O. P. JINDAL SCHOOL, RAIGARH (CG) 496 001, INDIA

Phone: 07762-227042, 227293, (Extn. 227001 - 49801, 02, 04, 06, 09); Fax: 07762-262613; website: www.opjsrgh.in; e-mail: opjsraigarh@jspl.com

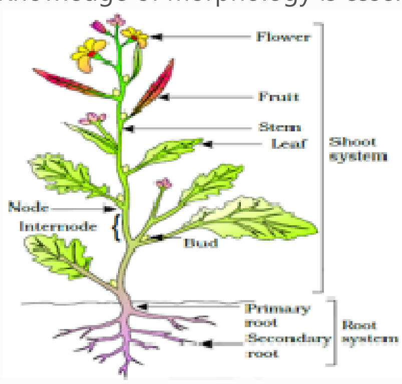
CLASS: XI - BIOLOGY

MORHOLOGY OF THE FLOWERING PLANTS

Morphology is the branch of biological science that deals with the study of form, size, colour, structure and relative position of various parts of organisms.

Importance of morphology-

1. Knowledge of morphology is essential for recognition or identification of plants.



2. It gives information about the range of variations found in species.
3. Deficiency and toxicity symptoms are morphological changes that occur in response to shortage or excess of minerals.

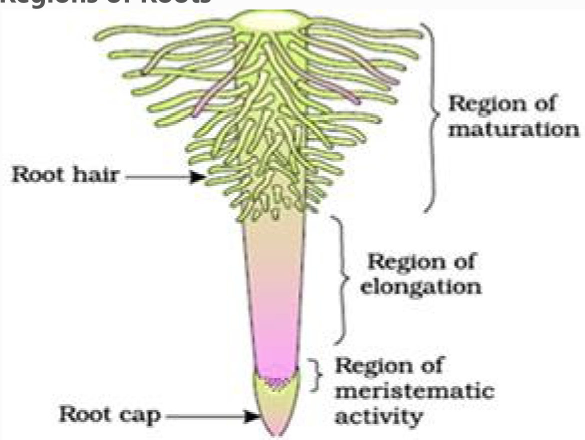
Parts of Flowering Plants–

- All the flowering plants have roots, stem, leaves, flower and fruits. The underground parts of flowering plant are the **root system** and the portion above the ground forms the **shoot system**.

The Root

- In Dicotyledons, elongation of radicle forms the primary roots which bears lateral roots of several orders called secondary roots, tertiary roots, etc.
  Primary roots along with lateral roots forms the **Tap root system**. Example: Mustard, Gram, etc.
- In monocotyledons, primary root is replaced by large number of roots at its base of stem to constitute the **Fibrous root system**. Wheat, rice etc.
- The roots that arise from other parts of plant beside radicle are called **adventitious roots**. Example- Grass, Banyan tree, Maize, etc.
- The main function of root system are absorption of water and minerals from soil, providing proper anchorage to the plant parts and storing reserve food materials.

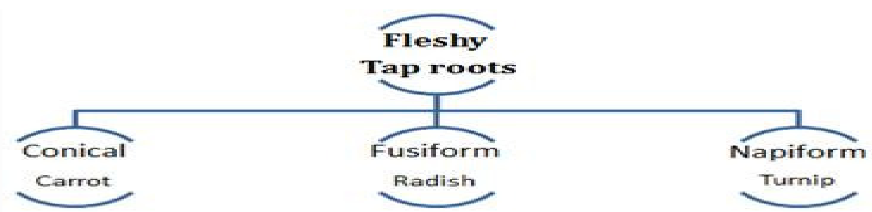
Regions of Roots–



- The apex of root is covered by a thimble like structure called **root cap**, it protect the tender apex of root while making way through soil.
- Above the root cap is **region of meristematic activity** having small cells with dense cytoplasm.
- The part above the region of meristematic activity is **region of elongation** where cells under go elongation and enlargement to increase the length of root.
- **Region of maturation** contain root hairs that help in absorption of water and minerals.

Modification of roots- Roots are modified for storage, nitrogen fixation, aeration and support.

- Tap root of carrot, turnip and adventitious root of sweet potato get swollen to store food.
- Prop root of Banyan and Stilt root of maize and sugarcane have supporting root coming out from lower node of stems.
- In Rhizophora, Pneumatophores help to get oxygen for respiration as it grows in swampy areas.

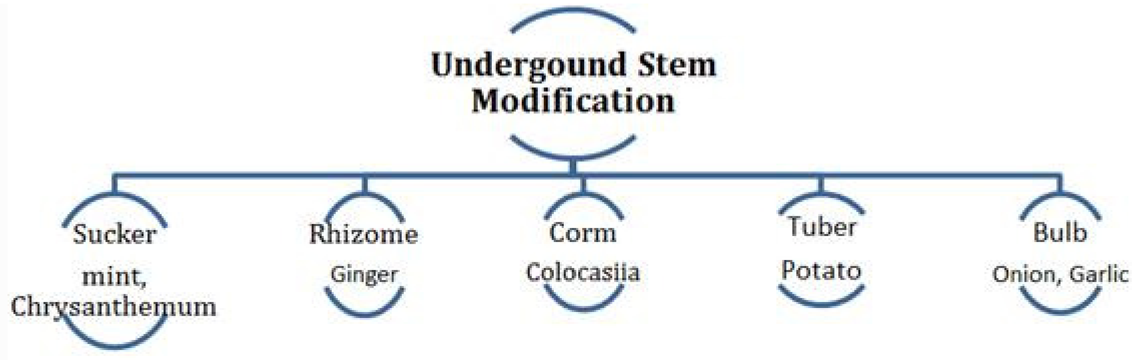


The Stem

- It is the ascending part of axis bearing branches, leaves, flowers and fruits. It develops from Plumule of the embryo.
- Stem bears nodes and internodes. The region of stem where leaves are born are called nodes and portion between two nodes are called internodes.
- The main function of stem is spreading branches, bearing leaves, flowers and fruits. It also conducts water and minerals from root to leaves and product of photosynthesis.
- Some stem perform special functions like storage of food, support, protection and vegetative propagation.

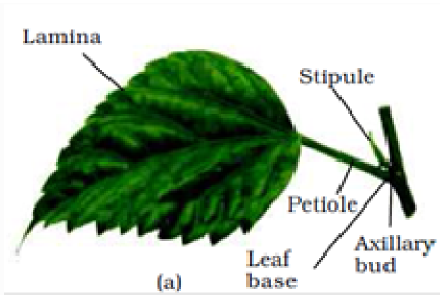
Modification of stems–

- Underground stem of potato, ginger and turmeric are modified to store food. They also act as organ of perennation in unfavorable conditions.
- Stem tendril help plants to climb as in cucumber, pumpkins, and grapes.
- Axillary buds of stem may modify into woody, straight and pointed thorns as in Citrus and Bougainvillea.
- Plants of arid regions modify their stem to flattened (Opuntia), fleshy cylindrical (Euphorbia) having chlorophyll for photosynthesis.



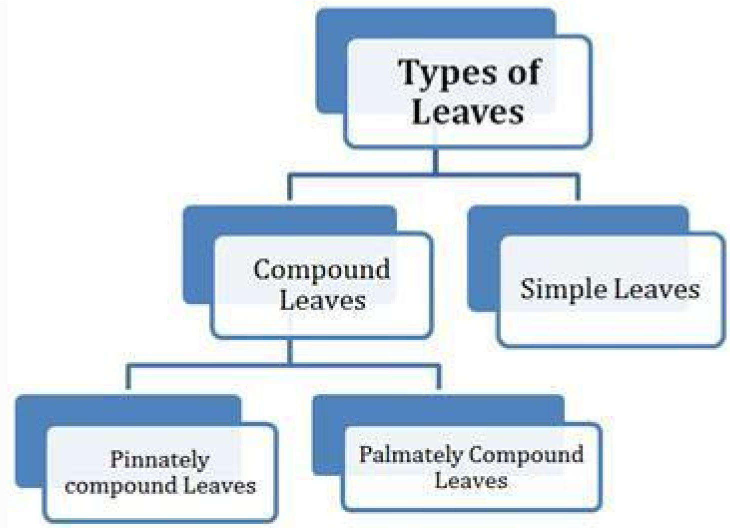
The Leaf

- Leaf is a green, dissimilar exogenous lateral flattened outgrowth which is borne on the node of a stem or its branches is specialized to perform photosynthesis.



- Leaves originate from shoot apical meristem and are arranged in an acropetal order.
- A typical leaf consists of three parts- **Leaf base, Petiole, Lamina**. Leaf is attached with stem by Leaf Base which may bear two small leaf like structure called stipule.
- Middle prominent vein is called mid vein. Veins provide rigidity to the leaf blade and act as channel for transport of water and minerals.
- The arrangement of vein and veinlets in the lamina is called venation.

Reticulate venation	**Parallel venation**
1. Veinlets form a network. 2. Veins are irregularly distributed. 3. It is present in all Dicotyledons like Gram, Pea, Beans and Mango etc.	1. A network is absent. 2. Veins are parallel to one another. 3. It is present in Monocotyledons like Grass, Banana, Rice, etc.



- A leaf having a single or undivided lamina is called **Simple leaf**. The incisions do not touch the mid rib. Example- Mango, Guava etc.
- When the incision of lamina reach up to the midrib and breaking it into a number of leaflets, it is called **Compound leaves**.
- In a **Pinnately compound leaves**, a number of leaflets are present on common axis called rachis. Example- Neem.
- In **Palmately compound leaves**, the leaflets are attached at common point. Example- Silk cotton.
- The pattern of arrangement of leaves on the stem or branch is called **Phyllotaxy**.
- In **alternate type of phyllotaxy** single leaf arise at each node as in China rose.
- In **opposite types of phyllotaxy** a pair of leaves arise from each node opposite to each other as in Guava.
- If more than two leaves arise at a node and form a whorl is called **whorled type** of phyllotaxy as in Alstonia.
- Leaves are modified to perform other functions like converted to tendril for climbing as in Peas and spines for defence in Cactus.

Inflorescence

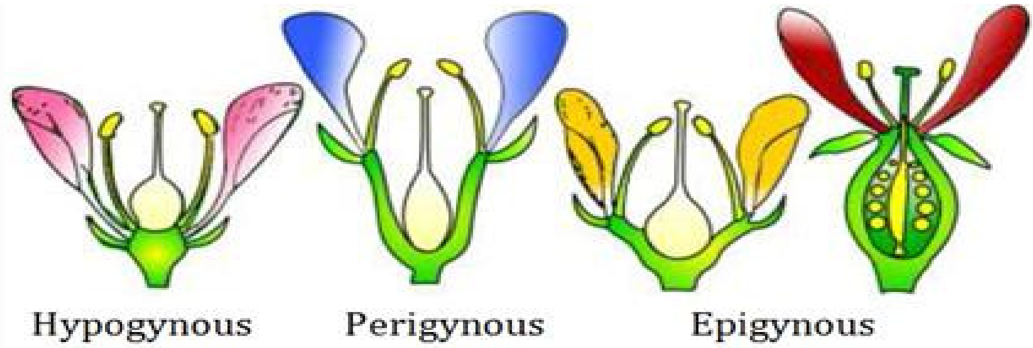
The arrangement of flowers on the floral axis is termed as inflorescence. Two main types of inflorescence are racemose and cymose.

Racemose	**Cymose**
1. The main axis continuous to grow. 2. Flowers are borne laterally in an acropetal succession. 3. Example- Radish, Mustard.	1. Main axis terminates in flower having limited growth. 2. Flowers are borne in a basipetal succession. 3. Example- Jasmine, Bougainvillea.

The flower

- Flower is the reproductive part of angiospermic plants for sexual means of reproduction.
- A typical flower has four whorls arranged on a swollen end of stalk or pedicel called **thalamus.** They are **Calyx, Corolla, Androecium and Gynoecium**.
- When a flower has both androecium and gynoecium, the flower is called bisexual and flower having either androecium or gynoecium only is called unisexual.
- When flower can be divided into two equal radial halves in any radii passing through center the symmetry of flower is called **actinomorphic** (radial symmetry) as in Mustard, Datura, and Chili.

