Introduction to biochemistry

Syllabus
Introduction to biochemistry: Scope of biochemistry in pharmacy; Cell and its biochemical organization
Introduction to biochemistry:

- Biochemistry is the study of the chemical processes and substances that occur within living organisms.

- It combines the principles of chemistry, biology, and physics to understand the complex chemical reactions and structures that make up living systems.

- Biochemists study the structure and function of biomolecules such as proteins, nucleic acids, carbohydrates, and lipids, as well as the enzymes and metabolic pathways that drive these reactions.

- They also investigate the genetic and molecular mechanisms that regulate these processes. Biochemistry is a fundamental field in the life sciences, with applications in medicine, agriculture, and biotechnology.

Scope of biochemistry in pharmacy:
The scope of biochemistry in pharmacy is quite broad, as it encompasses many different aspects of drug discovery, development, and delivery. Some of the key areas where biochemistry plays a role in pharmacy include:

1. **Drug design and development:** Biochemistry is used to understand the structure and function of biomolecules such as enzymes and receptors, which are important targets for drug development. Biochemists use this knowledge to design and develop new drugs that can bind to these targets and modulate their activity.

2. **Drug metabolism and pharmacokinetics:** Biochemistry is also used to understand how drugs are metabolized in the body, which can affect their efficacy and safety. Biochemists use this knowledge to optimize the pharmacokinetics of drugs, making them more effective and less toxic.

3. **Natural products:** Biochemistry is used to identify and isolate natural compounds from plants, microbes, and other sources, which can be used as drugs or drug leads. Biochemists use techniques such as chromatography and mass spectrometry to purify and analyze these compounds.

4. **Biotechnology:** Biochemistry is used to develop biotechnology products such as vaccines, diagnostic tests, and gene therapies. Biochemists use techniques such as recombinant DNA technology and protein engineering to create these products.

5. **Pharmaceutical formulation:** Biochemistry is used to develop dosage forms of drugs such as tablets,

capsules, and injectable solutions. Biochemists use this knowledge to optimize the stability, solubility, and bioavailability of drugs in these dosage forms.

Overall, biochemistry plays a critical role in many different aspects of pharmacy, from drug development to formulation to delivery.

Cell and its biochemical organization:

The cell is the basic unit of life and is composed of a variety of different biochemical compounds and structures. The main components of a cell include:

1. **The cell membrane:** The cell membrane is a selectively permeable barrier that surrounds the cell, it composed of a lipid bilayer that controls the movement of molecules in and out of the cell.

2. **The cytoplasm:** The cytoplasm is the gel-like substance that fills the cell and contains all of the cell's organelles and other structures.

3. **The nucleoplasm:** The nucleoplasm is the gel-like substance that fills the nucleus of the cell, it contains the genetic material of the cell (DNA) which is responsible for the cell's growth and reproduction.

4. **The mitochondria:** The mitochondria are structures within the cytoplasm that are responsible for generating the energy needed by the cell through the process of cellular respiration.

5. **The ribosomes:** The ribosomes are small structures within the cytoplasm that are responsible for synthesizing proteins, they are made up of RNA and proteins

6. **The endoplasmic reticulum and Golgi apparatus:** The endoplasmic reticulum and Golgi apparatus are structures that help to transport and modify molecules within the cell, they are essential for the cell's internal organization and communication.

7. **The lysosomes:** The lysosomes are small structures within the cytoplasm that are responsible for breaking down and recycling waste materials within the cell.

All of these different structures and compounds work together to maintain the integrity and function of the cell, and to ensure that the cell can carry out all of its necessary functions such as growth, reproduction, and metabolism.

Biochemistry and Clinical Pathology

Proteins

- Definition, classification of proteins based on composition and solubility with examples
- Definition, classification of amino acids based on chemical nature and nutritional requirements with examples
- Structure of proteins (four levels of organization of protein structure)
- Qualitative tests and biological role of proteins and amino acids
- Diseases related to malnutrition of proteins

Definition.

➢ **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.

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.

Classification of proteins based on composition.

1. **Complete Proteins: –** Proteins which contain all the essential amino acids in required quantity are called complete Proteins.
2. **Incomplete Proteins: -** Proteins not containing all the essential amino acid are called incomplete protein.

Also classified as-

1. **Simple Proteins 2. Conjugated Proteins 3. Derived Proteins**
1. **Simple Proteins: -** Simple protein contain only amino acid reduce and other intimately bound material. Ex- Albumins, globulins, glutelin etc.
2. **Conjugated Proteins: –** Conjugated proteins contain in addition to polypeptide chain others substance or groups which impart characteristics properties. Ex- Nucleoproteins, Glycoproteins, Haemoglobin, Phosphoproteins etc. \
3. **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.

Classification of protein based on solubility.

It is divided into two types-

a. Globular protein— It is made by the irregular amino acid sequence and forms the rounded or spherical structure.

- It is generally soluble in water.
- It is also called as functional protein and it is more sensitive towards PH and temperature change.

b. Fibrous protein— It is made by same type of amino acid sequence and forms the It is generally Insoluble in water.

- It is also called as structural protein and it is less sensitive towards PH and temperature change.

AMINO ACIDS

Definition

- Amino acids are building blocks of protein.
- Amino acids are compound that contain and amino group and 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 there are 20 amino acids at present in our body in which 9 Essential and 2 Non-essential amino acids.

Properties of Amino Acids

A. Physical properties of the Amino acids.

1. Solubility.

- All amino acids are Soluble in water but their Solubility various to a great extent.
- Solubility depends on the nature of R- group. i.e., polarity of the amino acid.
- Polar amino acids are highly Soluble in water.
- Non-polar amino acids are highly Soluble in organic solvents like chloroform, ether etc.

2. Acid and base behaviours.

- Amino acids contain the acidic carboxyl group (-COOH) and the basis group amino (-NH2) Hence amino acids are called as amphoteric molecules or ampholytes (i.e., Amphoteric electrolytes).

3. Optical activity.

- All standard amino acid except glycine has an asymmetric carbon atom due to these amino acids are optically active

B. Chemical properties of the Amino acids.

1. Ninhydrin reaction:

Amino acid + Ninhydrin Purple/Blue Pigment + Aldehyde

2. Reaction with Dansyl Chloride:

Amino acid + Dansyl Chloride Fluorescent Dansyl derivative
Of amino acids.

3. Reaction due to COOH Group: -

- Salt formation with alkalis.
- Ester formation with alcohols.
- Amide formation with amines and decarboxylation

Classification of amino acids based on chemical nature.

