classified into three types.

- Simple proteins
- Compound or conjugated proteins
- Derived proteins

**Simple Proteins**

Proteins, which give only amino acids or their derivative upon hydrolysis, are called simple proteins.

**Examples****Albumins**

These are water soluble proteins. They are coagulated by heat. e.g. egg albumin, serum albumin

**Globulins**

These are insoluble in water but soluble in dilute salt solution

They are found in animals e.g. lactoglobulin is found in muscles

**Legumin and Collagen**

These are present in connective tissues of the body. These are most abundant protein in animal Kingdom. It comprises about 25 - 35% of the body proteins.

**Compound Or Conjugate Proteins**

The molecules in which proteins are attached or conjugated to non-protein part are called compound or conjugate proteins.

Non-protein part is called prosthetic group

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Examples

Phosphoproteins are conjugated with phosphoric acid  
 Lipoproteins are conjugated with lipid substance like lecithin, cholesterol and fatty acids.

Derived Proteins

The proteins, which are derived from simple and conjugative proteins, are called derived proteins.

Examples

Proteases enzymes, Peptones, Oligopeptides, Polypeptides

CLASSIFICATION ON THE BASIS OF FUNCTION

On the basis of function, proteins can be classified as regulatory or hormonal proteins, structural proteins, transport proteins, genetic proteins etc.

STRUCTURE OF PROTEINS

Protein has three dimensional structure. Proteins are highly convoluted molecules with definite position of atoms.

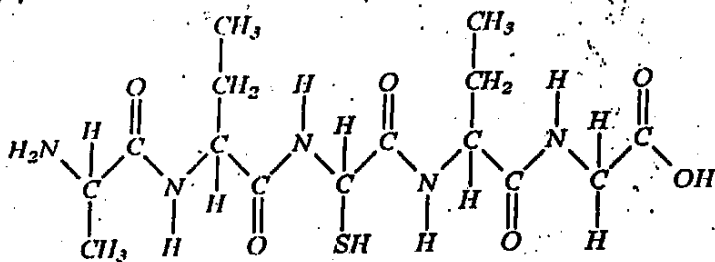
Proteins have four level of structural organization.

- i) Primary structure
- ii) Secondary structure
- iii) Tertiary structure
- iv) Quaternary structure

Primary Structure

Sequence of amino acids in a protein is called primary structure

Amino acids are linked together by peptide bonds. The chain formed is called polypeptide chain. Sequence of amino acids greatly affects the physico-chemical properties of proteins.



Secondary Structure

Regular coiling or zigzagging of polypeptide chain give rise to secondary structure.  
 Coiling of polypeptide chain form spiral helix structure.  
 The helix may be right handed or left handed.  
 Right handed helix is called  $\alpha$ -helix while left handed helix is called  $\beta$ -helix.  
 Spiral helix secondary structure is stabilized by hydrogen bonding b/w NH and C=O groups of amino acids

Tertiary Structure

Three dimensional twisting and folding of polypeptide chain give rise to tertiary structure of protein.

Note

Some proteins also show quaternary level of structural organization

DENATURING OF PROTEIN

The disruption in structure of protein by heating or changing pH or by using oxidizing agents and reducing agents is called denaturation of protein.

Example

Albumin protein is present in egg. When it is heated, it is hardened. This change is irreversible.

IMPORTANCE OF PROTEINS

1. Proteins are essential part of protoplasm, which is the basis of life.
2. Nucleoproteins are complex proteins with nucleic acids. These are carriers of genetic information, generation after generation.
3. Enzymes are also proteins. These are biological catalysts
4. Haemoglobin is a protein. It carries oxygen throughout body.
5. Hormones are also protein in nature. These perform regulatory functions e.g. insulin, thyroxin etc.
6. Protein has great importance in industry. In leather industry tanning of hides is done by precipitation of protein by tannic acid.

LIPIDS

Lipids are naturally occurring organic compounds of plants and animal origin, which are soluble in organic solvents and belong to very heterogeneous group of substances.

Explanation

Word lipid is derived from Greek word Lipos meaning fat.

Simple lipids on hydrolysis give alcohol and fatty acids.