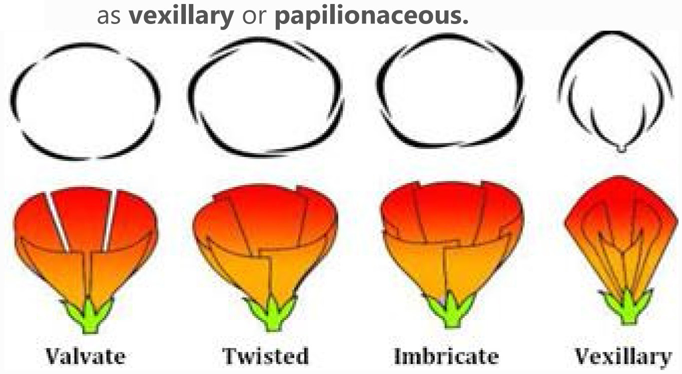
- When flower can be divided into two similar parts only in one vertical plane it is **zygomorphic** as in Pea, Gulmohar, Cassia etc.
- When Floral appendages are in multiple of 3,4 or 5 they are called **trimerous, tetramerous** and p**entamerous** respectively. Flower with bracts are called **bracteates** and without it **ebracteate**.
- Based on the position of ovary with respect to other floral part on thalamus, flowers are of following types:



1. **Hypogynous flower**– Ovary occupies the highest position. The ovary in such case is called superior. Eg. Mustard, brinjal and china rose.
2. **Perigynous flowers-**If the gynoecium is situated at the centre and other parts are on the rim at same height. Ovary is called half-inferior.
3. **Epigynous flowers-** The margin of thalamus grows to completely cover the ovary. Ovary is said to be inferior.

Calyx is the outermost whorl of the flower; its members are called sepals. They are generally green and leafy; protect the flower in bud stage. It may be **gamosepalous** (sepals united) or **polysepalous** (sepals free).
Corolla consists of petals, brightly coloured to attract the insects for pollination. They may be gamopetalous or polypetalous.

1. The mode of arrangement of sepals or petals in floral bud with respect to the other members of same whorl is called aestivation. In **valvate**, the whorls of sepals or petals touch each other as in Calotropis.
   In **Twisted** aestivation, the whorls overlap each other as in China rose.
2. In **Imbricate** aestivation, margin overlap each other but not in particular fashion as in Gulmohur.
3. In pea and bean flowers, there are five petals- the largest (standard) overlaps the two lateral petals (wings) which in turn overlap two smallest anterior petals (keel). This type of aestivation is known as **vexillary** or **papilionaceous.**



The Androecium

- Androecium represent the male reproductive parts of flower, consists of stamens. Each stamen consists of filament and anther. Pollen grains are produced in pollen sac. Sterile stamen is called **Stemenode**.
- When stamens are attached with petals it is called epipetalous (Brinjal). Stamen may be free (polyandrous) or may be united in one bundle (monoadelphous), two bundles (diadelphous), more than two (polyadelphous).

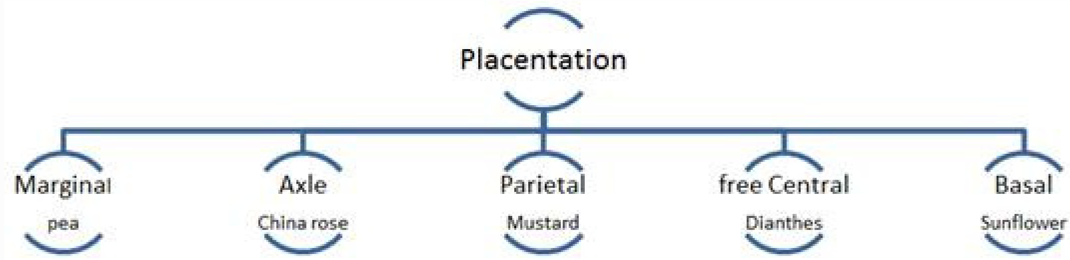
The Gynoecium

- Female reproductive part of flower consists of one or more carpels. Each carpel is made up of stigma style and ovary.

- When more than one carpel is present, it may be free (**apocarpous**) as in lotus and rose or fused together (**syncarpous**) as in mustard and tomato.
- After fertilisation, ovules change into seeds and ovary mature into fruits.

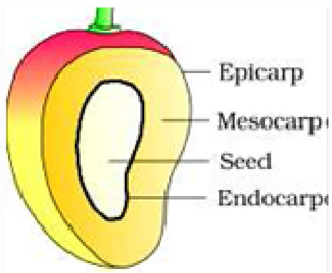
Placentation

- The arrangement of ovules within the ovary is called placentation.

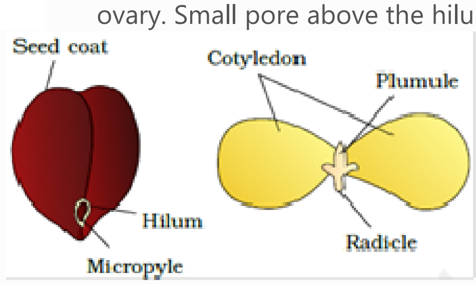


The fruit

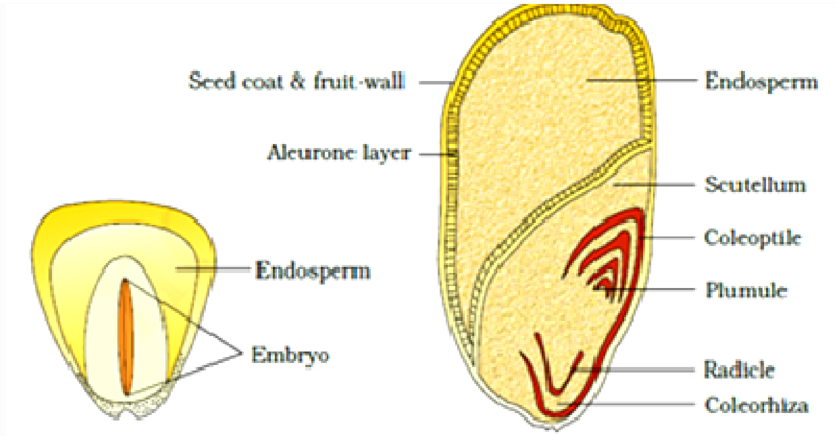
- Mature and ripened ovary developed after fertilisation is fruit. If a fruit is formed without fertilisation of ovary it is called **parthenocarpic fruit**.
- Fruit consists of seeds and pericarp. Thick and fleshy pericarp is three layered called epicarp, mesocarp and endocarp.



- Dicotyledonous Seed is made up of a seed coat and an embryo. Embryo is made up of embryonal axis, radicle and cotyledons.
- Seed coat has two layers outer **testa** and inner **tegmen**. Hilum is scar through which seed is attached to the ovary. Small pore above the hilum is called micropyle.



Monocotyledonous seeds



- In monocotyledonous seed, outer covering of endosperm separate the embryo by a proteinous layer called **aleurone layer.**
- Single cotyledon is called as scutellum having a short axis bearing Plumule and radicle.
- Plumule and radicle are closed inside sheaths called as coleoptile and coleorhiza respectively.

SEMI -TECHNICAL DESCRIPTION OF A TYPICAL FLOWERING PLANT

The plant is described beginning with its habit, vegetative characters – roots, stem and leaves and then floral characters inflorescence and flower parts.

The floral formula is represented by some symbols. In the floral formula, **Br** stands for bracteate **K** stands for calyx , **C** for corolla, **P** for perianth, **A** for androecium and **G** for Gynoecium. Fusion is indicated by enclosing the figure within bracket and adhesion by a line drawn above the symbols of the floral parts.

Family Fabaceae-

- This family was earlier known as Papilionoideae. Herbs, shrubs or tree root with root nodules. Pinnately compound leaves with reticulate venation.

Floral Formula: $\% ⚥ K_{(5)}\ C_{1+2+(2)}\ A_{(9)+1}\ \underline{G}_1$

Economic importance

Plants belonging to this family are sources of pulses like Gram, Arhar, Bean. Pea etc. and edible oils like groundnut, soybean, etc.

Family Solanaceae-

- Plant body herbs or shrubs, rarely small trees, commonly known as **potato family**. Leaves simple or pinnately compound. Reticulate venation.

Floral Formula: $\oplus ⚥ K_{(5)}\ \overset{\frown}{C_{(5)}\ A_5}\ \underline{G}_{(2)}$

Many of them are source of food (potato, tomato, Brinjal etc.), spices (Chilli) etc.

Family Liliaceae

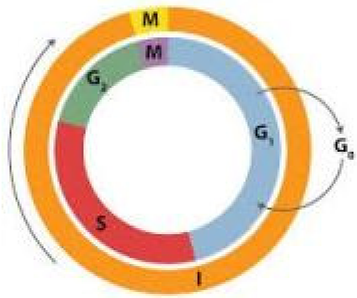
- Commonly known as Lily family. Monocots, perennial herbs. Leaves alternate with parallel venation.
- Underground bulbs, corms or rhizomes.
- Flower bisexual, actinomorphic, sepals and petals are absent, having perianth.

Floral Formula: Br $\oplus ⚥ \overset{\frown}{P_{(3+3)}\ A_{3+3}}\ G_{(3)}$

It includes ornamental plants (Tulip), Medicine (aloe) and vegetable (colchicine).

Cell Cycle and Cell Division

1. **Introduction:** It is the process by which a mature cell divides and forms two nearly equal daughter cells which resemble the parental cell in a number of characters.
2. **Discovery:** Prevost and Dumas (1824) first to study cell division during the cleavage of zygote of frog.
3. Nagelli (1846) was the first to propose that new cells are formed by the division of pre-existing cells.
4. Rudolf virchow (1859) proposed "omnis cellula e cellula" and "cell lineage theory".
5. A cell divides when it has grown to a certain maximum size which disturb the karyoplasmic index (KI)/Nucleoplasmic ratio (NP)/Kernplasm connection.
6. Two processes take place during cell reproduction.
   - **Cell growth:** (Period of synthesis and duplication of various components of cell).
   - **Cell division:** (Mature cell divides into two cells).
7. **Cell cycle:** Howard and Pelc (1953) first time described it. The sequence of events which occur during cell growth and cell division are collectively called cell cycle. Cell cycle completes in two steps:
   - Interphase
   - M-phase/Dividing phase

     (i) Interphase : It is the period between the end of one cell division to the beginning of next cell division. It is also called resting phase or not dividing phase. But, it is actually highly metabolic active phase, in which cell prepares itself for next cell division. In case of human beings it will take approx 25 hours. Interphase is completed in to three successive stages.

     (a) G_1 phase/Post mitotic/Pre-DNA synthetic phase/Gap Ist

     (b) S-phase/Synthetic phase

     (c) G_2-phase/Pre mitotic/Post synthetic phase/gap-IInd

     (ii) M-phase/Dividing phase/Mitotic phase

     (a) Nuclear division i.e. karyokinesis occurs in 4 phases - prophase, metaphase, anaphase and telophase. It takes 5-10% (shortest phase) time of whole division.

     (b) Cytokinesis : Division of cytoplasm into 2 equal parts. In animal cell, it takes place by cell furrow method and in plant cells by cell plate method.
8. **Duration of cell cycle:** It depends on the type of cell and external factors such as temperature, food and oxygen. Time period for G_1, S, G_2 and M-phase is species specific under specific environmental conditions. e.g. 20 minutes for bacterial cell, 8-10 hours for intestional epithelial cell, and onion root tip cells may take 20 hours.
9. **Regulation of cell cycle:** Stage of regulation of cell cycle is G_1 phase during which a cell may follow one of the three options.
   - It may start a new cycle, enter the S-phase and finally divide.
   - It may be arrested at a specific point of G_1 phase.
   - It may stop division and enter G_0 quiscent stage. But when conditions change, cell in G_0 phase can resume the growth and reenter the G_1 phase.
10. Cell division is of three types, Amitosis, Mitosis and Meiosis.
11. Difference between cell Mitosis and Meiosis

S.No	Characters	Mitosis	Meiosis
I. General			
(1)	Site of occurrence	Somatic cells and during the multiplicative phase of gametogenesis in germ cells.	Reproductive germ cells of gonads.
(2)	Period of occurrence	Throughout life.	During sexual reproduction.
(3)	Nature of cells	Haploid or diploid.	Always diploid.