On the basis of chemical nature amino acids are divided as-
a. Acidic amino acid- Ex- Aspartic acid, Glutamic acid.
b. Basic amino acid- Ex- Histidine, Lysine, Arginine.
c. Hydrophilic amino acid- Ex- Asparagine, Glutamine.
d. Hydrophobic amino acid-Ex- Leucine, isoleucine, valine.
e. Sulphur containing amino acid- Ex- cystine, Methionine.
f. Aromatic amino acid- Ex- Phenylalanine, Tyrosine.

Classification of amino acids based on nutritional requirements

1. Essential Amino Acids.

- The amino acids which cannot be synthesized in the body but are required for normal function of body are called as essential amino acids.
- These amino acids should be supplied through diet.

2. Non-Essential Amino Acids.

- The amino acids which are synthesized in the body are called as non-essential amino acids.

S. N	Essential Amino acids	Non-Essential Amino acids
1.	Valine	Alanine
2.	Histidine	Asparagine
3.	Leucine	Aspartic acid
4.	Phenylalanine	Cysteine
5.	Tryptophan	Glutamic acid
6.	Lysine	Glutamine
7.	Alginine	Glycine
8.	Methionine	Cysteine
9.	Threonine	Proline
10.	Isoleucine	Serine

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

Due to arrangement of the amino acids in the protein, we find the four level of organisation/modification in the proteins.

1. **Primary protein:** - It is the simple/basic/polypeptide chain like proteineous 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 tests for Proteins and Amino acids.

1. Heat test: -

When protein solution is heated in boiling water both the protein gets coagulated and lose their biological activity.

- This is called thermal denaturation of proteins.

- e.g. – Boiling the eggs.

2. Test with trichloroacetic acid (TCA)-

- TCA is normally used to precipitate proteins from their solution. TCA denatures the proteins.

3. Biuret Test: -

- Biuret reagents consists of copper sulphate in an alkaline medium when proteins are treated with Biuret reagent it's shows a violet colour.

4. Hydrolysis Test: -

- Proteins on hydrolysis gives free amino acids Hydrolysis can be carried out by acids like HCL, H_2SO_4, etc. Or Alkalis like – NaOH, KOH etc.

5. Xanthoproteic test: -

- Nitration of aromatic amino acids of protein give yellow colour concentrated nitric acid is used for Nitration.

6. Millon's Test: -

- Phenolic group of tyrosine of proteins react with mercuric sulphate in the presence of sodium nitrate and sulphuric acid to give red colour.

7. Precipitation test: -

- Protein are Precipitated by using different agents the common precipitation agents are salt, Organic solvent heavy metal ion, acids etc.

- Salt – Ammonium sulphate, Sodium chloride.
- Acids – Trichloroacetic acid (TCA), Acetic acid, Hydrochloric acid.
- Organic solvents – Acetone alcohol
- Heavy metal ions – Ammonium molybdate, Copper or Mercury salts.

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 of proteins.

A. Kwashiorkor: -

- The symptoms of the diseases slow down the growth, oedema and change in skin, hair pigmentation and texture.

- Frequently there is liver enlightenment there is vomiting and diarrhoea and stools contain much undigested food.

- The course of this disease due to large family size, poor mental health, poor environmental conditions and delayed supplementary feeding.

Note: - This disease appears most commonly in children between the ages of 1 to 4 year.

B. Nutritional oedema: -

- It results from long contained loss of protein and usually occurs in famine areas. The Proteins deficiency in adults is very rare.

- The deficiency symptoms include loss of weight reduced fat, infections, frequent loose stools delay in healing of wounds and Oedema.

- Use of soybean, milk and eggs and other nutritious diet can cure the Protein deficiency syndrome in adults.

C. Marasmus: -

- It is a disease of infants below one year of age.

- Its cause is Proteins and carbohydrate or other nutritional factor deficiencies.

- Proteins and energy deficiency disease is also known as

Marasmus kwashiorkor. Marasmus is more likely to occur in poor people.

Clinical Pathology

Lipids

- Definition, classification with examples
- Structure and properties of triglycerides (oils and fats)
- Fatty acid classification - Based on chemical and nutritional requirements with examples
- Structure and functions of cholesterol in the body
- Lipoproteins - types, composition and functions in the body
- Qualitative tests and functions of lipids

Lipids

Definition—The lipids are a heterogeneous group of compounds, including fats, oils, steroids, waxes, and related compounds, that are related more by their physical than by their chemical properties. They have the common property of being

(1) relatively insoluble in water and

(2) soluble in nonpolar solvents such as ether and chloroform.

They are important dietary constituents not only because of the high energy value of fats, but also because essential fatty acids and fat-soluble vitamins and other lipophilic micronutrients are contained in the fat of natural foods. So, we consider lipids, (lipo-, fat) a third major class of biomolecules.

Classification of lipid with examples—

Lipid are classified as mainly three classes as-

1. **Simple lipids—** The simplest lipids are the fatty acids that have the general formula R— COOH, where R represents a hydrocarbon chain composed of various

lengths of —CH2-(methylene) units. It includes fats and waxes which are esters of fatty acids with various alcohols.

b. **Waxes—** Esters of fatty acids with higher molecular weight monohydric alcohols.
a. **Fats—** Esters of fatty acids with glycerol. Oils are fats in the liquid state.

Lipids

2. **Complex Lipids—**Complex lipids are esters of fatty acids containing groups in addition to an alcohol and one or more fatty acids.

a. **Phospholipids—** Lipids containing, in addition to fatty acids and an alcohol, a phosphoric acid residue. They frequently have nitrogen-containing bases (eg, choline) and other substituents. In many phospholipids the alcohol is glycerol (glycerophospholipids), but in sphingophospholipids it is sphingosine, which contains an amino group.

b. **Glycolipids (Glycosphingolipids)—** Lipids containing a fatty acid, sphingosine, and carbohydrate.
C. **Other complex lipids—** Lipids such as sulfolipids and amino lipids. Lipoproteins may also be placed in this category.

3. **Derived/precursor lipid—** These include fatty acids, glycerol, steroids, other alcohols, fatty aldehydes, ketone bodies, hydrocarbons, lipid-soluble vitamins and micronutrients, and hormones.

NOTE— Acylglycerols (glycerides), cholesterol, and cholesteryl esters are termed neutral lipids because they are uncharged.

Fatty Acids

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).

1. **Saturated fatty acids—** Saturated fatty acids may be envisaged as based on acetic acid (CH_3 —COOH) as the first member of the series in which— CH_2 — is progressively added between the terminal CH_3 — and —COOH groups. Ex-Palmitic acid.

