Teacher: Sir Javed Iqbal Written By: M. Zeeshan

(Chapter # 21)

(Biochemistry)

Introduction:

biochemistry is a hybrid science. It is the branch of chemistry which deals with the studying of various bio molecules that are present in living cells and their chemical reactions.

macromolecules

four main type of macromolecules control all the activities of cell.

1- Carbohydrates
2- Lipids
3- Proteins
4- nucleic acids

Carbohydrates

def: They are polyhydroxy aldehydes and ketones or converted

to such substances as simple oxidation, reduction & hydrolysis.

Formula

Their general formula is $C_n(H_2O)_n$

Note

The organic compounds which have hydrogen and oxygen in proportion of 2:1 are not carbohydrates

Formaldehyde $(HCHO) = C(H_2O)$

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

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

anywhere, Rhamnose $C_6H_{12}O_5$ does not have the ratio of H_2 to O_2 as in H_2O, but it is carbohydrate

Classification of Carbohydrate

They are classified into three types:

1- monosaccharides
2- Oligo/disaccharides
3- polysaccharides

Monosaccharides

The simplest sugar which cannot be further hydrolyzed are called monosaccharide

'mono' means one and 'saccharide' means sugar

Example Fructose, glucose and galactose

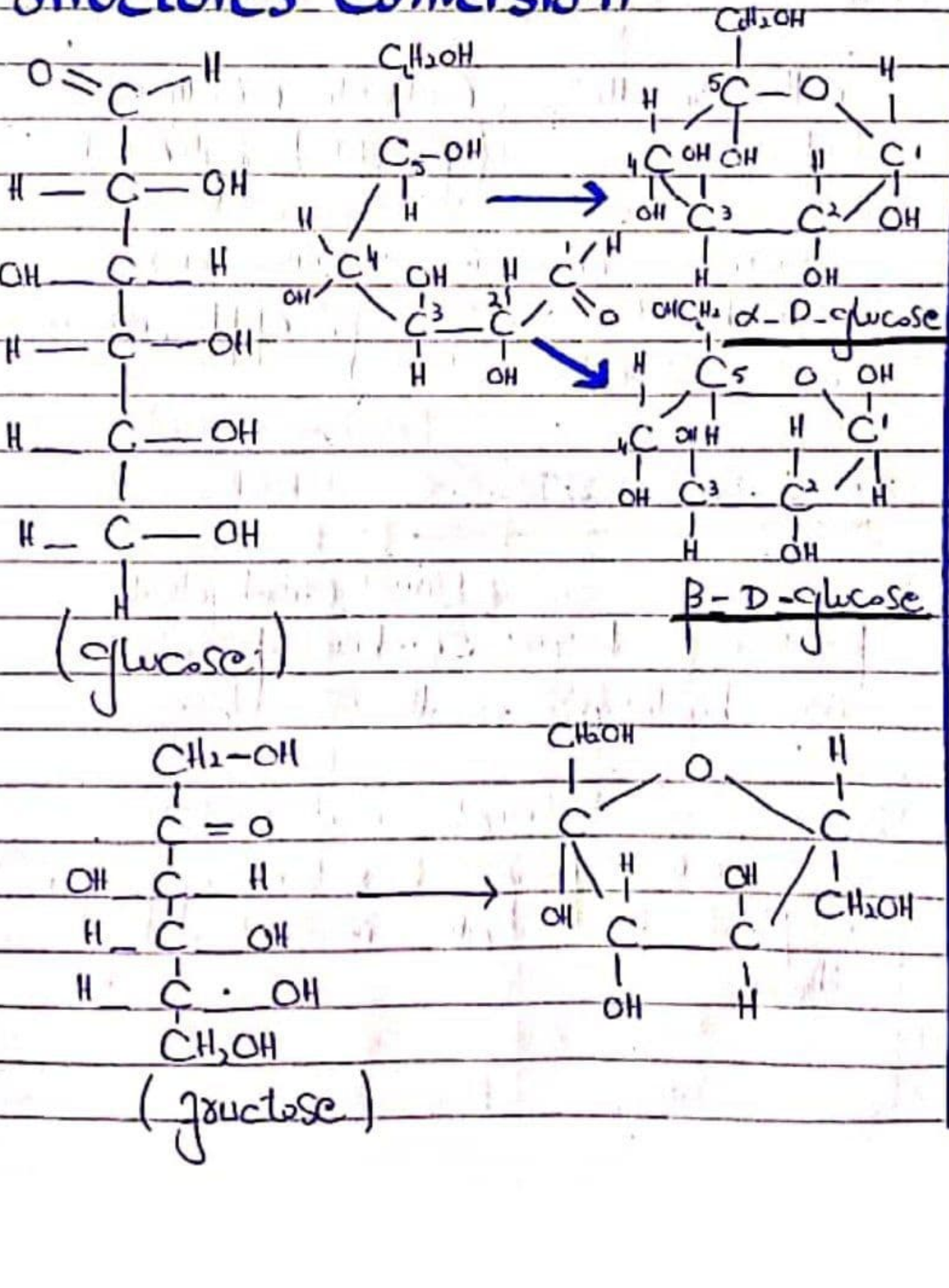
Properties

→ glucose is also called as blood sugar. It is present in corn and honey.

→ galactose is present in milk and dairy products.

→ fructose in like grapes and present in fruits vegetables

Structures Conversion



disaccharide

→ They are the carbohydrate molecules which upon hydrolysis form 2 to units of simple sugar

Example lactose, maltose and sucrose

$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$
(Sucrose) (glucose) (fructose)

Lactose is formed in the milk

$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6 + C_6H_{12}O_6$
lactose (galactose) (glucose)

Sucrose occurs in sugar-cane, sugar beet, mango, pineapple, almond and apricot

Polysaccharides

→ The carbohydrates producing large number of monosaccharide on hydrolysis called polysaccharide

Example Starch and Cellulose are polysaccharides glycogen also involved in plant it them

Functions of Carbohydrates

1__ They are involved in building, maintaining and repairing of body tissues.

2__ They are necessary for regulation of nerve tissue and a source of energy for brain.

3__ Certain types support growth for healty bacteria in the intesting for digestion

4__ Some carbohydrates have high fibres which help to prevent constipation and lower the risk for cancer, heart problems and diabetes

Nutritional importance of Carbohydr...

Body Weight regulation

1__ people who take more carbohydrates in their diet have less body weigh or fat.

2__ Starch and sugar quickly satisfy the craving of food than those of fats.

3__ high carbohydrates in the diet

in comparison to high fat can regulates normal body weight.

Diabetes

1_ There is no evidence that sugar consumption is linked to the development of diabetes_ diabtes is caused by obesity and physical inactivity_

2_ weigh reduction is the primarly aim for the diabetes patient

3_ most recommedations for the dietary management allows a modest amount of ordinary sugar_

Dental health

1_ Food containing sugar and starch can be broken down by the ~~bacteria~~ and bacteria in the mouth to produce enamel of teeths by the acid_

2_ after enamel Slva provides a natural repair to rebuild the enamel_

3_ when sugars are taken over time this natural process

disable to work, decay of teeth is increased.

Note

— 1g of carbohydrate contain 4kiLocalories.