(4)	Number of divisions	Parental cell divides once.	Parent cell divides twice.
(5)	Number of daughter cells	Two.	Four.
(6)	Nature of daughter cells	Genetically similar to parental cell. Amount of DNA and chromosome number is same as in parental cell.	Genetically different from parental cell. Amount of DNA and chromosome number is half to that of parent cell.
II. Prophase			
(7)	Duration	Shorter (of a few hours) and simple.	Prophase-I is very long (may be in days or months or years) and complex.
(8)	Subphases	Formed of 3 subphases : early-prophase, mid-prophase and late-prophase.	Prophase-I is formed of 5 subphases: leptotene, zygotene, pachytene, diplotene and diakinesis.
(9)	Bouquet stage	Absent.	Present in leptotene stage.
(10)	Synapsis	Absent.	Pairing of homologous chromosomes in zygotene stage.
(11)	Chiasma formation and crossing over.	Absent.	Occurs during pachytene stage of prophase-I.
(12)	Disappearance of nucleolus and nuclear membrane	Comparatively in earlier part.	Comparatively in later part of prophase-I.
(13)	Nature of coiling	Plectonemic.	Paranemic.
III. Metaphase			
(14)	Metaphase plates	Only one equatorial plate	Two plates in metaphase-I but one plate in metaphase-II.
(15)	Position of centromeres	Lie at the equator. Arms are generally directed towards the poles.	Lie equidistant from equator and towards poles in metaphase-I while lie at the equator in metaphase-II.
(16)	Number of chromosomal fibres	Two chromosomal fibre join at centromere.	Single in metaphase-I while two in metaphase-II.
IV. Anaphase			
(17)	Nature of separating chromosomes	Daughter chromosomes (chromatids with independent centromeres) separate.	Homologous chromosomes separate in anaphase-I while chromatids separate in anaphase in anaphase-II.
(18)	Splitting of centromeres and development of inter-zonal fibres	Occurs in anaphase.	No splitting of centromeres. Inter-zonal fibres are developed in metaphase-I.
V. Telophase			
(19)	Occurrence	Always occurs	Telophase-I may be absent but telophase-II is always present.
VI. Cytokinesis			
(20)	Occurrence	Always occurs	Cytokinesis-I may be absent but cytokinesis-II is always present.
(21)	Nature of daughter cells	2N amount of DNA than 4N amount of DNA in parental cell.	1 N amount of DNA than 4 N amount of DNA in parental cell.
(22)	Fate of daughter cells	Divide again after interphase.	Do not divide and act as gametes.

VII. Significance			
(23)	Functions	Helps in growth, healing, repair and multiplication of somatic cells. Occurs in both asexually and sexually reproducing organisms.	Produces gametes which help in sexual reproduction.
(24)	Variations	Variations are not produced as it keeps quality and quantity of genes same.	Produces variations due to crossing over and chance arrangement of bivalents at metaphase-I.
(25)	In evolution	No role in evolution.	It plays an important role in speciation and evolution.

12. **Types of Mitosis**
    - **Anastral mitosis:** It is found in plants in which spindle has no aster.
    - **Amphiastral mitosis:** It is found in animals in which spindle has two asters, one at each pole of the spindle. Spindle is barrel-like.
    - **Intranuclear or Promitosis:** In this nuclear membrane is not lost and spindle is formed inside the nuclear membrane e.g. Protozoans (Amoeba) and yeast. It is so as centriole is present within the nucleus.
    - **Extranuclear or Eumitosis:** In this nuclear membrane is lost and spindle is formed outside nuclear membrane e.g. in plants and animals.
    - **Endomitosis:** Chromosomes and their DNA duplicate but fail to separate which lead to polyploidy e.g. in liver of man, both diploid (2N) and polyploid cells (4N) have been reported. It is also called endoduplication and endopolyploidy.
    - **Dinomitosis:** In which nuclear envelope persists and microtubular spindle is not formed. During movement the chromosomes are attached with nuclear membrane.
13. **Types of meiosis:** On the basis of time and place, meiosis is of three types
    - **Gametic/Terminal meiosis:** In many protozoans, all animals and some lower plants; meiosis takes place before fertilization during the formation of gametes. Such meiosis is described as gametic or terminal.
    - **Zygotic or Initial Meiosis:** In fungi, certain protozoan groups, and some algae fertilization is immediately followed by meiosis in the zygote, and the resulting adult organisms are haploid. Such a meiosis is said to be zygotic or initial. This type of life cycle with haploid adult and zygotic meiosis is termed the haplontic cycle.
    - **Sporogenetic Meiosis**

      (a) Diploid sporocytes or spore mother cells of sporophytic plant, undergo meiosis to form the haploid spores in the sporangia.

      (b) Haploid spore germinates to form haploid gametophyte which produces the haploid gametes by mitosis.

      (c) Haploid gametes fuse to form diploid zygote which develops into diploid sporophyte by mitotic divisions. e.g. in higher plants like pteridophytes, gymnosperms and angiosperms.

The cell theory developed in 1839 by microbiologists Schleiden and Schwann describes the properties of cells. It is an explanation of the relationship between cells and living things. The theory states that:

- all living things are made of cells and their products.
- new cells are created by old cells dividing into two.
- cells are the basic building blocks of life.

The cell theory applies to all living things, however big or small. The modern understanding of cell theory extends the concepts of the original cell theory to include the following:

- The activity of an organism depends on the total activity of independent cells.

- Energy flow occurs in cells through the breakdown of carbohydrates by respiration.
- Cells contain the information necessary for the creation of new cells. This information is known as 'hereditary information' and is contained within DNA.
- The contents of cells from similar species are basically the same.

STRUCTURE OF CELL

Cells are the smallest form of life; the functional and structural units of all living things. Your body contains several billion cells, organised into over 200 major types, with hundreds of cell-specific functions.

Some functions performed by cells are so vital to the existence of life that all cells perform them (e.g. cellular respiration.

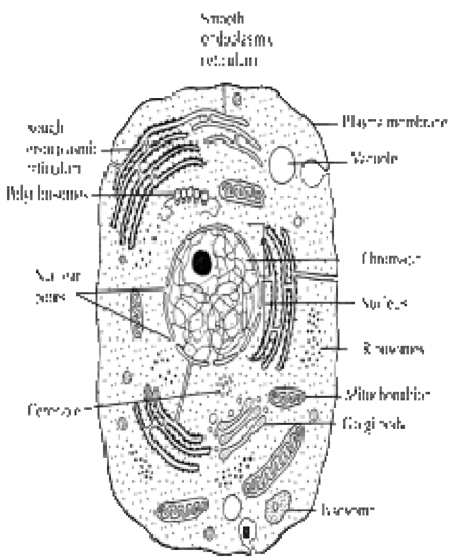


Diagram of the cell ultrastructure of an animal cell.

Cell wall

The cell wall is a rigid non-living layer that is found outside the cell membrane and surrounds the cell. Plants, bacteria and fungi all have cell walls. In plants, the wall is comprised of cellulose. It consists of three layers that help support the plant. These layers include the middle lamella, the primary cell wall and the secondary cell wall.

Middle lamella: Separates one cell from another. It is a thin membranous layer on the outside of the cell and is made of a sticky substance called pectin.

Primary cell wall: Is on the inside of the middle lamella and is mainly composed of cellulose.

Secondary cell wall: Lies alongside the cell membrane. It is is made up of a thick and tough layer of cellulose which is held together by a hard, waterproof substance called lignin. It is only found in cells which provide mechanical support in plants.

Functions of the cell wall

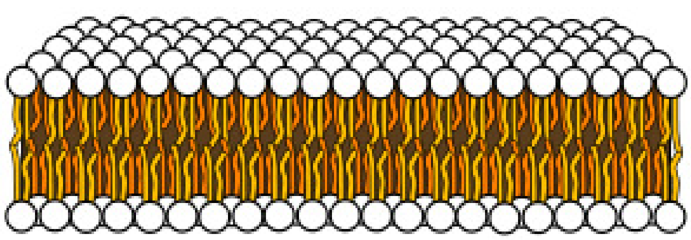
- The main function of the wall is to protect the inner parts of the plant cell, it gives plant cells a more uniform and regular shape and provides support for the plant body.
- The cell wall is completely permeable to water and mineral salts which allows distribution of nutrients throughout the plant.
- The openings in the cell wall are called plasmodesmata which contain strands of cytoplasm that connect adjacent cells. This allows cells to interact with one another, allowing molecules to travel between plant cells.

Cell membrane

The **cell membrane**, also called the plasma membrane, physically separates the intracellular space (inside the cell) from the extracellular environment (outside the cell). All plant and animal cells have cell membranes. The cell membrane surrounds and protects the **cytoplasm**. Cytoplasm is part of the protoplasm and is the living component of the cell.

The cell membrane is composed of a double layer (bilayer) of special lipids (fats) called **phospholipids**. Phospholipids consist of a **hydrophilic** (water-loving) head and a **hydrophobic** (water-fearing) tail. The hydrophobic head of the phospholipid is **polar** (charged) and can therefore dissolve in water. The hydrophobic tail is **non-polar** (uncharged), and cannot dissolve in water.

The lipid bilayer forms spontaneously due to the properties of the phospholipid molecules. In an aqueous environment, the polar heads try to form hydrogen bonds with the water, while the non-polar tails try to escape from the water. The problem is solved by the formation of a bilayer because the hydrophilic heads can point outwards and from hydrogen bonds with water, and the hydrophobic tails point towards one another and are 'protected' from the water molecules .



The lipid bilayer showing the arrangement of phospholipids, containing hydrophilic, polar heads and hydrophobic, non-polar tails

Structure	Function	
Phospholipid bilayer	Consists of two layers of phospholipids. Each phospholipid has a polar, hydrophilic (water-soluble) head as well as a non-polar, hydrophobic (water-insoluble) tail.	It is a semi-permeable structure that does not allow materials to pass through the membrane freely, thus protecting the intra and extracellular environments of the cell.
Membrane proteins	These are proteins found spanning the membrane from the inside of the cell (in the cytoplasm) to the outside of the cell. Membrane proteins have hydrophilic and hydrophobic regions that allow them to fit into the cell membrane.	Act as carrier proteins which control the movement of specific ions and molecules across the cell membrane.
Glycoproteins	Consist of short carbohydrate chains attached to polypeptide chains and are found on the extracellular regions of the membrane.	These proteins are useful for cell-to-cell recognition.
Glycolipids	Carbohydrate chains attached to phospholipids on the outside surface of the membrane.	Act as recognition sites for specific chemicals and are important in cell-to-cell attachment to form tissues.
Hypertonic (concentrated)	**Isotonic**	**Hypotonic** (dilute)
The medium is concentrated with a lower water potential than inside the cell, therefore the cell will lose water by osmosis.	The water concentration inside and outside the cell is equal and there will be no nett water movement across the cell membrane. (Water will continue to move across the membrane, but water will enter and leave the cell at the same rate.)	The medium has a higher water potential (more dilute) than the cell and water will move into the cell via osmosis, and could eventuality cause the cell to burst.

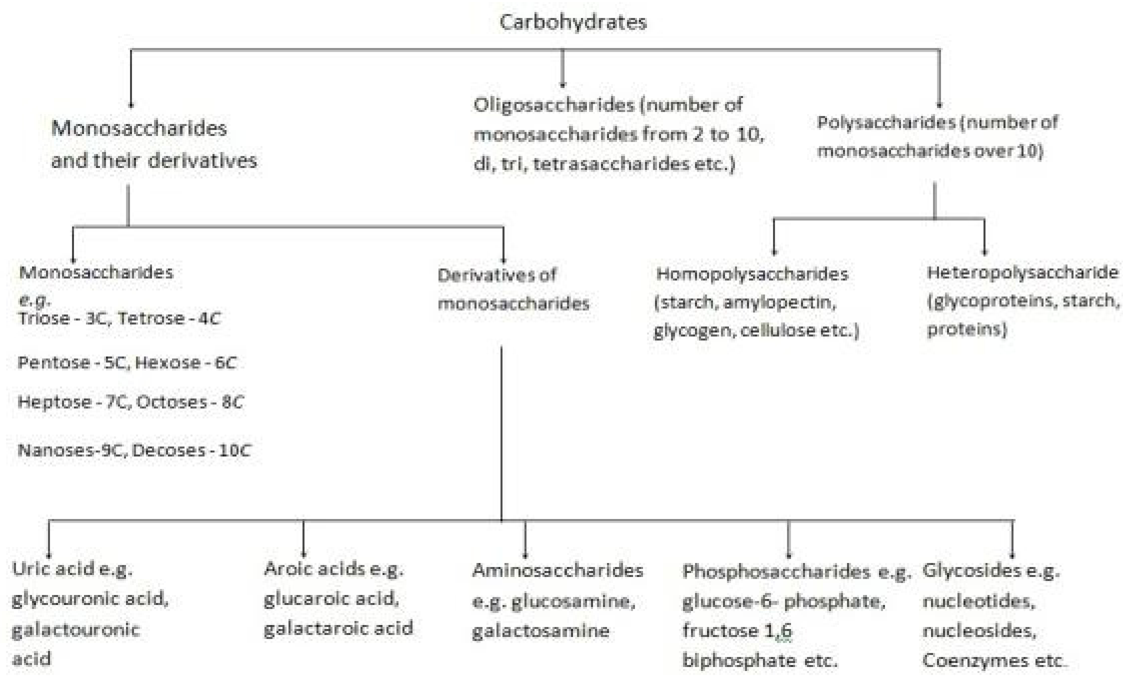
Plant cells use osmosis to absorb water from the soil and transport it to the leaves. Osmosis in the kidneys keeps the water and salt levels in the body and blood at the correct levels.