2. **Unsaturated fatty acids—** Fatty acids contain one or more Double bonds

   A. Monounsaturated— containing one double bond. Ex-oleic acid.

   B. Polyunsaturated— containing two or more than two double bonds. Ex-linoleic acid.

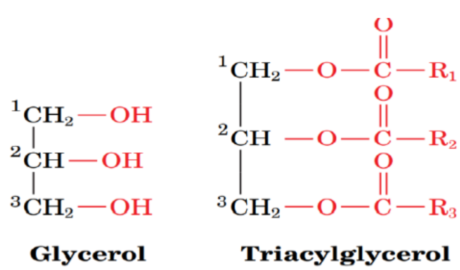
   C. Eicosanoids— These compounds, derived from eicosa (20-carbon) polyenoic fatty acids. Ex- Prostaglandins, thromboxanes.

4. **Omega 3(ω3) –** Long chain ω3 fatty acids such as α-linolenic (ALA) (found in plant oils), eicosapentaenoic (EPA) (found in fish oil) and docosahexaenoic (DHA) (found in fish and algal oils) have anti-inflammatory effects, perhaps due to their effects in promoting the synthesis of less inflammatory prostaglandins and leukotrienes as compared to ω6 fatty acids.

Triglycerides

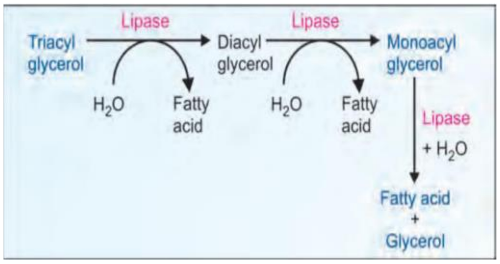
Triacylglycerols (formerly triglycerides) are the esters of glycerol with fatty acids. The fats and oils that are widely distributed in both plants and animals are chemically triacylglycerols. They are insoluble in water and non-polar in character and commonly known as neutral fats.

Fats (solid at room temperature) and **oils** (liquid at room temperature) are complex mixtures of triacylglycerols whose fatty acid compositions vary with the organism that produced them. Plant oils are usually richer in unsaturated fatty acid residues than animal fats, as the lower melting.



Properties of triglycerides—Triacylglycerols are less oxidized than carbohydrates or proteins and hence yield significantly more energy per unit mass on complete oxidation.

1. **Hydrolysis—** Triacylglycerols undergo stepwise enzymatic hydrolysis to finally liberate free fatty acids and glycerol. The process of hydrolysis, catalysed by lipases is important for digestion of fat in the gastrointestinal tract and fat mobilization from the adipose tissues.



2. **Saponification—** The hydrolysis of triacylglycerols by alkali to produce glycerol and soaps is known as saponification.
Triacylglycerol + 3 NaOH Glycerol + 3 R-COONa (soaps).

5. **Rancidity—** Rancidity is the term used to represent the deterioration of fats and oils resulting in an unpleasant taste. Fats containing unsaturated fatty acids are more susceptible to rancidity. Rancidity occurs when fats and oils are exposed to air, moisture, light, bacteria etc.

6. **Lipid peroxidation—** In the living cells, lipids undergo oxidation to produce peroxides and free radicals which can damage the tissue. The free radicals are believed to cause inflammatory diseases, ageing, cancer, atherosclerosis etc

Lipoproteins

Definition and compositions— Lipoproteins are molecular complexes of lipids with proteins. They are the transport vehicles for lipids in the circulation.
Classification of lipoprotein— Based on their separation by electrophoresis is classified in five major class.

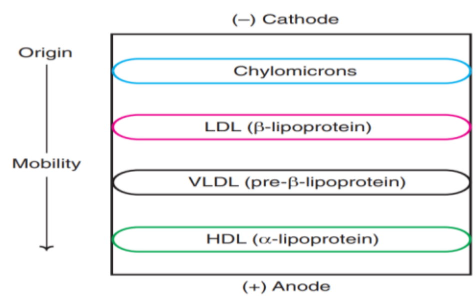
1. **Chylomicrons (CM)—** They are synthesized in the intestine and transport exogenous (dietary) triacylglycerol to various tissues. They consist of highest (99%) quantity of lipid and lowest (1%) concentration of protein. The chylomicrons are the least in density and the largest in size, among the lipoproteins.

2. **Very low-density lipoprotein (VLDL)—** They are produced in liver and intestine and are responsible for the transport of endogenously synthesized triacylglycerols.

3. **Low density lipoprotein (LDL)—** They are formed from VLDL in the blood circulation. They transport cholesterol from liver to other tissues.

4. **High density lipoprotein (HDL)—** They are mostly synthesized in liver. Three different fractions of HDL (1, 2 and 3) can be identified by ultracentrifugation. HDL particles transport cholesterol from peripheral tissues to liver (reverse cholesterol transport).

4. **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



Electrophoresis of plasma lipoprotein Chart

Functions of Lipoprotein—

- Lipoproteins deliver the lipid components (cholesterol, triacylglycerol etc.) to various tissues for utilization.
- They function as transport vehicles for lipids in blood plasma.

Cholesterol

Definition and structures— Cholesterol is found exclusively in animals; hence it is often called as animal sterol. The total body content of cholesterol in an adult man weighing 70 kg is about 140 g i.e., around 2 g/kg body weight. Cholesterol is amphipathic in nature, since it possesses both hydrophilic and hydrophobic regions in the structure. In healthy individuals, the total plasma cholesterol is in the range of 150-200 mg/dl.

Biosynthesis of cholesterol— About 1 g of cholesterol is synthesized per day in adults. Almost all the tissues of the body participate in cholesterol biosynthesis. The largest contribution is made by liver (50%), intestine (15%), skin, adrenal cortex, reproductive tissue etc.

The enzymes involved in cholesterol synthesis are found in the cytosol and microsomal fractions of the cell. Acetate of acetyl CoA provides all the carbon atoms in cholesterol.

Cholesterol was first isolated from bile. Cholesterol literally means 'solid alcohol from bile.'

Functions of Cholesterol—

- It is the structural components of the cell, which maintain the stability and the metabolism of the cells.
- Cholesterol is the precursor for the synthesis of all other steroids in the body. These include steroid hormones, vitamin D and bile acids.
- It is an essential ingredient in the structure of lipoproteins in which form the lipids in the body are transported.
- Fatty acids are transported to liver as cholesteryl esters for oxidation.

Qualitative tests of lipids

1. Solubility—

- Solubility of Lipid in organic solvents depends on length of hydro-carbon chain of the fatty acids attached to glyceride.
- Lipids are soluble in solvents like- Chloroform, ether, alcohol, hexane etc.

2. Formation of translucent spot-on paper/Spotting effects—

- All the lipids are greasy in nature therefore the test may be taken as group test for lipids. So, take 3ml of ether in a test tube and dissolve 5 drops of oil in test tube.
- The put a drop of the solution on the filter/ normal paper and let it dry.
- A translucent spot on the filter paper observed and this indicates the greasy character of lipids.

