

Chapter 1

Introduction to Biochemistry

- **Bio** : living organisms
- **Chemistry** : chemistry
- Also called as chemistry of life/ living cells.
- Biochemistry involves the study of chemistry of life.
- The term biochemistry was introduced by Carl Neuberg in 1903.
- Which specialises in the chemical process and chemical transformation in living organisms.
- It lies between Biology and Chemistry that studies complex chemical rxn chemical structure giving rise to life.
- It deals with chemical basis of life in plants and animals.
- It relies on basic laws of chemistry.
- Like growth, reproduction, metabolism, response towards stimuli etc.

Defination

- The chemistry of life.
- The science concerned with the chemical basis of life.
- The science concerned with the various molecular that occurs in living cells and organisms and their chemistry reaction.

Scope of bio chemistry in pharmacy

Various scope of Biochemistry

- Bio-Chemical Test
- The Half-life
- Drug Constitution
- Drug Storage
- Drug Metabolism

- ⇒ **Bio-Chemical Test** : These tests help fix the specific half life or date of expiring of drugs.
- ⇒ **The half life** : This is a test done on Bio-Chemical drugs to know how long a drug is stable when kept at so & So Temperature.
- ⇒ **Drug Constitution** : Bio Chemistry gives an idea of the constitution of the drug.
 - It chance of dehydration with vary into Temperature etc.
 - How modification in the medicinal chemistry helps to improve efficiency minimize the side effects.

- ⇒ **Drug Storage** : The storage condition required can be estimated by the Bio-Chemical Test for example many enzymes.
 - Hormones are stored for dispensing.
 - These get deteriorated over time due to temperature or oxidation contamination & also due to improve storage.
- ⇒ **Drug Metabolism** : It gives an idea of how drug molecules are metabolised by many biochemical reaction in the presence of enzymes.
 - This helps to avoid drug which have a poor metabolism.

Cell and its Biochemical Organisation

- ◇ A cell is the basic living structural and functional unit of body enclosed with membrane.
- ◇ Life consists of various complex lifeless chemical molecules.
- ◇ Like protein nucleic acid (DNA & RNA) Polysaccharides etc.
- ◇ **Example** : e.coli the unicellular bacterium has around 6000 types of organic compounds and a complex organisms like human contain around 100000 types of molecules how ever only few of them are recognized.

Complex molecules

- Small organic compounds such as aminoacids, nucleotides & monosaccharides function such as the monomeric units building blocks.

Major complex Biomolecules of cells

Biomolecules	Building Blocks (monomer units)	Major functions
Protein	Aminoacids	Form basic structure & function frame work of cell
DNA (Deoxyribonulic Acid)	Deoxyribonucleotides	Carries of hereditary information
RNA (Ribonuclic Acid)	Ribonuclotides	Carrying information regarding protein biosynthesis
Polysaccharides Glycogen	Monosaccharides (glucose)	Body stores energy in this form & utilise it to meet short term demand
Lipids	Fatty Acids Glycerol	Second major source of energy

Micromolecules

- Micromolecules are small organic molecules present in the cytosol of a living cell.
- No. of these molecules in a cell is around 100-200.
- Some common examples of micromolecules are amino acids, nucleotides, sugar, & their phosphorylated derivatives.
- Most of these molecules are water soluble, polar, are charged and present in micromolar to millimolar concentration.

Macromolecules

- The macromolecules have large molecular weight and are formed by polymerization of monomer units.
- Example polysaccharides (starch) are formed by polymerization of monosaccharide units.
- **Protein** : are formed by polymerization of amino acids.
- **Lipids** : are formed by polymerization of fatty acids.
- **DNA & RNA** : are formed by polymerization of nucleotide units.

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Diploma in Pharmacy 2nd Year
Biochemistry & Clinical Pathology
Chapter 2 : Carbohydrates

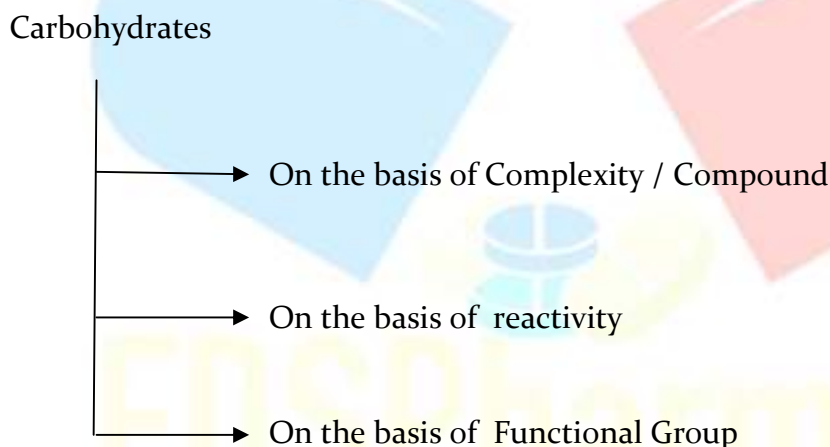
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Chapter 2

Carbohydrates

- Carbohydrates are Organic Compound with general formula $C_n(H_2O)_n$
- They are Composed of Carbon, Hydrogen, Oxygen,
- Carbohydrates are polyhydroxy aldehyde or ketone compound derived from hydrolysis.
- They are the Major source of chemical energy for the living organisms.
- Ex : Sugar & Starch.
- Starch & Cellulose are the two common carbohydrates.

Classification of Carbohydrates



Classification on the basic of complexity

1. Monosaccharides (Simple sugar)

- Carbohydrates that can't be hydrolysis to simple compound are called monosaccharides.
- These are single unit carbohydrates (have the one sugar molecules).
- Example : Glucose, Fructose, Galactose,

2. Oligosaccharides

- These are made up of 2-10 units of monosaccharides/ simple sugar
 - **Disaccharides** : These oligosaccharides consists of two monosaccharides units
 - Example : Sucrose Glucose + Fructose
 - **Trisaccharides** : These oligosaccharides consists of 3 monosaccharides units
 - Example : Raffinose. Glucose + Fructose + Galactose

3. Polysaccharides

- A single molecules of a polysaccharides sugar is formed by polymerization of more than 10 monosaccharides units
- Example : Starch or Cellulose

Classification on the basic of Reactivity

- **Reducing sugar** : These sugar act as reducing agent & these reduce fehling's & Tollens reagents.
- **Non Reducing Sugar** : These sugar do not reduce fehling's & Tollens reagents.

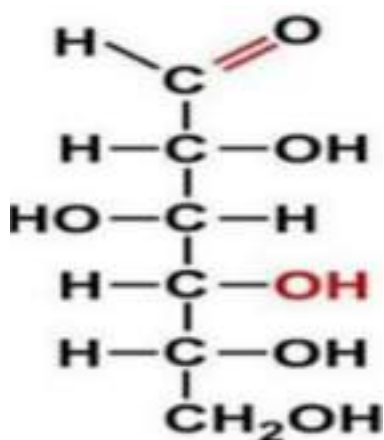
Classification on the basic of functional groups

- ◇ **Aldose** : These sugar have an aldehyde functional groups
 - **Example** : D-glucose
- ◇ **Ketose** : These sugar have a ketone functional group
 - **Example** : D-fructose

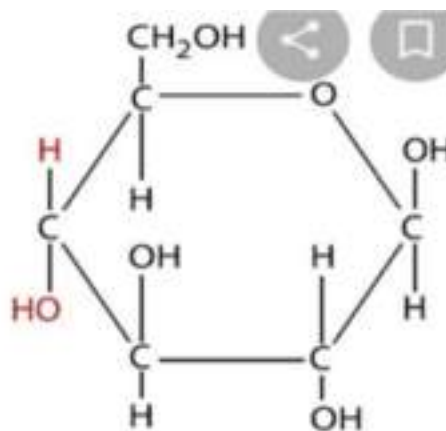
Monosaccharides

- Monosaccharides are derived from the Greek word mono which means single & saccharide which means sugar.
- Monosaccharides can't be hydrolysed further to provide simple sugar.
- Simple sugar are known as monosaccharides.
- They have a sweet flavour.
- They are water soluble.
- They have a Crystalline appearance.
- They have
- 3-10 carbon atom
- 2 or more hydroxyl (OH) groups
- One aldehyde (CHO) or Ketone (CO) groups
- Their general formula is $C_nH_{2n}O_n$

Structure of Glucose

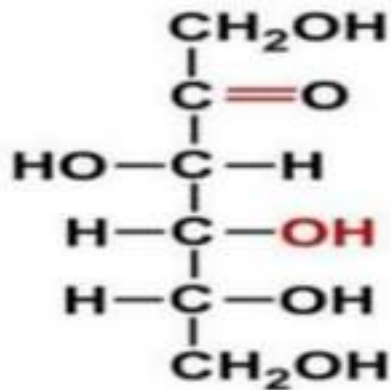


Glucose



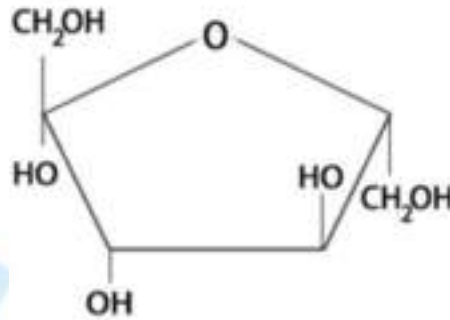
Glucose

Structure of Fructose

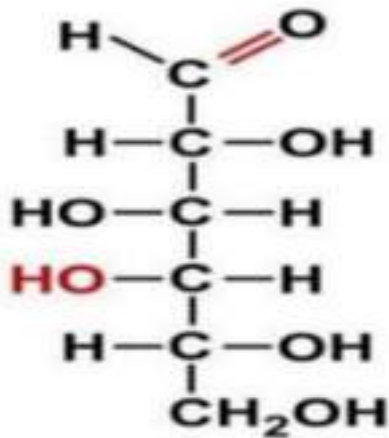


Fructose

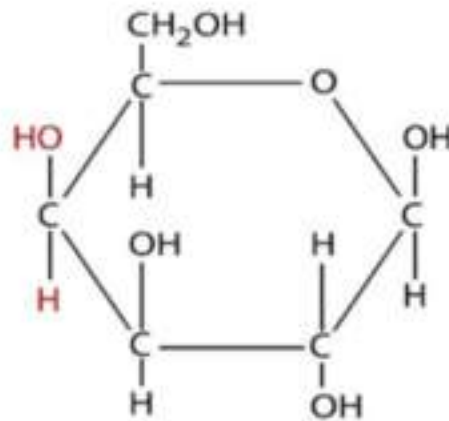
Fructose



Structure of Galactose



Galactose

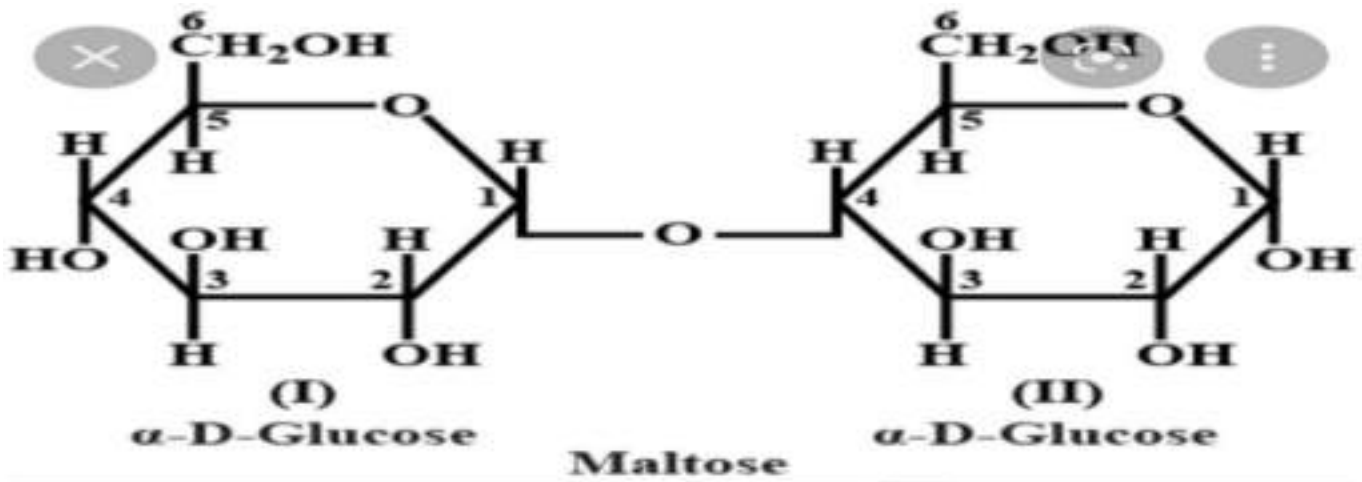


Galactose

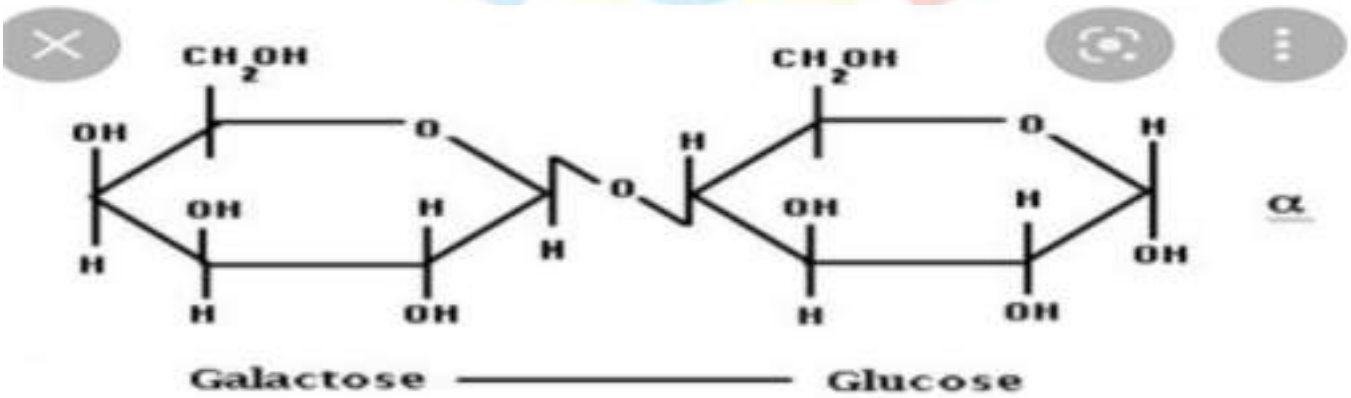
Disaccharides

- Disaccharides are those carbohydrates which are made up of two monosaccharides units
- They can be reducing sugar. Lactose
- They can be non reducing sugar. Sucrose

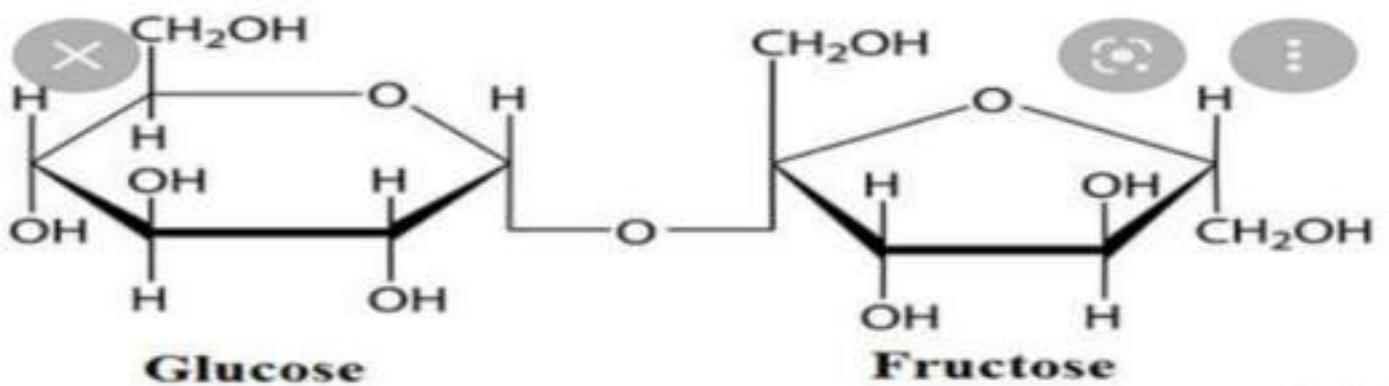
Structure of Maltose



Structure of Lactose



Structure of Sucrose



Polysaccharides

- They are composed of long carbohydrates molecules chain constituted of numerous simple monosaccharides
- Polysaccharides are considered to be the major class of biomolecules
- This complex Biomolecules function as a important source of energy in animals and form a structural components in plant cells
- They do not have a sweet flavour
- Many are water insoluble
- They are naturally hydrophobic
- They are carbohydrates with a high molecular weight
- They are made up of 3 elements hydrogen, carbon, oxygen,

Classification of Polysaccharides

1. Homopolysaccharides :

- The monomeric units are arranged in the form of long chain either unbranched or branched. • Eg: Starch, Glycogen, Cellulose etc.