Carbohydrates:

(1) e.g. sugars, glycogen (animal starch), plant starch and cellulose.

(2) **Source of carbohydrate:** Mainly photosynthesis. It exists only in 1% but constitutes 80% of the dry weight of plants.

(3) **Composition:** It consists of carbon, hydrogen and oxygen in the ratio C_nH_2N. It is also called saccharide and sugars are their basic components.



(4) **Properties of monosaccharide**

(a) Monosaccharides are colourless, sweet tasting, solids.

(b) Due to asymmetric carbon, they exist in different isomeric forms. They can rotate polarized light hence they are dextrorotatory and leavorotatory.

(c) D-glucose after reduction gives rise to a mixture of polyhydroxy alcohol, sorbitol or mannitol.

(d) The sugars with a free aldehyde or ketone group reduce Cu^{++} to Cu^{+} (cupric to cuprous)

(e) Sugars show oxidation, esterification and fermentation.

(f) The aldehyde or ketone group of a simple sugar can join an alcoholic group of another organic compound bond C-O-C the process involves loss of water and is called condensation (H-O-H) or H+OH → H_2O.

Lipids

(1) Term lipid was coined by Bloor.

(2) These are esters of fatty acids and alcohol.

(3) They are hydrophobic insoluble in water but soluble in benzene, ether and chloroform.

(4) Lipids are classified into three groups:–

(A) **Simple lipids:** These are the esters of fatty acids and glycerol. Again they are typed as:–
(a) **Fats and Oils:** (Natural lipids or true fats). These are triglycerides of fatty acid and glycerol. Fats which are liquid at room temperature are called oils. Oils with polyunsaturated fatty acids are called polyunsaturated e.g. sunflower oil, lower blood cholesterol.
(b) **Fatty acids:** Obtained by hydrolysis of fats. Formic acid is simplest fatty acid (HCOOH). These are of 2 types:–
(i) Saturated fatty acids: The fatty acids which do not have double bond in between carbon atoms.e.g. butyric acid, palmitic acid,hexanoic acid, etc. They have high melting points, solid at room temperature and increase blood cholesterol.
(ii) Unsaturated fatty acids: The fatty acids which have double bonds in carbon atoms. e.g. 8 hexadecanoic acid, 9 octadecanoic acid etc. They have lower melting points mostly found in plant fats, liquid at room temperature and lower the blood cholesterol.
(c) **Waxes:** These are simple lipids composed of one molecule of long chain fatty acid and long chain monohydric alcohol. Waxes have high melting point, insoluble in water, resistant to atmospheric oxidation, chemically inert and not digested by enzymes. They reduce rate of transpiration by making plant tissue water proof and work as excellent lubricant.
(B) **Compound lipids:** They contain some additional or element. Group with fatty acid and alcohol on the basis of group they may be of following types:

(a) **Phospholipids:** These contain phosphoric acid. It helps in transport, metabolism, blood clotting and permeability of cell membrane. It is a bipolar molecule i.e. phosphate containing end is hydrophilic whereas fatty acid molecules represent hydrophobic (non-polar tail).
(b) **Glycolipids:** These contain nitrogen and carbohydrate beside fatty acids. Generally found in white matter of nervous system. *e.g.* sesocine frenocin.
(c) **Chromolipids :** It includes pigmented lipids *e.g.* carotene.
(d) **Aminolipids :** Also known as sulpholipids. It contains sulphur and amino acids with fatty acid and glycerol. Cutin and suberin are also compound lipids resistant to water and also provide mechanical support in plants.
(iii) **Derived lipids:** These are obtained by hydrolysis of simple and compound lipids.
(5) **Functions of lipids**

(a) Oxidation of lipids yields comparatively more energy in the cell than protein and carbohydrates. 1gm of lipids accounts for 39.1 KJ.

(b) The oil seeds such as groundnut, mustard, coconut store fats to provide nourishment to embryo during germination.

(c) They function as structural constituent i.e. all the membrane systems of the cell are made up of lipoproteins.

(d) Amphipathic lipids are emulsifier.

(e) It works as heat insulator.

(f) Used in synthesis of hormones.

(g) Fats provide solubility to vitamins A, D, E, and K.

Amino Acids

(1) Amino acids are normal components of cell proteins (called amino acid).

(2) They are 20 in number specified in genetic code and universal in viruses, prokaryotes and eukaryotes.

(3) **Structure and Composition :** Amino acids are basic units of protein and made up of C, H, O, N and sometimes S. Amino acids are organic acids with a carboxyl group (–COOH) and one amino group($-NH_2$) on the a -carbon atom. Carboxyl group attributes acidic properties and amino group gives basic ones. In solution, they serve as buffers and help to maintain pH. General formula is $R\text{-}CHNH_2.COOH$.
(4) **Classification**
Based on R-group of amino acids
(a) **Simple amino acids:** These have no functional group in the side chain. e.g. glycine, alanine , leucine, valine etc.
(b) **Hydroxy amino acids:** They have alcohol group in side chain. e.g. threonine, serine, etc.
(c) **Sulphur containing amino acids:** They have sulphur atom in side chain. e.g. methionine, cystenine.
(d) **Basic amino acids:** They have basic group ($-NH_2$) in side chain. e.g. lysine, arginine.
(e) **Acidic amino acids:** They have carboxyl group in side chain. e.g. aspartic acid, glutamic acid.
(f) **Acid amide amino acids:** These are the derivatives of acidic amino acids. In this group, one of the carboxyl group has been converted to amide ($-CONH_2$). e.g. asparagine, glutamine.
(g) **Heterocyclic amino acids:** These are the amino acids in which the side chain includes a ring involving at least one atom other than carbon. e.g. tryptophan, histidine.
(h) **Aromatic amino acids:** They have aromatic group (benzene ring) in the side chain. e.g. phenylalanine, tyrosine, etc.

Nucleotides:

(1) Structurally a nucleotide can be regarded as a phosphoester of a nucleoside.

(2) A combination of nitrogens base and a sugar is called nucleoside and combination of a base, a sugar and phosphate group is known as nucleotide.

Types of nitrogen base	Nucleoside	Nucleotide
Adenine	Adenosine	Adenylic acid
Guanine	Guanosine	Guanylic acid

Cytosine	Cytidine	Cytidilic acid
Thymine	Thymidine	Thymidylic acid
Uracil	Uridine	Uridylic acid

(3) **Functions of nucleotides:** Following are the major functions of nucleotides.

(a) **Formation of nucleic acids:** Different nucleotides polymerize together to form DNA and RNA.

(b) **Formation of energy carrier:** They help in formation of ATP,AMP, ADP, GDP, GTP, TDP,TTP, UDP, etc. which on breaking release energy.

(c) **Formation of Coenzymes:** Coenzymes like NAD, NADP, FMN, FAD, CoA, etc are formed. Coenzymes are non-proteinaceous substance necessory for the activity of the enzymes.

Ptroteins

(1) The word protein was coined by Berzelius in 1838 and was used by G. J. Mulder first time 1840.

(2) 15% of protoplasm is made up of protein. Average proteins contain 16% nitrogen, 50–55% carbon, oxygen 20–24%, hydrogen 7% and sulphur 0.3 – 0.5%. Iron, phosphorous, copper, calcium, and iodine are also present in small quantity.

(3) **Structure of proteins:** It is due to different rearrangement of amino acids. When carboxyl group of one amino acid binded with amino group (– NH_2) of another amino acid the bond is called peptide bond. A peptide may be dipeptide, tripeptide and polypeptide. The simplest protein is Insulin. According to Sanger (1953) insulin consists of 51 amino acids. A protein can have up to four level of conformation.

(i) **Primary structure:** The primary structure is the covalent connections of a protein. It refers to linear sequence, number and nature of amino acids bonded together with peptide bonds only. e.g. ribonuclease, insulin, haemoglobin, etc.

(ii) **Secondary structure:** The folding of a linear polypeptide chain into specific coiled structure (α - helix) is called secondary structure and if it is with intermolecular hydrogen bonds the structure is known as ß - pleated sheet. α - helical structure is found in protein of fur, keratin of hair claws, and feathers. ß - pleated structure is found in silk fibres.

(iii) **Tertiary structure:** The arrangement and interconnection of proteins into specific loops and bends is called tertiary structure of proteins. It is stabilized by hydrogen bond, ionic bond, hydrophobic bond and disulphide bonds. It is found in myoglobin (globular proteins).

(iv) **Quaternary structure:** It is shown by protein containing more than one peptide chain. The protein consists of identical units. It is known as homologous quaternary structure e.g. lactic dehydrogenase. If the units are dissimilar, it is called as heterogeneous quaternary structure e.g. hemoglobin which consists of two α - chains and two ß - chains.

Nucleic Acid

(1) **Definition:** Nucleic acids are the polymers of nucleotide made up of carbon, hydrogen, oxygen, nitrogen and phosphorus and which controls the basic functions of the cell.

(2) These were first reported by Friedrich Miescher (1871) from the nucleus of pus cell.

(3) Altmann called it first time as nucleic acid.

(4) They are found in nucleus. They help in transfer of genetic information.

(5) **Types of nucleic acids :** On the basis of nucleotides i.e. sugars, phosphates and nitrogenous bases, nucleic acids are of two types which are further subdivided. These are DNA (Deoxyribonucleic acid) and RNA (Ribonucleic acid).

(A) DNA (Deoxyribonucleic acids)

(i) **Types of DNA:** It may be linear or circular in eukaryotes and prokaryotes respectively.

(a) **Palindromic DNA:** The DNA helical bears nucleotide in a serial arrangement but opposite in two strands.

-T-T-A-A-C-G-T-T-A-A….

-A-A-T-T-G-C-A-A-T-T….

(b) **Repetitive DNA:** This type of arrangement is found near centromere of chromosome and is inert in RNA synthesis. The sequence of nitrogenous bases is repeated several times.

(c) **Satellite DNA:** It may have base pairs up to 11 – 60bp and are repetitive in nature. They are used in DNA matching or finger printing (Jefferey). In eukaryotes, DNA is deutrorotatory and sugars have pyranose configuration.

(B) RNA or Ribonucleic acid: RNA is second type of nucleic acid which is found in nucleus as well as in cytoplasm *i.e.* mitochondria, plastids, ribosomes etc. They carry the genetic information in some viruses. They are widely distributed in the cell.

BIOMOLECULES

Enzymes

- Enzymes (Gk. *en* = in; *zyme* = yeast) are proteinaceous substances which are capable of catalysing chemical reactions of biological origins without themselves undergoing any change.
- Enzymes are biocatalysts.
- An enzyme may be defined as "a protein that enhances the rate of biochemical reactions but does not affect the nature of final product."
- Maximum enzymes (70%) in the cell are found in mitochondrion. The study of the composition and function of the enzyme is known as **enzymology**.