3. Emulsification—

- When oil or liquid fat is shaken with water. It is finely divided and is displayed in the water to form what is known as emulsion.
- Shake a drop of oil with little water in a test tube. The oil becomes finally divided forming an emulsion.

4. Iodine absorption test.

- This test is for unsaturated fatty acids for fat. A drop of iodine is added to fat (Fat some is prepared in chloroform) and shaken.
- This solution will decolorize if unsaturated fatty acid is present.

Importance/functions of lipids

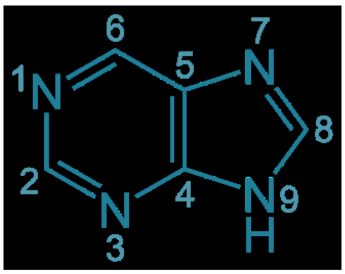
- It is the dietary constituents and provide the energy after metabolism, so we consider lipids a third major class of biomolecules.
- Lipids serve additional functions in the body, for example, some fat-soluble vitamins have regulatory or coenzyme functions, and the prostaglandins and steroid hormones play major roles in the control of the body's homeostasis.
- Lipid also provide the hydrophobic barrier that permits partitioning of the aqueous contents of cells and subcellular structures.
- Fat is stored in adipose tissue, where it also serves as a thermal insulator in the subcutaneous tissues and around certain organs. Nonpolar lipids act as electrical insulators, allowing rapid propagation of depolarization waves along myelinated nerves.
- Lipids have essential roles in nutrition and health and knowledge of lipid biochemistry is necessary for the understanding of many important biomedical conditions, including obesity, diabetes mellitus, and atherosclerosis.

Nucleic acids

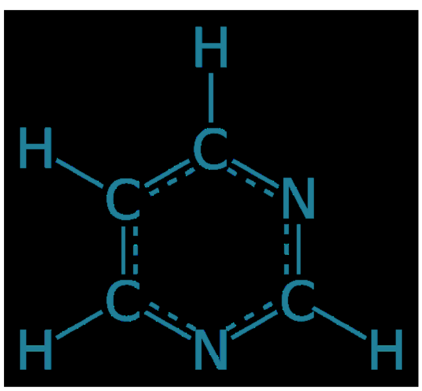
- Definition, purine and pyrimidine bases
- Components of nucleosides and nucleotides with examples.
- Structure of DNA (Watson and Crick model), RNA and their functions

Purine and Pyrimidine

- Purines and pyrimidine are both organic compounds that take part in the synthesis of DNA and RNA, therefore they are called as the building blocks of the genetic material – DNA and RNA.



- They are nitrogenous bases that make up the two different nucleotides in DNA and RNA.
- Purine is a heterocyclic aromatic organic compound composed of a pyrimidine ring fused with imidazole ring.It comprises adenine and guanine as nucleases.
- It consists of two hydrogen-carbon rings and four nitrogen atoms.
- The melting point of purine is 214 °C .Catabolism results in the production of uric acid
- **Example-Purines (adenine and guanine) are two-carbon nitrogen ring base.**



- Pyrimidine is a heterocyclic aromatic organic compound that is composed of carbon and hydrogen.
- It comprises cytosine, thymine, uracil as nucleobases.
- It consists of one hydrogen-carbon ring and two nitrogen atoms.
- The melting point of pyrimidine is 20-22 °C. Catabolism produces carbon dioxide, beta-amino acids and ammonia

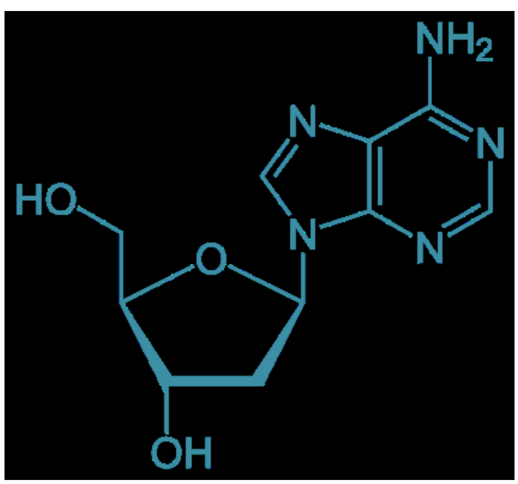
Example - pyrimidines (cytosine and thymine) are one-carbon nitrogen ring bases.

Nucleoside and Nucleotide

1. Nitrogenous Base: They comprise pyrimidine or purine base. DNA contains adenine (A), guanine (G), cytosine (C) and thymine (T) whereas RNA contains adenine, guanine, cytosine and uracil (U).
2. Sugar: A nucleotide comprises a pentose sugar. DNA (Deoxyribonucleic acid) contains deoxyribose sugar and RNA (Ribonucleic acid) contains a ribose sugar.
   A Nitrogenous base attached with the sugar is called "Nucleoside".
3. Phosphate: Phosphate is associated with the sugar of nucleoside by an ester bond with the 5thC hydroxyl group. Nucleotides at least contain one phosphate group.
   A nucleoside is a purine or a pyrimidine nucleobase with a pentose sugar component, which is either ribose or deoxyribose.

Therefore:

- **nucleoside = nucleobase + ribose or deoxyribose**
- A nucleoside is a glycoside formed from the hydrolysis of nucleic acid.
- In a nucleoside, the anomeric carbon is attached to the N9 of a purine (or to the N1 of a pyrimidine) by a glycosidic bond.



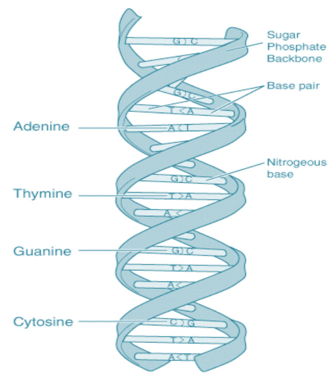
Nucleoside structure:

- Nucleotides are organic molecules consisting of a nucleoside and a phosphate.
- They serve as monomeric units of the nucleic acid ***polymers – deoxyribonucleic acid*** and **ribonucleic acid**, both of which are essential biomolecules within all life-forms on Earth.
- A molecule consisting of a nitrogen-containing base (adenine, guanine, thymine, or cytosine in DNA; adenine, guanine, uracil, or cytosine in RNA), a phosphate group, and a sugar (deoxyribose in DNA; ribose in RNA).

nucleotide = nucleoside + phosphate group

Nucleotide structure:

Watson and Crick model of DNA



- DNA as an acidic substance present in the nucleus was first identified by Frederich 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.

Structure of DNA double helix

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.

Note: The proposition of a double helix structure for DNA and its simplicity in explaining the genetic implication become revolutionary.