2. Heteropolysaccharides :

- Hemicellulose is a polymer containing D-xylose, L-arabinoc, D-Galactose, LRhamnose, D-Monnose and D-Glucuronic acid • Eg. : Heparin

Chemical Nature of Starch

- Glucose is stored in plants in the form of starch.
- It is composed of two components " Amylose "and " Amylopectin"
- Amylose is made up of 250 - 300 glucose , that are joined together by α -1 , 4 glycosidic bond.
- Amylose chains are unbranched and coiled.
- Amylose are consist about 15 - 20 %
- Amylopectin is a glucose polymer with α 1, 4 glycosidic linkage.
- Side chains with about 12 glucose are linked to the main chain with α -1,6 glycosidic linkage.

Chemical Nature of Glycogen

- ◇ Glucose is stored in the form of glycogen in animals.
- ◇ It is found mostly in liver and muscles.
- ◇ It is often called animal starch.
- ◇ It converted in to glucose and provide energy in short term requirement.
- ◇ It is a polymer which is highly branched , and 8 - 10 glucose units present per branch.
- ◇ The chain of glycogen are joined together by α 1, 4 glycosidic link.
- ◇ and branches are joined to the main chain by α 1, 6 glycosidic bond.
- ◇ The structure of glycogen is similar to amylopectin but it is more highly branched.

Qualitative Test

The qualitative tests are performed for identification of carbohydrates are following :

- 1) **Fehling's Test** : In this test , 1-2 ml each of the Fehling's solution A and B are added to few drops of the test solution and boiled for a few minutes . A Yellowish red colour appears that confirms the presence of reducing sugar (carbohydrate).
- 2) **Tollen's test** : In this test , 2-3ml of Tollen's reagent is added to 2-3 ml of aqueous solution of carbohydrate , and boiled in a water bath for 10 minutes . A shining silver mirror indicates the presence of reducing carbohydrates.

Biological role of Carbohydrates

- ▲ They are source of energy for living organism.
- ▲ They are used as dietary fibers like cellulose.
- ▲ They are used as flavouring and sweating agent.
- ▲ They are stored in our body in the form of glycogen in liver and muscles and converted into glucose to provide energy according to need.
- ▲ They are important component of brain cells.
- ▲ They are important component of DNA & RNA (Deoxyribose and Ribose sugar)
- ▲ They act as an anticoagulant in the form of Heparin.
- ▲ They are major component of cartilage , tendon and bones.
- ▲ They are used in clearance test in the form of Inulin.
- ▲ They are used in the treatment of heart diseases in the form of Glycosides.

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Chapter 3 : Proteins

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Learn and Educate

Chapter 3

Proteins

- Proteins are naturally occurring polymers made up of amino acids.
- Almost everything that occurs in the cells involves one or more Proteins.
- Proteins provide structure, cellular reaction and carried out the tasks.
- 20 amino acids are found in protein and they are called standard amino acid. These amino acids contain the carboxyl group and the amino group attached to α carbon.

Classification of proteins

Based on composition and Solubility

- **Simple Proteins** : Simple protein contain only amino acid reduce and other intimately bound material.
 - Ex : Albumins, globulins, glutelin etc.
- **Conjugated Proteins** : Conjugated proteins contain in addition to polypeptide chain others substance or groups which impart characteristics properties.
 - Ex : Nucleoproteins, Glycoproteins, Haemoglobin, Phosphoproteins etc.
- **Derived Proteins** : Derived protein are derived from partial to complete hydrolysis from the simple or conjugated proteins by the action of acids, alkalis or enzymes.
 - Ex : Peptones, peptides, proteoses etc.

Role of Protein

- Protein performs difference role in the living system.
- Proteins which catalyse by your chemical reactions are called enzymes.
- Proteins are responsible for transportation of metabolites fructose, Glucose or Gases (like Oxygen, Carbon dioxide) are called transport proteins.
- Protein which are responsible for to protect from infection and other toxic substances are called antibiotics or defense proteins
- Proteins which are required to give strength to cells or tissue are called structural proteins.
- Proteins which are required to carry out mechanical work are called muscle proteins.

AMINO ACIDS

- Amino acids are building blocks of protein.
- Amino acids are compound that contain an amino group and a carboxyl group and the amino group attached to alpha carbon.
- The key elements of an amino acid are Carbon (C) Hydrogen (H) Oxygen (O) and nitrogen (N).
- There are 20 amino acids present in our body in which 9 Essential and 11 Non-essential amino acids

Classification of amino acids

On the basis of chemical nature

- **Neutral amino acids** : The amino acids have equal amount of amino and carboxylic group are called neutral amino acids , examples : Glycine, alanine.
- **Acidic amino acids** : The amino acids have negative R group or chain are called acidic amino acids , examples : aspartic acid , glutamic acids.
- **Basic amino acids** : The amino acids have positive R group or chain are called basic amino acids , examples : arginine, lysine
- **Sulphur containing amino acids** : methionine, cystine.
- **Aromatic amino acids** : The amino acids have aromatic ring are called aromatic amino acids . example phenylalanine.

On the basis of Nutritional requirement

- ◆ **Essential Amino Acids** : The amino acids are not synthesised in the body and are obtained from dietary sources are called Essential Amino Acids .(VIPHALLMTT)
 - **Example** : Valine, Isoleucine, Phenylalanine, Histidine, Arginine
- ◆ **Non Essential Amino acids** : The amino acids are synthesised in the body and are Non Essential Amino acids.
 - **Example** : Glycine, Tyrosine, Proline, Cysteine

Structure of proteins (four levels of organization of protein structure)

1. **Primary protein** : It is the simple/basic/polypeptide chain like proteinoous structure formed by the joining of amino acid by the help of covalent or peptide bond. Its biological activity mainly depends on the, types of amino acids. Many of genetic disorders are occurs due to changes in the primary protein structure.
2. **Secondary protein** : Secondary structure forms by the interaction between the polypeptide chain of primary protein amino group and carboxyl group. It mainly presents two structural forms-
 - α secondary protein (Helix Form).
 - β secondary protein (Sheet/Plate form).
3. **Tertiary protein** : Tertiary protein form by the further chemical modification between the secondary protein. It is stabilized due to presence of the H-bond, electrostatic forces, disulphides bonds, and Vander walls forces.
4. **Quaternary protein** : The quaternary structure of a protein is the association of several protein chains or subunits into a closely packed arrangement.

Qualitative test of protein and amino acids

- ◇ **Ninhydrin test** : Amino acids and proteins a give Blue to violet colour with Ninhydrins solution.
- ◇ **Biuret test** : When biuret is treated with dilute copper sulphate in alkaline medium a purple colour is obtained.
- ◇ **Millon's test** : When proteins are treated with Millon's reagent a white precipitate is formed.
- ◇ **.Xanthoproteic test** : Nitration of aromatic amino acids of protein give yellow colour concentrated nitric acid is used for Nitration.
- ◇ **Hydrolysis Test** : Proteins on hydrolysis gives free amino acids Hydrolysis can be carried out by acids like HCL, H₂SO₄, etc. Or Alkalis like – NaOH, KOH etc.

Biological role of Proteins and amino acids.

- ▲ Proteins give amino acids on hydrolysis during digestion and amino acids are the building blocks required for a cell to synthesis for proteins.
- ▲ Proteins are the structural component of protoplasm cell and tissues
- ▲ Enzymes and few hormones are Proteins in nature antibiotics, haemoglobin are also Proteins.
- ▲ Protein is one of the important components of diet it is required to maintain growth and healthy functioning of the body.
- ▲ In the cell, cell membrane is also made up by the protein, protein play the role in the transporting the cellular and outer material through the active or passive transport.

- ▲ In our body some amount of protein stored, for the starvation, critical condition for energy.
- ▲ During the clinical condition protein also play the major role (protein excrete in urine, during blood examination)

Diseases Related to Malnutrition(deficiency) of proteins

- 1) **kwashiorkor** : This disease occurs due to severe deficiency of dietary proteins .The affected person have abnormally thin or week body parts , but have swollen ankles , feet and belly due to fluid retention in them.

Symptoms

- Loss of weight.
- Growth and weigh gain stop.
- Ankles , feet and belly swell.
- Immune system is damage , and get infection easily.
- The natural colour of skin and hair changes to a rust color.

Treatment

- Kwashiorkor can be treated by increasing the proteins in diet .

- 2) **Marasmus** : This disease occurs due to severe deficiency of all macronurients (proteins , carbohydrates , fats). Children are mostly suffer from this disease.

Symptoms

- Loss of weight.
- Growth and weigh gain stop.
- The natural colour of skin and hair changes to a rust color .
- Chronic diarrhea.
- Respiratory infection.

Treatment

- Marasmus can be treated by increasing the proteins , carbohydrates , fats and other essential nutrients in diet .

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Chapter 4 : Lipids

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Chapter 4

Lipids

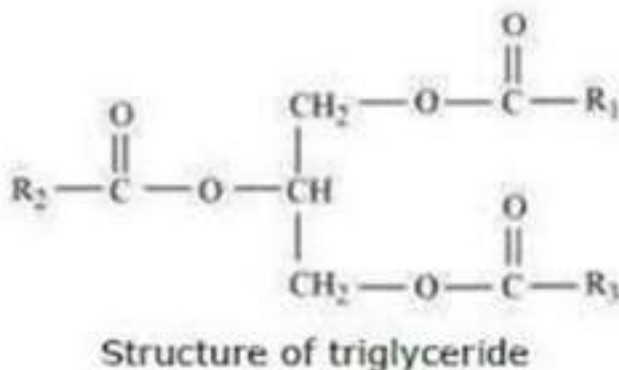
- The word lipid is derived from the Greek word lipos meaning fat; universally present in all plants and animal cells.
- They are naturally occurring waxy, greasy, or oily organic compounds and are known as oils and fats.
- Lipids are hydrophobic in nature, i.e., insoluble in water but soluble in non-polar solvents (chloroform, benzene, ether, etc.).
- They are present in cell membrane and also found as storage molecules. They are a source of high energy value, therefore are important constituent of the diet.

Classification of lipid with examples

1. **Simple Lipids** : These are esters of fatty acids containing various alcohols and carry no other substance
 - **Fats and Oils** : These are esters of fatty acids containing glycerol, Oils are also fats but are present in the liquid state. Waxes: These are esters of fatty acids containing high molecular weight monohydric alcohols.
2. **Compound Lipids** : These are esters of fatty acids, containing an alcohol, a fatty acid, and other groups
 - **Phospholipids** : These lipids consist of fatty acids, an alcohol, and a phosphoric acid residue. They frequently have nitrogen-containing bases and other substituents, e.g., in glycerophospholipids the alcohol is glycerol and in sphingophospholipids the alcohol is sphingosine.
 - **Glycolipids (Glycosphingolipids)** : These lipids consist of a fatty acid, sphingosine, and carbohydrate.
3. **Derived Lipids** : These are hydrolysed derivatives of simple or compound lipids. Examples of this class of lipids are fatty acids, glycerol, steroids, terpenes, carotenoids, fatty aldehydes, etc.

Structure and Properties of Triglycerides

→ Triglycerides are organic compounds in which three different fatty acids are linked to the glycerol by ester bonds.



Properties of triglyceride

- Non-polar : They are non polar(they does not have charge at the end).
- In soluble in water : They are insoluble in water.
- Soluble in organic substance : like Ester chloroform.
- Hydrophobic : They are hydrophobic in nature.

Fatty Acids

- Chemically, fatty acids are monocarboxylic acid with aliphatic carbonic chain .
- In higher plants and animals, the predominant fatty acid residues are those of the C₁₆ and C₁₈ species — palmitic, oleic, linoleic, and stearic acids.
- Fatty acids that occur in natural fats usually contain an even number of carbon atoms. The chain may be saturated (containing no double bonds) or unsaturated (containing one or more double bonds)

Classification of Fatty Acids

On the basis of chemical nature

1. **Saturated Fatty Acids** : The fatty acids contain straight chain with single C-C bond and have no C=C Double bonds are called saturated fatty acids . Examples Stearic acid , Palmitic Acid , Arachidic Acid.
2. **Unsaturated Fatty Acids** : The fatty acids have one or more C=C bonds in carbon chain are called unsaturated fatty acids . examples Linoleic Acid , Linolenic Acid , Arachidonic acid.

Types of unsaturated fatty acids

a) **monounsaturated fatty acids (MUFA)** : The fatty acid have one double bond in carbon chain.

b) **Polyunsaturated fatty acids (PUFA)** : The fatty acid has two or more double bond in carbon chain.

example

O = Oleic Acid (one double bond)

L = Linoleic Acid (2 double bond)

L = Linolenic Acid (3 double bond)

A = Arachidonic Acid (4 double bond)

Nutritional requirement of fatty acid

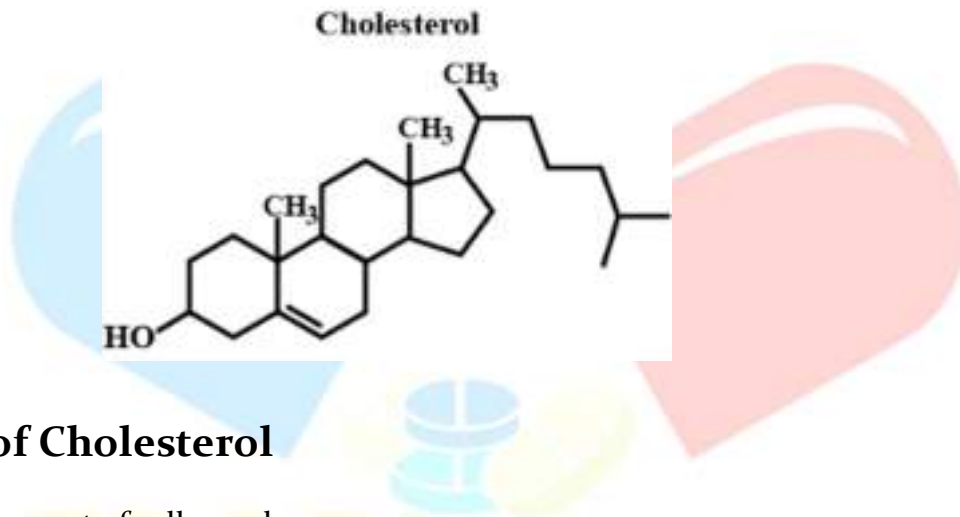
- 1) **Essential fatty acid** : These are the fatty acids which are not produced in human body they are must be taken through food (diet). examples Linoleic Acid , Linolenic Acid , Arachidonic acid .
- 2) **Non essential fatty acids** : The fatty acids are produced in human body and no need to take through foods (diet). Examples Stearic acid , Palmitic Acid , Arachidic Acid.

Structure and Functions of Cholesterol in the body

Cholesterol

→ Cholesterol is a type of lipids that found in all the cells of the body.

Structure of Cholesterol



Functions of Cholesterol

- It is a component of cell membrane.
- It maintains the permeability of cell membrane.
- It helps in bile production.
- It helps in the formation of vitamin D.
- It metabolize (break down) fat soluble vitamins.
- It helps in the formation of male and female sex hormones.
- It insulate the nerve fiber.

Lipoproteins

→ Lipoproteins are molecular complexes of lipids with proteins. They are the transport vehicles for lipids in the circulation.

Types of Lipoproteins

On the basis of electrophoresis separation , five types of lipoproteins are found in human plasma.

- **Chylomicrons** : This types of lipoproteins are synthesized in the intestine and have the highest lipid content (98%) and lowest protein content (2%) , and have the lowest density and are biggest in size . (have 4% of cholesterol of 98% of lipids)
- **Very low density lipoproteins (VLDL)** : These proteins are produced in the liver and intestine , and have 10% of proteins and 90% of lipids . (have 24% of cholesterol of 90% of lipids).
- **Low Density lipoproteins(LDL) (Bad Cholesterol)** : These lipoproteins are produced in the blood stream from VLDL and transport cholesterol from liver to the rest of the body, and have 20% of proteins and 80% of lipids . (have 56% of cholesterol of 80% of lipids).
- **High density Lipoproteins (HDL) (good cholesterol)** : These lipoproteins are produced in the liver and transport cholesterol from peripheral tissues (skeletal muscle , adipose) to liver , and they have 40% of proteins and 60% of lipids . (have 40% of cholesterol of 60% of lipids).
- **Free fatty acids Albumin** : Free fatty acids in the circulation are in a bound form to albumin. Each molecule of albumin can hold about 20-30 molecules of free fatty acids. This lipoprotein cannot be separated by electrophoresis.

Function of lipoproteins In the body

- ✓ Absorption and transportation of lipids in small intestine.
- ✓ Transportation of lipids from liver to tissues.
- ✓ Transportation of lipids from tissues to liver.

Qualitative Test of Lipids

- **Grease spot Test :** In this test one drop of oil and a drop of water are put on a paper . at first , both areas look wet but after some time water is evaporates and the spot dries whereas lipid spot remains visible .
- **Solubility test :** In this test we add some drops of sample of lipid to organic substance and water and observe . it will miscible with organic substances like chloroform , ether and immiscible with water .
- **Test for Free Fatty Acids:** A few drops of phenolphthalein solution are taken in a test tube and added with 1-2 drops of very dilute alkali solution to develop a pink colour. This solution is shaken with a few drops of oil. The pink colour disappears due to neutralisation of the alkali by the free fatty acids present in the oil.