CHARACTERISTICS OF LIPIDS

- They are insoluble in water
- They are soluble in non-polar solvents like ether, chloroform, benzene etc.
- Their primary building blocks are fatty acids, glycerol and sterols
- They can be utilized by living organisms

CLASSIFICATION

Lipids may be classified as follows

Simple Lipids

These are esters of fatty acids with glycerol

Example

Common fats, oils

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Compound Lipids

These contain radicals in addition to fatty acids and alcohols

Example

Phospholipids, sphingolipids, lipoproteins and lipopolysaccharides

Derived Or Associated Lipids

These lipids are hydrolytic products of compound lipids.

Example

Sterols, Vitamin D, Terpenes etc

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FATS AND OILS

Fats and oils are the most important lipids. These are among three major food factors needed for human body.

These three factors are carbohydrates, proteins and fats/oils

SOURCE OF FATS AND OILS

Three main sources of fats and oils are

- Animals
- Plants
- Marine organisms

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Animals

Animals fat is mainly located in adipose tissue cells.

e.g. butter and ghee are special types of animal fat. These are made from milk.

Plants

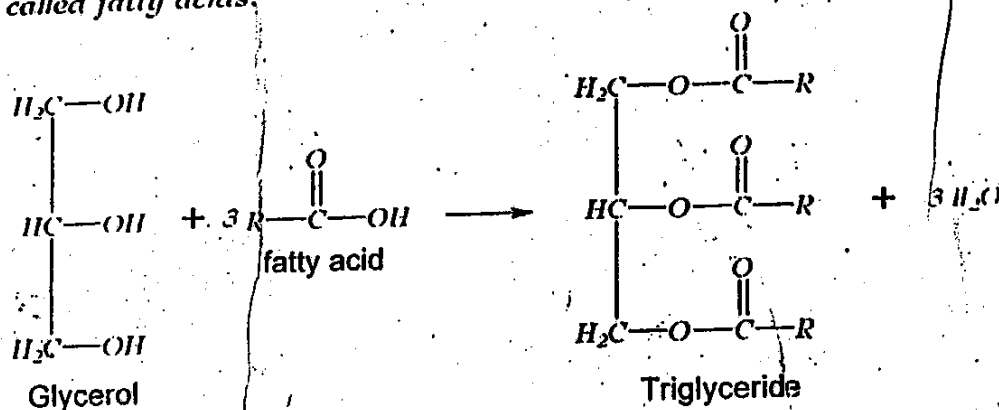
Vegetable oils are present in seed and nuts of plants e.g. soyabean oil, corn oil etc

Marine Organisms

Marine oils are obtained from sea animals like salmons, wales etc.

STRUCTURE AND COMPOSITION OF FATS AND OILS

Structure of animal fats and plant oils is same. Basically, these are esters. These esters are formed by chemical combination of glycerol and long chain acids called fatty acids.



The ester produced is called triester. A triester of glycerol is called a triglyceride or glyceride.

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CLASSIFICATION OF GLYCERIDES

Glycerides may be classified as follows

Simple Glycerides

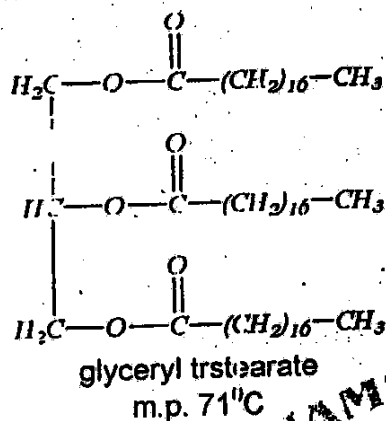
The glycerides in which all R groups are identical

Mixed Glycerides

The glycerides in which all R groups are different

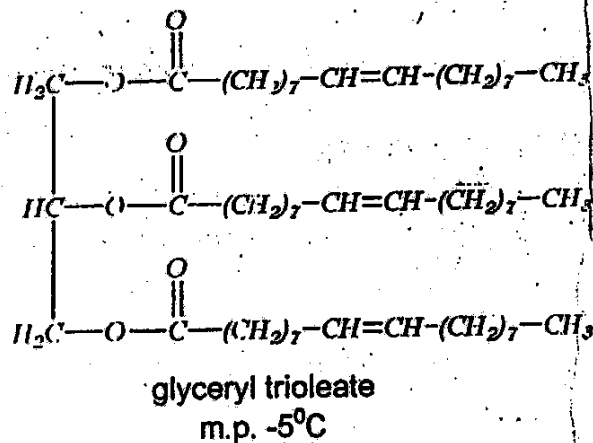
Solid or liquid nature of glyceride depends upon the degree of unsaturation in long chain of fatty acids. Glycerides may also be classified according to phase as follow

- The glyceride in which long chain of saturated acids is present are generally solid or semi-solid. These are called fats. These are mostly obtained from animals.