— 1g of protein contain upto 4kcal

— 1g of fat contains 9kcal

Proteins

def: The molecules which yeild amino acids on complete hydrolysis. They contain N_2, C, H_2 and O_2

Example enzymes, Hb, keratin

Classification of Proteins

They are classified into three types

1- Simple Protein
2- Conjugated protein
3- derived protein

Simple protein

The proteins which yeild only amino acid or derivatives on hydrolysis

Example albumins, histone, glutelins

Conjugated protein

The proteins which are attached or conjugated to some non protein groups called prosthetic group

Example nucleoprotein, mucoprotein, glycoprotein are some examples.

Derived Protein

The proteins which are derived from simple and conjugated proteins are called derived protein

Example proteans, proteoses, peptones and peptides

Structures of Proteins

There are four common structures of protein:

1. primary
2. Secondary
3. Tertiary
4. quaternary

Primary Structure

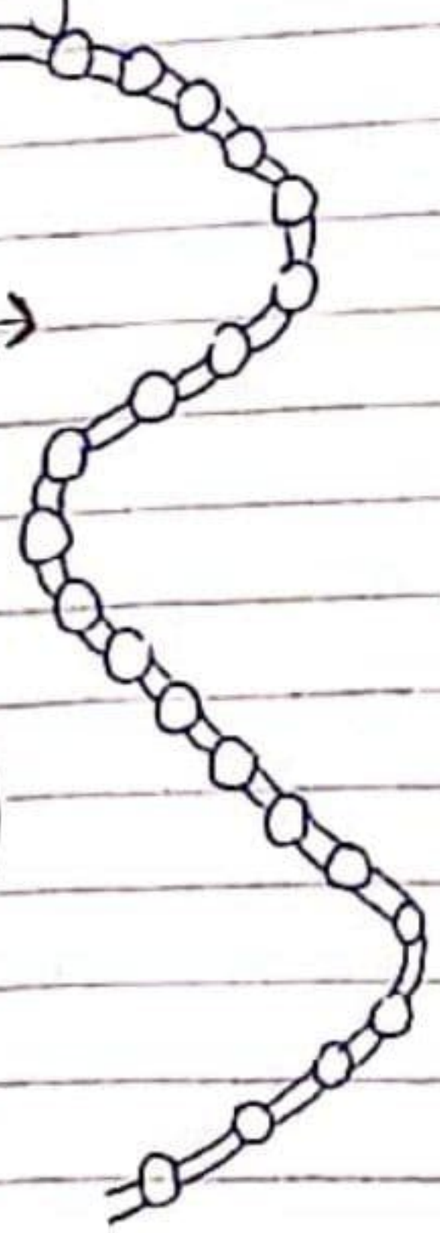
The sequence of amino acids in a peptide chain is called primary structure. amino acids are linked through peptide bonds.

(Structure) ⟶ (amino acid sequence)

Secondary Structure

The peptide chain acquire Spiral Shape or may be present in zig-zag manner this coiling or zig-zagging of polypeptide is due to hydrogen bonding.

(α-helix) ⟶



(Secondary Structure)

Tertiary Structure

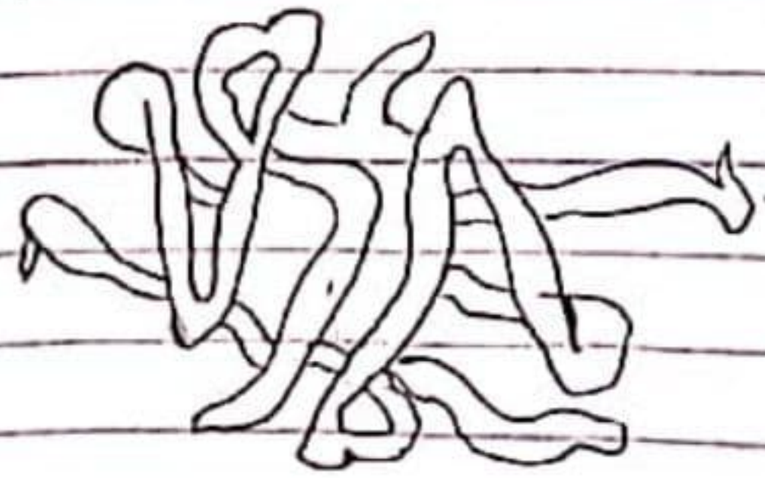
The twisting and folding of polypeptide chain structure of proteins

(Tertiary Structure)

(folding of polypeptides)

Quaternary Structure

Quaternary means four It is fourth phase in the creation of protein. The arrangement of multiple folded protein or coiling of polypeptides in multiple subunit of complex.



(Quaternary Structure)

(more than one amino acid)

(hydrogen bonding, disulphide bridges are present)

properties of proteins

1- They are involved in digestion cell structure catalysis and energy manipulation.

2- Their are 20-22 kind of amino acids in proteins. They are differenciated by 'R' group.

3- amino acids are joined together in a long chain called polypeptide amino acids combined with each other by peptide bond having molarmass upto 10,000 are termed as polypeptide

Importance of proteins

1- They plays a important role in formation of protoplasm.

2- nucleoproteins are complex proteins act as a carrier of heredity from one generation to other.

3- Hb (haemoglobin) act as a carrier of O_2.

4- proteins are involved in tanning of hides. gelatin is obtained by by heating bones used for bakery products.

Enzymes

def: The word 'En' means in a 'Zyme' means yeast enzymes are complex protein which speed up the reaction without being consumed they are biological catalysts

Example pepsin, trypsin, amylase

enzymes as biocatalysts

Metabolism is the sum of all the chemical reactions that occur in living organisms in order to sustain life

metabolism consist of anabolism and Catabolism

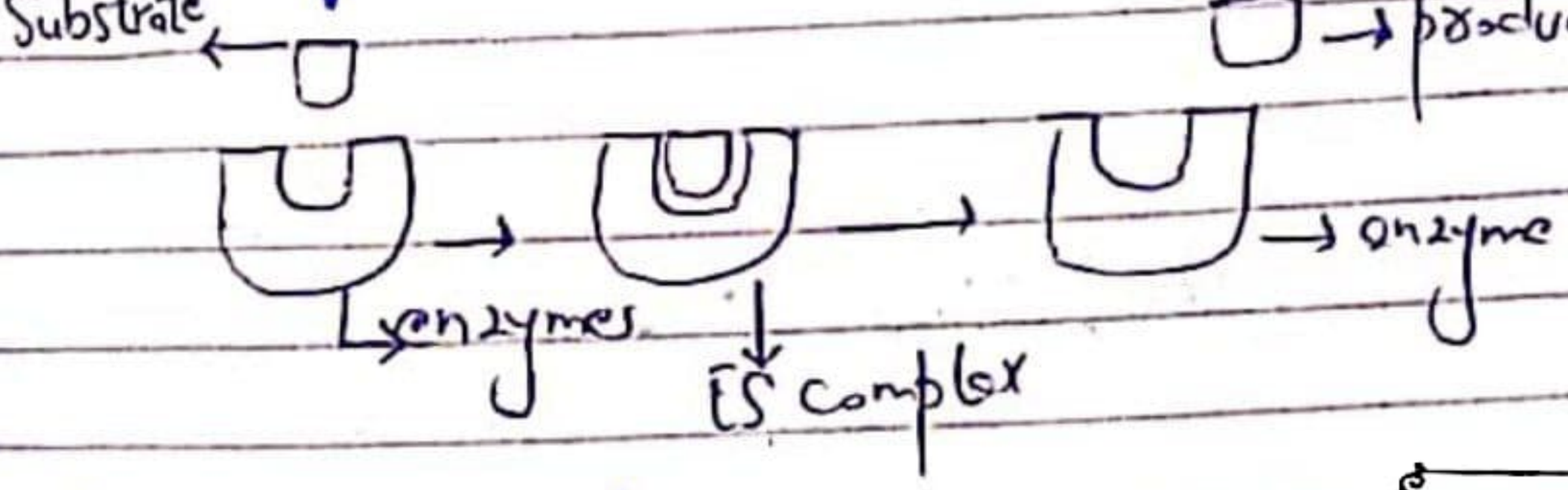
Anabolism includes the biochemical reactions in which larger molecule are synthesized