Function of lipids

- ▲ **Source of energy :** It is a best source of energy it provide energy more that carbohydrates and proteins.
- ▲ **Cell membrane :** They are important component of the cell membrane (phosphoric)
- ▲ **Membrane permeability :** They regulate membrane permeability.
- ▲ **Vitamins :** They store fat soluble vitamins (KEDA).
- ▲ **Enzyme :** They are components of various types of enzymes.
- ▲ **Thermal insulation :** fat deposited in the subcutaneous layer provide insulation and protection from cold.
- ▲ **Transport :** lipoproteins proteins transport cholesterol and triglyceride from their origin to site of use.
- ▲ **Electrical insulation :** They act as electrical insulator to the nerve fibres in the form of myelin sheath.
- ▲ **Storage :** They Store meaning of compounds.
- ▲ **Signalling :** They act as signaling molecule.

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Chapter 5 : Nucleic acids

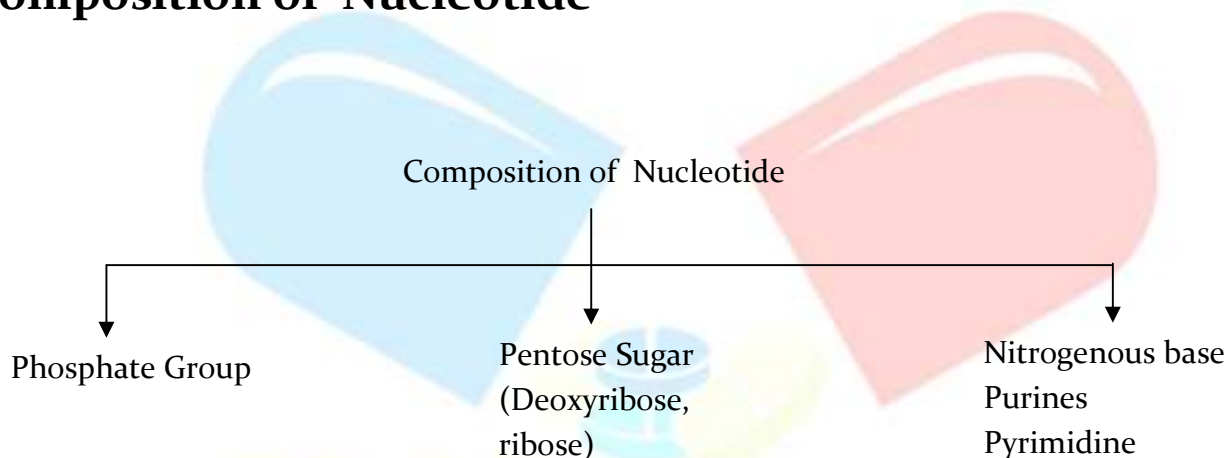
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Chapter 5 Nucleic acids

- Nucleic Acids (DNA & RNA) are formed by the polymerization of Nucleotide Subunits.
- Nucleic Acids are made up of a ribose sugar, nitrogenous base & Phosphate group.
- Deoxyribonucleic Acid (DNA) & Ribonucleic Acid (RNA) are two types of nucleic acids that act as sources and carriers of genetic Information.

Composition of Nucleotide



- **Purine** : They Contain two carbon nitrogen rings one of them is 6 membered and other is 5 membered
 - **Example** : Adenine, Guanine.
- **Pyrimidine** : It is 6 membered carbon nitrogen ring at the 1st & 3rd position it contain N(Nitrogen) instead of carbon
 - **Example** : Cytosine, Thymine, Uracil.

Component of Nucleoside & Nucleotide

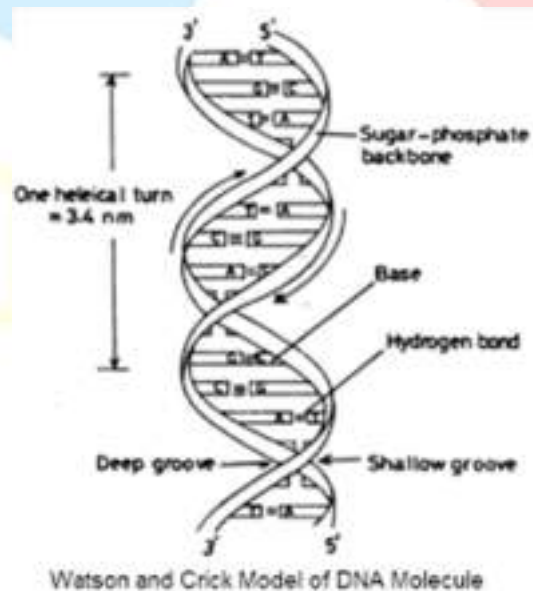
- Nucleoside : It is made up with the combination of Pentose sugar and nitrogenous base by glycosidic bond.
 - Nucleotide : Are Organic Substance made up of nucleoside and phosphate.
- Or
- Nucleotide are organic substance made up of pentose sugar, Nitrogenous base, phosphate group.

DNA (Deoxyribonucleic Acid)

- DNA (a polymer molecule) is made up of monomeric units called nucleotides.
- Polymer is known as polynucleotide.
- A 5-Carbon sugar (deoxyribose), nitrogenous base attach to the sugar and a phosphate group.

Watson and Crick model of DNA

- DNA as an acidic substance present in the nucleus was first identified by Frederick Meischer in 1869. He named it as 'nucleon'. Due to technical limitations in isolating such a long polymer intact the elucidation of structure of DNA remained elusive for a long period of time.
- It was only in 1953 that James Watson and Francis Crick proposed the very simple but famous double helix model for the structure of DNA.
- The main opposition was base pairing between the two strands of polynucleotide chains



The salient features of double helix structure of DNA are as follows :

- ▲ It is made up of two polynucleotide chains.
- ▲ The two chains have antiparallel polarity if one has polarities and the second chain must have polarity.
- ▲ The base into strands is paired through hydrogen bond forming base pairs. Adenine forms to hydrogen bonds with thymine from opposite strands and vice versa.
- ▲ Similarly guanine forms three H bonds with cytosine. As a result, purine comes opposite to pyrimidine.
- ▲ Because of this approximate a uniform distance between the two strengths of The Helix occurs.

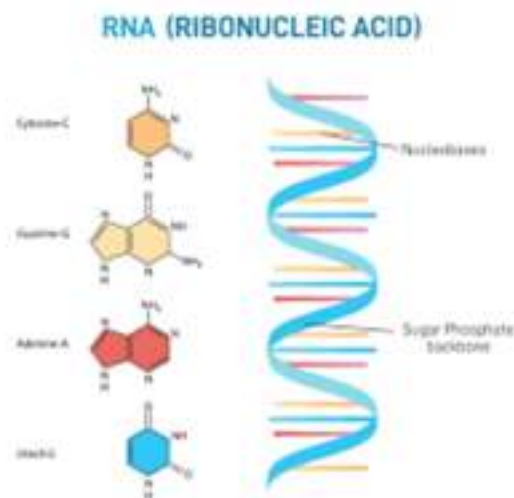
- ▲ The two chains are called in a right-handed fashion. Pitch of the helix is and there are roughly 10bp in each turn.
- ▲ The plane of one base pair is stacked over the other in a double helix. This confirms stability of the helical structure.

Function of DNA

1. **Genetic Information** : It transfer genetic information from mother to the child.
2. **Replication** : It makes its copy during cell division.
3. **Transcription** : When RNA is formed from DNA it is called transcription.
4. **DNA finger print** : It help to determine the identity of suspected person on the basis of nucleotide sequences

Structure of RNA

- Ribonucleic Acid RNA is a long unbranched macromolecule consisting of nucleotides joined by 3' to 5' Phosphodiester bonds.
- RNA is a single strand does not contain regions of double helical structure.
- RNA contain ribose sugar instead of 2-deoxyribose that present in DNA.
- The Structure of RNA Molecule was described by Robert William Holley in 1965.
- It contain four major bases such as
 - Purine base : Adenine & Guanine
 - Pyrimidine base : Cytosine & Uracil
- RNA Pairs
 - Adenine with Uracil
 - Cytosine with Guanine



Types of RNA / Function

- ✓ **mRNA** : It takes genetic messages from DNA and help in protein synthesis.
- ✓ **t-RNA** : It transfer amino acids to the codes information of mRNA.
- ✓ **r-RNA (ribose RNA)** : It play an important role in protein synthesis.

Diploma in Pharmacy 2nd Year
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Chapter 6 : Enzymes

Topics	Page No
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Mechanism of action of enzymes, Enzyme inhibitors	
Therapeutic and pharmaceutical importance of enzymes	4

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Chapter 6

Enzymes

→ The specific type of proteins that catalyse (increase the rate of) chemical reactions in living cells are called enzymes.

Or

→ Enzymes are catalysts(a thing that causes changes) that catalyse the chemical reaction.

Properties of Enzymes

- ◆ Enzymes increase the rate of reaction
- ◆ They are unstable
- ◆ Their activity can be decreased or enzymes can be destroyed by variety of condition like temperature, changes in PH
- ◆ Enzymes are complex macromolecules with high molecular weight
- ◆ All enzymes are protein except the group of catalytic of RNA

IUB (International Union of Biochemistry)and MB (molecular Biology)

Classification

- 1) **Oxidoreductases** : These type of enzymes involve in oxidation(loss of electron) reduction(gain of electron) example s dehydrogenases , oxidases.
- 2) **Transferases** : These type of enzymes involve in transferring of chemical group such as alcohol, carboxyl , sulphate , phosphate, aldehyde, ketone . example transaminases , kinases.
- 3) **Hydrolases** : These type of enzymes involve in breaking of different bonds .Examples Lipase , peptidase , glycosidase.
- 4) **Lyases** : These type of enzymes involve addition or removal of the elements of water (hydrogen, oxygen), ammonia (nitrogen, hydrogen), or carbon dioxide (carbon, oxygen) at double bonds. For example, decarboxylases remove carbon dioxide from amino acids and dehydrases remove water.
- 5) **Isomerases** : These type of enzymes are involve in isomerization reaction (Isomerization is a process in which one isomer is formed from another. An isomer is any of the two or more forms of a molecule with the same chemical formula but with a different stereochemical arrangement of the atoms).
- 6) **Ligases** : These type of enzymes involve in biding or joining of two molecules together. e.g. Synthetases , carboxylases.

Factors Affecting Enzymes Activity

- ▲ **Temperature** : Enzymes have optimal temperatures at which they function best. An increase in temperature can increase enzyme activity, but excessive heat can denature the enzyme, rendering it inactive.
- ▲ **pH** : Enzymes have optimal pH levels at which they function best. A change in pH can affect the shape of the enzyme, making it unable to bind to its substrate, and therefore less active.
- ▲ **Substrate concentration** : As the concentration of substrate increases, the rate of enzymecatalyzed reactions also increases, up to a point. Beyond that point, the enzymes become saturated and the reaction rate levels off.
- ▲ **Enzyme concentration** : Increasing the amount of enzyme present will increase the rate of the reaction, up to a point. Beyond that point, the reaction rate levels off.
- ▲ **Inhibitors** : Compounds that bind to enzymes and prevent them from functioning properly are called inhibitors. They can be competitive or non-competitive, and can be reversible or irreversible.
- ▲ **Co-factors** : Many enzymes require small, non-protein molecules, called cofactors, to function. Cofactors can be metal ions or organic molecules, and if they are not present, the enzyme will not function

Mechanism of Action of Enzymes

Step 1 : The enzyme attracts the substrate to its active site and becomes Enzyme - Substrate comple .



Step 2 : a process called catalysis occurs

Step 3 : Now The enzyme release the Substrate and now substrate is called Product (p) .



There are two models which explained the Mechanism of action of enzyme :

1. Lock and Key Hypothesis (Emil Fisher)
2. Induced fit Hypothesis (Koshland)

Enzyme Inhibitors

→ The agents which prevent or decrease the action of Enzymes are called Enzyme inhibitors :

Types of Enzyme Inhibitors

- **Reversible / competitive Inhibitors** : This type of Inhibitors have structural similarity with substrate , and bind at the active site of enzymes and inhibit the action of enzyme . If the concentration of Substrate increase then the inhibition is reversed.
- **Non - Competitive or Irreversible Inhibitors** : This type of Inhibitors bind with functional group other than the active site , and inhibit the action of enzymes for ever . If the concentration of Substrate increase then the inhibition does not reverse.

Therapeutic and Pharmaceutical Importance of Enzymes

Therapeutic Importance

- Trypsin ,is used to treat Inflammation
- Streptokinase are used to treat thrombosis
- Lysozyme is used as antibiotic
- Urokinase is used to dissolve blood clots

Pharmaceutical Importance

- Enzymes (used in manufacturing of drugs)
- Glucose isomerase is used for production of High fructose syrup
- Penicillin acylase is used in production of penicillin
- Amylase is used for diagnosis of Pancreatitis .(inflammation of pancreas , in which serum amylase level increase)

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Chapter 7 : Vitamins

Topics	Page No
Vitamins	3
Definition and classification with examples	
Sources, chemical nature, functions, coenzyme form, recommended dietary requirements, deficiency diseases of fat-and water-soluble vitamins	5



Chapter 7

Vitamins

- The word “Vitamin” comes from the Latin word “Vita” means “life”.
- Vitamins are organic component in food that is needed in very small amount for growth and for maintaining good health.
- Vitamins are chemicals found in very small amounts in many different foods.
- They required to the body through diet because they cannot be synthesized by the body.
- Water soluble vitamins cannot be stored in human’s tissues. Their excess is excreted with urine.
- Fat soluble vitamins can be stored in adipose tissue and the liver.

Function of Vitamins

- They build up the resistance of the body against disease.
- Prevent and cure various disease caused by deficiency.
- Help the Digestion and Utilization of Minerals salts and carbohydrates in the in the body.
- Stimulate and give strength to digestive & Nervous system.
- Help Maintenance of Proper Health & normal Growth.

Classification

- **Fat Soluble Vitamins** : Vitamins that dissolve in fat because fat is easily stored in our body, Fat soluble vitamins can be stored within out fat. This means they can accumulate and be saved for later use.
 - Vitamins A • Vitamins D • Vitamins E • Vitamins K
- **Water Soluble Vitamins** : Water Soluble Vitamins that dissolve in water because our body is a watery environment. These vitamins can move through our body pretty easily & they can also be flushed out by the kidneys.
 - Vitamin B Complex & Vitamin C

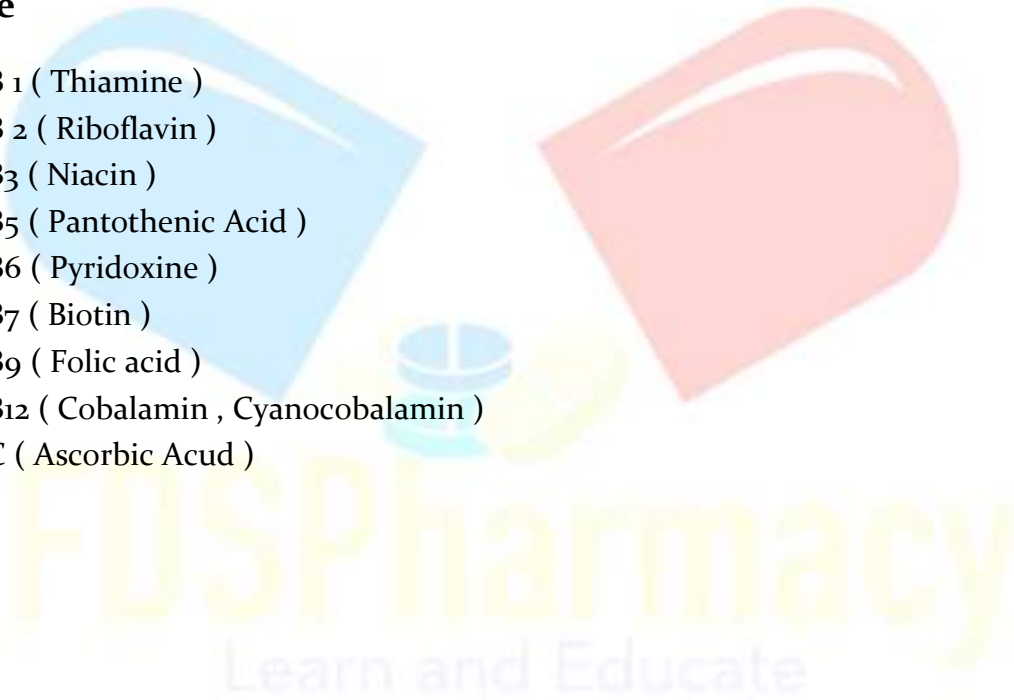
Scientific name of Vitamins

Fat soluble

- Vitamin A (Retinol)
- Vitamin D (Calciferol)
- Vitamin E (TocoPherol)
- Vitamin K (Phylloquinone)

Water soluble

- Vitamin B₁ (Thiamine)
- Vitamin B₂ (Riboflavin)
- Vitamin B₃ (Niacin)
- Vitamin B₅ (Pantothenic Acid)
- Vitamin B₆ (Pyridoxine)
- Vitamin B₇ (Biotin)
- Vitamin B₉ (Folic acid)
- Vitamin B₁₂ (Cobalamin , Cyanocobalamin)
- Vitamin C (Ascorbic Acid)



Sources, chemical nature, functions, coenzyme form, recommended dietary requirements, deficiency diseases of fat-and water-soluble vitamins

Vitamin A (retinol)

→ Vitamin A is an unsaturated alcohol called retinol

Chemical Nature

- It is insoluble in Water.
- Soluble in ethanol & freely soluble in organic solvent like fats & oils.
- It is an Anti-Oxidant.
- Low sensitive light, heat, & Iodine.
- Retinoids occurs in three forms
 - Alcoholic Retinol
 - Aldehyde Retinol
 - Acid Retinoic Acid

Functions

- ✓ It is necessary for normal Vision.
- ✓ It is important for body growth.
- ✓ It helps in growth of bones and Neurological System.
- ✓ It keeps the skin , Kidneys , and other organs perfect.