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- The glycerides in which long chain of acid contain unsaturation are generally liquid. These are called oils. These are mostly obtained from plants

Note

Melting point of mixed glyceride depend upon the degree of unsaturation in the molecule. Polyunsaturated glycerides have very low m.p. and these are liquids.

Common oils and fats are chemically a mixture of saturated and unsaturated triglycerides present in various ratios.

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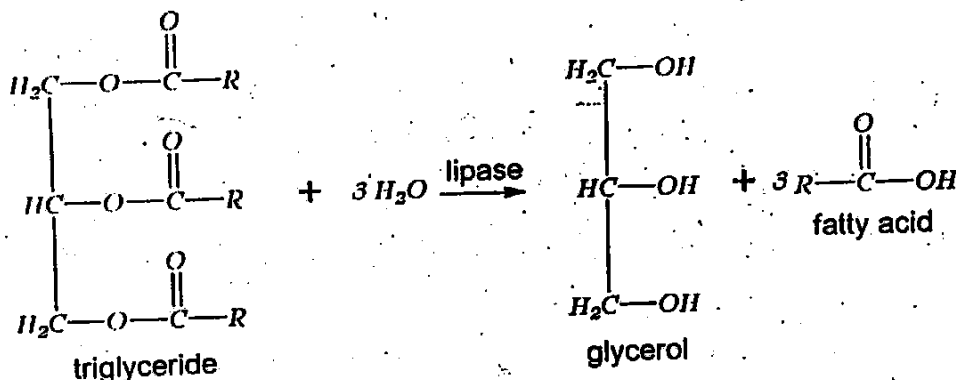
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**PHYSICAL PROPERTIES**

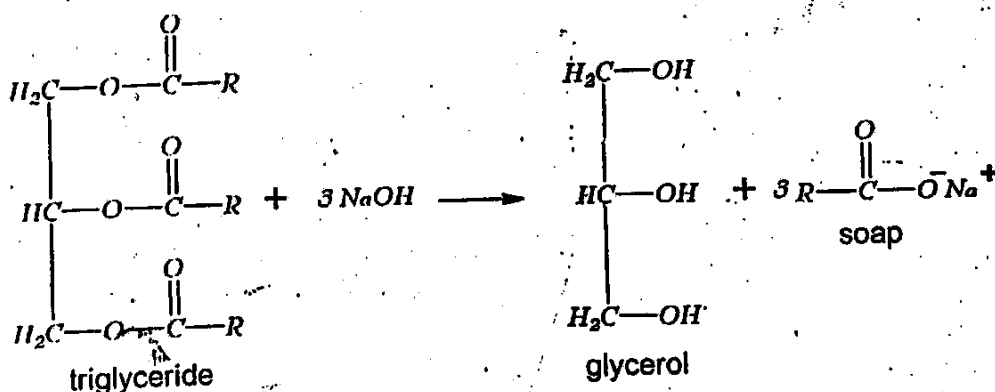
1. Oils and fats may be either liquids or non-crystalline solids at room temperature.
2. In pure form, they are colourless, odourless and tasteless
3. They are insoluble in water
4. They are readily soluble in organic solvents. e.g. diethyl ether, acetone,  $\text{CCl}_4$  and  $\text{CS}_2$
5. They readily form emulsions, when they are agitated with water in the presence of soap or other emulsifiers.
6. They are poor conductor of heat and electricity. Thus, these act as insulators for human body.

**CHEMICAL PROPERTIES**Hydrolysis

These are hydrolyzed by enzyme lipase to fatty acids and glycerol

Saponification

Hydrolysis of fat or oil with an alkali to form soap is called saponification. Saponification produces soap (salt of fatty acid) and glycerol

Hardening Of Oil

Unsaturated glycerides are converted to saturated glyceride by the addition of  $\text{H}_2$  in the presence of metal catalyst. This reaction is called hardening of oil.