Catabolism includes the biochemical reaction in which larger molecules are broken down into smaller ones

enzymes are biocatalysts which speed up and regulate metabolic pathway.
The molecules on which enzymes acts are substrate and the formed molecules are called product

Lock and Key model

Emil fischer in 1894 proposed lock and key model
→ according to this model enzymes are highly specific for their substrates
→ one enzyme can catalyze one substrate.
→ active site of enzyme is rigid
Exp → urease

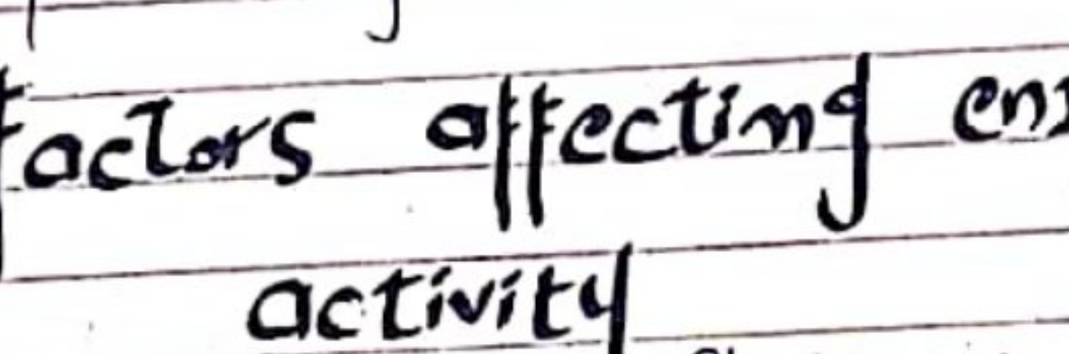


Induced fit model

→ daniel koshland in 1958 proposed this model
→ This model states that enzymes are not very specific for substrates.
→ one enzyme can catalyze more than one substrate.

→ active site of enzyme is flexible

Exp Carbonic anhydrase



Factors affecting enzyme activity

There are three factors which affect the activity of enzyme.

a) Temperature

The temp at which a enzyme perform its maximum activity is called optimum temperature

Example

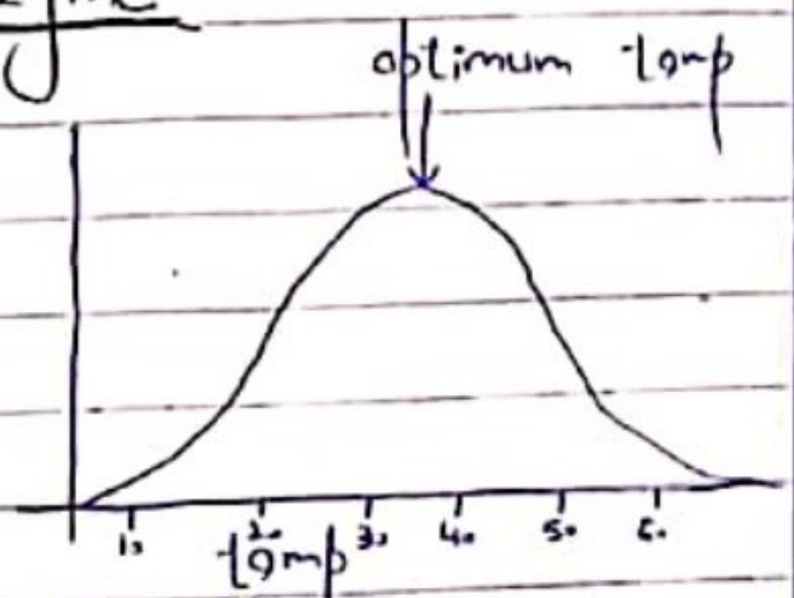
animals 37°C
plants 60°C
bacterias 70°C

→ When temperature rises to a certain limit heat adds in

the activation energy and also provide kinetic energy for reaction.

→ When the temp is raised above the limit the vibrations of atoms of enzyme and globular structure is lost this is called denaturation of enzyme

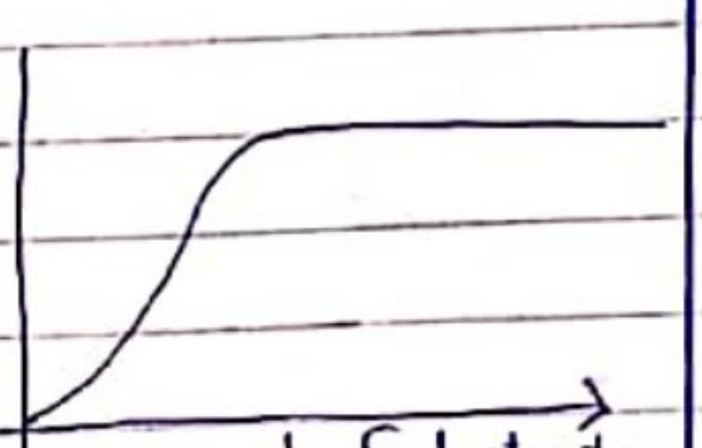
graph →



Substrate Concentration

→ If the enzymes are kept constant and rate of substrate is increased the rate of reaction increases to a certain limit because when all the active sites of enzymes are filled by substrates then their is no enzyme available for more substrates.

graph →



PH

→ all enzymes work maximum at a narrow range of PH called

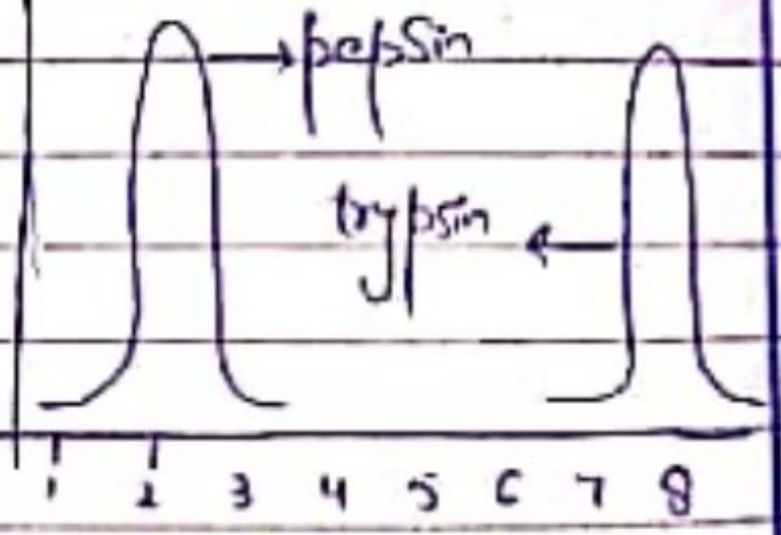
optimum PH

Example

pepsin active in acidic medium (PH=2) while trypsin works in alkaline PH = 8-9

→ a slightly change in PH blocks the enzyme activity completely.