Deficiency Diseases

- ◇ Night Blindness
- ◇ Xerophthalmia – (Blindness in Childhood)
- ◇ Keratomalacia (ulceration of cornea)
- ◇ Dryness of skin .etc

Coenzyme form

- The active form of vitamin A is retinal, which converted from retinol by the action of retinol dehydrogenase enzyme and finally transported throughout the body.
- Retinoic acid (hormone like substance and is involved in the cell growth and differentiation).

Dietary requirements

- ▲ For adult men : 900 micrograms (mcg).
- ▲ For adult women : 700 micrograms (mcg).
- ▲ For pregnant and lactating women have higher requirements.

Sources

- ✓ Green Vegetables , fruits , cereals , liver , milk , Butter , and egg yolk.

Vitamin D (Calciferol)

→ Vitamin D is also known as Anti-Rachitic Vitamin due to its property of curing or preventing ricket.

Chemical Nature

- It is insoluble in water Moderately soluble in fats, oils, & ethanol.
- Freely soluble in acetone, ether, & petroleum ether.
- It is sensitive to oxygen, light, & Iodine.
- Heating or mild acidity can convert it to the inactive forms.

Functions

- ✓ It increases the absorption of Calcium and Phosphorus from Intestine.
- ✓ It promotes the normal growth and development of bones.
- ✓ It keeps bones healthy.
- ✓ It promotes the normal growth of the body.

Deficiency Diseases

- ◇ Rickets in children
- ◇ Osteomalacia

Coenzyme form

- Calcitriol is an active form of vitamin D and acts as a coenzyme.

Dietary requirements

- ▲ According to the Institute of Medicine (IOM), the daily intake for adults is 600-800 international units (IU).

Sources

- ✓ Cod liver oil, fish liver oil, egg yolk, animal liver.

Vitamin E (Tocopherol)

→ Vitamin E is also known as anti-sterility vitamin or fertility vitamin due to its necessity in healthy functioning of reproductive system fertility of males and birth process in females.

Chemical Nature

- It is insoluble in water & soluble in fats & oils.
- They are anti-oxidants
- They are stable in air.
- It is acidic in nature.
- It is oil at room temperature.

Functions

- ✓ It is helpful for healthy reproductive system.
- ✓ It is an good antioxidant.
- ✓ It prevents liver cells from toxicity.
- ✓ It protect nerve fibres from demylination.
- ✓ It prevents rancidity.

Deficiency diseases

- ◇ Tooth discoloration
- ◇ Weakness of RBC
- ◇ Thrombocytosis and oedem
- ◇ Sterility in male , death of fetus in uterus in female

Coenzyme

- Tocopherols and Tocotrienols.

Dietary requirements

- ▲ According to the national institutes of health (NIH), the recommended daily intake for adult men and women is 15 milligrams per day.

Sources

- ✓ Meat , liver , fish , chicken , vegetable oils , green leafy vegetables ,egg yolk

Vitamin K (phylloquinone)

→ Vitamin K is also known as anti-haemorrhagic drugs or coagulation vitamin or vitamin for blood clotting.

Chemical Nature

- Insoluble in water, slightly soluble in ethanol, freely soluble in ether, chloroform, fats & oils.
- It is sensitive to light.

Functions

- ✓ It increases the activity of blood clotting factors.
- ✓ It helps the liver to manufacture the enzyme that catalyses the formation of prothrombin.

Deficiency diseases

- ◇ Delay in blood clotting
- ◇ Improper functioning of liver.

Coenzyme form

- Phylloquinone – Vitamin-K₁
- Menaquinone – Vitamin-K₂
- Menadione – Vitamin-K₃

Dietary requirements

- ▲ The recommended intake for the adult men and women is 120 micrograms per day

Sources

- ✓ green leafy vegetables(Spinach , Cabbage etc.) , Soya beans , wheat germ.

Vitamin B₁ (Thiamine)

→ Anti-Beri Beri Vitamin ang Anti-Neuritic Vitamin are other names for vitamin B₁.

Chemical Nature

- It is highly soluble in water, moderately soluble in methanol & glycerol, & insoluble in fats & oils.
- It is colourless crystal.

Functions

- ✓ It is necessary for maintaining good appetite.
- ✓ It helps in utilizing the carbohydrates in body.
- ✓ It is needed for brain metabolism.

Deficiency diseases

- ◇ Beri-Beri (nerve system problems , oedema , weakness , headache , Insomnia , GIT disorders.)
- ◇ Anorexia (loss of appetite)

Coenzyme form

- Thiamine pyrophosphate

Dietary requirements

- ▲ Dietary supply for adults 1-1.5 mg/day.
- ▲ For children 0.7-1.2 mg/day.
- ▲ Pregnancy and lactation 2 mg/day.

Sources

- ✓ rice bran , wheat bran , whole grains , nuts , pulses , beam , yeast , liver , eggs , fish , meat , and milk.

Vitamin B₂ (Riboflavin)

→ It is essential for growth, development, & cellular function in body.

Chemical Nature

- It is moderately soluble in water, insoluble in fats & oils.
- It is light sensitive.

Functions

- ✓ It helps the regulation of some carbohydrate- metabolising hormones.
- ✓ In presence of light , it stimulate the optic nerve.

Deficiency diseases

- ◇ Injury of lips
- ◇ Cracks at the mouth' s angle)
- ◇ Eczema on face (red and dry skin and itch)
- ◇ Hair loss
- ◇ Red eye reproductive problems
- ◇ Cataract

Coenzyme form.

- Flavin mononucleotide (FMN).
- Flavin adenine dinucleotide (FAD).

Dietary requirements

- ▲ Daily requirement for adults 1.2-1.7 mg.

Sources

- ✓ Milk , liver , eggs yolk , sprouts cereals

Vitamin B₃ (Niacin)

→ Niacin is essential for cellular process & energy production.

Chemical Nature

- It is of amphoteric nature.
- It is soluble in water & insoluble in fats.
- It is stable in dry form.

Functions

- ✓ It perform metabolic function.
- ✓ It converts carbohydrates into glucose.
- ✓ It keeps nervous system working properly.

Deficiency diseases

- ◇ Dermatitis (Itchy inflammation of skin)
- ◇ Diarrhoea
- ◇ Demantia (memory loss , neuronal disorder)

Coenzyme form.

- Nicotinamide adenine dinucleotide (NAD⁺).
- Nicotinamide adenine dinucleotide phosphate (NADP⁺).

Dietary requirements

- ▲ Daily requirements for adults is 15-20 mg.

Sources

- ✓ Liver , fish , bean , and peanuts.

Vitamin B₅ (Pantothenic Acid)

→ Pantothenic acid is involved in energy production, hormone formulation & metabolism of dietary fats, protein, and carbohydrates.

Chemical Nature

- It is yellow viscous oil.
- It is soluble in water & ether, & insoluble in organic solvents like fats.

Functions

- ✓ It is essential for growth of infants and children.
- ✓ It is required for Breakdown of fats and carbohydrates for energy.
- ✓ It is required for formation of RBCs.

Deficiency diseases

- ◇ Anaemia
- ◇ Growth problem
- ◇ Liver problems
- ◇ Nausea
- ◇ Vomiting
- ◇ Fatty liver

Coenzyme form

- Coenzyme A

Dietary requirements

- ▲ Daily intake for adult is 5-10 mg.

Sources

- ✓ Honey , cereals , nuts , eggs , liver ,fish , milk , meat , bran

Vitamin B6 (Pyridoxine)

→ Pyridoxine or pyridoxal or pyridoxamine is an anti-oxidant that helps in protein metabolism & production of RBCs, neurotransmitters & haemoglobin in the body.

Chemical Nature

- It is colourless crystal at room temperature.
- Highly soluble in water & insoluble in chloroform and fat.
- It is stable in solution.

Functions

- ✓ It is needed for Infant growth.
- ✓ It is required for formation of dopamine , serotonin etc.
- ✓ Formation of RBCs and WBCs.

Deficiency diseases its deficiency rarely occurs

- ◇ Depression
- ◇ Confusion
- ◇ Decrease immune function
- ◇ Anaemia

Coenzyme form

- Pyridoxal phosphate (PLP).

Dietary requirements

- ▲ Daily requirements about- 2-2.2 mg/day.
- ▲ During pregnancy/lactation 2.5 mg/day.

Sources

- ✓ Milk , liver , eggs yolk , meat , leafy vegetables etc.

Vitamin B₇ (Biotin)

→ Biotin helps in metabolism of lipids, proteins, & Carbohydrates from food, & releases energy from Carbohydrates.

Chemical Nature

- It is white crystalline substance.
- It is soluble in water & insoluble in fats.
- It is soluble in air.

Functions

- ✓ It helps in metabolism of carbohydrates , lipids , proteins and produces energy.

Deficiency diseases

- ◇ Alopecia (hair loss)
- ◇ Hair graying

Coenzyme form

- Biocytin is coenzyme form.

Dietary requirements

- ▲ Daily requirement for adult is 100-300 mg.

Sources

- ✓ Honey , Milk , liver , eggs yolk , meat , fish etc.

Vitamin B₉ (Folic acid)

→ Folic acid or Folate Or Folacinm helps in protein metabolism, RBC stimulation, reduces the risk of neural tube birth defects, controls homocysteine levels, & reduces the risk of coronary heart diseases.

Chemical Nature

- It is an organic yellow crystalline substance.
- Soluble in water & insoluble in fats.
- Unstable in light.

Functions

- ✓ It help in Protein metabolism,.
- ✓ Controls Homocysteine level.
- ✓ It break Homocysteine amino acid.

Deficiency diseases

- ◇ Affect DNA Synthesis
- ◇ Megaloblastic anaemia. (abnormal large Red Blood cells).

Coenzyme form

- Tetrahydrofolate (THF or FH₄).

Dietary requirements

- ▲ Daily requirements in adults are 200 µg.
- ▲ During pregnancy 400 µg.
- ▲ During lactation 300 µg.

Sources

- ✓ leafy vegetables liver , eggs etc .

Vitamin B₁₂ (Cobalamine)

→ Cobalamin is involved in the formation of genetic material, RBC Production, & Nervous system maintenance.

Chemical Nature

- It is red, red-orange or yellow crystalline substance.
- Soluble in water & insoluble in fats.
- Stable in heat.

Functions

- ✓ It is required for formation of genetic materials.
- ✓ For formation and maturation of RBCs.
- ✓ It is needed for maintenance of nervous system.

Deficiency diseases

- ◇ Neurological disorder
- ◇ Infertility
- ◇ Demyelination
- ◇ Megaloblastic anaemia

Coenzyme form

- Methylcobalamin (MeCbl).
- Adenosylcobalamin(AdoCbl).

Dietary requirements.

- ▲ Daily requirement for adult is 3µg.
- ▲ For children 0.5-1.5 µg/day.
- ▲ During pregnancy/lactation 4µg

Sources.

- ✓ Liver, kidney, Milk., Fish., Curd, Chicken etc

Vitamin C (ascorbic acid)

- Vitamin c is also named as anti scorbutic acid because it prevents scurvy.
- It is also recognized as an anti-rabies or anti-cancer vitamin.

Chemical Nature

- It is soluble in water, & in soluble in fats.
- In aqueous solution, dehydroascorbic acid is unstable.

Functions

- ✓ It is necessary for Iron absorption.
- ✓ It provides immunity against viruses and cold.
- ✓ It keeps gums and capillaries healthy.
- ✓ It helps in wound Healing.

Deficiency diseases

- ◇ Scurvy disease
 - Bleeding from gums and decaying teeth.
 - Loosing teeth.
 - Haemorrhage due to weakness of capillaries.
 - Delay in wound healing.

Coenzyme form

- Ascorbic acid.

Dietary requirements

- ▲ Daily requirements for the adult is 60-70 mg.

Sources

- ✓ Citrus fruits, Goose berry, Guava, Green vegetables, Tomatoes, Adrenal gland and gonads.

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Chapter 8 : Metabolism

Topics	Page No
Metabolism (Study of cycle/pathways without chemical structures)	
Metabolism of Carbohydrates : Glycolysis, TCA cycle and glycogen metabolism, regulation of blood glucose level. Diseases related to abnormal metabolism of Carbohydrates	3
Metabolism of lipids : Lipolysis, β -oxidation of Fatty acid (Palmitic acid) ketogenesis and ketolysis. Diseases related to abnormal metabolism of lipids such as Ketoacidosis, Fatty liver, Hypercholesterolemia	4
Metabolism of Amino acids (Proteins) : General reactions of amino acids and its significance– Transamination, deamination, Urea cycle and decarboxylation. Diseases related to abnormal metabolism of amino acids, Disorders of ammonia metabolism, phenylketonuria, alkaptonuria and Jaundice.	6
Biological oxidation : Electron transport chain and Oxidative phosphorylation	

Metabolism

→ Different types of chemical reactions that occurs in a living organism is called metabolism.

Major types of Metabolism

- ❖ Catabolism : Break Down of molecules to obtain energy.
- ❖ Anabolism : Synthesis of any compound needed by body.

Metabolism of Carbohydrates

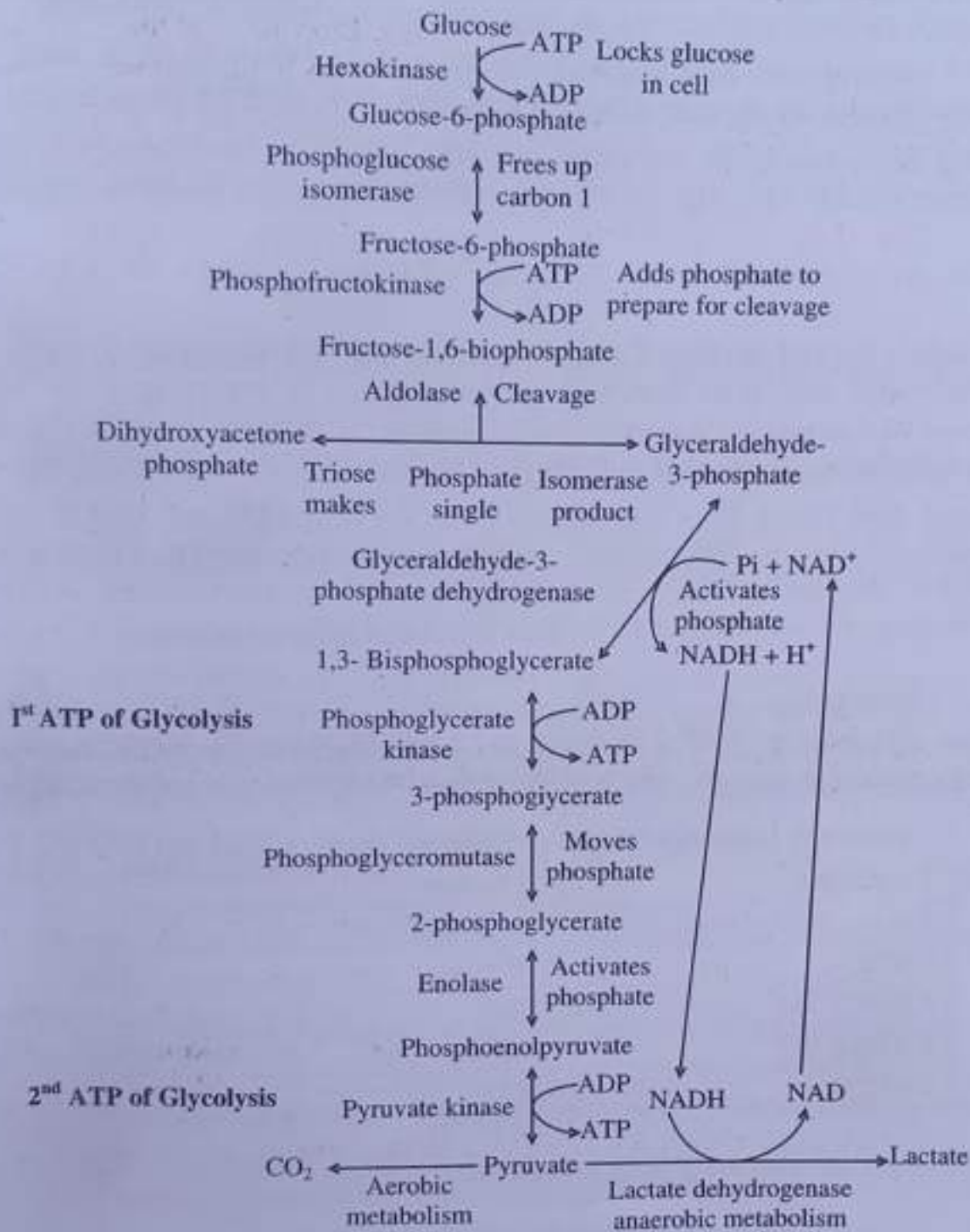
- Biochemical processes involved in synthesis, breakdown, and inter-conversion of carbohydrates in living organisms, are collectively called as carbohydrate metabolism
- Glucose (a monosaccharide metabolised by nearly all organisms) is the essential molecule of carbohydrate metabolism which participates in various metabolic pathways. Insulin is the primary metabolic hormone synthesised in pancreas and regulates glucose level in blood.
- The metabolism of carbohydrate is simplest than other like protein , and fat , that is why it is used as immediate source of energy.
- The unused glucose stored in the liver in the form of Glycogen.