By this reaction, liquid glycerides (an oil) is converted into a semi-solid glyceride (a fat)

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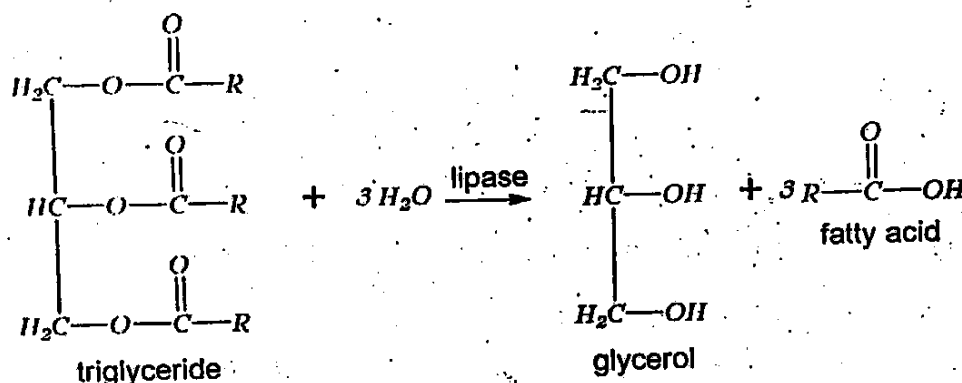
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**PHYSICAL PROPERTIES**

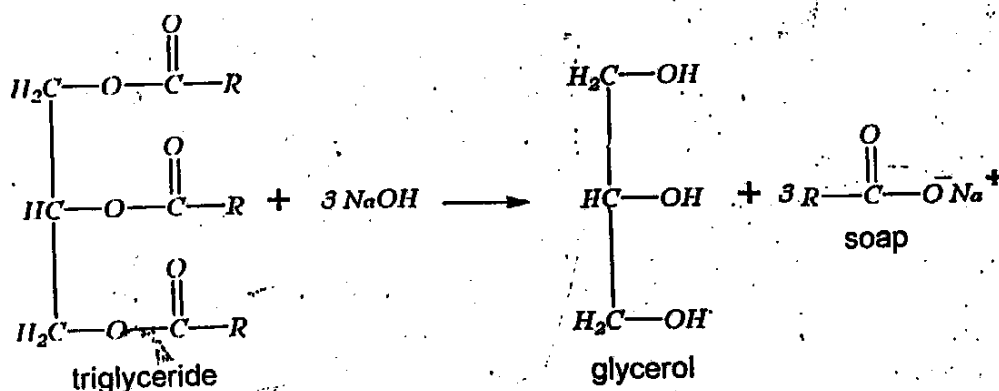
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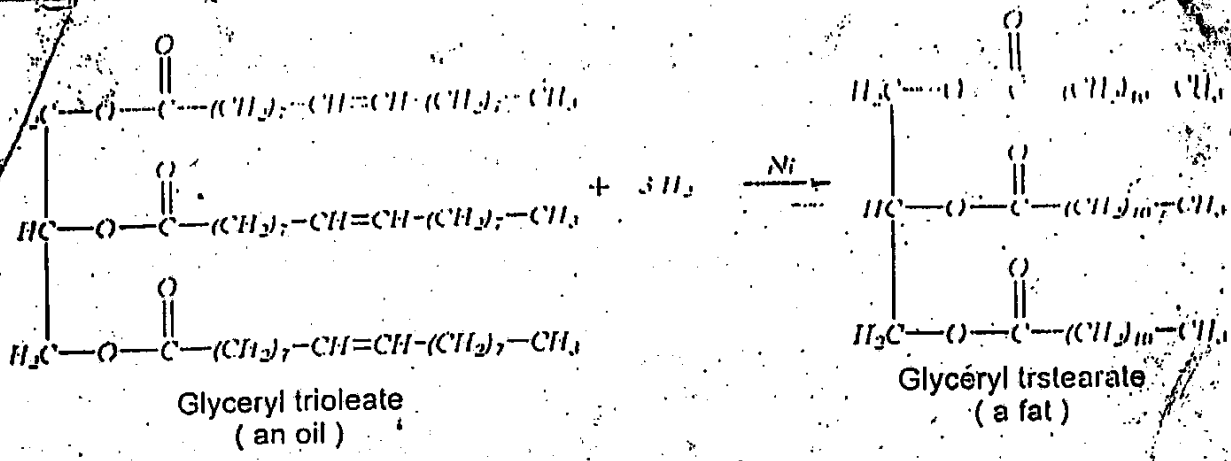
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Hardened oil are also extensively used for making soaps and candles.