graph →



Inhibition of enzyme

→ The molecule which bind with enzyme and stops its activity called inhibitor

→ Inhibition can be reversible and irreversible

Irreversible inhibition — when the inhibitor react and form strong covalent

bond with the active site of enzyme it is called irreversible inhibition

Example These inhibitors are malonate etc_

reversible inhibition

The inhibition in which the activity of enzyme is restored called reversible inhibition It has two types

a) Competitive inhibition

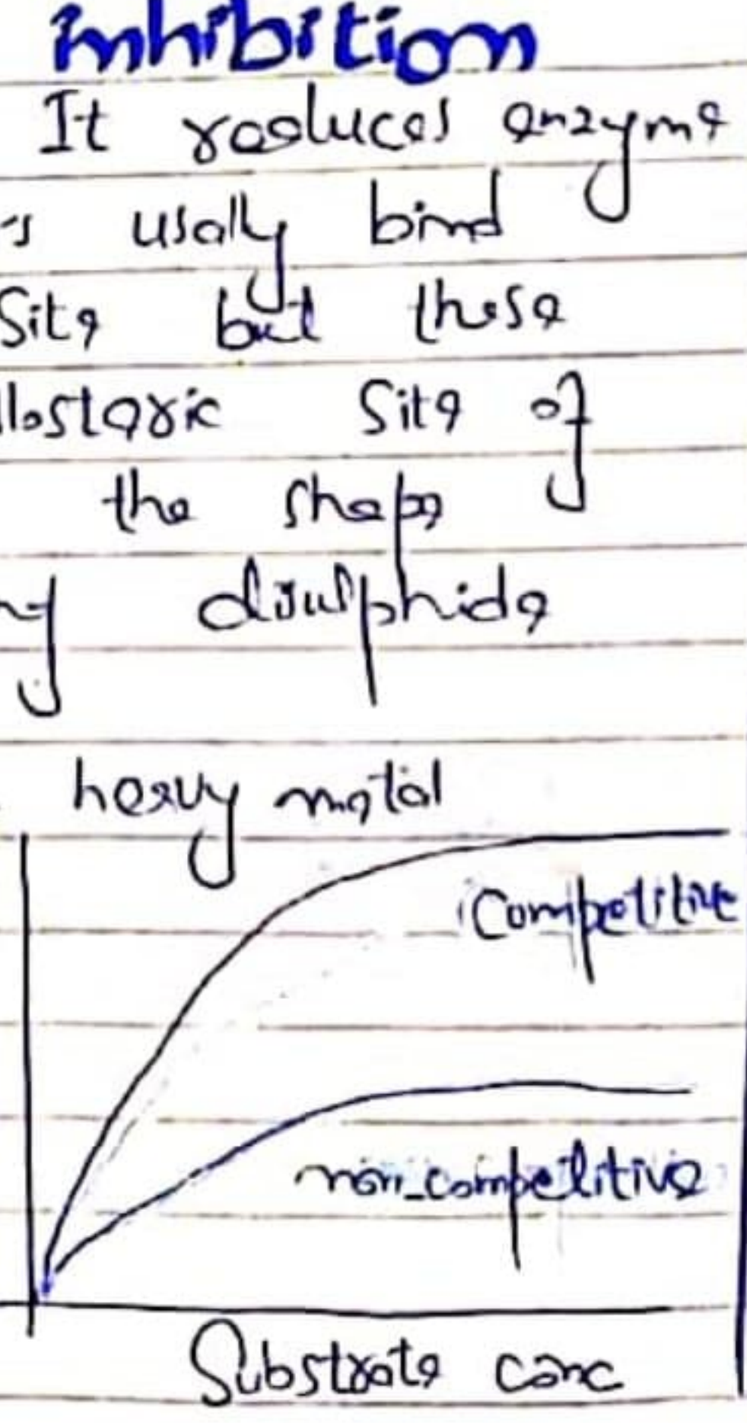
It resembles the substrate It can bind to the enzyme in the same way like substrates do_

b) non_Competitive inhibition

It reduces enzyme activity_ The inhibitors usally bind at the active site but these inhibitors bind the allosteric site of enzyme It denatures the shape of enzyme breaking disulphide bridges

Exp — Cyanides, Salts of heavy metal

graph ⟶



Applications of enzymes

Food industry:

enzymes break starch into simple sugar and used in the production of bread, buns

Paper industry:

enzymes break starch to lower its viscosity that aids in making paper

detergents:

protease enzyme is used for the removal of protein stains

dairy industry:

lipase enzymes are implemented during the production of cheese

molecular biology:

DNA ligase and polymerase enzymes are used to manipulate DNA in genetic engineering

Lipids

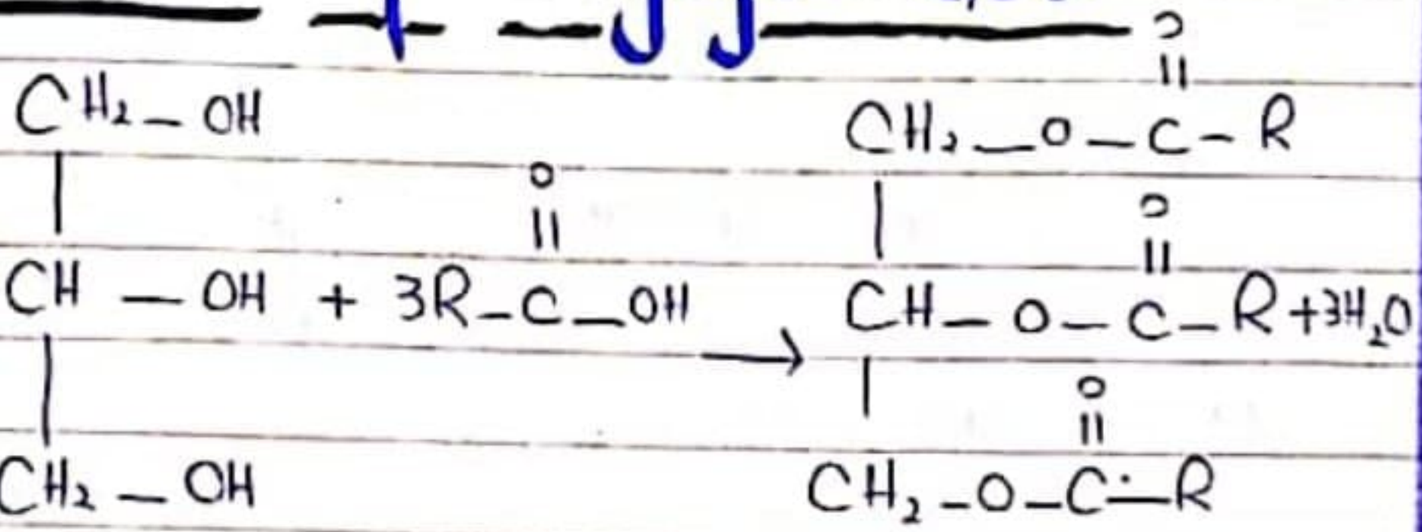
The esters of long chain fatty acids and glycerol are called lipids

Lipids are the main part

of all the membranes of cell, good storage molecules, vitamin A, D [and K], cholesterol

Fats and oils are made up of two kind of molecules one is glycerol and fatty acid. Since there are three fatty acids attached called triglycerides or neutral lipids.