Some Pathways of Metabolism of Carbohydrate

- ❖ Glycolysis : Break Down of glucose into ATP (energy) and Pyruvate and Lactate.
- ❖ Citric Acid Pathway or Cycle (Krebs Cycle , Tricarboxylic Acid Cycle (TCA)) : It is the common metabolic Pathway for Carbohydrates , Fats and protein Oxidation.
- ❖ Glycogenesis : In this pathway , The glycogen is synthesised from Glucose.
- ❖ Glycogenolysis : In this pathway glycogen is converted into Glucose.
- ❖ Gluconeogenesis : In this pathway glucose is Synthesised from a non- carbohydrate source , (fats and proteins)

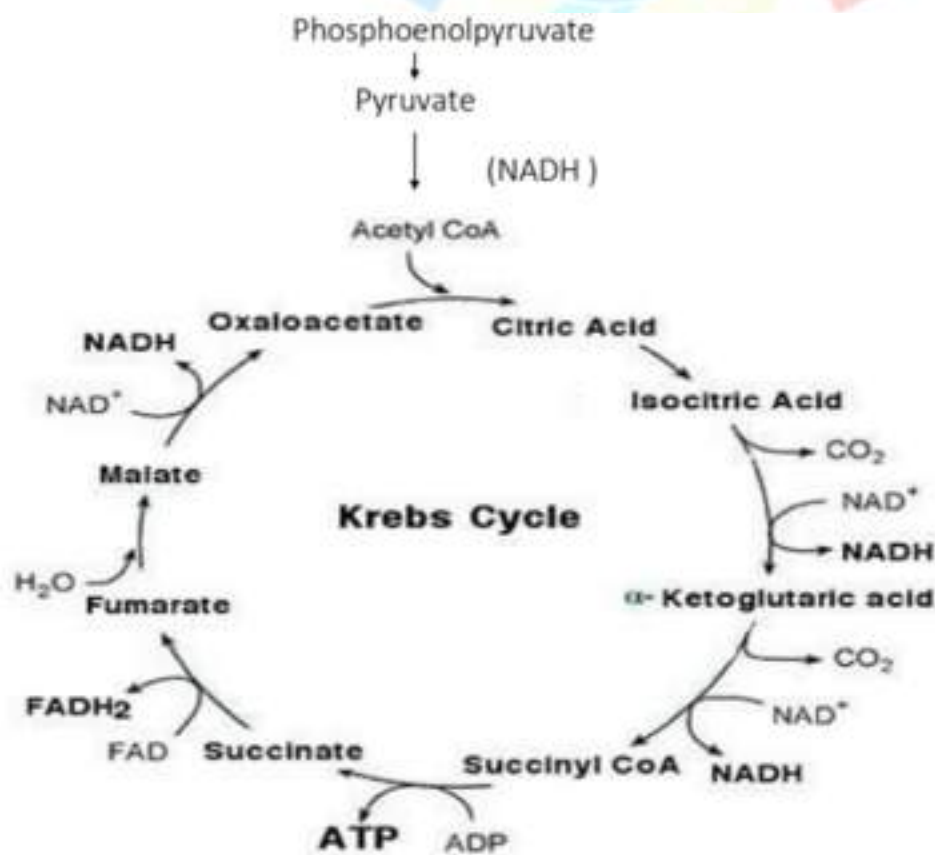
Glycolysis

- Glycolysis is an important pathway of Carbohydrate metabolism and it occurs in the Cytoplasm of a living cell.
- Glycolysis is important to maintain ATP balance.
- The Enzymes involved in Glycolysis are present in Cytosol of cell.



Citric Acid Pathway or Cycle (Krebs Cycle , Tricarboxylic Acid Cycle (TCA)) :

- It is the common metabolic Pathway for Carbohydrates , Fats and protein .
- First time , Hans Crebs had given the reaction of Citric Acid Cycle , that is why it is called Crebs Cycle.
- The end product of glycolysis Pyruvate , enters into mitochondria by Active Transport , and Converted into Acetyl Co-A .
- Now Acetyl Co-A enters into Crebs Cycle , which occurs in the matrix of Mitochondria .
- When one crebs cycle completed in the presence of optimum amount of O₂ 12 ATPs are generated .
- Catabolism of one glucose in aerobic Condition (if O₂ is present in mitochondria) gives 38 ATP , including :
 - 8 ATPs in Glycolysis
 - 6 ATPs in conversion of Pyruvate to Acetyl-CoA .
 - 24 ATPs in Crebs cycle .



Glycogen Metabolism

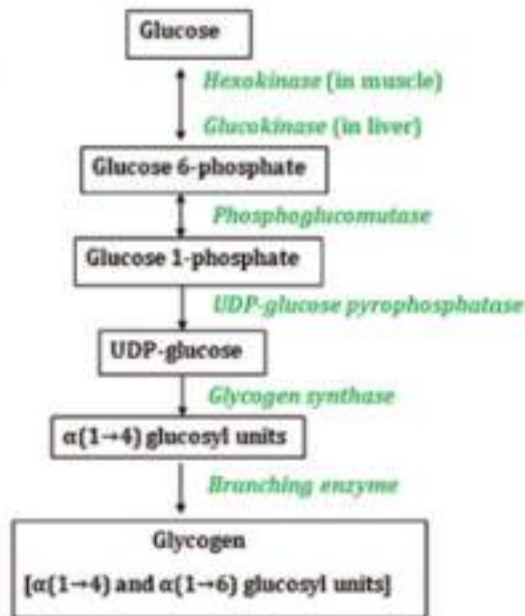
- Glycogen is a highly branched polysaccharide (polymer of carbohydrates) , and 8-10 glucose units present at per branch.
- Glucose is stored in animal in the form of Glycogen.
- Glycogen is mainly stored in liver (6-8 %) and in muscles cells (1-25)
- According to NCBI about (500g) glycogen stored in muscles and (100g) in liver.
- Glycogen stored in the form of granules in cell cytosol , where most of the enzymes are found which required for glycogen synthesis and breakdown.
- First of all liver glycogens are consumed for energy.

Glycogen Metabolism is also in two types :

- Glycogenesis
- Glycogenolysis

Glycogenesis

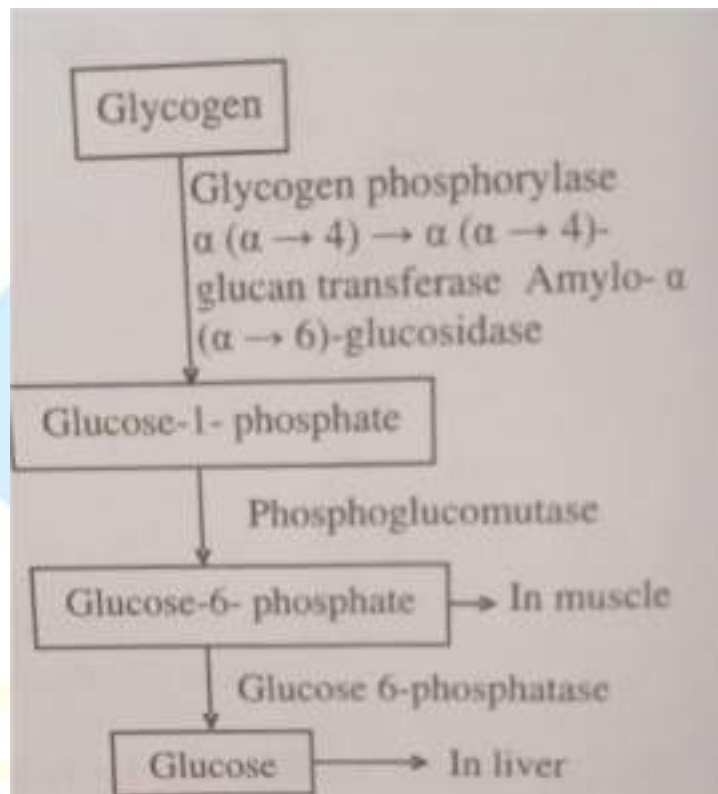
- The formation (synthesis) of glycogen from glucose is called Glycogenesis . Glycogen is a highly branched polysaccharide (polymer of carbohydrates) , and 8-10 glucose units present at per branch .



Glycogenesis

Glycogenolysis

- The process of conversion of stored Glycogen into glucose is called glycogenolysis.



Regulation of Blood glucose Level

- ⇒ The normal blood Glucose level is necessary for proper functioning of body's organs.
- ⇒ The blood glucose level is regulated by two hormones Insulin and Glucagon , both are secreted by Pancreas.

Insulin

- The β cells of pancreas secrete insulin hormone.
- The secretion of insulin increases when concentration of glucose increased in blood , and its secretion decreases when concentration of glucose decreased.
- Insulin helps the glucose for entering into cells , by this way increase the consumption of glucose.
- A fasting glucose level of 99 mg/dl or less is normal . but less than 70 mg/dl is not normal (may lead to hypoglycemia)

Glucagon

- The α cells of pancreas secrete glucagon.
- The secretion of glucagon increases when concentration of glucose decreases in blood, and its secretion declines when blood glucose level increases.
- The glucose stored in liver in the form of glycogen, released in blood under influence of glucagon.
- Glucagon also stimulates the liver and other cells to synthesize glucose from proteins and fats, when it is required.

Diseases Related to Abnormal Metabolism of Carbohydrates

1) Diabetes Mellitus

- ⇒ Diabetes Mellitus is an inherited or acquired disease that occurs due to a defect in insulin secretion or insulin action or both, in which blood sugar level is high for a long time.
- ⇒ It is also called Hyperglycemia.

Symptoms

- Presence of sugar in urine
- Increase in thirst
- Increase in frequency of urination
- Extreme hunger
- Fatigue
- Blurred vision
- Headache
- Frequent infection
- Delay in healing of cuts and wounds
- Itchy skin

2) Galactosaemia

- It is a genetic disorder in which the body is unable to metabolize galactose sugar, and blood galactose level increases. The absence or non-functionality of Galactose-1-Phosphate Uridyltransferase Enzyme is responsible for this disorder.

Symptoms

- Appetite loss
- Jaundice
- Enlargement of liver
- Liver damage
- Abdominal swelling due to fluid accumulation

3) Glycogen Storage Disease (GSD)

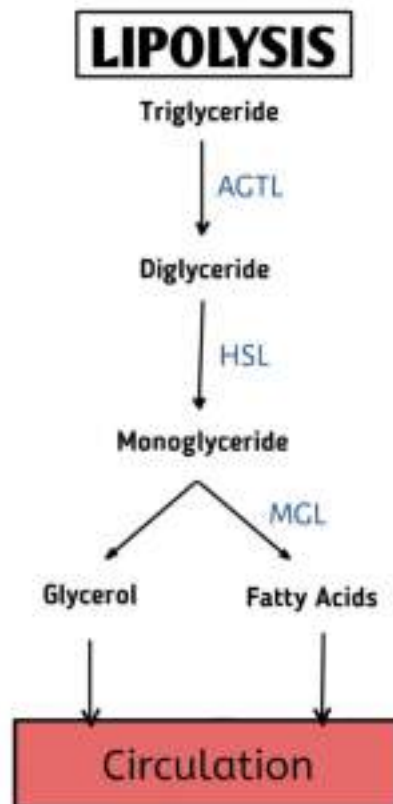
- The breakdown of glycogen to glucose is facilitated by some enzymes , if they gets blocked , the glycogen accumulate in the liver and muscles and Glycogen Storage Disease developed.

4) Glucose -6- Phosphate Dehydrogenase Deficiency Disease

- It is a genetic disorder in which the quantity of Glucose -6- Phosphate Dehydrogenase decreased and causes breakdown of Premature RBCs . This destruction of RBCs is called Haemolysis , and causes Haemolytic anaemia

Metabolism of Lipids

- Lipids are present in our bodies in different forms like triglycerides , phospholipids , fatty acids,
- The breakdown of lipids to release fatty acids is called lipolysis.
- Triglycerides are (85-90%) of total lipids , and stored in adipose tissues. They are released from there to produce energy after long starvation.



β -Oxidation of Fatty Acids

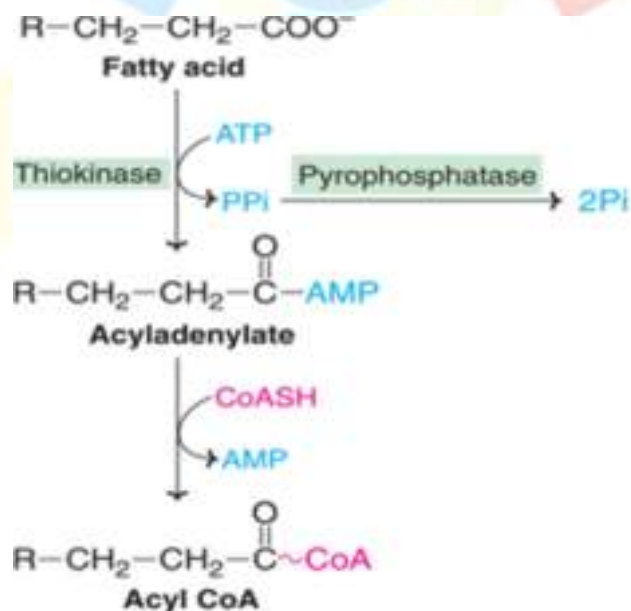
→ β -Oxidation of fatty acid is a process by which fatty acids are broken down to produce energy .

The beta oxidation of fatty acids occurs in three stages ;

- 1) Activation of fatty acids in the cytosol.
- 2) transport of activated fatty acids into mitochondria.
- 3) Beta oxidation of fatty acid in the matrix of mitochondria.

1. Activation of fatty acids

→ Fatty acids are activated to acyl CoA by thiokinase or acyl CoA synthetases. The reaction occurs in two steps and requires ATP, coenzyme A and Mg^{2+} . Fatty acid reacts with ATP to form acyladenylate which then combines with coenzyme A to produce acyl CoA. In the activation, two high energy phosphates are utilized, since ATP is converted to pyrophosphate (PPi). The enzyme inorganic pyrophosphatase hydrolyses PPi to phosphate (Pi). The immediate elimination of PPi makes this reaction totally irreversible.

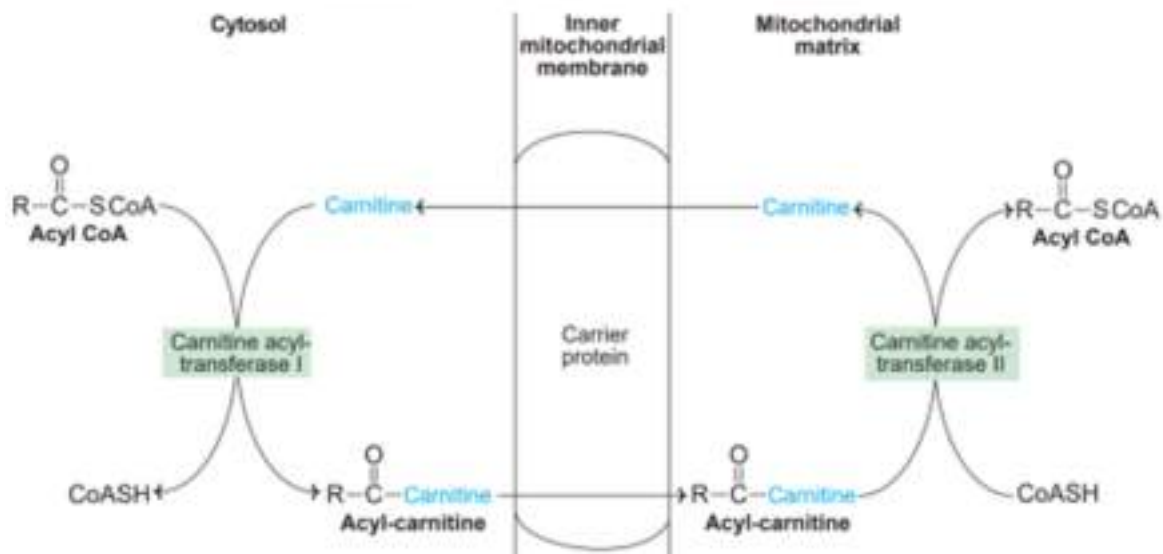


2. Transport of fatty acids into mitochondria

→ The inner mitochondrial membrane is impermeable to fatty acids. A specialized carnitine carrier system (carnitine shuttle) operates to transport activated fatty acids from cytosol to the mitochondria.