Function of DNA and RNA:

RNA:

- You can think of an RNA molecule, as a disposable copy of a segment of DNA, a working copy of a single gene.
- RNA has many functions, but most RNA molecules are involved in protein synthesis only.
- RNA controls the assembly of amino acids into proteins.

DNA has two functions:

1. Hold information on how to make proteins

2. Make more DNA

The main function of DNA is to store genetic information.

- The information that DNA stores is how, when, and where to make protein.
- The second function of DNA is simply to make more DNA; this is called replication

Enzymes

- **Definition, properties and IUB and MB classification**
- **Factors affecting enzyme activity**
- **Mechanism of action of enzymes, Enzyme inhibitors**
- **Therapeutic and pharmaceutical importance of enzymes**

Enzymes:
An enzyme is a biomolecule that can be synthesized biologically (naturally occurring) or through other processes (synthetically). Its main function is to act as a catalyst to speed up a reaction without itself being changed in the process.

Properties:

- Enzymes are specific in action.
- Enzymatic activity decreases with increase in temperature.
- They show maximum activity at an optimum pH of 6 – 8.
- Enzymes are complex macromolecules with high molecular weight.
- They catalyze biochemical reactions in a cell. They help in the breakdown of large molecules into smaller molecules or bring together two smaller molecules to form a larger molecule.
- Enzymes do not start a reaction. However, they help in accelerating it.
- Enzymes affect the rate of biochemical reaction and not the direction. Most of the enzymes have a high turnover number. Turnover number of an enzyme is the number of molecules of a substance that is acted upon by an enzyme per minute. High turnover number of enzymes increases the efficiency of the reaction.

Classification of Enzymes:

Classification of Enzymes by IUB System

Enzymes are classified by complex system, suggested by commission on enzymes of International Union of Biochemistry (IUB). Based on their action they are divided into 6 major classes.

1. **Oxido-Reductases:** Enzymes in this class are involved in Oxidation-Reduction reactions. Example: Alcohol Dehydrogenase.

2. **Transferases:** Enzymes that catalyze transfer of Functional groups are called as Transferases. Example: Phosphorylases

3. **Hydrolases:** These are enzymes that bring about hydrolysis of various compounds. Example: Lipase
4. **Lyases:** Enzymes specialized in addition or removal of water. Example: Aldolase
5. **Isomerases:** The Isomerases enzymes catalyze the structural shifts present in a molecule, thus causing the change in the shape of the molecule.
6. Enzymes involved in all isomerization reactions. **Example: Phosphotriose Isomerase.**

7. **Ligases:** The Ligases enzymes are known to charge the catalysis of a ligation process.

Enzymes catalyzing synthetic reactions where two molecules are joined together and ATP are used. Example: Succinate thiokinase

Factors affecting enzyme activity
Enzyme activity can be affected by several factors, including:

1. **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.

2. **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.

3. **Substrate concentration**: As the concentration of substrate increases, the rate ofenzyme-catalyzed reactions also increases, up to a point. Beyond that point, the enzymes become saturated and the reaction rate levels off.

4. **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.

5. **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.

6. **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.

The mechanism of action of enzymes can be broken down into several steps

1. **Binding:** The enzyme and substrate bind to form an enzyme-substrate complex. The binding process is specific, with the enzyme's active site (a specific region on the enzyme's surface) fitting the substrate like a lock and key.

2. **Catalysis:** Once the enzyme and substrate are bound, the enzyme catalyzes a chemical reaction that converts the substrate into a product. The enzyme does this by lowering the activation energy required for the reaction to occur.

3. **Release:** After the reaction is complete, the product is released from the enzyme's active site. The enzyme is then free to bind to another substrate and repeat the process.

- It's important to note that enzymes are not consumed or changed in the reaction and can be used again.

Mechanism of action of enzymes:

- Enzymes catalyze reactions by lowering the activation energy required for the reaction to occur. Enzymes do this by binding the substrate at the active site, a specific region on the enzyme where the substrate binds, and bringing the substrate into a favorable conformation for the reaction to occur.

Enzyme inhibitor

- Enzyme inhibitors are molecules that bind to enzymes and decrease their activity. There are several types of enzyme inhibitors, including competitive inhibitors, non-competitive inhibitors, and irreversible inhibitors.

- Competitive inhibitors bind to the active site of an enzyme and prevent substrate molecules from binding, while non-competitive inhibitors bind to a different site on the enzyme and alter its conformation, making it less active.

- Irreversible inhibitors covalently bind to the enzyme and permanently inactivate it.

- Enzyme inhibitors are commonly used in medicine to target specific enzymes involved in disease processes and in the development of pesticides.

Therapeutic and pharmaceutical importance of enzymes

Enzymes play a critical role in many biological processes and are therefore important targets for the development of therapeutics and pharmaceuticals.

- **Metabolic disorders:** Enzymes involved in metabolic pathways, such as those involved in the breakdown of sugars and lipids, can be targeted to treat metabolic disorders such as diabetes and hyperlipidemia.

- **Cancer:** Many enzymes are involved in the growth and proliferation of cancer cells, and targeting these enzymes can be an effective strategy for cancer treatment. For example, the enzyme EGFR is often overexpressed in certain types of cancer, and drugs that target EGFR have been developed to treat these cancers.

- • **Inflammation:** Enzymes involved in the inflammation process can be targeted to reduce inflammation and treat inflammatory diseases such as rheumatoid arthritis and inflammatory bowel disease.

- **Synthesis of drugs:** Enzymes are used in the synthesis of many drugs, including antibiotics, hormones, and vaccines. For example, enzymes such as penicillin amylase and recombinant DNA technology are used to produce many drugs.

- **Pesticides:** Enzymes involved in the growth and survival of pests can be targeted for the development of pesticides. For example, enzymes such as chitin synthase and acetyl cholinesterase are targeted for the development of pesticides.

- **Antibiotics:** Enzymes play a critical role in bacterial growth and survival, and targeting these enzymes can be an effective strategy for the development of antibiotics.