Classification of Enzymes

CLASSIFICATION OF ENZYMES		
Group of Enzyme	**Reaction Catalysed**	**Examples**
1. Oxldoreductases	Transfer of hydrogen and oxygen atoms or electrons from one substrate to another.	Dehydrogenases Oxidases
2. Transferases	Transfer of a specific group (a phosphate or methyl etc.) from one substrate to another.	Transaminase Kinases
3. Hydrolases	Hydrolysis of a substrate.	Estrases Digestive enzymes
4. Isomerases	Change of the molecular form of the substrate.	Phospho hexo isomerase, Fumarase
5. Lyases	Nonhydrolytic removal of a group or addition of a group to a substrate.	Decarboxylases Aldolases
6. Ligases (Synthetases)	Joining of two molecules by the formation of new bonds.	Citric acid synthetase

Inorganic part of enzyme acts as prosthetic group in few enzyme they are called activator. These activators are generally metals. Hence these enzymes are called "Metallo enzyme" such as

S.No.	Activators	Enzymes
(1)	Iron (*Fe)*	Acotinase, Catalase and Cytochrome oxidase
(2)	Zinc (*Zn)*	Dehydrogenase, Carbonic andydrase
(3)	Copper (*Cu*)	Triosinase, Ascorbic acid oxidase
(4)	Magnesium (*Mg*)	Kinase, Phosphatase
(5)	Manganese (*Mn*)	Peptidase, Decarboxylase
(6)	Molybdenum (*Mo)*	Nitrate reductase
(7)	Nickel (*Ni*)	Urease
(8)	Boron	Enolase

Mode of Action of Enzymes

There are two views regarding the mode of enzyme action :

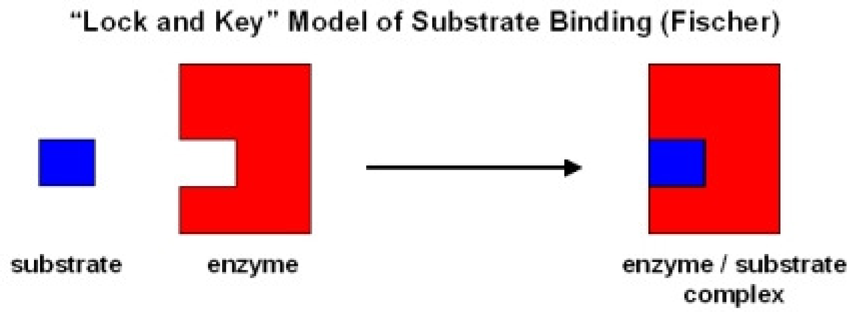
(1) Lock and key hypothesis

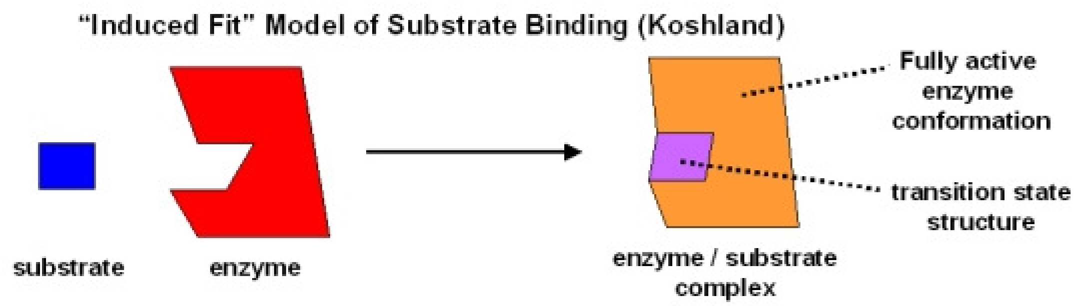
(2) Induced fit hypothesis

(1) **Lock and key hypothesis :** The hypothesis was put forward by Emil Fisher (1894) . According to this hypothesis the enzyme and its substrate have a complementary shape. The specific substrate molecules are bound to a specific site of the enzyme molecule.

(2) **Induced fit hypothesis :** This hypothesis was proposed by Daniel, E. Koshland (1959).

According to this view, the active sites of an enzyme are not rigid. When the substrate binds to enzyme, it may induce a change in shape of the enzyme molecule in such a way that it is fit for the substrate-enzyme interaction. The change in shape of the enzyme molecules can put strain on the substrate. This stress may help bonds to break, thus promoting the reaction.





Mineral Nutrition

(1) **Macronutrients (Macroelements or major elements):** Nutrients which are required by plants in larger amounts (Generally present in the plant tissues in concentrations of 1 to 10 *mg per* gram of dry matter).

(2) The macronutrients include carbon, hydrogen, oxygen, nitrogen, phosphorous, sulphur, potassium, calcium, magnesium.

(3) **Micronutrients (Microelements or minor elements or trace elements):** Nutrients which are required by plants in very small amounts, *i.e.,* in traces (equal to or less than 0.1 *mg* per gram dry matter).

(4) The micronutrients include iron, manganese, copper, molybdenum, zinc, boron and chlorine. Recent research has shown that some elements, such as cobalt, vanadium and nickel, may be essential for certain plants.

(5) The usual concentration of essential elements in higher plants according to D.W. Rains (1976) based on the data of Stout are as follows:

Element	% of dry weight
Carbon	45
Oxygen	45
Hydrogen	6
Nitrogen	1.5

Potassium	1.0
Calcium	0.5
Magnesium	0.2
Phosphorus	0.2
Sulphur	0.1
Chlorine	0.01
Iron	0.01
Manganese	0.005
Boron	0.002
Zinc	0.002
Copper	0.0001
Molybdenum	0.0001

Major Role of Nutrients

Various elements perform the following major role in the plants:

(1) **Construction of the plant body:** The elements particularly C, H and O construct the plant body by entering into the constitution of cell wall and protoplasm. They are, therefore, referred to as **frame work elements**. Besides, these (C, H and O) N, P and S also enter in the constitution of protoplasm. They are described as **protoplasmic elements**.

(2) **Maintenance of osmotic pressure:** Various minerals present in the cell sap in organic or inorganic form maintain the osmotic pressure of the cell.

(3) **Maintenance of permeability of cytomembranes:** The minerals, particularly Ca^{++}, K^{+} and Na^{+} maintain the permeability of cytomembranes.

(4) **Influence the pH of the cell sap:** Different cations and anions influence on the *pH* of the cell sap.

(5) **Catalysis of biochemical reaction:** Several elements particularly *Fe, Ca, Mg, Mn, Zn, Cu, Cl* act as metallic catalyst in biochemical reactions.

(6) **Toxic effects:** Minerals like *Cu, As,* etc. impart toxic effect on the protoplasm under specific conditions.

(7) **Balancing function:** Some minerals or their salts act against the harmful effect of the other nutrients, thus balancing each other.

Specific Role of Macronutrients

The role of different elements is described below:

(1) **Carbon, hydrogen and oxygen:** These three elements though cannot be categorized as mineral elements, are indispensible for plant growth. These are also called **'framework elements'**.

2) **Nitrogen:** Nitrogen is an essential constituent of proteins, nucleic acids, vitamins and many other organic molecules as chlorophyll. Nitrogen is also present in various hormones, coenzymes and ATP etc.

(i) **Deficiency symptoms:** The symptoms of nitrogen deficiency are as follows:

(a) Impaired growth
(b) Yellowing of leaves due to loss of chlorophyll, *i.e.*, **chlorosis**.
(c) Development of anthocyanin pigmentation in veins, sometimes in petioles and stems.
(d) Delayed or complete suppression of flowering and fruiting.

(3) **Phosphorus**

(a) Phosphorous is present abundantly in the growing and storage organs such as fruits and seeds. It promotes healthy root growth and fruit ripening by helping translocation of carbohydrates.
(i) **Deficiency symptoms**
(a) Leaves become dark green or purplish.
(b) Sometimes development of anthocyanin pigmentation occurs in veins which may become necrotic (**Necrosis** is defined as localised death of cells).
(c) Premature fall of leaves.

(4) **Sulphur**
(i) **Functions**
(a) Sulphur is a constituent of amino-acids like cystine, cysteine and methionine; vitamins like biotin and thiamine, and coenzyme A.
(ii) **Deficiency symptoms**
(b) Leaf tips and margins roll downwards and inwards *e.g.*, tobacco, tea and tomato.
(c) Premature leaf fall.
(d) Delayed flowering and fruiting.

(5) **Potassium**
(i) **Functions**
(a) It differs from all other macronutrients in **not being a constituent** of any metabolically important compound.
(b) It is the **only monovalent cation** essential for the plants.
(c) It acts as an activator of several enzymes including DNA polymerase.
(ii) **Deficiency symptoms**
(a) **Mottled chlorosis** followed by the development of necrotic areas at the tips and margins of the leaves.
(b) K^+ deficiency inhibits proteins synthesis and photosynthesis. At the same time, it increases the rate of respiration.
(c) The internodes become shorter and root system is adversely affected.

(6) **Calcium**

(i) **Functions**
(a) It is necessary for formation of middle lamella of plants where it occurs as calcium pectate.
(b) It is necessary for the growth of apical meristem and root hair formation.
(c) It acts as activator of several enzymes, *e.g.*, ATPase, succinic dehydrogenase, adenylate kinase, etc.
(ii) **Deficiency symptoms**
(a) Ultimate death of meristems which are found in shoot, leaf and root tips.
(b) Chlorosis along the margins of young leaves, later on they become necrotic.
(c) Distortion in leaf shape.

(7) **Magnesium**

(i) **Functions**

(a) It is an important constituent of **chlorophyll**.

(b) It is present in the **middle lamella** in the form of magnesium pectate.

(c) It plays an important role in the metabolism of carbohydrates, lipids and phosphorus.

(ii) Deficiency symptoms

(a) **Interveinal** chlorosis followed by anthocyanin pigmentation, eventually necrotic spots appears on the leaves. As magnesium is easily transported within the plant body, the deficiency symptoms first appear in the mature leaves followed by the younger leaves at a later stage.

(b) Stems become hard and woody, and turn yellowish green.

(c) Depression of internal **phloem** and extensive development of **chlorenchyma**.

Specific Role of Micronutrients

(1) **Iron**

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i) **Functions**

(a) Iron is a structural component of ferredoxin, flavoproteins, iron prophyrin proteins (Cytochromes, peroxidases, catalases, etc.)

(b) It plays important roles in energy conversion reactions of photosynthesis (phosphorylation) and respiration.

(c) It acts as activator of nitrate reductase and aconitase.

(ii) **Deficiency symptoms**

(a) Chlorosis particularly in younger leaves, the mature leaves remain unaffected.

(b) It inhibits chloroplast formation due to inhibition of protein synthesis.

(c) Stalks remain short and slender.

(2) **Manganese**

(i) **Functions**

(a) It acts as activator of enzymes of respiration (malic dehydrogenase and oxalosuccinic decarboxylase) and nitrogen metabolism (nitrite reductase).

(b) It is essential for the synthesis of chlorophyll.

(c) It is required in photosynthesis during photolysis of water.

(ii) **Deficiency symptoms:**

(a) Chlorosis (interveinal) and necrosis of leaves.

(b) Chloroplasts lose chlorophyll, turn yellow green, vacuolated and finally perish.

(c) Root system is poorly developed.

(d) Formation of grains is badly affected.

(3) **Copper**

(i) **Functions**

(a) It activates many enzymes and is a component of phenolases, ascorbic acid oxidase, tyrosinase, cytochrome oxidase.

(b) Copper is a constituent of plastocyanin, hence plays a role in photo-phosphorylation.

(c) It also maintains carbohydrate nitrogen balance.

(ii) **Deficiency symptoms**

(a) Both vegetative and reproductive growth are reduced.

(b) The most common symptoms of copper deficiency include a disease of fruit trees called '**exanthema**' in which trees start yielding gums on bark and '**reclamation of crop plants**', found in cereals and legumes.

(c) It also causes necrosis of the tip of the young leaves (*e.g., Citrus*). The disease is called **'die back'**.

(4) **Molybdenum**

(i) **Functions**

(a) Its most important function is in nitrogen fixation because it is an activator of **nitrate reductase**.

(b) It is required for the synthesis of ascorbic acid.

(c) It acts as activator of some dehydrogenases and phosphatases.

(ii) **Deficiency symptoms**

(a) Mottled chlorosis is caused in the older leaves as in nitrogen deficiency, but unlike nitrogen-deficient plants, the cotyledons stay healthy and green.

(b) It is also known to inhibit flowering, if they develop, they fall before fruit setting.

(c) It leads to drop in concentration of ascorbic acid.

(5) **Zinc**

(i) **Functions**

(a) It is required for the synthesis of tryptophan which is a precursor of indole acetic acid-an auxin.

(b) It is a constituent of enzymes like carbonic anhydrase, hexokinase, alcohol dehydroge-nase, lactic dehydrogenase and carboxypeptidase.

(c) It is required for metabolism of phosphorus and carbohydrates.

(6) **Boron**

(i) **Functions**

(a) It facilitates the translocation of sugars.

(b) It is involved in the formation of pectin.

(c) It is also required for flowering, fruiting, and photosynthesis and nitrogen metabolism.

(7) **Chlorine**

(i) Functions

(a) It is required for photolysis of water during photosynthesis in photosystem-II.

(b) In tobacco, it increases water volume inside the cell and also regulates carbohydrate metabolism.

(c) With Na+ and K+, chlorine helps in determining solute concentration and anion cation balance in the cells.

DIGESTION AND NUTRITON

Process of conversion of complex food substances to simple absorbable forms is called digestion.