This occurs in four steps

- Acyl group of acyl CoA is transferred to carnitine (β -hydroxy γ -trimethyl aminobutyrate), catalysed by carnitine acyltransferase I (present on the outer surface of inner mitochondrial membrane).
- The acyl-carnitine is transported across the membrane to mitochondrial matrix by a specific carrier protein.
- Carnitine acyl transferase II (found on the inner surface of inner mitochondrial membrane) converts acyl-carnitine to acyl CoA.
- The carnitine released returns to cytosol for reuse

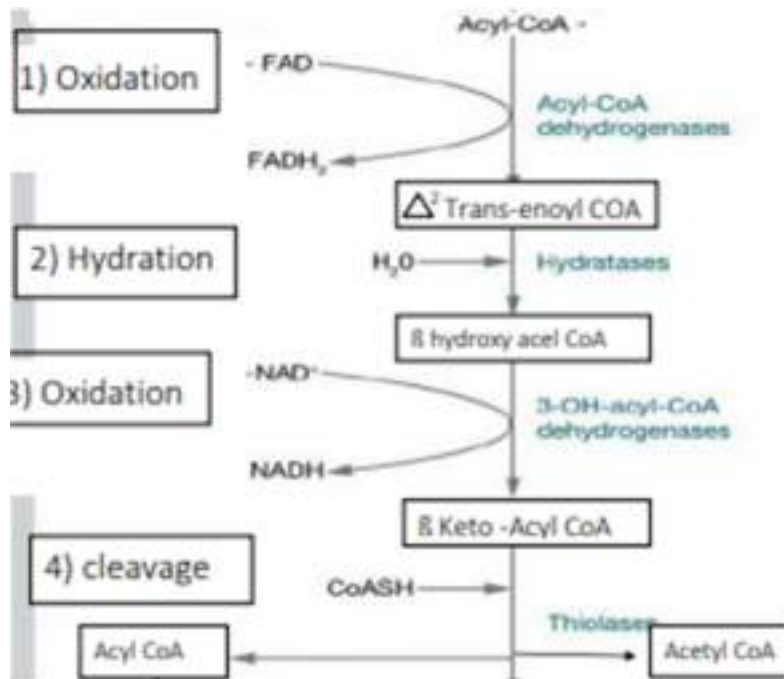


3. β -Oxidation proper in the mitochondrial matrix

→ Each cycle of β oxidation, liberating a two-carbon unit-acetyl CoA, occurs in a sequence of four reactions.

1. **Oxidation** — Acyl CoA undergoes dehydrogenation by an FADdependent flavoenzyme, acyl CoA dehydrogenase. A double bond is formed between α and β carbons (i.e., 2 and 3 carbons).

2. **Hydration** — Enoyl CoA hydratase brings about the hydration of the double bond to form β -hydroxyacyl CoA.
3. **Oxidation** — β -Hydroxyacyl CoA dehydrogenase catalyses the second oxidation and generates NADH. The product formed is β -ketoacyl CoA.
4. **Cleavage** — The final reaction in β -oxidation is the liberation of a 2- carbon fragment, acetyl CoA from acyl CoA. This occurs by a thiolitic cleavage catalysed by β -ketoacyl CoA thiolase.

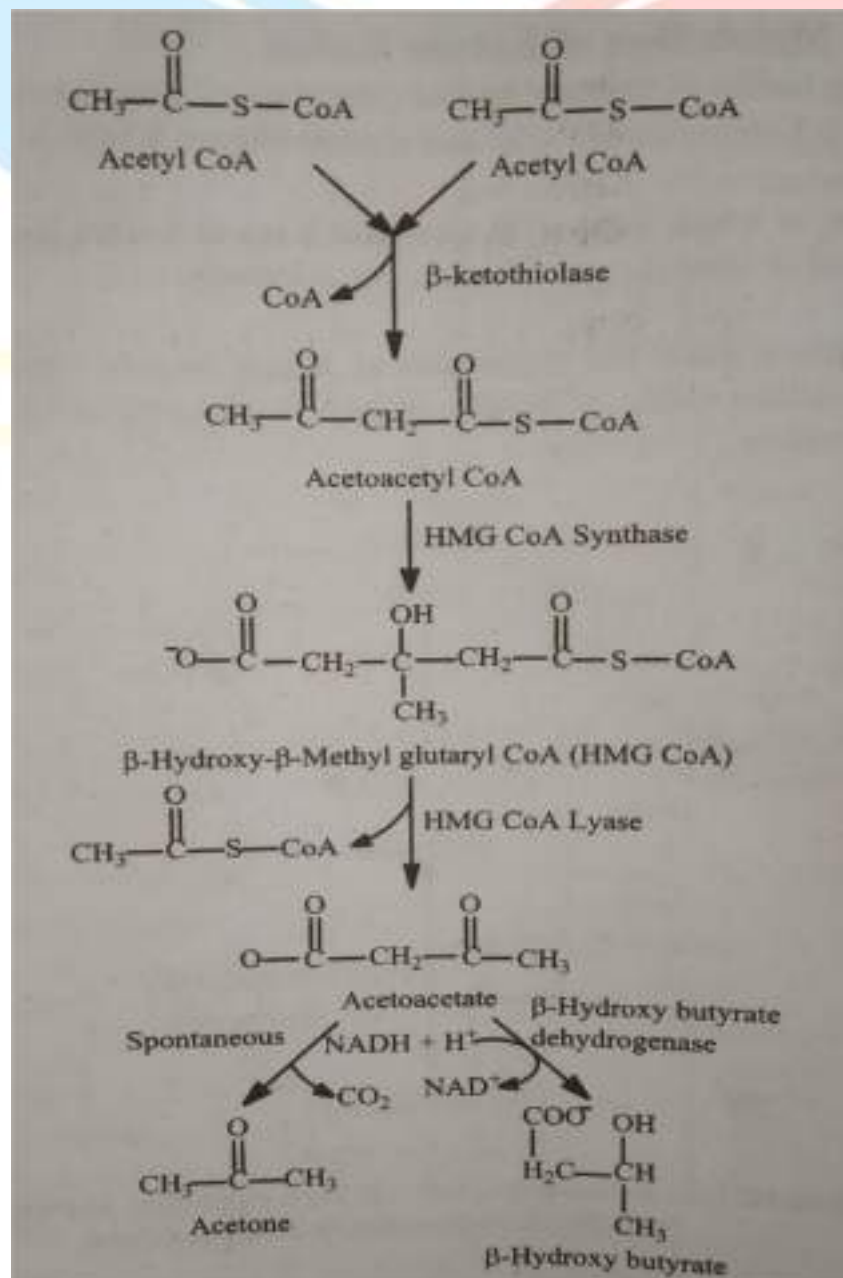


Ketogenesis

- The synthesis of ketone bodies occurs in the liver. The enzymes for ketone body synthesis are located in the mitochondrial matrix. Ketone bodies are water-soluble and energy yielding. Acetyl CoA, formed by oxidation of fatty acids, pyruvate or some amino acids, is the precursor for ketone bodies.
- The three main types of ketone bodies produced are acetone, acetoacetate, and beta-hydroxybutyrate. Ketone bodies can be used by the brain and other tissues as an alternative energy source when glucose is scarce, and they are also involved in regulating blood glucose levels and reducing inflammation.
- However, excessive production of ketone bodies can lead to a condition known as ketoacidosis, which is a potentially lifethreatening metabolic state characterized by high levels of ketone bodies in the blood.

Ketogenesis occurs through the following reactions

1. Two moles of acetyl CoA condense to form acetoacetyl CoA. This reaction is catalysed by thiolase, an enzyme involved in the final step of E-oxidation. Hence, acetoacetate synthesis is appropriately regarded as the reversal of thiolase reaction of fatty acid oxidation.
2. Acetoacetyl CoA combines with another molecule of acetyl CoA to produce β -hydroxy β -methyl glutaryl CoA (HMG CoA). HMG CoA synthase, catalysing this reaction, regulates the synthesis of ketone bodies. 3. HMG CoA lyase cleaves HMG CoA to produce acetoacetate and acetyl CoA.
3. Acetoacetate can undergo spontaneous decarboxylation to form acetone.
4. Acetoacetate can be reduced by a dehydrogenase to β -hydroxybutyrate.



Ketolysis

- Ketolysis is the metabolic process by which ketone bodies are broken down and converted into energy in the body's cells. This process occurs primarily in the mitochondria of cells, where the ketone bodies are broken down into acetyl-CoA, which can then enter the citric acid cycle to produce ATP, the energy currency of cells.
- This process is important for individuals who rely on ketone bodies as their primary source of energy, such as those on a ketogenic diet or during periods of prolonged fasting.
- The rate of Ketolysis is influenced by several factors, including the availability of ketone bodies and the metabolic state of the cells.
- In some metabolic disorders, such as diabetes, there can be a disruption in the balance between ketone production and utilization, leading to an accumulation of ketone bodies in the blood and potentially causing ketoacidosis

Diseases related to abnormal metabolism of lipids

1. Ketoacidosis

- Increase in concentration of both acetoacetate and β hydroxybutyrate (strong acids) in blood would cause acidosis. The carboxyl group has a pKa around 4. Therefore, the ketone bodies in the blood dissociate and release H^+ ions which lower the PH. Diabetic ketoacidosis is dangerous—may result in coma, and even death, if not treated. Ketosis due to starvation is not usually accompanied by ketoacidosis

2. Hypercholesterolemia

- Increase in plasma cholesterol (> 200 mg/dl) concentration is known as hypercholesterolemia and is observed in many disorders
- **Diabetes mellitus** Due to increased cholesterol synthesis since the availability of acetyl CoA is increased.
- **Hypothyroidism (myxoedema)** This is believed to be due to decrease in the HDL receptors on hepatocytes.
- **Obstructive jaundice** Due to an obstruction in the excretion of cholesterol through bile.
- **Nephrotic syndrome** Increase in plasma globulin concentration is the characteristic feature of nephrotic syndrome. Cholesterol elevation is due to increase in plasma lipoprotein fractions in this disorder.

3. Fatty liver

- The normal concentration of lipid in liver is around 5%. Liver is not a storage organ for fat, unlike adipose tissue. However, in certain conditions, lipids— especially the triacylglycerols— accumulate excessively in liver, resulting in fatty liver. In the normal liver, Kupffer cells contain lipids in the form of droplets. In fatty liver, droplets of triacylglycerols are found in the entire cytoplasm of hepatic cells. This causes impairment in metabolic functions of liver. Fatty liver is associated with fibrotic changes and cirrhosis,

Fatty liver may occur due to two main causes

- Increased synthesis of triacylglycerols
- Impairment in lipoprotein synthesis

Metabolism Of Amino Acids (Proteins)

- Proteins are the most abundant organic compounds and constitute a major part of the body dry weight (10-12 kg in adults).
- They perform a wide variety of static (structural) and dynamic (enzymes, hormones, clotting factors, receptors etc.) functions. About half of the body protein (predominantly collagen) is present in the supportive tissue (skeleton and connective) while the other half is intracellular.
- Amino acid—Proteins are nitrogen-containing macromolecules consisting of LD-amino acids as the repeating units. Of the 20 amino acids found in proteins, half can be synthesized by the body (non-essential) while the rest have to be provided in the diet (essential amino acids).
- The proteins on degradation (proteolysis) release individual amino acids. Amino acids are not just the structural components of proteins. Each one of the 20 naturally occurring amino acids undergoes its own metabolism and performs specific functions.
- Some of the amino acids also serve as precursors for the synthesis of many biologically important compounds (e.g., melanin, serotonin, creatine etc.).
- Certain amino acids may directly act as neurotransmitters (e.g., glycine aspartate, glutamate).

General Reactions of Amino Acids and Its Significance

General of Amino Acids are following :

- 1) **Transamination** : It means movement of an amino ($--NH_2$) group from an amino acid to a Keto Acid . A group of enzymes called Transaminase catalyses this reaction . Keto acid is a compound that contains a Carboxyl Group ($--COOH$) and a Ketone Group ($>C=O$).
- 2) **Deamination** : Loss of amino group from amino acid is Deamination . It is of two types, Oxidative, Non-Oxidative.
- 3) **Decarboxilation** : Removal of CO_2 From a compound is called Decarboxilation.

Transamination

- The transfer of an amino (NH_2) group from an amino acid to a keto acid is known as transamination. This process involves the interconversion of a pair of amino acids and a pair of keto acids, catalysed by a group of enzymes called transaminases /aminotransferases.

Silent features of Transamination

- All transaminases require pyridoxal phosphate (PLP), a coenzyme derived from vitamin B6. It is reversible and no free NH_3 liberated, only the transfer of amino group occurs. Transamination diverts the excess amino acids towards energy generation.
- Specific transaminases exist for each pair of amino and keto acids. However, only two—namely, aspartate transaminase and alanine transaminase—make a significant contribution for transamination.
- Transamination is very important for the redistribution of amino groups and production of non-essential amino acids, as per the requirement of the cell. It involves both catabolism and anabolism of amino acids.
- The amino acids undergo transamination to finally concentrate nitrogen in glutamate. Glutamate is the only amino acid that undergoes oxidative deamination to a significant extent to liberate free NH_3 for urea synthesis.
- All amino acids except lysine, threonine, proline and hydroxyproline participate in transamination. Serum transaminases are important for diagnostic and prognostic purposes.

Mechanism of transamination

- It occurs in two stages
 - Transfer of the amino group to the coenzyme pyridoxal phosphate (bound to the coenzyme) to form pyridoxamine phosphate.
 - The amino group of pyridoxamine phosphate is then transferred to a keto acid to produce a new amino acid and the enzyme with PLP is regenerated.

Deamination

→ The removal of amino group from the amino acids as NH_3 is deamination. Deamination results in the liberation of ammonia for urea synthesis (transamination involves only the shuffling of amino groups). It may be either oxidative or non-oxidative.

1. Oxidative deamination : Oxidative deamination is the liberation of free ammonia from the amino group of amino acids coupled with oxidation. This takes place mostly in liver and kidney. The purpose of oxidative deamination is to provide NH_3 for urea synthesis and D-keto acids for a variety of reactions, including energy generation

- **Oxidation of glutamate-by-glutamate dehydrogenase :** In the transamination process glutamate is formed. Now, Glutamate rapidly undergoes oxidative deamination, catalysed by glutamate dehydrogenase (GDH) to liberate ammonia. This enzyme is unique in that it can utilize either NAD^+ or NADP^+ as a coenzyme. Conversion of glutamate to α -ketoglutarate occurs through the formation of an intermediate, α -iminoglutarate.
- **Oxidative deamination by amino acid oxidases :** L-Amino acid oxidase and D-amino acid oxidase are flavoproteins, possessing FMN and FAD, respectively. They act on the corresponding amino acids (L or D) to produce D-keto acids and NH_3 . In this reaction, oxygen is reduced to H_2O_2 , which is later decomposed by catalase.

2. Non-oxidative deamination : Some of the amino acids can be deaminated to liberate NH_3 without undergoing oxidation.

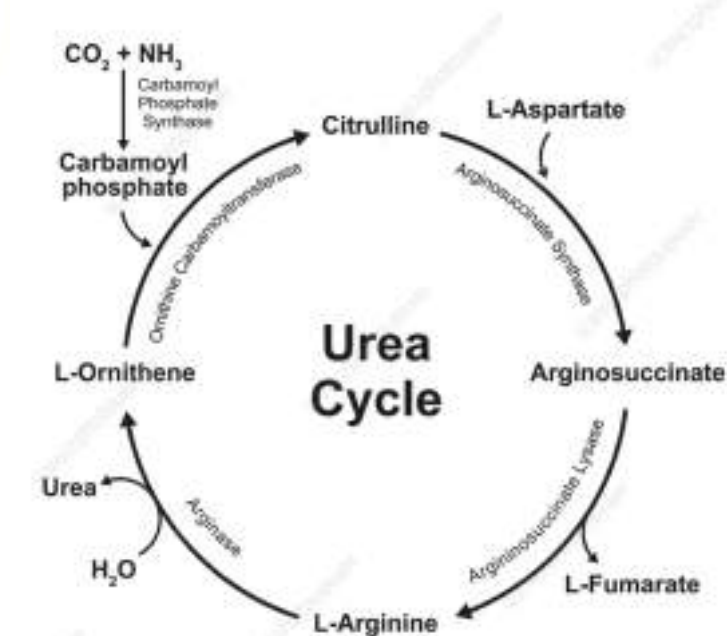
- a. **Amino acid dehydrases :** Serine, threonine and homoserine are the hydroxy amino acids. They undergo non-oxidative deamination catalysed by PLP-dependent dehydrases (dehydratases).
- b. **Amino acid desulfhydrases :** The sulphur amino acids, namely cysteine and homocysteine, undergo deamination coupled with desulfhydration to give keto acids.
- c. **Deamination of histidine :** The enzyme histidase acts on histidine to liberate NH_3 by a non-oxidative deamination process

Urea cycle

- Ammonia is constantly being liberated in the metabolism of amino acids (mostly) and other nitrogenous compounds. At the physiological pH, ammonia exists as ammonium (NH_4^+) ion. Ammonium ions are very important to maintain acid-base balance of the body.
- The production of NH_3 occurs from the amino acids (transamination and deamination), biogenic amines, amino group of purines and pyrimidines and by the action of intestinal bacteria (urease) on urea.