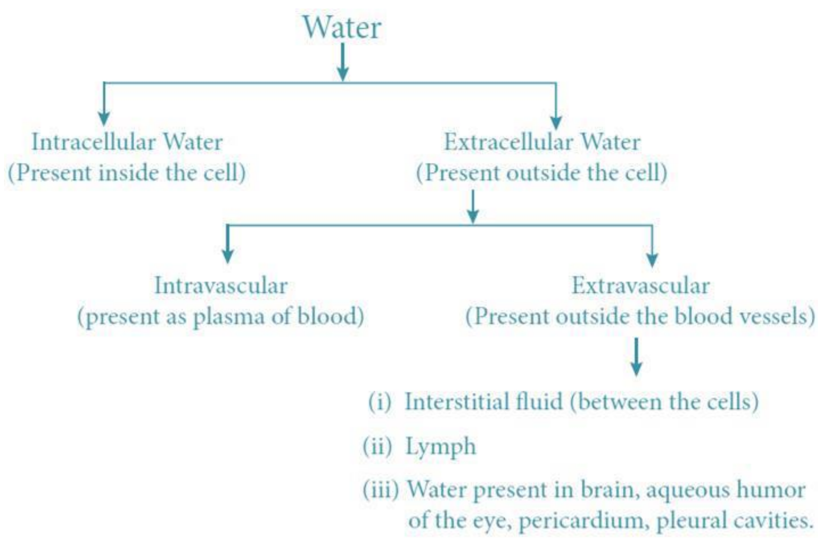
- **Enzyme replacement therapy:** Some diseases are caused by the lack of a specific enzyme, such as Gaucher disease, Fabry disease and Pompe disease, these disorders can be treated by administering the missing enzyme.
- Overall, enzymes are important targets for the development of therapeutics and pharmaceuticals because they are involved in a wide range of biological processes and their inhibition can have a significant impact on disease process

Water and Electrolytes

Water and Electrolytes

- Distribution, functions of water in the body
- Water turnover and balance
- Electrolyte composition of the body fluids, Dietary intake of electrolyte and Electrolyte balance
- Dehydration, causes of dehydration and oral rehydration therapy

Water and Electrolytes:
Water and the principal electrolytes (sodium, potassium, and chloride) are often excluded from lists of nutrients, these substances are essential dietary components, in that they must be acquired from the diet either exclusively or—in the case of water—in amounts well in excess of that produced by metabolism in the body.
WATER
Water is the most abundant constituent of the human body, accounting for one-half to four-fifths of body weight, depending mainly on body fat content. Accordingly, body water, as a percentage of body mass, is higher in men than in women and tends to fall with age in both.
Distribution:



Functions of Water:
Major functions of water:

- **Carrier of Food Nutrients:** Every nutrient in soluble form in water is carried from intestines to tissues through blood.

- **Constituent of Liquid:** Water is the major constituent of all liquids of body as blood, urine, sweat, lymph.

- **Regulate body temperature:** Water helps to regulate and control body temperature. Heat is produced when food is burnt for energy. Water is evaporated through respiration and sweat and body temperature is maintained normal. Body’s heat is lost through the skin, lungs, urine and faeces.

- **Safety/Security of Delicate Organs:** Water is around lungs, heart, brain which protects them from outer injury. Thus provide security to these organs and thereby to human being.
- **Water as lubricant:** Water acts as lubricant in joints. Water around joints help normal circulation process in cells. It is an essential constituent of all the cells of the body and the internal environment.

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.

Mechanisms involved in water turnover and balance:

1. Thirst mechanism: The body's thirst mechanism helps regulate water intake by stimulating the desire to drink water when there is a need to replace fluids lost through sweat, urine, and breathing.

2. Kidneys: The kidneys play a crucial role in water balance by regulating the amount of water excreted in urine. When the body needs to conserve water, the kidneys reduce urine output by reabsorbing more water back into the body.

3. Antidiuretic hormone (ADH): ADH is a hormone produced by the pituitary gland that regulates water balance by controlling the amount of water excreted in urine. When the body needs to conserve water, ADH levels increase, causing the kidneys to reabsorb more water and produce less urine.

4. Sweating: Sweating is a mechanism by which the body cools itself down and removes excess heat. However, excessive sweating can lead to dehydration, which can be dangerous.

5. Breathing: Water is lost through breathing as water vapor in the air wexhaleThis loss is more significant in dry environments and during physical exertion.

6. Gastrointestinal tract: Water is lost through the gastrointestinal tract through feces. The body can reabsorb some of this water in the large intestine to maintain water balance.

Factors affecting water balance:

1. Temperature: Hot environments or physical exertion can increase water loss through sweating and breathing, leading to dehydration.

2. Dietary intake: Drinking fluids and eating foods with high water content, such as fruits and vegetables, can help maintain water balance.

3. Medications: Some medications can affect water balance by increasing or decreasing urine output.

4. Medical conditions: Certain medical conditions, such as diabetes insipidus, can affect the body's ability to regulate water balance.

5. **Dietary intake of electrolyte:**

- Electrolytes are minerals that carry an electric charge in the body and include sodium, potassium, calcium, magnesium, chloride, and phosphate.

- Electrolytes play a crucial role in various bodily functions such as maintaining fluid balance, regulating blood pressure, and facilitating muscle contractions and nerve impulses.

- Dietary sources of electrolytes include foods such as fruits, vegetables, dairy products, and meats.

- Sodium is commonly found in table salt, processed foods, and condiments, while potassium is abundant in fruits and vegetables.

- Calcium and magnesium can be obtained from dairy products, leafy greens, nuts, and seeds.

- Chloride and phosphate are found in foods such as processed meats, dairy products, and grains.

- Adequate electrolyte intake is important for overall health, but excessive intake of certain electrolytes such as sodium can lead to health issues such as high blood pressure and increased risk of cardiovascular disease.

6. **Electrolyte balance:**

- Electrolyte balance refers to the proper distribution of electrolytes in the body's fluid compartments, including the blood, cells, and extracellular spaces.
- Electrolyte balance is maintained by various mechanisms, including the kidneys, hormones such as aldosterone and antidiuretic hormone (ADH), and the thirst mechanism.

- Electrolyte imbalances can occur due to a variety of reasons, including excessive fluid loss through sweating, vomiting, or diarrhea, or due to certain medical conditions such as kidney disease.

- An electrolyte imbalance can have various symptoms depending on the specific electrolyte affected, including muscle weakness or spasms, cramping, irregular heartbeat, confusion, or seizures.

- Treatment of an electrolyte imbalance may involve dietary changes or supplements, medications, or in severe cases, hospitalization for intravenous electrolyte replacement.

Dehydration, causes of dehydration and oral rehydration therapy

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:

There are several causes of dehydration, including:

1. 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.

2. Excessive Fluid Loss: Dehydration can also occur if the body loses too much fluid through sweating, urination, or diarrhea.

3. Medical Conditions: Certain medical conditions can also cause dehydration, including diabetes, kidney disease, and fever.

4. 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.

Oral rehydration salt (ORS):

Oral rehydration therapy is a type of fluid replacement used to prevent and treat dehydration, especially due to diarrhea.
It involves drinking water with modest amounts of sugar and salts, specifically sodium and potassium. Oral rehydration therapy can also be given by a nasogastric tube.

- It is expanded as Oral rehydration salt.
- It is composed of 4 constituents, sodium chloride, trisodium citrate, potassium chloride, and glucose.