Formation of triglycerides



Classifications

They are classified as:

Simple lipids — They are esters of fatty acid with glycerol.
Exp- neutral lipids, waxes

Compound lipids — They contain radical in addition to fatty acids and alcohols.
Exp- liposital, plasmalogen, phospholipid

derived lipids

These are hydrolylic product of compound lipids

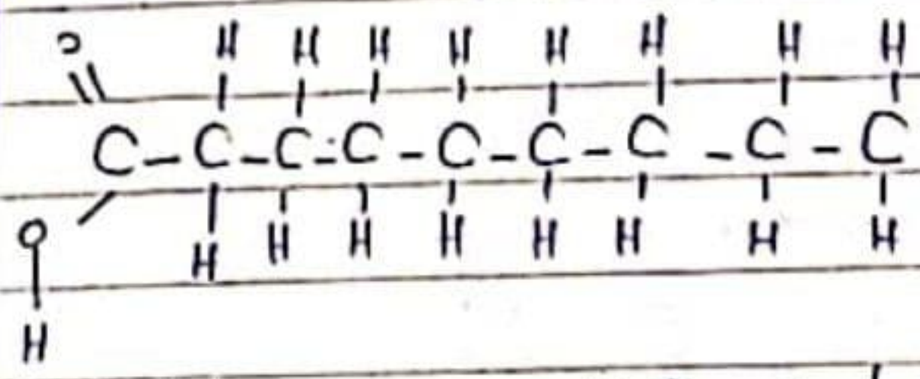
Exp ⟶ fatty acids

Structure of lipids

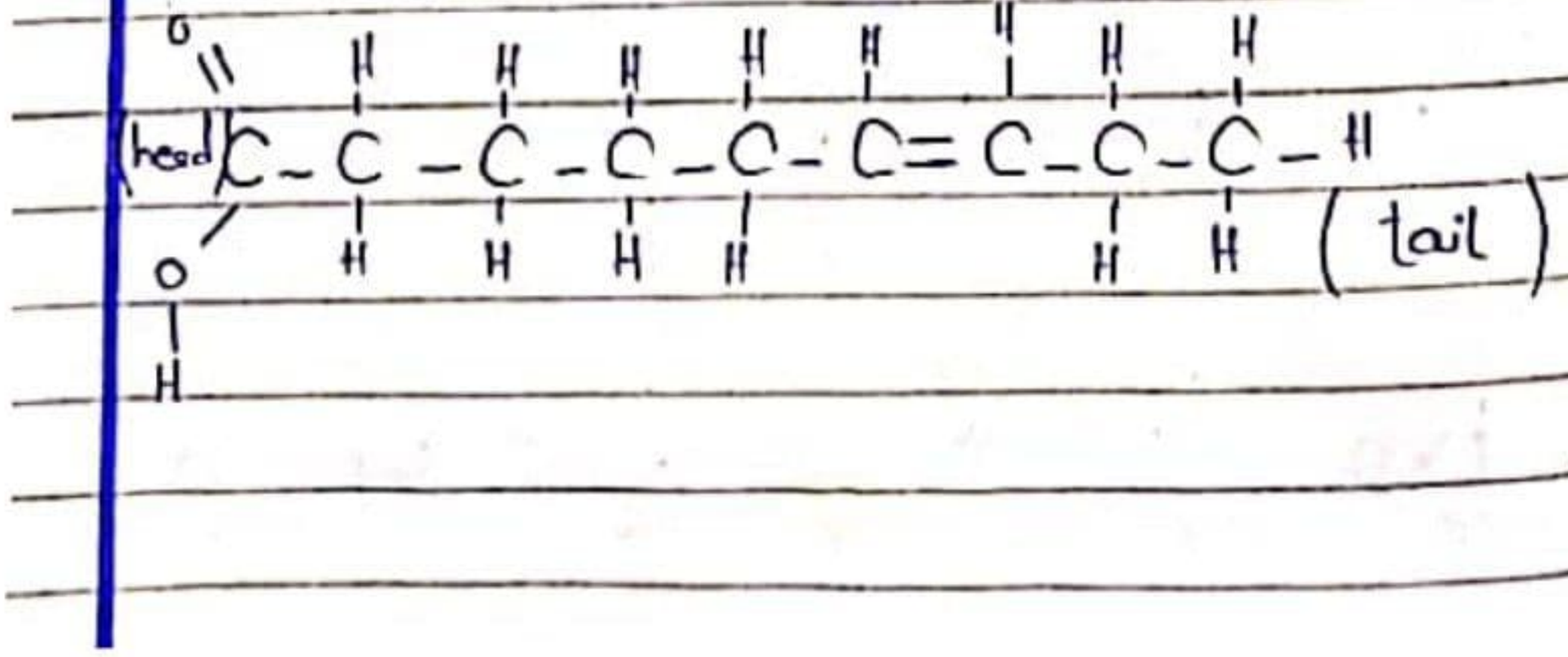
In the structure of fatty acid ⟶ the tail of acid is a long hydr.carbon chain making it hydrophobic

The head of fatty acid ⟶ is carboxyl group it is hydrophilic in nature

Fats are saturated having single bond between carbon atoms



Oils are unsaturated having double bond between carbon atom



properties of lipids

physical properties

1_ Oils and fats may be liquid or non-crystalling Solids at room temperature.

2_ pure oils and fats are colourless, tasteless.

3_ The colour arises due to foreign substance e.g yellow colour of butter is due to presence of keratin, Cresin.

4_ They are lighter than water & insoluble in water.

5_ They are poor conductor of heat and electricity and acts as insulator for animal body.