**SAPONIFICATION NUMBER**

It is the number of mg. of KOH required to saponify one gram of fat or oil.

**Example**

One mole of glyceryl trioleate (mol wt. = 836) requires 168,000 mg. of KOH for saponification. Thus 1 g will require 168000/836 mg of KOH. Hence saponification number of glyceryl trioleate is 208.

**RANCIDITY OF FATS OR OILS**

The spoilage of fats and oils and development of unpleasant odour is called rancidity.

Rancidity occurs due to hydrolytic and oxidative reactions. These reactions produces foul smelling aldehydes and fatty acids.

Oils obtained from marine organisms contain high degree of unsaturation. These spoil rapidly.

**IODINE NUMBER**

It is the number of grams of iodine, which will react with 100 g of fat and oils.

It is used to determine the degree of unsaturation in fats and oils. Generally, higher the iodine number higher the degree of unsaturation.

Iodine is added on double bond of unsaturated compounds. Thus value of iodine number depends upon the number of double bonds present in the glyceride.

Saturated glyceride with no double bond has zero iodine number.

**ACID NUMBER**

It is the number of mg. of KOH required to neutralize one gram of fat.

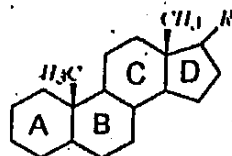
Acid number gives the amount of free fatty acid present in a fat or an oil.

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2004 - 2005

## STERIODS

These are naturally occurring lipids. Their parent nucleus contain three six membered rings (A, B and C) and one five membered ring (D). This nucleus is called perhydrocyclopentanophenanthrene structure. In this structure, rings are fused together and have total 17 - C atoms.



Steroid Nucleus

Small structural changes in the bonding of atoms in the ring and in the groups attached to them give rise to different compounds. These compounds have different biological activities.

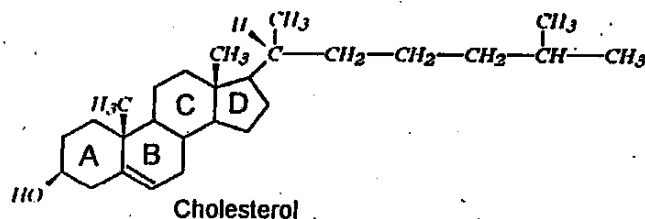
Some naturally occurring lipids are cholesterol, ergosterol, male and female sex hormones and the hormones of the adrenal cortex.

## CHOLESTEROL

It is the most abundant animal sterol.

It occurs in animals. It is also found in some higher plants. It is present both in free and esterified form. It is present in blood, animal tissues, egg, yolk, various oils and fats and nerve tissues.

Increased amount of cholesterol in blood form a plaque like deposit in the arteries. This deposit causes blood pressure and other heart diseases.



Cholesterol

## ERGOSTEROL

It is the sterol of fungi and yeasts.

When exposed to UV light, it is converted into ergocalciferol or vitamin D<sub>2</sub>.

## PHOSPHOLIPIDS

These molecules are of biological importance.

In these compounds, two hydroxyl groups are esterified with fatty acids. While third hydroxyl group is linked with phosphoric acid or a derivative of phosphoric acid.

## IMPORTANCE OF LIPIDS

1. These are good source of energy
2. These make the food palatable
3. These are store house of energy in the body.
4. These are integral part of cell protoplasm and cell membrane.
5. Some lipids are precursors of very important physiological compounds. e.g- cholesterol is the precursor of steroid hormones.

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**ENZYMES**

Enzymes are reaction catalysts of biological system produced by living cells and are capable of catalyzing chemical reactions.

**EXPLANATION**

Enzymes are either pure proteins or they contain protein as essential component. Enzymes may contain a non-protein part. The protein part of enzyme is called apoenzyme. And the non-protein part is called co-factor or co-enzyme.

**Apoenzyme**

The protein part of enzyme is called apoenzyme

**Co-enzyme or Co-factor**

The non-protein part of enzyme is called co-factor or co-enzyme.

Co-factors include inorganic ions, complex organic or organo-metallic molecules.

Important inorganic co-factors alongwith their enzymes are  $Fe^{2+}$  (chrome oxidase),  $Zn^{2+}$  (carbonic anhydrase) &  $Mg^{2+}$  (glucose-6-phosphate) etc.