- It helps in preventing dehydration caused by diarrhea.

- The combination improves fluid absorption in the intestines, allowing fluids to be restored more quickly.

Introduction to Biotechnology

- Biotechnology is multidisciplinary field which has major impact on our lives.

- The technology is known since years which involves working with cells or cell-derived molecules for various applications.

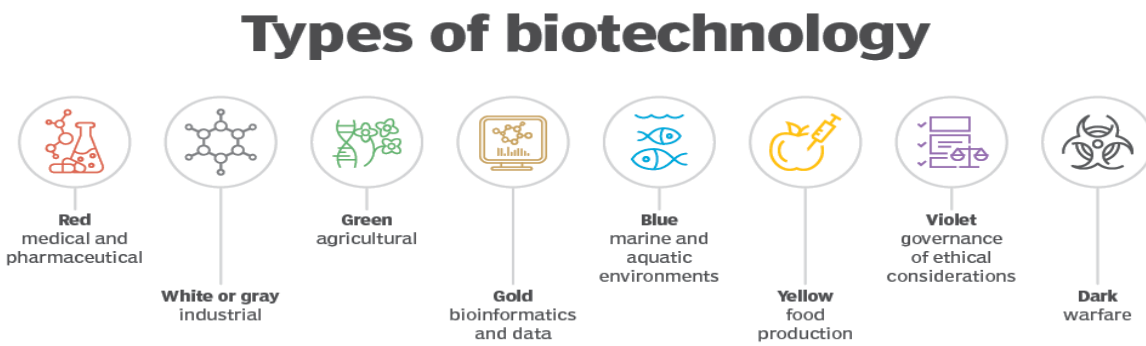
- It has wide range of uses and is termed "technology of hope" which impact human health, well being of other life forms and our environment.

- Biotechnology is the use of living organisms or their products to create useful products, processes, or services. It involves the manipulation of biological materials, including cells, DNA, and proteins, to develop new medicines, foods, and other products. Biotechnology encompasses a wide range of fields, including genetic engineering, molecular biology, biochemistry, microbiology, and cell biology.

- The applications of biotechnology are vast and have the potential to benefit many industries and areas of life. In medicine, biotechnology has revolutionized the development of new drugs and therapies, including vaccines, gene therapies, and personalized medicine. In agriculture, biotechnology has improved crop yields, created drought-resistant crops, and enhanced livestock production.

- Biotechnology also plays a critical role in environmental conservation, with bioremediation technologies using microorganisms to clean up pollutants and biodegradable plastics and biofuels reducing dependence on fossil fuels.

Type of Biotechnology:



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

Organ function tests

Organ function tests

- **Functions of kidney and routinely performed tests to assess the functions of kidney and their clinical significances**

- **Functions of liver and routinely performed tests to assess the functions of liver and their clinical significances**

- **Lipid profile tests and its clinical significances**

Organ function tests:

- Organ function tests are medical tests that are performed to assess the functioning of various organs in the body.

- These tests are usually recommended by doctors when a patient is experiencing symptoms that suggest a problem with a particular organ or when a patient has a condition that can affect the functioning of an organ.

Some common organ function tests include:

- **Liver function tests:** These tests are used to assess the functioning of the liver and to detect liver damage or disease. The tests measure levels of various enzymes, proteins, and other substances in the blood that are produced by the liver.

- **Kidney function tests:** These tests are used to assess the functioning of the kidneys and to detect kidney damage or disease. The tests measure levels of various substances in the blood and urine that are produced or excreted by the kidneys.

- **Lung function tests:** These tests are used to assess the functioning of the lungs and to detect lung diseases such as asthma, chronic obstructive pulmonary disease (COPD), and lung cancer. The tests measure how much air a person can breathe in and out, how quickly they can exhale, and how well their lungs are exchanging oxygen and carbon dioxide.

- **Cardiovascular function tests:** These tests are used to assess the functioning of the heart and blood vessels and to detect cardiovascular disease. The tests include electrocardiograms (ECGs), stress tests, and imaging tests such as echocardiograms and angiograms.
- **Endocrine function tests:** These tests are used to assess the functioning of the endocrine system, which includes glands such as the thyroid, adrenal glands, and pancreas. The tests measure levels of hormones in the blood or urine that are produced by these glands.
- **Gastrointestinal function tests:** These tests are used to assess the functioning of the digestive system and to detect gastrointestinal diseases such as ulcers, gastritis, and inflammatory bowel disease (IBD). The tests include imaging tests such as endoscopies and colonoscopies, as well as tests that measure the levels of enzymes and other substances in the blood.

Functions of kidney and routinely performed tests to assess the functions of kidney and their clinical significances:

Functions of kidney:

- The kidneys are two bean-shaped organs located in the abdomen that are responsible for filtering waste and excess fluid from the blood and excreting it as urine.
- They also help regulate blood pressure, maintain electrolyte balance, and produce hormones that help regulate red blood cell production and bone health.

The kidneys have several important functions in the body, including:

- **Regulation of fluid balance:** The kidneys help regulate the balance of fluids in the body by filtering waste and excess fluids from the blood and excreting them as urine.
- **Regulation of electrolyte balance:** The kidneys help regulate the balance of electrolytes in the body, such as sodium, potassium, and calcium, by filtering and selectively reabsorbing these ions as needed.
- **Regulation of blood pressure:** The kidneys help regulate blood pressure by producing hormones that control the diameter of blood vessels and the volume of blood circulating in the body.
- **Production of red blood cells:** The kidneys produce a hormone called erythropoietin, which stimulates the bone marrow to produce red blood cells.
- **Regulation of acid-base balance:** The kidneys help regulate the pH balance of the body by excreting excess acids or bases in the urine.
- **Excretion of waste products:** The kidneys filter waste products from the blood, such as urea, creatinine, and uric acid, and excrete them as urine.

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:
You may also need a kidney function test if you have symptoms that indicate possible kidney problems. These symptoms might include:

- 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.

- **Functions of liver and routinely performed tests to assess the functions of liver and their clinical significances:**
  Functions of liver:
  The liver is a vital organ in the body that performs many essential functions. Some of the functions of the liver include:

- 1. **Bile production:** The liver produces bile, which helps in the digestion of fats.
- 2. **Protein synthesis:** The liver produces various proteins, such as albumin, that are essential for maintaining proper fluid balance in the body.
- 3. **Detoxification:** The liver detoxifies harmful substances, such as drugs, alcohol, and toxins, from the blood.
- 4. **Storage of vitamins and minerals:** The liver stores vitamins A, D, E, and K, as well as iron and copper.
- 5. **Metabolism:** The liver metabolizes carbohydrates, fats, and proteins to provide energy to the body.