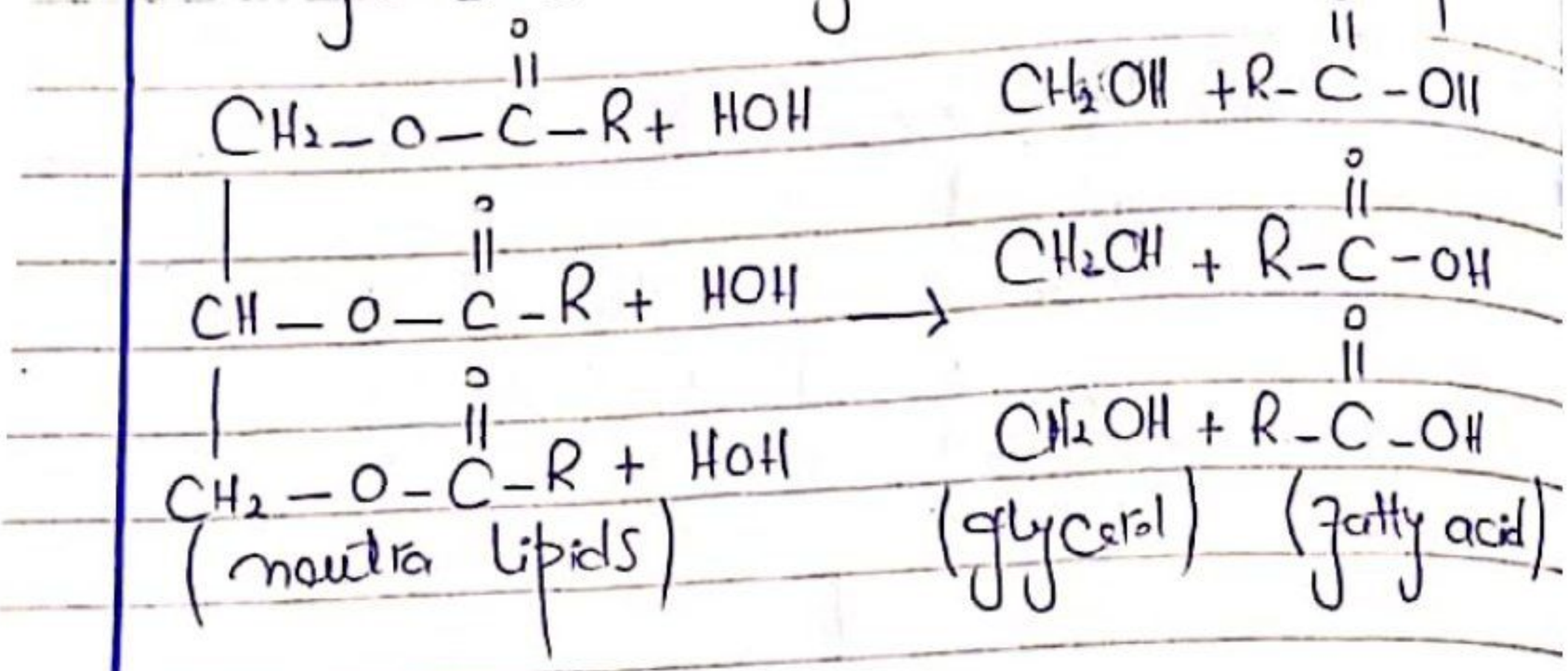
Chemical properties

→ fats and oils undergo various type of reaction:

1) hydrolysis of fats & oils

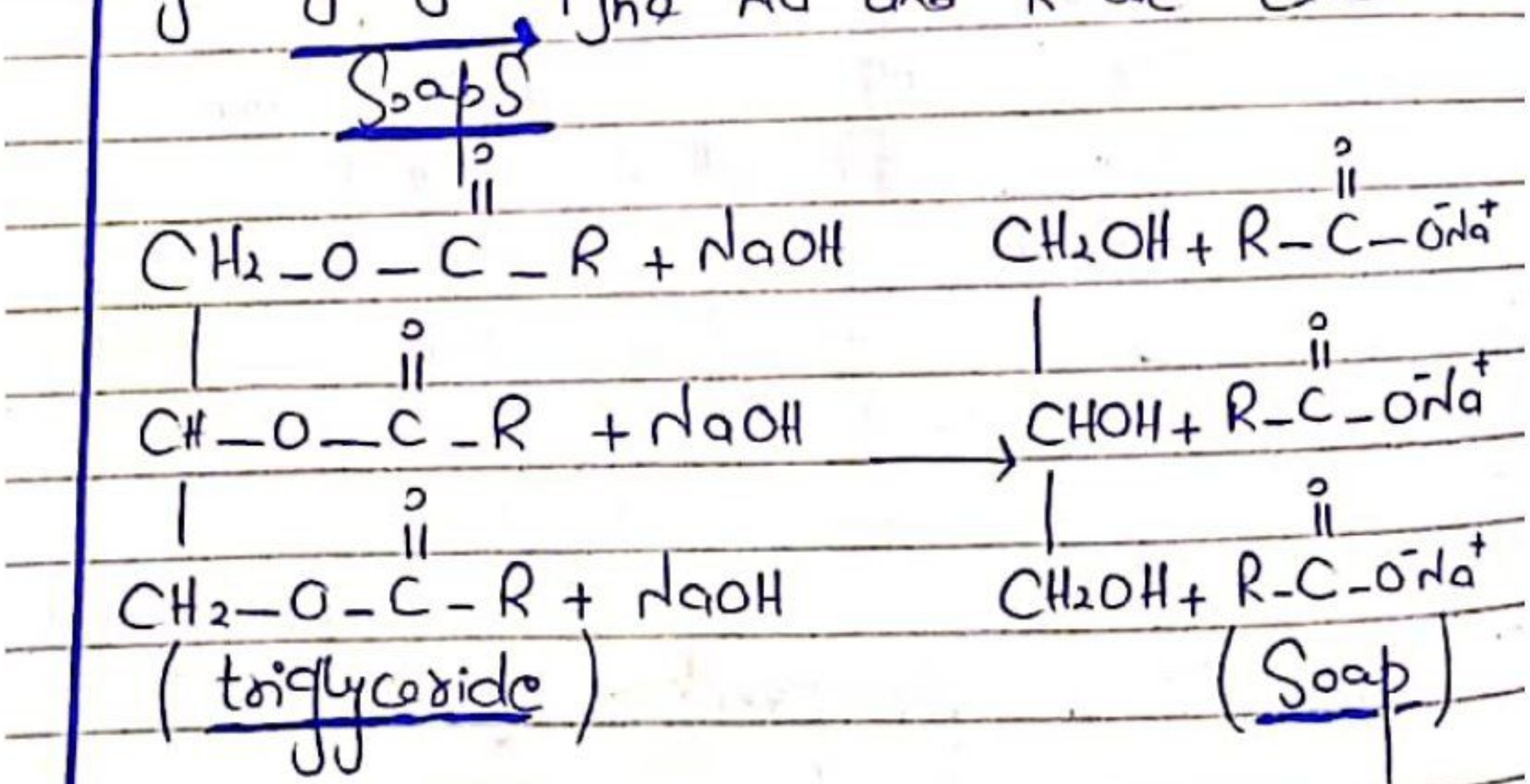
→ fats and oils are triglycerides They are hydrolyzed by enzymes act as

catalysts. The enzymes are called lipases.