(ii) Intracellular: When the process of digestion occurs within the cell in the food vacuole.

Examples:

Protozoa, Porifera, Coelenterata and free living Platyhelminthes

(iii) Extracellular: When the process of digestion occurs outside the cell, **Examples:** Coelenterates and phylum Platyhelminthes to phylum Chordata.

(iv) Digestion in vertebrates occurs in the digestive tract or alimentary canal. The various parts involved in digestion can be broadly grouped in two groups –

(1) Digestive tract or alimentary canal

(2) Digestive glands

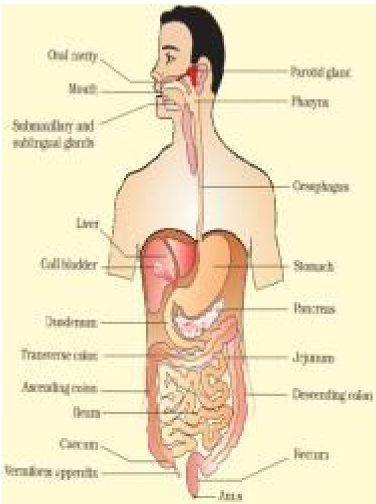
On the basis of the embryonic origin, the alimentary canal of vertebrates can be divided into three parts–

(1) Fore gut / Stomodaeum: Ectodermal. It includes buccal cavity / oral cavity, pharynx, oesophagus, stomach and small part of duodenum.
(2) Mid gut/Mesodaeum: Endodermal. It includes small intestine, and large intestine.
(3) Hind gut/Proctodaeum:

Ectodermal. It includes anal canal and anus.

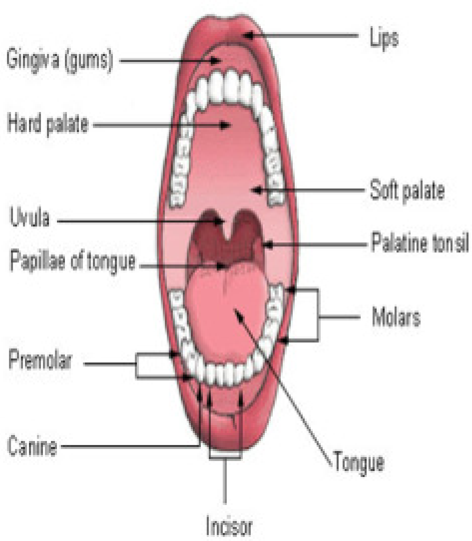
Human Digestive System

The human digestive system is a complex series of organs and glands that processes food. It converts ingested food so that it can be assimilated by the organism. The human digestive system consists of following parts:-



Mouth

Mouth is also known as the oral cavity or buccal cavity. It is the first portion of the alimentary canal. Food and saliva are received by mouth. Mouth has inner lining of mucous membrane epithelium.



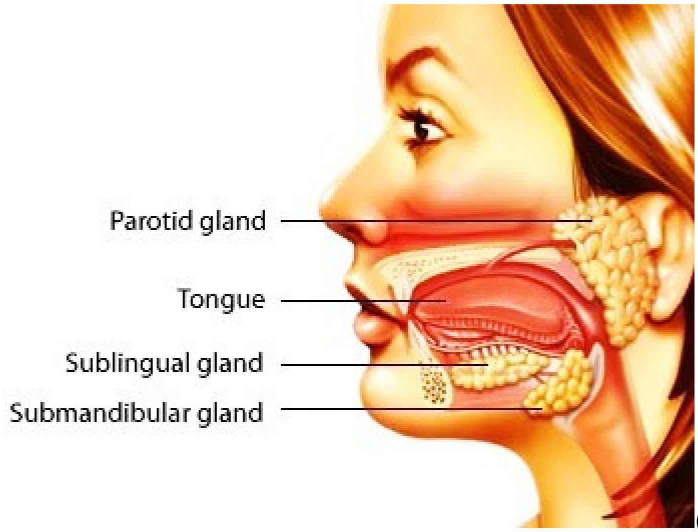
Digestive Glands: –

(A) Salivary glands:-

(i) These are the exocrine glands that produce saliva.

(ii) These are the glands with ducts which also secrete amylase.

(iii) Amylase is an enzyme that breaks down starch into maltose.



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iv) **Three types of salivary glands are: -**

1)Parotid gland

2)Submandibular gland

3) Sublingual gland

(B) Gastric glands:-

(i) The gastric glands (fundic gland) secrete acids and digestive enzymes.

(ii) Secretion of gastric gland is called gastric juice.

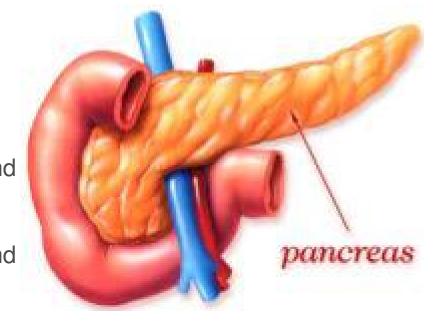
(iii) There are approximately 35 million gastric glands present in human stomach.

(C) Intestinal glands:-

(i) Intestinal glands in maamals is a collective name for **crypts of Liberkuhn** (secretes alkaline enzymatic juice) and **Brunner's glands** (secrete mucous).

(ii) Intestinal glands secrete **intestinal juice** or **sucus entericus.**

(D) Pancreas:-



(i) Pancreas has two different kind of tissue- exocrine and endocrine.

(ii) Pancreatic secretion is stimulated by **cholecystokinin** and **secretin** both.

(iii) Complete digestive juice is pancreatic juice as it contains amylolytic, lipolytic and proteolytic enzymes.

(iv) It produces several important hormones like insulin, glucagon, somatostatin and pancreatic polypeptide.

(E) Liver:-

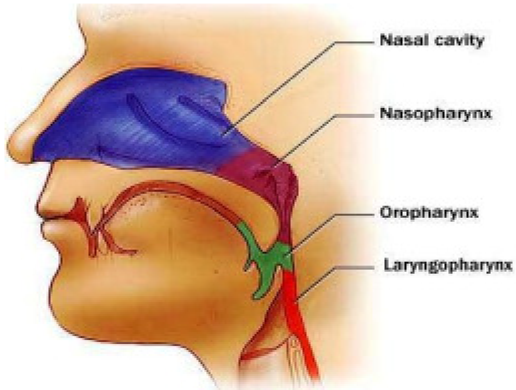
(i) Liver is the **largest digestive gland of the body,** weighing about 1.2 to 1.5 Kg in an adult human.

(ii) It is situated in the abdominal cavity, just below the diaphragm and has two lobes (small left and large right lobe).

(iii) The liver has a wide range of functions to perform in the body:

a) It detoxifies various metabolites

b) It helps in protein synthesis.



c) various biochemical necessary for digestion are produced by liver.

Pharynx: -

It is the opening of oral and nasal cavities. **It is classified as: -**

1) Nasopharynx

2) Oropharynx

3) Laryngopharynx

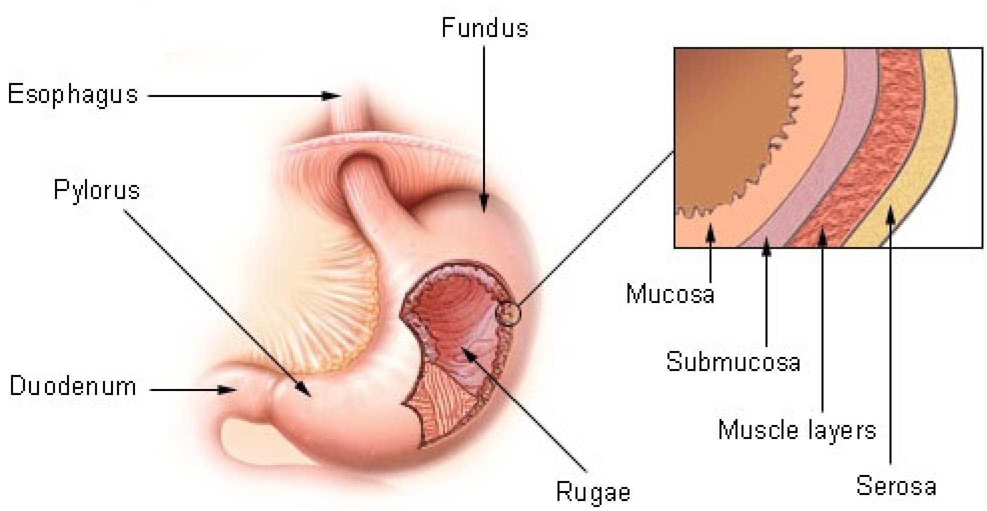
Oesophagus: -

Oesophagus connects pharynx with stomach.

Opening of oesophagus is regulated by **gastro-oesophageal sphincter.**

Stomach: -

It is a J-shaped, muscular, hollow and dilated part of the digestive system. It is located between the oesophagus and the small intestine. It has 1 liter capacity. It secretes protein-digesting enzymes (proteases) and strong acids which aid in food digestion.



The stomach has three parts:

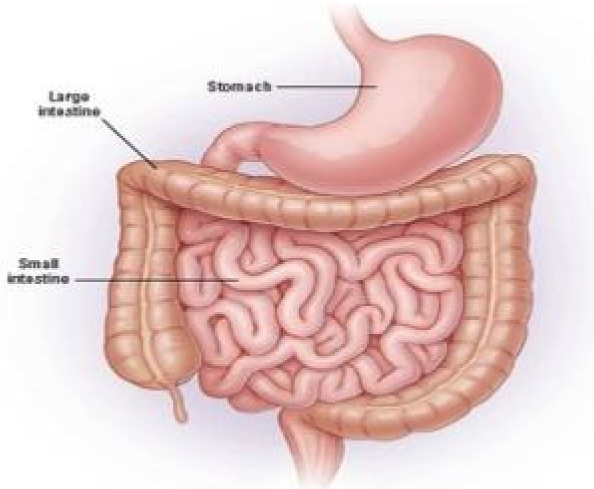
Cardiac: The part of the stomach into which oesophagus opens.

Fundus: It is the air filled portion of stomach.

Pyloric: The portion of the stomach that opens into the small intestine.

Small Intestine:-

(i) It is the part of the gastrointestinal tract that comes after the stomach and is followed by the large intestine.



II)Small intestine distinguished into three parts:

(a) **Duodenum:** It is 'U' shaped first part of the small intestine.
(b) **Jejunum:** It is the longer, coiled middle portion.
(c) **Ileum:** Ileum is the highly coiled posterior part of the small intestine.

Large Intestine: –

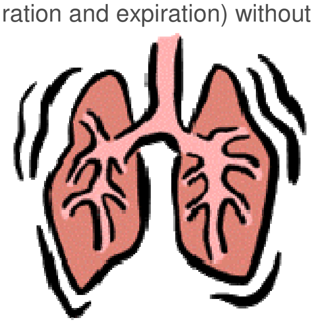
Large intestine consists of three parts:
(a) Caecum: It is a small blind sac. **Vermiform appendix** is a finger-like blind tubular projection of caecum.
(b) Colon: The Caecum opens into colon. Colon has three distinct parts-
- Ascending colon
- Transverse colon
- Descending colon
(c) Rectum: It is the final straight portion of the large intestine.

Breathing and Exchange of Gases

Pulmonary Volumes and Capacities

There are following respiratory volumes and capacity:

(i) **Tidal volume (TV)**: It is volume of air normally inspired or expired in one breath (i.e. inspiration and expiration) without any extra



effort. It is about 500 ml in normal healthy adult. In infants it is 15 ml and in fetus it is 0 ml.
(ii) **Inspiratory reserve volume (IRV) :** By taking a very deep breath, you can inspire a good deal more than 500 ml. This additional inhaled air, called IRV is about 3000 ml.
(iii) **Expiratory reserve volume (ERV) :** If you inhale normally & then exhale as forcibly as possible, you should be able to push out 1200 ml of air in addition to 500ml. of T.V. The extra 1200 ml is called ERV.
(iv) **Residual volume (RV):** Even after expiratory reserve volume is expelled, considerable air remains in the lung, this volume, which cannot be measured by spirometry, and it is called residual volume is about 1200 ml.
(v) **Dead space**: Portion of tracheobronchial tree where gaseous exchange does not occur is called dead space. It is also called conductive zone. Dead space is 150 ml.

(vi) **Functional residual capacity (FRC):** It is the amount of air that remains in the lungs after a normal expiration. It is about 2300 ml.