Routine liver function tests are performed to assess the liver's health and function.
These tests include:

1. **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.
2. **Alkaline phosphatase (ALP):** This test measures the levels of ALP in the blood. Elevated levels of ALP may indicate liver or bone disease.
3. **Bilirubin:** This test measures the levels of bilirubin in the blood. High levels of bilirubin may indicate liver disease or hemolytic anemia.
4. **Albumin:** This test measures the levels of albumin in the blood. Low levels of albumin may indicate liver disease.
5. **Prothrombin time (PT):** This test measures the time it takes for blood to clot. Abnormal PT may indicate liver disease.
6. **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 of liver function tests include:

1. **Detection of liver disease:** Liver function tests can help detect liver disease in its early stages, before symptoms appear.
2. **Monitoring of liver function:** Liver function tests are used to monitor the progress of liver disease and assess the effectiveness of treatment.
3. **Diagnosis of liver injury:** Liver function tests can help diagnose liver injury caused by drugs, toxins, or infections.
4. **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 and its clinical significances: 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.

Poisoning Introduction to Pathology of Blood and Urine

- **Lymphocytes and Platelets, their role in health and disease.**
- **Erythrocytes - Abnormal cells and their significance.**
- **Normal and Abnormal constituents of Urine and their significance.**

Introduction to Pathology of Blood and Urine—

- The pathology of blood involves the study of the cellular and molecular components of blood and their interactions.
- Blood is composed of various cells and plasma, which contains nutrients, hormones, electrolytes, and other vital components that are essential for the body's normal functioning.
- Any abnormality in the composition or function of these components can lead to a wide range of medical conditions.

Common blood disorders include anemia, leukemia, and hemophilia.

- Anemia is a condition in which the body does not have enough red blood cells, causing fatigue and weakness.

- Leukemia is a type of cancer that affects the blood and bone marrow, leading to an overproduction of abnormal white blood cells.

- Hemophilia is a genetic disorder that causes the blood to clot abnormally, leading to excessive bleeding.

Lymphocyte's role in health and diseases.

Lymphocytes are a type of white blood cell that plays a crucial role in the immune system. They are responsible for identifying and attacking foreign substances such as viruses, bacteria, and cancer cells. There are two main types of lymphocytes: B cells and T cells.

- B cells produce antibodies that help identify and neutralize pathogens. When a B cell encounters a foreign substance, it produces a specific antibody that binds to the pathogen and signals other immune cells to destroy it.

- T cells play a variety of roles in the immune system, including recognizing and destroying infected cells, regulating the immune response, and helping B cells produce antibodies.

- Abnormalities in lymphocytes can lead to various diseases, such as lymphoma, leukemia, and autoimmune disorders. Lymphoma and leukemia are cancers that affect lymphocytes, while autoimmune disorders occur when the immune system mistakenly attacks the body's own cells and tissues.

Platelet's role in health and diseases.

- Platelets, also known as thrombocytes, are small fragments of cells that help the blood clot to stop bleeding. They are formed in the bone marrow and circulate in the blood. When a blood vessel is damaged, platelets rush to the site and stick together, forming a plug to stop the bleeding.

- Abnormalities in platelet function can lead to bleeding disorders, such as hemophilia and von Willebrand disease, or thrombotic disorders, such as deep vein thrombosis and pulmonary embolism.

- Hemophilia and von Willebrand disease are inherited disorders that impair the blood's ability to clot, while deep vein thrombosis and pulmonary embolism occur when blood clots form in the veins and travel to other parts of the body, leading to serious complications.

Erythrocytes - Abnormal cells and their significance.

Red blood cells (RBCs) or erythrocytes are the most abundant type of blood cells in the human body, and their main function is to transport oxygen from the lungs to the body tissues and to carry carbon dioxide from the tissues back to the lungs. The shape of RBCs is an important characteristic that can provide information about a person's health status. A medical professional can evaluate

1. Normal RBCs— Normal RBCs have a biconcave shape with a flattened centre, which increases their surface area for efficient gas exchange. Normal RBCs are essential for oxygen transport and carbon dioxide removal.
2. Sickle cell-shaped RBCs— Sickle cell-shaped RBCs have a crescent or sickle shape and are characteristic of sickle cell anaemia, a genetic disorder that affects the production of haemoglobin. These abnormal RBCs can cause blockages in the blood vessels, leading to pain, organ damage, and other complications.
3. Schistocyte-shaped RBCs— Schistocyte-shaped RBCs have an irregular shape and are fragmented due to physical damage, such as from trauma or mechanical heart valves. These abnormal RBCs can cause haemolysis, anaemia, and other blood disorders.
4. Target-shaped RBCs— Target-shaped RBCs have a central dark spot surrounded by a lighter ring and an outer dark ring. Target-shaped RBCs can be caused by iron deficiency anaemia, liver disease, thalassemia, and other conditions.
5. Ovalocyte-shaped RBCs— Ovalocyte-shaped RBCs have an oval or elliptical shape and can be seen in various blood disorders, including hereditary elliptocytosis, thalassemia, and myelofibrosis.
6. Tear-drop-shaped RBCs— Tear-drop-shaped RBCs have a teardrop or pear-shaped appearance and can be seen in various blood disorders, including thalassemia, myelofibrosis, and other conditions.

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.

Examination of urine.

The investigation of urine, also known as urinalysis, is a medical test that evaluates the composition and properties of urine to diagnose various medical conditions. Here are some common investigations of urine:

1. Physical examination— This includes the colour, odour, and appearance of the urine. Normal urine is pale yellow in colour, clear, and has a mild odour. Abnormal urine may be cloudy, have a strong odour, or be a different colour, which can indicate various medical conditions.

2. Chemical analysis: A dipstick test is used to check for the presence of different chemicals in the urine, such as glucose, protein, ketones, blood, and bilirubin. Abnormal results can indicate conditions such as diabetes, kidney disease, or liver disease.

3. Microscopic examination: The urine sample is examined under a microscope to detect the presence of abnormal cells, bacteria, crystals, or other particles. This can help diagnose conditions such as urinary tract infections, kidney stones, or cancer.

4. Culture and sensitivity testing: If there is evidence of infection in the urine, a culture and sensitivity test may be performed to identify the type of bacteria causing the infection and determine the most effective antibiotic to treat it.

5. Urine cytology: This is a microscopic examination of the urine to detect abnormal cells that may indicate bladder cancer or other urinary tract cancers.

6. 24-hour urine collection: This test involves collecting all urine produced in a 24-hour period and measuring the volume, composition, and excretion of certain substances in the urine. It can be used to diagnose kidney disorders and other conditions.

Stone analysis: If a person has kidney stones, the stones can be analysed to determine their composition, which can help determine the cause and treatment of the stones.