2) Saponification

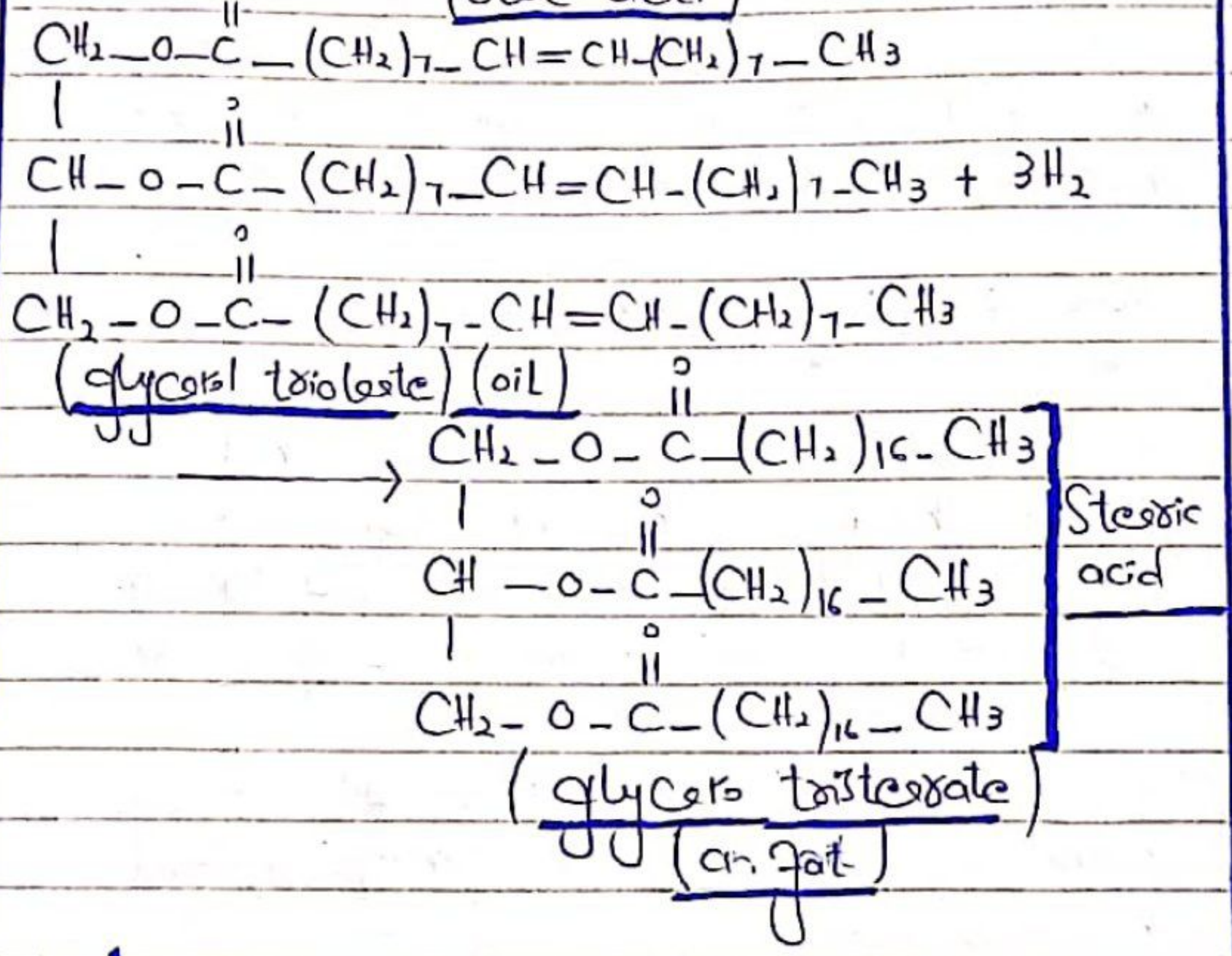
It is the hydrolysis of triglyceride by alkalies. glycerol is produced along with Na or K salts of fatty acid. The Na and K are called Soaps.



3) hardening of Oil

unsaturated triglycerides are liquid at room temperature. They are called oils. The can be saturated by passing H_2 in them

by the presence of metal catalyst. This process is called hardening of oil. This reaction is used to produce vegetable ghee or margarine.



Neutritional roles of lipids

1. Lipids provid energy since saturated and unsaturated fats provide 9kcal per gram
2. It does not necessarily cause weight gain if we calculate our total intake.

biochemical roles of lipid

1_ for Lipids act as a storage form metabolic energy_

2_ Lipids are Component of cell membranes

3_ Lipids act as messanger e.g Steroid hormone_

essential lipids

→ The lipids which are not synthesized by our body and are supplied to our body through diet are called essential lipids

The essential lipids are polyun-saturated fats called omega_6 and omega_3

resources

→ Omega_6 is obtained from vegetable oils and nuts

→ Omega_3 is obtained from walnuts and fish

non_essential lipids

→ monounsaturated fatty acids are not essential in the

diet they are synthesized by our body. They help to reduce risks of heart diseases.

resources → They are present in meat, cheese, palm, coconut oil and butter.

Note

Our body make 2g cholestrol per day that make up about 85% of blood cholestrol while 15% comes from diet

Nucleic acid

def

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

Types

It has two types

1- DNA (deoxyribonucleic acid)
2- RNA (ribonucleic acid)

Structural Component of DNA and RNA

DNA consist of very large polymeric molecule. Its monomers are called nucleotides

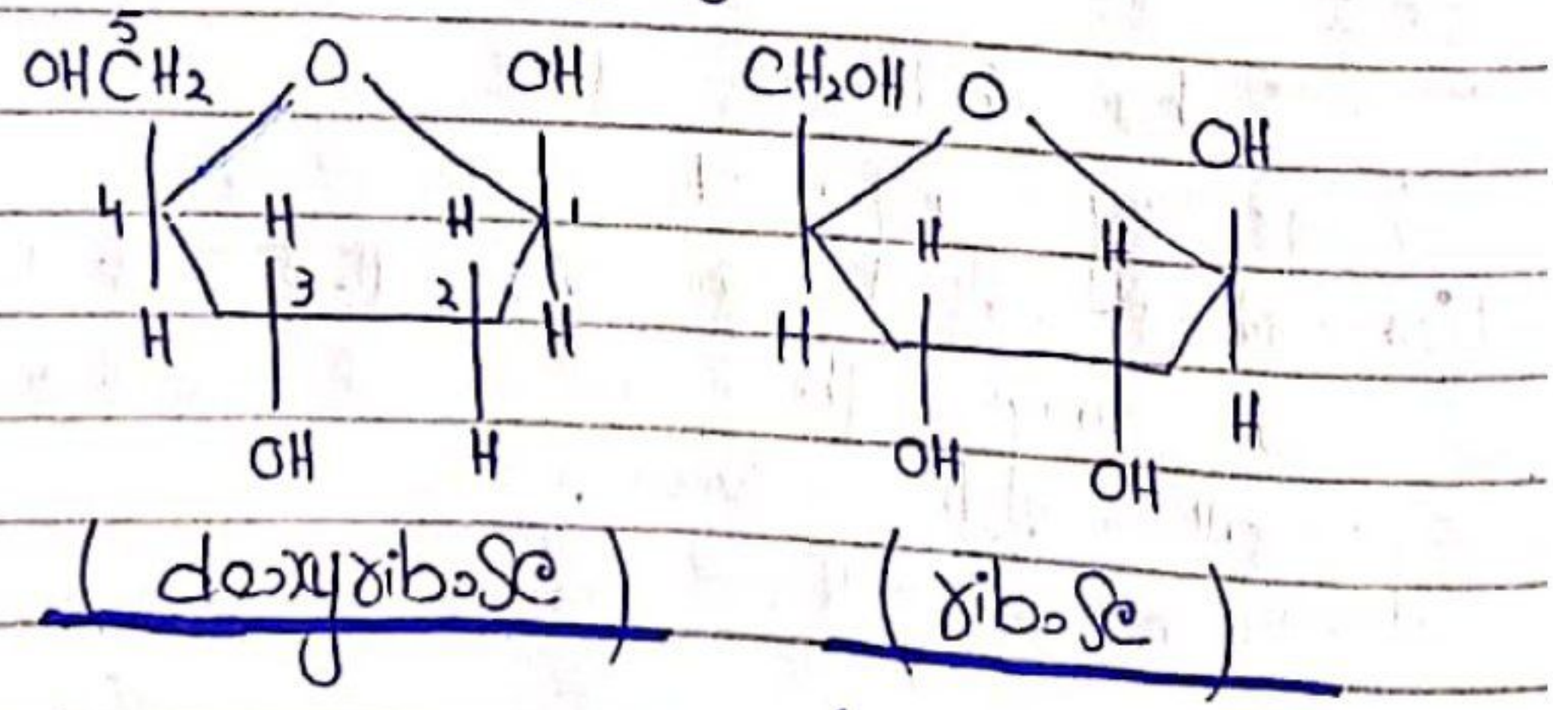
DNA is a double helix structured molecule while RNA is a single stranded molecule