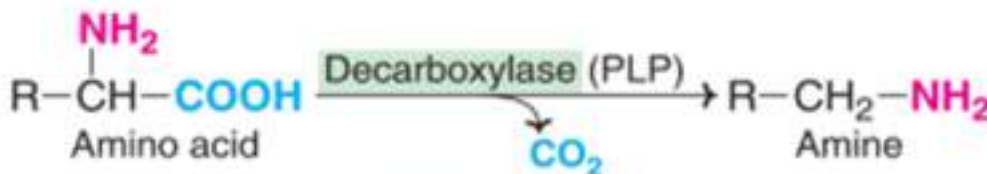
Introduction about urea cycle

- Urea is the end product of protein metabolism (amino acid metabolism). The nitrogen of amino acids, converted to ammonia, is toxic to the body. It is converted to urea and detoxified. As such, urea accounts for 80-90% of the nitrogen containing substances excreted in urine.
- Urea is synthesized in liver and transported to kidneys for excretion in urine. Urea cycle is the first metabolic cycle that was elucidated by Hans Krebs and Kurt Henseleit (1932), hence it is known as Krebs-Henseleit cycle. The individual reactions, however, were described in more detail later on by Ratner and Cohen. Urea has two amino (NH_2) groups, one derived from NH_3 and the other from aspartate. Carbon atom is supplied by CO_2 . Urea synthesis is a five-step cyclic process, with five distinct enzymes. The first two enzymes are present in mitochondria while the rest are localized in cytosol



Decarboxylation

- Decarboxylation of an amino acid is a chemical reaction in which the carboxyl group (-COOH) of an amino acid is removed, leading to the formation of an amine group (-NH₂) and the release of carbon dioxide (CO₂). This reaction is catalysed by enzymes called decarboxylases.
- In general, the decarboxylation of amino acids or their derivatives results in the formation of amines.
- The decarboxylation of amino acids plays an important role in many biological processes. For example, the amino acid histidine is decarboxylated to form histamine, which is involved in regulating many physiological processes, including digestion and immune response. Similarly, the amino acid glutamic acid is decarboxylated to form the neurotransmitter gamma-aminobutyric acid (GABA), which is involved in the regulation of neuronal activity.



Significance of amino acid metabolism

- It is necessary for proper functioning of body .
- It is very important pharmacologically also .
- Some are important precursor of steroid hormones .
- Some function as Coenzyme .
- Some are act as neurotransmitter (GABA)

Diseases Related to Abnormal Metabolism of Amino Acids

1) **Albinism** : It is a Group of inherited disorder it develops when tyrosine metabolism does not occur properly , and then synthesis of melanin becomes very low or no melanin production . Melanin is a pigment , so the affected person has little or no colour in hair and skin . this condition increases the risk of skin cancer

2) **Tyrosinemia** : It is a inherited disorder in which metabolism of t yrosin badly affected and accumulate in body tissues , and because of its toxic effect many of problems created .

Symptoms :

- Bloody stool
- Diarrhoea
- Fatigue
- Vomiting.
- Painful wounds on skin,
- Red eyes
- convulsion
- intelactual
- Intellectual disability.

Disorder of Ammonia Metabolism

1) **Phenylketonuria (PKU)** : It is a Congenital disorder characterized by inability to convert phenylalanine to tyrosine , so phenylalanine accumulated in the body and appears in urine

Symptoms :

- Delay in growth and development
- Mental problem (retardation)
- Psychiatric disorder
- Weakness of bone
- Rashes on skin
- Fair skin and blue eyes
- Hyperactivity and behavioral problems.

2) **Alkaptonuria (black Urine Disease)** It is a rare and genetic disorder , in which Homogentisic Acid accumulated in the tissues due to low production of HOMo- Gentisic - Dioxygenase enzyme .

Symptoms : Dark or black coloured urine upon air exposure.

3) Jaundice

- Amino acid metabolism disorders can lead to jaundice if there is a disruption in the pathway that converts bilirubin into a form that can be eliminated from the body. For example, a genetic disorder called CriglerNajjar syndrome can lead to jaundice because it impairs the ability of the liver to convert bilirubin into a form that can be excreted in the bile. This can cause bilirubin to build up in the blood, leading to jaundice.
- Similarly, other genetic disorders such as Gilbert's syndrome can cause jaundice due to problems with bilirubin metabolism. In Gilbert's syndrome, there is a deficiency of an enzyme called UDPglucuronosyltransferase, which is responsible for conjugating bilirubin so that it can be eliminated from the body. Without this enzyme, bilirubin builds up in the blood and can lead to jaundice

Biological Oxidation

- Oxidation is a reaction with oxygen directly or indirectly / removal of hydrogen or electron .
- This reaction carried out by enzymes .
- The electron released by this reaction accepted by Electron acceptors (NAD , FAD) , and then formation of ATP occurs , this process takes place in living tissues , and necessary for survival so it is called Biological Oxidation .

Electron Transport Chain and Oxidative Phosphorylation

- Electron Transport Chain is a series of protein complex and other molecules that accept and transfers electron from NADH and FADH₂ to Oxygen , when they combine with oxygen the synthesis of ATP occurs.
- In formation of ATP Phosphorus is used and Oxidation - Reduction reaction involved that is why it called Oxidative phosphorylation.

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Biochemistry & Clinical Pathology
Chapter 9 : Minerals

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Chapter 9

Minerals

- Minerals are the elements which are necessary for different types of Physiological functions and many of biochemical process.
- Minerals are essential for the normal growth and maintenance of the body. Many of the essential minerals are widely distributed in foods, and most people eating a mixed diet are likely to receive adequate intakes. daily requirement of mineral is more than 100 mg, they are called major elements or macro minerals. If the requirement of minerals is less than 100 mg/day, they are known as minor elements or microminerals or trace elements.
- Mineral availability depends on the region/soil or environmental condition because of mineral percentage vary region to region.

Types

- 1) **Macro-Minerals or Essential or Major Minerals** : The minerals are required more than 100mg per day as a daily requirement are called Macro-minerals such as : Sodium , Potassium , Calcium , chloride , Magnesium , Phosphorus.
- 2) **Micro-Minerals or Trace Minerals** : The minerals are required less than 100mg per day as a daily requirement are called Macro-minerals such as : Iodine , Fluorine , Copper , Cobalt , Manganese , iron , zinc , Selenium , Sulphate , Arsenic , Vanadium.

Functions of Minerals

- They are required for :
 - For transport of Oxygen (Fe)
 - For maintenance of tissues and bones . (Ca^{++})
 - For working of nervous system . (Ca^{++})
 - For muscle contraction . (Ca^{++})
 - For blood coagulation (Ca^{++})
 - For Cardiac activity (K^{+})
 - For acid-base balance (Na^{+})
 - For thyroid Hormone synthesis (Iodine)
 - For formation of sperms (Zn)
 - For maintenance of Osmotic pressure of blood (Na^{+} , K^{+} , Cl^{-})

Macro-Minerals

Calcium

→ Calcium is a main component of bone and teeth , calcium is taken in diet in the form of Calcium Phosphate and calcium carbonate . It is the most abundant mineral in human body (1200 g approximately).

Functions

- For formation and development of bone and teeth.
- Calcium is necessary for bone calcification (it is a process in which calcium builds up in the bones and teeth and make them harden.
- It helps in the blood coagulation , helps in conversion of prothrombin into thrombin.
- It helps the body in muscles contraction.
- It activates enzymes.
- It acts as an intracellular Messenger of different Hormones.
- It increase the permeability of Plasma membrane.
- It plays an important role in action Potential.

Deficiency Diseases

- ▲ Hypocalcemia (Low blood calcium level)
- ▲ Osteoporosis (weak and fragile)
- ▲ Tetany (Involuntary muscles contraction due to lack of calcium in blood)
- ▲ Requets (in children)
- ▲ Osteomalacia (In adult)

Recommended Dietary Requirement

✚ 500mg /day for a healthy adult , 1.5 - 1.0 g /d for Pregnant women.

Phosphorus

→ It is also a major component of bones and used for Energy production.

Functions

- Formation and development of bone and teeth.
- For formation of nucleic acids and Phospholipids.
- For formation of Co-enzymes like NADP,
- For formation of ATP , ADP, AMP.

Deficiency Diseases

- ▲ Hypophosphatemia.
- ▲ Rickets
- ▲ Osteomalacia

Recommended Dietary Requirement

- ✚ 500-700 mg /d for a healthy adult.

Sodium

→ It is the chief cation of the extra cellular compartment , around 50mmol/kg sodium is found in a healthy man.

Function

- It involves in maintaining body fluid through osmosis.
- It retains water in the body.
- It helps in excitability of nerves.
- It helps in acid - base balance.
- It helps in maintaining viscosity of blood.
- It maintains electrolyte balance.

Deficiency Diseases

- ▲ Hyponatremia

Recommended Dietary Requirement

- ✚ 5-6 g / for a healthy adult

Potassium

It is major intracellular Cation , and performs following functions

Functions

- For acid-base balance
- It helps in cardiac muscles function
- For neuromuscular function activity

Deficiency diseases

- ▲ Hypokalemia

Recommended Dietary Requirement

- ✚ 2-2.4 g for a healthy adult.

Chloride

→ It is major anoin in the body . Around 125mmol/l chloride is found in cerebrospinal fluid (CSF) . about 80 g chloride ions found in a healthy adult.

Functions

- It involves in acid-base balancing.
- It helps in secretion of HCL in stomach.
- It helps in maintaining fluid balance by osmosis.

Deficiency Disease

- ▲ Hypochloremia

Recommended Dietary Requirement

- ✚ 5-10 g for a normal adult

Magnesium

Functions

- It helps in activation of enzymes.
- It is required for DNA replication , transcription , and translations.

Deficiency diseases

- ▲ Fatigue , Weakness , appetite loss , nausea and vomiting.

Daily requirement

- ✚ 350 mg/d for a adult man.

Micro-Minerals

Iron

→ It very important for formation of haemoglobin , around 3-5 g oiron is found in a healthy adult.

Functions

- It required For formation of Hb /RBCs
- It required For formation myoglobin .(it store oxygen in muscle cells)
- It required for synthesis of DNA.
- It transport O₂ Co₂.

Deficiency diseases

- ▲ Iron deficiency anemia

Recommended Dietary Requirement

- ✚ 15-20 mg /d for a healthy adult

Iodine

Functions

- It required For synthesis of thyroid Hormone
- It required for growth and development of body

Deficiency diseases

- ▲ Goiter , Hypothyrodism , Cretinism (stopped physical and mental growth).

Recommended Dietary Requirement

- ✚ 120- 140 mcg

Copper

Functions

- It involves in haemoglobin synthesis
- It required for melanin formation.

Deficiency diseases

- ▲ Hypochromic,
- ▲ Recommended Dietary Requirement
- ▲ About 900 mcg /d for a normal adult.

Fluorine

Functions

- Tooth development,
- Dental health,
- Bone development (it increase calcium and phosphate reaction).

Deficiency diseases

- ▲ Dental caries

Recommended Dietary Requirement

- ✚ 2-4 mg /d for adults

Zinc

Functions

- It requires for enzyme formation it requires for sperm formation.
- It helps in production of DNA and proteins.
- It helps in wound healing

Deficiency diseases

- ▲ Diarrhoea,
- ▲ Skin disorders,
- ▲ obesity,
- ▲ diabetes mellitus.
- ▲ Delay in wound healing

Recommended Dietary Requirement

- ✚ 8 - 11 mg for adults

✓

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Amir Khan

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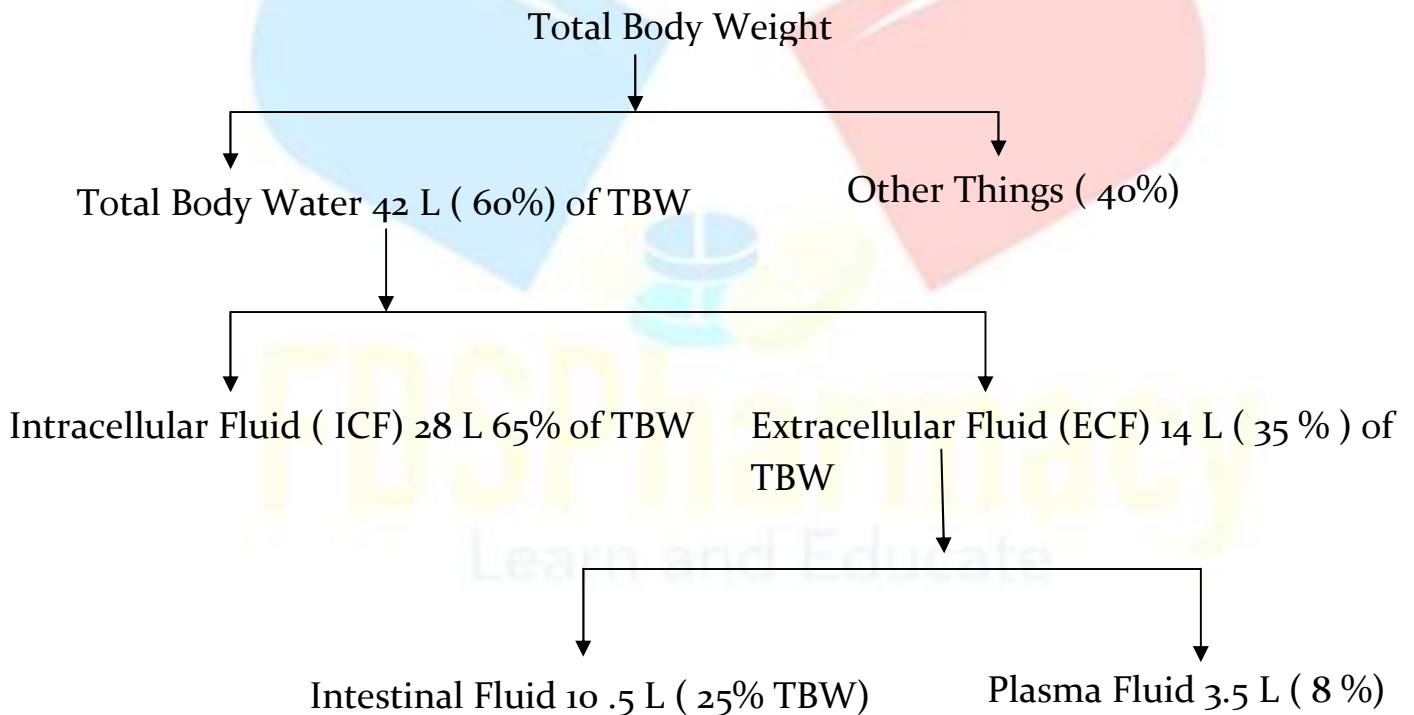
Keep Supporting

Chapter 10

Water and Electrolytes

- Water is the most important component of the human body.
- It is necessary for normal function of the body.
- Chemically water is an inorganic compound, its molecular formula is H_2O .
- It forms approximately 55-66% mass of an average adult's Body.
- The total water content decrease in older people due to reduced muscles mass.

Distribution of Water in the Body



Distribution of water in different body organs

- Brain and heart are composed of 73 % of water
- Lungs are composed of 83 % of water
- Skin are composed of 64 % of water
- Muscles and kidneys are composed of 79 % of water

Function of Water in the body

- It maintains body temperature.
- It provides lubrication in joints and protects the bones.
- It makes the blood plasma thin and helps in proper flowing to tissues.
- It helps in excretion of wastes from body.
- It helps in intracellular transportation.
- It prevents dryness of skin.
- It helps in occurrence of many enzymatic reaction.
- It helps in formation of saliva.
- It prevents constipation.
- It helps in maintenance of blood pressure.
- It helps kidney to perform properly.
- It helps in the maintenance of pH of the body.

Water turnover and balance

- Water is an essential component of the human body, making up about 60% of body weight in adults. The balance of water in the body is regulated by several mechanisms to maintain proper hydration levels.
- Water turnover refers to the process by which water is continually exchanged between the body and the environment. This turnover can occur through various routes such as the skin, lungs, and gastrointestinal tract.
- Water balance refers to the balance between water intake and water excretion. The body must maintain water balance to prevent dehydration or overhydration.

Electrolytics

- Electrolytes are minerals which dissolved in water and release ions.
- They are found in body fluids also like sodium , Chloride , potassium , and maintain osmotic pressure.
- They maintain amount of water in the body , particularly Sodium maintains water balance through Osmosis.