FRC = ERV + RV

= 1100 + 1200 = 2300 ml.

(vii) **Vital capacity (VC):** This is the maximum amount of air that can be expired forcefully from his lungs after first filling these with a maximum deep inspiration. It is about 4600 ml.

VC = IRV + TV + ERV

= 3000+500+1100 = 4600 ml.

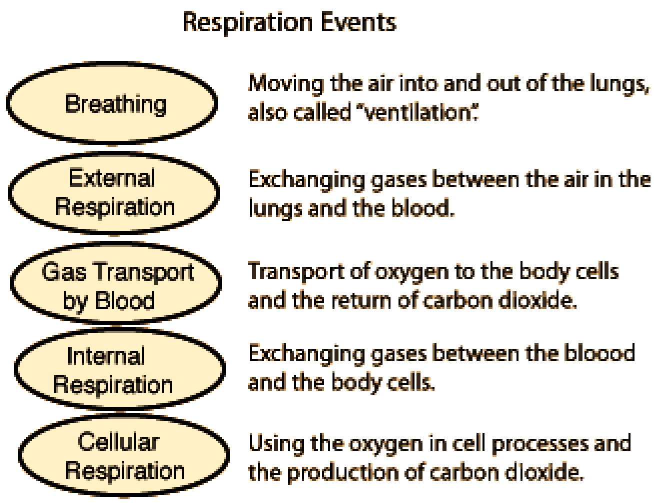
(viii) **Total lung capacity (TLC):** TLC is the sum of vital capacity (VC) and residual volume (RV). It is about 5800ml.

TLC = VC + RV

= 4600 + 1200 = 5800 ml.

(ix) **Inspiratory capacity (IC):** It is the total amount of air a person can inspire by maximum distension of his lungs.

I.C. = TV + IRV



= 500 + 3000 = 3500 ml.

Process of Respiration

The process of respiration is completed in 4 steps:

(i) Breathing or ventilation

(ii) Exchange of gases or External respiration

(iii) Transport of gases

(iv) Cellular respiration

(i) Ventilation or breathing:

Breathing is movement of thorax, expansion (inflation) and deflation of lungs and flow of air into the lungs and from the lungs. It is extracellular, energy consuming and physical process. Sum of inspiration and expiration is called respiratory movement. There are two steps of breathing:

(a) **Inspiration:** Intake of fresh air in lungs from outside. It is an active process. Blood pressure increases during later part of respiration.

(b) **Expiration:** Out flow of the air from the lungs is called expiration. When expiration occurs, the inspiratory muscles relax. As the external intercostal relax, ribs move inferiorly and as the diaphragm relaxes, its dome moves superiorly owing to its elasticity.

(c) **Mechanism of ventilation/breathing:**

Inspiration

Enlargement of thoracic cavity due to action of muscles of inspiration

↓

Lungs follow the enlargement of thoracic cavity and expand.

↓

Expansion of lungs leads to reduction of air pressure within the lungs than the atmospheric pressure.

↓

Air from the outside, where pressure of air is high, comes inside the lungs.

↓

At the top point of inspiration contraction of inspiratory muscles suddenly stops. — Impulses from CNS

↓

Expiration

Inspiratory muscles relax and also due to elastic recoil, lungs shrink.

↓

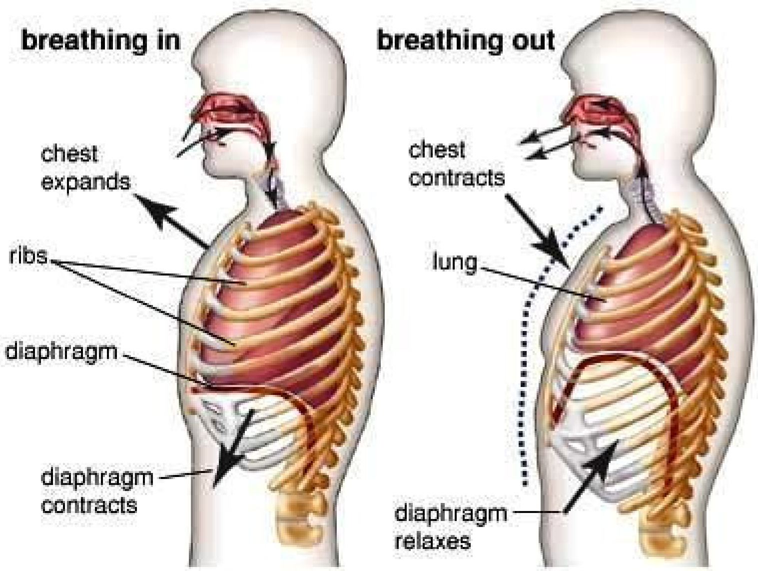
Air pressure within lungs exceeds atmospheric air pressure.

↓

Air is expelled out into the atmosphere.

(ii) **Exchange of gases:**

(a) **Exchange of gases in lungs:** It is also called external respiration. In this gaseous exchange oxygen passes from alveoli to pulmonary capillary blood and CO_2. Comes to alveoli from pulmonary capillary.



(2) **Release of CO_2 by the blood:** The P_{CO_2} (partial pressure of carbon dioxide) of blood reaching the alveolar capillaries is higher than the P_{CO_2} of alveolar air. Therefore, carbon dioxide diffuses from the blood of alveolar capillaries into the alveolar air.

(b) **Exchange of gases in tissues:** In the tissues, exchange of gases occurs between the blood and the tissue cells. This exchange occurs via tissue fluid that bathes the tissue cells. The blood reaching the tissue capillaries has P_{O_2} higher than that in the tissue cells and P_{CO_2} lower than that in the tissue cells.

(iii) **Transport of gases:** Blood carries O2 from respiratory organs to the tissue cells for oxidation and CO2 from tissue cells to respiratory organs for elimination. Blood should be slightly alkaline to help the transport of O2 and CO2 properly.

Difference between breathing and respiration

Breathing (Ventilation)	**Respiration**
It is a physical process.	It is a biochemical process.
It is simply an intake of fresh air and removal of foul air.	It involves exchange of gases and oxidation of food.
No energy is released rather used.	Energy is released that is stored in ATP.

It occurs outside the cells, hence it is an extra-cellular process.	It occurs inside the cells, hence it is an intra-cellular process.
No enzymes are involved in the process.	A large number of enzymes are involved in the process.
Breathing mechanism varies in different animals.	Respiratory mechanism is similar in all animals.
It is confined to certain organs only.	It occurs in all living cells of the body.

Partial pressures of respiratory gases in mm Hg

Gas	Inspired air	Alveolar air	Venous blood	Arterial blood	Expired air	Tissue cells
Oxygen	158	100 – 105	40	95 – 100	116	20 – 40
Carbon dioxide	0.3	40	46	40	32	45 – 52
Nitrogen	596	573	573	573	565	–

Composition of three samples of air

Gases	Inspired air	Expired air	Alveolar air	Gain / loss %
Oxygen	20.84%	15.70%	13.6%	Gain 5.14%
Carbon dioxide	0.04%	4.00%	5.3%	Loss 3.96%
Nitrogen	78.62%	74.50%	74.9%	Gain 4.12%
Water	0.5%	6.2%	6.2%	Loss 5.7%

For the control of respiration following respiratory centres are found in hind brain

Type of centre	Location	Function
Inspiratory centre	Medulla oblongata	Inspiration (2 second active condition)
Respiratory centre	Medulla oblongata	Expiration (3 second inactive condition)
Apneustic centre	Pons	Slow and deep inspiration
Pneumotaxic centre	Pons	Control other centres and produce normal quite breathing
Gasping centre	Pons	Sudden and shallow respiration

Oxygen content: Total volume of O2 in 100 *ml.* of whole blood *i.e.* volume of O2 in physical solution form and oxyhaemoglobin form. It is equal to 19.7 + 0.3 = 20 *ml* of oxygen.

Oxygen capacity: Maximal amount of O2 that can be held by the blood at 760 *mm Hg* pressure and 37^{0}C. Oxygen capacity is about 20 *ml*/100 *ml.*

Body Fluids and Circulation

Circulatory System

This system is concerned with the circulation of body fluids to distribute various substances to various body parts. **The circulatory system is also known as the cardiovascular system.** It is an organ system that allows blood to circulate and transport nutrients (such as electrolytes and amino acids), oxygen, carbon dioxide, hormones, and blood cells. These are circulated to and from cells in the body to nourish it. The components of the human circulatory system include the heart, blood, red and white blood cells, platelets, and the lymphatic system.

Functions of Circulatory System

(1) Transport of various substances such as nutrients, waste products, respiratory gases, metabolic intermediates (Such as lactic acid from muscle to liver), and vitamins hormones etc.

(2) Regulation of body pH by means of buffer, body temperature homeostasis, water balance etc.

(3) Prevention of disease by means of antibodies and antitoxins.

(4) Support or turgidity to certain organs like penis and nipples.

Differences between open and closed circulatory system

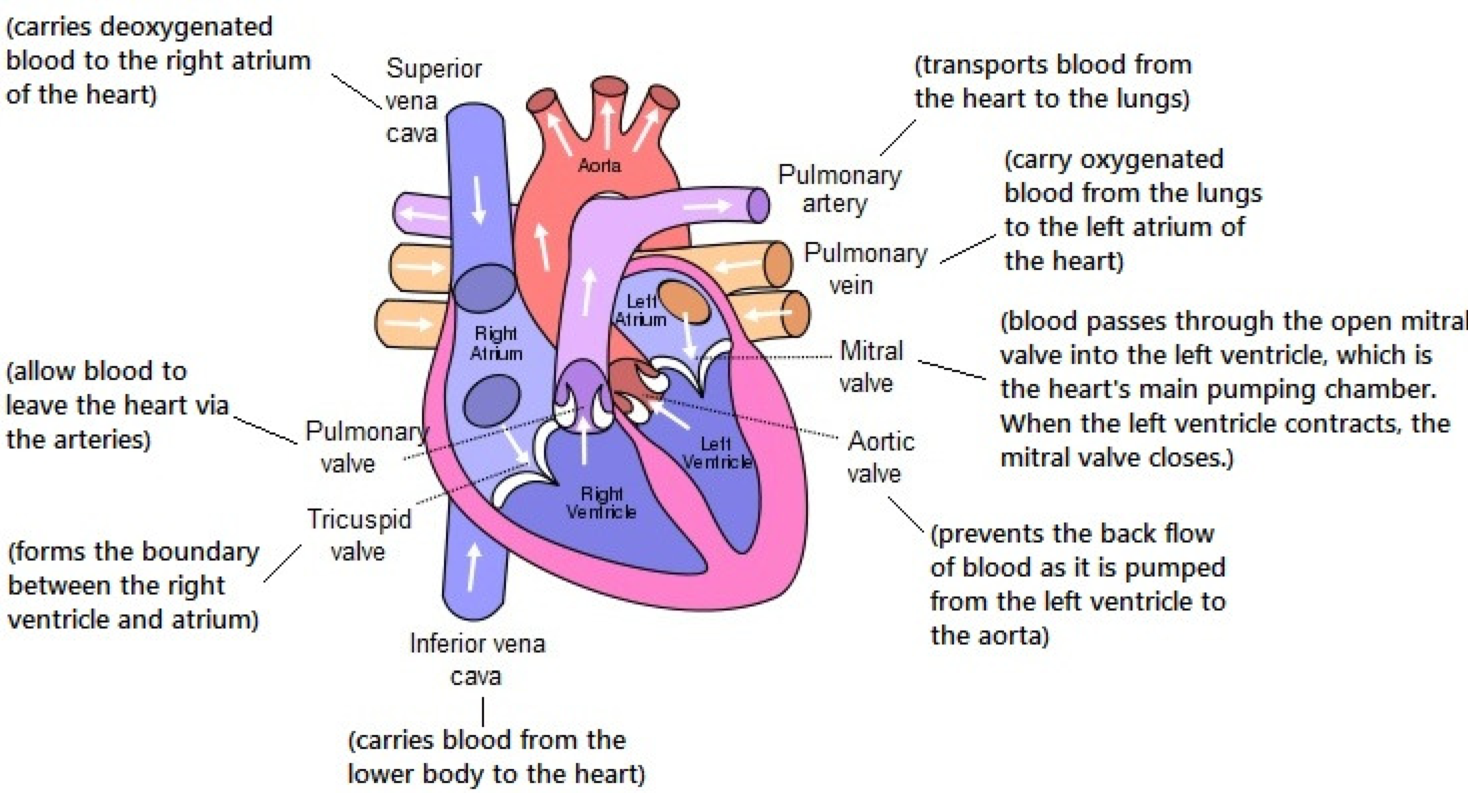
Open circulatory system	Closed circulatory system
(1) In open circulatory system blood flows through large open spaces and channels called lacunae and sinuses among the tissues.	(1) In closed circulatory system blood flows through a closed system of chambers called heart and blood vessels.
(2) Tissues are in direct contact with the blood.	(2) Blood does not come in direct contact with tissue.
(3) Blood flow is very slow and blood has very low pressure.	(3) Blood flow is quite rapid and blood has a high pressure.
(4) Exchange of gases and nutrients takes place directly between blood and tissues.	(4) Nutrients and gases pass through the capillary wall to the tissue fluid from where they are passed on to the tissues.
(5) Less efficient as volume of blood flowing through a tissue cannot be controlled as blood flows out in open space.	(5) More efficient as volume of blood can be regulated by the contraction and relaxation of the smooth muscles of the blood vessels.
(6) Open circulatory system is found in higher invertebrates like most arthropods such as prawn, insects, etc., and in some molluscs.	(6) closed circulatory system is found in echinoderms, some molluscs, annelids and all vertebrates.
(7) Respiratory pigment, if present, is dissolved in plasma; RBCs are not present.	(7) Respiratory pigment is present and may be dissolved in plasma but is usually held in RBCs.