Components of nucleotides

Three component present in each nucleotide

1) Pentose Sugar

In deoxyribose the hydroxyl group at C-2 is replaced by hydrogen atom



(deoxyribose) (ribose)

2) nitrogenous Bases

The following are the nitrogenous bases involved

in the nucleotides. Two are purines and two are pyrimiding bases.

pyrimidine bases → They consist of six membered rings composed of four 4 carbon and two nitrogen atoms. The pyrimiding Bases involved in the structure of DNA are Cytosine (C) and thymine (T)

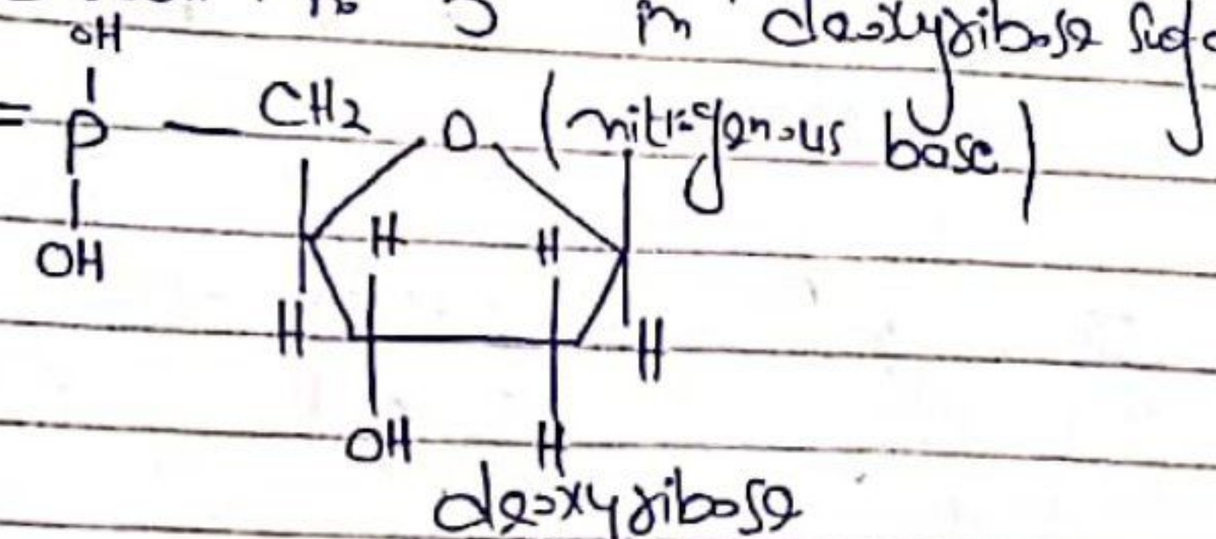
purine bases → They are combination of one six membered ring and one five membered ring. Only 2 purine bases are involve in the DNA and RNA adenine (A) and guanine (G)

Note

Uracil (U) replaces thymine in RNA

3) Phosphoric acid

H_3PO_4 is linked to Carbon no 5 in deoxyribose sugar



difference between DNA, RNA

1_ RNA contain ribose sugar while DNA contain deoxyribose sugar

2_ nitrogenous bases in DNA are cytosine, thymine, adenine and guanine. In comparison RNA has Uracil at thymine

3_ DNA is double stranded while RNA is Single stranded

Storage of genetic information

1_ → DNA and RNA Stores genetic information that is passed on to the offspring.

2_ → The DNA & RNA are self replicating molecules. They replicate genetic information before cell division.

3_ → The DNA replicates into two identical daughter DNA molecule.

4 → DNA transcribes a piece of genetic code into messenger RNA.

Minerals

→ They are the nutrients present in body and are as essential as our need of oxygen to sustain life.

→ They all are important factors in maintaining all physiological processes of bones, tissues, blood, teeth and nerve cells.

Types of nutrients

1) Macronutrients

are the nutrients which require in larger amount.

Exp— Ca, phosphorus, Mg, Sulpher.

2) Micronutrients

are the nutrient which are required in small amount to the body.

Exp— iron, zinc, Copper and iodine.

Sources and importance

1) Iron

Sources red meat, egg yolk, whole wheat, fish, Spinach and mustard.

Importance

1— iron is a part of haemoglobin which is a carrier of oxygen in blood.

2— It is lost through bleeding and Sweating Studies indicate that 34% female runner and 8% male runner are iron deficient.

3— iron is needed for development of placenta and also for pre-birth babies.

4— iron is present in some enzymes that catalyze reaction of cellular oxidation

2) Calcium

It is important for bone growth, blood clotting

Sources

milk, cheese, egg yolk, beans, nuts, Cabbage, leafy vegetables

Importance

1— There a six Stable isotopes of Calcium: calcium 40 is the most common (97%) and calcium 46 is the least abundant (.003%)

2— The loss of calcemic action

of vitamin D leads to hyperparathyroidism and hypophosphataemia which results in rickett and osteomalacia.

3___ Its deficiency also cause osteoporosis

4___ It carries charge during an action potential across membrane.

3) Phosphorus

Sources egg yolk, cheese, milk, cabbage

Importance

1___ phosphorus is a component of ATP

2___ Their is about 454g in the body.

3___ It is found in complex organic compounds in the blood, muscles, nerves and in Calcium phosphate.

4___ It is involved in the formation of bones and teeths

5___ It works with the vitamin B.

6___ It is involved in nerve conduction and regulation of heartbeat.

4) Zinc

Sources Oysters, red meat, chicken, beans

dairy products.

Importance

1___ Zinc is the most important trace element involved in human metabolism.

2___ human body contain about 2mg of zinc.

3___ enzymes requiring zinc for their activity.

4___ enthorpathica is caused by zinc absorption.

5___ It also impared the immune system, gastrointestinal System and neurology.

6___ zinc is excreted through urine, sweat and surface losses.