Vitamins are also present as co-factor e.g. nicotinamide adenine dinucleotide (NAD) contains nicotinamide vitamin. Thiamine pyrophosphatase contains vitamin B.

**NOMENCLATURE OF ENZYME**

Enzymes are named in following ways

- Some enzymes are given common names  
e.g. ptyalin, pepsin, trypsin etc.
- Some enzymes are named according to substrate on which they act.  
e.g. Urease acts on urea.  
Sucrase acts on sucrose etc.
- Some enzymes are named on the basis of product formed  
e.g. In one reaction invertase sugar is produced. This reaction is catalyzed by invertase enzyme.
- Some enzymes are named according to reaction type  
e.g. alcoholic dehydrogenase, oxidase, reductase etc.

**CLASSIFICATION OF ENZYME**

International Union of Bio-Chemistry (IUB) has classified enzyme in six main types.

**1. Oxidoreductases**

These enzymes catalyze oxidation-reduction reactions.

e.g. oxidases, reductases, dehydrogenases and peroxidases.

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Transferases

These enzymes carry out exchange of functional group such as phosphate or acyl group between two compounds.

e.g. phospho-transferases, transaminases etc.

3. Hydrolases

These enzymes catalyze hydrolysis.

These include proteases called proteolytic enzyme.

e.g. amylases, peptidases, lipases etc.

4. Lyases

These enzymes catalyze addition of  $\text{NH}_3$ ,  $\text{H}_2\text{O}$  or  $\text{CO}_2$  to double bonds or removal of these from double bond.

e.g. Fumease enzyme converts fumaric acid to maleic acid.

Similarly decarboxylases, deaminases, aldolases etc.

5. Isomerases

These enzymes catalyze the transfer of groups within molecules to give isomeric products.

e.g. phospho-glyceromutases, epimerases, racemases etc.

6. Ligases

These enzymes link two molecules together through the breaking of high energy bonds.

e.g. acetyl - S - CCH, a carboxylase and succinic thiokinase.

PROPERTIES OF ENZYMES1. Specificity

Enzymes are highly specific in their action. A particular enzyme acts on only one substrate. Every enzyme has specific sites on it with which substrate binds. These sites are called active sites.

e.g. hexokinase catalyses conversion of hexoses like glucose, fructose and mannose to their 6-phosphate derivatives. But glucokinase is specific for glucose only.

2. Efficiency

Enzymes are highly efficient. An enzyme can speed up the reaction by a factor of  $10^{20}$  fold.

3. Protein Nature

Enzymes are mostly protein in nature. They are produced by living cells. These act in vivo as well as in vitro.

4. The Direction Of Enzyme Reactions

Most enzymatic reactions are reversible i.e. the same enzyme can catalyze reactions in both directions.

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5. Isoenzymes

The enzymes from the same organisms which catalyze the same reaction but are chemically and physically distinct from each other are called isoenzymes.

FACTORS AFFECTING ENZYME ACTIVITY1. Effect of Concentration

Rate of enzymatic reaction is directly proportional to the square root of the concentration of enzyme.

Rate of enzymatic reaction is also directly proportional to the concentration of the substrate.

2004 - 2005

2. Effect of Temperature

Optimum temperature for enzymatic reaction is about  $37^{\circ}\text{C}$ , which is the average normal body temperature. Rate of enzymatic reactions is increased with increase in temperature over a limited range of temperature. Enzymes usually destroy at high temperature. The activity of enzymes is reduced at low temperature.

The temperature at which an enzyme reaction occurs at fastest rate is called its optimum temperature.

3. Effect Of pH

Enzymes have an optimum pH at which an enzyme will catalyze the reaction at the maximum rate.

e.g. Optimum pH of salivary amylase is 6.4 to 6.9.

4. Effect Of Other Substances

The enzyme action is also increased or decreased in the presence of some other substances such as co-enzymes, activators and inhibitors.

Co-enzyme

Many enzymes act as a combination of a co-enzyme (non-protein part) and an apo-enzyme (protein part).

Activators

These are inorganic substances, which increase the enzyme activity.

e.g.  $\text{Mg}^{2+}$  ions activate phosphatase enzyme and  $\text{Zn}^{2+}$  ions activate carbonic anhydrase enzyme.

Inhibitors

These are the substances which reduce the enzyme activity.

5. Effect Of Radiations

Generally enzymes are readily inactivated by exposure to ultra-violet light, beta rays, gamma rays, and X-rays.

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