Heart of vertebrates

Class of vertebrates	Characteristics	Example
(1) Pisces (= Branchial heart)	Thick, muscular, made of cardiac muscles, has two chambers (i) auricle and (ii) ventricle. The heart is called venous heart since it pumps deoxygenated blood to gills for oxygenation. This blood goes directly from gills to visceral organs (single circuit circulation). A sinus venosus and conus arteriosus is present. Lung fishes have 2 auricles and 1 ventricle.	Labeo Scoliodon Neoceratodus
(2) Amphibians	**Heart consists of** (a) Two auricles (b) Undivided ventricle (c) Sinus venosus (d) Truncus arteriosus (conus + proximal part of aorta) Right auricle receives blood from all the visceral organs (deoxygenated) via precaval and post caval. Pulmonary artery carries deoxygenated blood to lungs for oxygenation. This blood returns to left auricle via	Frog Toad

	pulmonary vein (Double circuit circulation)	
(3) Reptiles	**Heart consists of :** (a) Left and right auricle (b) Incompletely divided ventricle (Ventricle in crocodiles gavialis and alligator is completely divided) (c) Sinus venosus (d) Conus arteriosus divided into right systemic, left systemic and pulmonary arch.	Lizards Snakes Turtles
(4) Aves	**Heart consists of** (a) Left and right auricle (b) Left and right ventricle (c) Complete separation of arterial and venous circulation (d) Only right systemic arch is present (e) Sinus venosus and truncus arterisious absent	Pigeon
(5) Mammals	Same as bird except that mammals have left systemic arch.	Rabbit, man

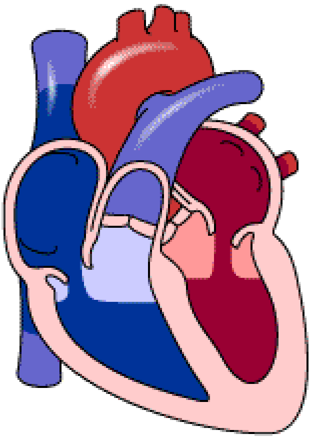
Human Heart



Circulation of Blood through Heart

(1) The heart pumps blood to all parts of the body.

(2) The deoxygenated blood is drained into right auricle through superior and inferior vena cava and coronary sinus whereas the pulmonary veins carry oxygenated blood from lungs to the left auricle. This is called as Auricular circulation.



(3) About 70% of the auricular blood passes into the ventricles during diastole. This phase is called diastasis.

(4) The rest of 30% of blood passes into the ventricles due to auricular systole (contraction).

(5) In this way, blood reaches the ventricles and is called ventricular filling.

(6) During ventricular systole (which starts first in left ventricle than in right ventricle), the pressure increases in the ventricles, thus, forcing the oxygenated blood from left ventricle into systemic aorta and deoxygenated blood from right ventricle into pulmonary aorta.

(7) The systemic arch distributes the oxygenated blood to all the body parts except lungs while pulmonary aorta carries the deoxygenated blood to lungs for oxygenation.

Differences between Neurogenic heart and Myogenic heart

Neurogenic heart	Myogenic heart
(1) The heart beat is initiated by a ganglion situated near the heart.	(1) The heart beat is initiated by a patch of modified heart muscle.
(2) The impulse of contraction originates from nervous system.	(2) The impulse of contraction originates itself in the heart.
(3) The heart normally stops beating immediately after removal from the body. Therefore, heart transplantation is not possible.	(3) The heart removed from the body continues to beat for some time. Therefore, heart transplantation is possible.
(4) Examples: Hearts of some annelids and most arthropods.	(4) Examples: Hearts of molluscs and vertebrates.

Fractions of cardiac output :

Amount of pure blood going to an organ per minute is called as fraction of the organ.

(i) Cardiac fraction – 200 ml/min.

(ii) Hepatic fraction – 1500 ml/min. (28% of blood as liver is the busiest organ of body and has maximum power of regeneration).

(iii) Renal fraction – 1300 ml/min (25% of blood)

(iv) Myofraction – 600-900 ml/min.

(v) Cephalic organs – 700-800 ml/min.

Differences between first and seconds heart sounds

First heart sound (Lubb)	Second heart sound (Dup)

(1) It is produced by closure of bicuspid and tricuspid valves at the start of ventricular systole.	(1) It is produced by closure of semilunar valves at the start of ventricular diastole.
(2) It is low pitched, less loud and of long duration.	(2) It is higher pitched, louder, sharper and of short duration.
(3) It lasts for 0.15 seconds.	(3) It lasts for 0.1 second.
(4) Its principal frequencies are 25 to 45 cycles per second.	(4) Its principal frequency is 50 cycles per second.

Electrocardiogram (ECG)

(1) A graphic record of electrical events occurring during a cardiac cycle is called Electrocardiogram.

(i) Depolarisation waves: They represent the generation of the potential difference. These waves appear only when both electrodes of galvanometer are in different fields. When both the electrodes are in same field, there are no deflection and wave drops down to base line.

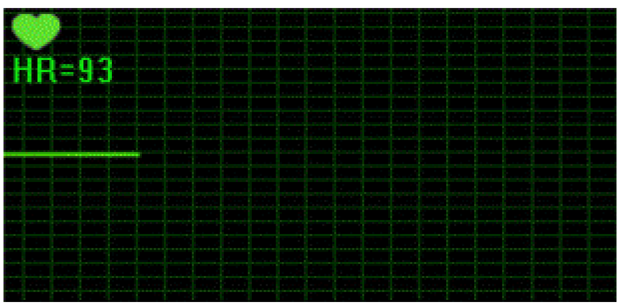
(ii) Repolarisation waves: They appear when depolarisation is over and the muscle fibre is returning to its original polarity. When both electrodes are in same polarity (means 100% repolarisation and 100% depolarisation), there is no deflection.

(a) *P* wave: Indicates impulse of contraction generated by S.A. node and its spread in atria causing atrial depolarisation. The interval *PQ* represents atrial contraction and takes 0.1 second.

(b) QRS complex: Indicates spread of impulse of contraction from A.V node to the wall of ventricles through bundle of His and pukinje fibres causing ventricular depolarisation. This complex also represents repolarization of S.A. node.

The RS of *QRS* wave and *ST* interval show ventricular contraction (0.3 seconds). QRS is related to ventricular systole.

(c) *T* wave: Indicates repolarisation during ventricular relaxation.



Types of Blood Circulation in Human

The physiology of blood circulation was first described by Sir William Harvey in 1628. The blood circulation in our body is divisible into 3 circuits –

(i) Coronary circulation: It involves blood supply to the heart wall and also drainage of the heart wall.

(a) Coronary arteries: One pair, arising from the aortic arch just above the semilunar valves. They break up into capillaries to supply oxygenated blood to the heart wall.

(b) Coronary veins: Numerous, collecting deoxygenated blood from the heart wall and drains it into right auricle through coronary sinus which is formed by joining of most of the coronary veins.

(ii) Pulmonary circulation: It includes circulation between heart and lungs. The right ventricle pumps deoxygenated blood into a single, thick vessel called pulmonary aorta which ascends upward and outside heart gets divided into longer, right and shorter, left pulmonary arteries running to the respective lungs where oxygenation of blood takes place.

(iii) Systemic circulation: In this, circulation of blood occurs between heart and body organs. The left ventricle pumps the oxygenated blood into systemic arch which supplies it to the body organs other than lungs through a number of arteries.

Lympahtic System

The lymphatic system is an extension of the circulatory system. It consists of a fluid known as lymph, lymph capillaries and lymph ducts.

(a) **Lymph:** It can be defined as blood minus RBC's. In addition to the blood vascular system all vertebrate possess a lymphatic system. It is colourless or yellowish fluid present in the lymph vessels. It is a mobile connective tissue like blood and is formed by the filtration of blood.

(b) **Lymph capillaries:** Small, thin, lined by endothelium resting on a basement membrane and fine whose one end is blind and other end unites to form lymphatic ducts.

(c) **Lymphatic ducts or vessels:** Numerous, present in various parts of body. These vessels are like veins as they have all the three layers – tunica externa, tunica media and tunica interna, and are provided with watch pocket or semilunar valves but valves are more in number than veins.

Differences between lymph and blood

S.No.	Characters	Blood	Lymph
(1)	RBC	Present	Absent
(2)	Blood platelets	Present	Absent
(3)	WBC	Persent, generally 7000/*cu mm*	Persent, generally 500-75000/*cu mm*
(4)	Plasma	Present	Present
(5)	Albumin : globulin	Albumin > Globulin	Albumin > Globulin
(6)	Fibrinogen	More	Less
(7)	Coagulation property	More	Less
(8)	Direction of flow	Two way, heart to tissues and tissues to heart	One way, tissues to heart
(9)	Rate of flow	Fast	Slow
(10)	Glucose, urea and CO_2	Less	More

PLANT GROWTH

Abscission : Shedding of plant organs like leaves, flowers and fruits etc. from the mature plant.

Apical dominance : Suppression of the growth of lateral buds in presence of apical bud.

Dormancy : A period of suspended activity and growth usually associated with low metabolic rate.

Photoperiodism : Response of plant to the relative length of day and night period to induce flowering.

Phytochrome : A pigment, which control the light dependent developmental process.

Phytohormone : Chemicals secreted by plants in minute quantities which influence the physiological activities.

Senescene : The last phase of growth when metabolic activities decrease.

Vernalisation : A method of promoting flowering by exposing the young plant to low temperature.

Growth : An irreversible permanent increase in size of an organ or its parts or even of an individual. Abbreviations IAA Indole acetic acid NAA Naphthalene acetic acid ABA Abscissic acid IBA Indole-3 butyric acid 2.4D 2.4 dichlorophenoxy acetic acid PGR Plant growth regulator

Measurement of growth : Plant growth can be measured by a variety of parameters like increase in fresh weight, dry weight, length, area, volume and cell number.

Phases of growth : The period of growth is generally divided into three phases, namely, meristamatic, elongation and maturation.
(i) Meristematic zone : New cell produced by metotic division at root-tip and shoot tip thereby show increase in size. Cells are rich in protoplasm and nuclei.
(ii) Elongation zone : Zone of elongation lies just behind the meristematic zone and concerned with enlargement of cells.
(iii) Maturation zone : The portion lies proximal to the phase of elongation. The cells of this zone attain their maximum size in terms of wall thickning and protoplasmic modification.

Growth rate : The increased growth per unit time is termed as growth rate. The growth rate shows an increase that may be arithmetic or geometrical.

Differentiation : A biochemical or morphological change in meristemic cell (at root apex and shoot apex) to differentiate into permanent cell is called differentiation.

Dedifferentiation : The phenomenon of regeneration of permanent tissue to become meristematic is called dedifferentiation.

Redifferentiation : Meristems/tissue are able to produces new cells that once again lose the capacity to divide but mature to perform specific functions.

PHYTO HORMONE OR PLANT GROWTH-REGULATOR

Growth promoting hormones : These are involved in growth promoting activities such as cell division, cell enlargement, flowering, fruiting and seed formation. e.g., Auxin, gibberellins, cytokinins. Growth inhibitor : Involved in growth inhibiting activities such as dormancy and abscission. e.g., Abscisic acid and Ethylene.

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