Electrolyte Balance

→ If electrolytes are present in proper amount as body needs it is called electrolyte balance.

Electrolyte Composition of Body Fluids

Cations (mmol/l)	Plasma	Intestine	Intracellular
Na	142	139	14
K	4.2	4.0	140
Ca	1.3	1.2	0
Mg	0.8	0.7	20
Anions (mmol/l)			
Cl	108	108	4.0
HCO ₃	24.0	28.3	10
Protein	1.2	0.2	4.0
HPO ₄	2.0	2.0	11

Dehydration

→ Dehydration refers to a condition where the body lacks adequate fluids to carry out normal physiological functions. It can occur when the body loses more fluids than it takes in, leading to an imbalance in the body's electrolytes and dehydration.

Causes of Dehydration

- ❖ **Inadequate Fluid Intake** : The most common cause of dehydration is not drinking enough fluids. This can occur if a person is not thirsty or if they are unable to access water.
- ❖ **Excessive Fluid Loss** : Dehydration can also occur if the body loses too much fluid through sweating, urination, or diarrhea.
- ❖ **Medical Conditions** : Certain medical conditions can also cause dehydration, including diabetes, kidney disease, and fever.
- ❖ **Medications** : Some medications can cause dehydration as a side effect.

Oral Rehydration Therapy

- Oral rehydration therapy (ORT) is a simple and effective way to treat dehydration. It involves drinking a solution of water, salt, and sugar to replace fluids and electrolytes lost due to dehydration.
- ORT is often used to treat dehydration caused by diarrhea, vomiting, and other illnesses that cause fluid loss.
- ORT is recommended by the World Health Organization (WHO) as the first-line treatment for dehydration.
- It can be given at home or in a healthcare setting and is suitable for all age groups.
- ORT solution can be made by dissolving the following in one liter of clean water:
 - 6 level teaspoons of sugar
 - 1/2 level teaspoon of salt
- The solution should be sipped slowly over a period of four to six hours. If vomiting occurs, the solution should be paused for 10 minutes and then restarted. ORT should be continued until the individual is rehydrated, and fluid losses have been replaced

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Chapter 11 : Introduction to Biotechnology

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Chapter 11

Introduction to Biotechnology

- Biotechnology is a branch of science in which using biology (living cell or bacteria or any part of them) and technology or scientific process , a new product is developed to improve human health and environment.
- Biotechnology is also called "biotech ". there are many subfields of biotechnology ,the main subfields are these :
- Medical (red) biotechnology
 - Agriculture (green) biotechnology
 - Industrial (white) biotechnology
 - Marine (blue) biotechnology
- **Medical biotechnology** : It is used for medicinal purpose for example gene therapy is used to treat genetic or acquired disease like cancer this therapy utilizes normal genes for replacing the defective gene.
- **Agriculture biotechnology** : This is related to agriculture product and processes for example one or two genes are combined together and developed a new variety of crop for increasing the yield.
- **Industrial biotechnology**: This is related to industrial process for example replacing genes of a microorganism a new organism id developed to produce a useful chemical.
- **Marine biotechnology** : This field involve in Marine resources to develop a novel pharmaceutical , drugs , chemicals products , enzymes or other industrial product.

Application of Biotechnology in Pharmaceutical Science

- Drug Production
- Pharmacogenomics
- Gene Therapy
- Genetic Testing
- Agriculture
- Biological Engineering

DNA Technology

- DNA technology is the use of various methods to manipulate, analyze, and modify DNA (deoxyribonucleic acid), which is the genetic material that carries the instructions for the development and function of all living organisms.
- DNA technology has revolutionized many fields of biology, including genetic engineering, molecular biology, and biotechnology.
- One of the most common uses of DNA technology is genetic engineering, which involves the manipulation of an organism's DNA to add, delete, or modify specific genes.
- This technology has allowed scientists to create genetically modified organisms (GMOs) with desired traits, such as resistance to pests, increased yield, or improved nutritional content.

Examples of DNA technologies:

- DNA cloning
- Polymerase chain reaction (PCR)
- Gel electrophoresis
- DNA sequencing

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Chapter 12 : Organ Function Test

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Chapter 12

Organ Function Test

Function of kidney

- **Regulation of blood volume** : They regulate blood volume by conserving the water or by excreting water in urine.
- **Regulation of blood pressure**: They regulate BP by regulating Blood volume.
- **Regulation of renin enzyme** : Renin is an enzyme which is produced by kidney and helps in the formation of angiotensin , which causes vasoconstriction and increased blood pressure.
- **Regulation of blood pH** : They regulate the pH of blood by excreting H^+ ions into the urine and conserve HCO_3^- ions , (it is an important buffer ions in the blood)
- **Regulation of blood ionic composition** : They regulate the concentration of some ions like Na^+ , K^+ , Ca^{++} , Cl^- etc.
- **Production of hormone** : they produce Calcitriol (the active form of vitamin D)which regulate the calcium homeostasis (the maintenance of constant concentration of calcium ion in the extracellular fluid)
- **Stimulation of RBC production** : They produce erythropoietin Hormone which stimulate RBC production.
- **Regulation of blood glucose level** : They take part in maintenance of blood glucose level as they increase blood glucose level by gluconeogenesis process.
- **Excretion of Wastes from body** : They excrete out waste materials from body like ammonia, urea , bilirubin , creatinine , uric acid , drug and toxins.

Kidney Function Test

The following are some commonly performed tests to assess kidney function and their clinical significances :

1. **Blood tests** : Blood tests that measure levels of creatinine and blood urea nitrogen (BUN) are commonly used to assess kidney function. Creatinine is a waste product that is produced by muscle metabolism and excreted by the kidneys, while BUN is a waste product of protein metabolism. Elevated levels of creatinine and BUN in the blood can indicate decreased kidney function or kidney damage.
2. **Urine tests** : Urine tests that measure levels of protein and albumin are commonly used to assess kidney function. Albumin is a protein that is normally present in the blood, but not in the urine, while proteinuria is the presence of excessive amounts of protein in the urine. Elevated levels of protein and albumin in the urine can indicate decreased kidney function or kidney damage.

3. **Glomerular filtration rate (GFR):** GFR is a measure of the rate at which blood is filtered by the kidneys. It is calculated based on a person's age, sex, and blood creatinine levels. A GFR of less than 60 mL/min/1.73m² for more than 3 months indicates chronic kidney disease.
 4. **Imaging tests :** Imaging tests such as ultrasounds, CT scans, and MRIs may be used to assess the size, shape, and structure of the kidneys and detect abnormalities such as cysts or tumors.
 5. **Biopsy :** Kidney biopsy may be performed to collect a sample of kidney tissue for microscopic examination to diagnose certain kidney diseases.
- Abnormal results from these tests can indicate kidney disease or dysfunction. Early detection and management of kidney disease can help prevent or delay progression to end-stage kidney disease, which may require dialysis or kidney transplantation.
- It is important to consult with a healthcare provider to interpret test results and determine the appropriate course of treatment

Clinical Significances

- ❖ **Problems with starting to pee :** This is a measure of how much urine is produced over a certain period of time. Low urine output can indicate poor kidney function.
- ❖ **Glomerular Filtration Rate (GFR) :** This is considered the most accurate measure of kidney function. It is a measure of how well the kidneys are filtering waste from the blood. GFR can be estimated through blood tests that measure levels of creatinine, a waste product produced by muscles.
- ❖ **Blood Urea Nitrogen (BUN) :** BUN is a test that measures the amount of nitrogen in your blood that comes from the waste product urea. The kidneys are responsible for removing urea from the blood, so high levels of BUN can indicate poor kidney function.
- ❖ **Serum Creatinine :** This is a blood test that measures the level of creatinine in the blood. Creatinine is a waste product that is produced by the muscles and eliminated by the kidneys. High levels of serum creatinine can indicate poor kidney function.
- ❖ **Urine Albumin :** This test measures the level of albumin, a protein, in the urine. Albumin should not normally be present in urine, so its presence can indicate kidney damage.
- ❖ **Urine Creatinine :** This test measures the level of creatinine in the urine. This measurement can be used to estimate GFR.

Function of liver

- **Metabolism of carbohydrate** : liver Plays an important role in the metabolism of carbohydrates and release glucose into blood , in case blood glucose level is high liver convert glucose into glycogen and store it.
- **Metabolism of protein and lipids** : In case glycogen is not enough to fulfill the body requirement of glucose , lever makes glucose from protein and fat which is called gluconiogenesis.
- **Detoxification** : Liver detoxifies the toxic substance like al cohool drug and steroid hormone and prevents other tissue from damage.
- **Storage** : liver stores glycogen , certain vitamins (fat soluble) and minerals (iron and copper)
- **Phagocytosis** : The aged RBCs , WBC s and some bacteria undergo phagocytosis by kuffer cells of liver and destroyed.
- **Formation of urea** : The ammonia is obtained during metabolism of protein which is highly toxic is converted into urea which is less toxic.
- Formation of RBC in foetal life.
- Destruction of aged RBC and formation of bile pigment.
- Formation of plasma protein : like albumin , globulin prothrombin and fibrinogen.
- Formation of heparin : it is a natural anticoagulant present in the blood.

liver function tests

- ❖ **Alanine transaminase (ALT) and Aspartate transaminase (AST)** : These tests measure the levels of liver enzymes in the blood. High levels of ALT and AST are indicative of liver damage.
- ❖ **Alkaline phosphatase (ALP)** : This test measures the levels of ALP in the blood. Elevated levels of ALP may indicate liver or bone disease.
- ❖ **Bilirubin** : This test measures the levels of bilirubin in the blood. High levels of bilirubin may indicate liver disease or hemolytic anemia.
- ❖ **Albumin** : This test measures the levels of albumin in the blood. Low levels of albumin may indicate liver disease.
- ❖ **Prothrombin time (PT)** : This test measures the time it takes for blood to clot. Abnormal PT may indicate liver disease.
- ❖ **Gamma-glutamyl transferase (GGT)** : This test measures the levels of GGT in the blood. Elevated levels of GGT may indicate liver disease or alcohol abuse.

Clinical significance

- ◇ **Detection of liver disease** : Liver function tests can help detect liver disease in its early stages, before symptoms appear.
- ◇ **Monitoring of liver function** : Liver function tests are used to monitor the progress of liver disease and assess the effectiveness of treatment.
- ◇ **Diagnosis of liver injury** : Liver function tests can help diagnose liver injury caused by drugs, toxins, or infections.
- ◇ **Screening for liver disease** : Liver function tests may be used to screen for liver disease in people who are at risk, such as heavy drinkers or those with a family history of liver disease.

Lipid Profile Tests

- A lipid profile test is a blood test that measures the amount of different types of lipids, or fats, in your blood. The lipids measured in a lipid profile test include:
1. **Total cholesterol** : This measures the total amount of cholesterol in your blood, including both high-density lipoprotein (HDL) and low-density lipoprotein (LDL) cholesterol.
 2. **HDL cholesterol** : This is often called the "good" cholesterol because it helps remove other types of cholesterol from your blood.
 3. **LDL cholesterol** : This is often called the "bad" cholesterol because it can build up in your arteries and lead to heart disease.
 4. **Triglycerides** : These are another type of fat that can build up in your blood and contribute to heart disease.

Clinical Significances

- The clinical significance of a lipid profile test is that it can help your doctor assess your risk of developing heart disease.
 - High levels of LDL cholesterol and triglycerides, and low levels of HDL cholesterol, are all risk factors for heart disease.
 - By measuring these levels, your doctor can determine whether you need to make lifestyle changes, such as changing your diet and increasing your exercise, or whether you need medication to help lower your cholesterol levels.
 - In addition to assessing your risk of heart disease, a lipid profile test may also be used to monitor the effectiveness of cholesterol-lowering medications, such as statins.
 - If you are taking medication to lower your cholesterol, your doctor may order a lipid profile test periodically to ensure that the medication is working as it should.

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Chapter 13 : Introduction to Pathology of Blood and Urine

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Chapter 13

Introduction to Pathology of Blood and Urine

Pathology of Blood

→ The study of blood related to diseases, causes and progression is called Pathology of blood. The tests performed for pathology of blood are called "Haematological Tests"

Lymphocytes and platelets - Role in health in diseases

Lymphocytes

- Lymphocytes are a type of WBC and a part of immune system. They are found in lymph that is why they are called lymphocytes,
- They are 20 - 30 % of WBCs.
- There are two main types of lymphocytes B lymphocytes (B-Cells) and t - lymphocytes (T - Cells)
 - B- lymphocytes produce antibodies that attack invading bacteria, viruses and toxins
 - t- cells destroy infected body's cells (host cells) destroy tumor cells and activate other immune cells
- Count of lymphocytes
 - B- lymphocytes : 100-600 cells / μ L of blood.
 - T- lymphocytes : 500-1200 cells / mm^3 (Cubic milliliter)

Functions

- ✚ They Help immune system
- ✚ They produce antibodies
- ✚ They fight against foreign substances (bacteria, viruses etc.)
- ✚ They destroy infected cells
- ✚ They kill tumor cells

Abnormal Lymphocyte

- ▲ Count an increase in lymphocyte count more than (4000 / μ L) in an adult, it is called lymphocytosis.
- ▲ High Lymphocyte count indicates any of following condition :
 - Infection
 - Cancer of lymphocytes (Lymphocytic leukemia)
 - Autoimmune disorder

Platelets

→ Platelets or thrombocytes are small and colourless blood cells. They are formed by bone marrow, They mainly promote blood clotting and stop bleeding.

Role of platelets

- ◇ **Vasoconstriction** : They secrete serotonin which causes constriction of blood vessels.
- ◇ **Blood Coagulation** : It plays an important role in blood clotting.
- ◇ **Fibrinolysis** : Platelets help in breakdown of the clot and healing of damage blood vessels.

Abnormal Platelets Count

- Blood Platelet count below normal range is called Thrombocytopenia when high level is called Thrombocythemia .
- Low level leads to
 - Improper blood clotting
 - Prolonged bleeding from cuts
 - Usually heavy menstrual flows
 - Blood in urine or stools
 - Fatigue
 - Bleeding from gums or nose
- High level of platelets can cause dangerous clots in blood vessels , increasing risk of stroke or heart attack.

Erythrocytes Abnormal Cells and their Significance

- Normal RBCs are round , disc-shaped , biconcave cells which don't have nucleus.
- Different type of abnormalities occurs in RBCs,
- Some of them are :
 - Variation in size
 - Variation in Shape
 - Alteration in colour

Variation in size

- A normal erythrocyte has an average diameter of $7.2 \mu\text{m}$ ($6.8 - 7.5 \mu\text{m}$) . the normal size cells are called normocyte . anisocytosis a common term is used for an increased RBCs cells size.

Variation in Shape

- Variation in Shape of a mature RBC have the shape other than normal Round , Disc shape and biconcave appearance . it is termed Poikilocytosis . Poikilocytosis may be different types like Acanthocytes , Blister Cells etc.

Alteration in colour

- The normal RBCs have a red color , which is provided by haemoglobin , the alteration in colour is occurs with the change in concentration of Heamoglobin . Note : any type of abnormality disturb the function of Erythrocytes.

Significance of Erythrocytes

- ◇ Transport of Oxygen from lungs to tissues.
- ◇ Transport of carbon dioxide from tissues to lungs.
- ◇ Transport of wastes from tissues to kidney.
- ◇ Dilation of blood vessels : It release the ATP which cause relaxation of vessels
- ◇ Immunity : when bacteria break the haemoglobin it release free radicals that rupture the bacterial cell wall and membrane which causes death of bacteria.

Disorder of Erythrocytes and their significance

- ▲ **Anaemia** : Deficiency of RBCs or Haemaglobin in blood.
 - Iron deficiency anaemia
 - magaloblastic anaemia (Vit. B 12 and B 9 deficiency)
 - pernicious anaemia (vit. B 12 deficiency)
 - Haemolytic anaemia
- ▲ Polycythemia (increased RBCs count)
- ▲ Hemoglobinopathies (sickle cell means misshape of RBCs)
- ▲ Red cell enzyme deficiency (G6PD)
- ▲ Hemochromatosis (iron overload , it can poison organs and lead to cancer)

Introduction to Pathology of Urine.

- The pathology of urine involves the analysis of the chemical and physical properties of urine and their relationship to disease.
- Urine is a waste product that is produced by the kidneys and excreted from the body through the urinary system. It contains a variety of components that can provide valuable diagnostic information when analyzed

Normal Constituents of Urine

- Urine is an aqueous solution , a by-product of the body, formed by the kidneys and excreted out through urethra by a process called micturition.
- Normal urine have 95% of water and 5% of other constituents.
- Normal constituents of Urine
 - urea (9.3 gm / lt)
 - Chloride (1.87 gm /L)
 - Sodium (1.17 gm /L)
 - Potassium (0.750 gm /L)
 - Creatinine (0.670 gm / L)
 - Some dissolved ions and other compounds (hormones , oxalic acid , hippuric acid etc.)

Abnormal constituents of urine and their significance

Abnormal Constituents	Significance diseases
Proteins	Proteinuria
Sugar	Glycosuria
Ketone bodies	Ketonuria
Bile pigments and salts	Jaundice
Blood	Haematuria