Biology

Target : Pre-Medical

Study Material for PRE-MEDICAL
(Distance Learning Programme)

Chapter # 05

STRUCTURAL ORGANISTION IN ANIMALS
(ANIMAL TISSUES & COCKROACH)

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STRUCTURAL ORGANISATION IN ANIMALS

ANIMAL TISSUES

Tissue : A group of cells in which cells are similar in structure, function and origin is called tissue. Group of similar cells along with intercellular substance perform a specific function such organisation is called tissue. But in a tissue, cells may be dissimilar in structure and function but they are always similar in origin.

Organ : Tissues are organised in specific proportion and pattern to form organ.

Organ system : When two or more organ perform common function by their physical &/or chemical interaction, they together form organ system.

Division of labour: Cell, tissue, organs and organ systems splits up the work in a way that they exhibit division of labour.

On the basis of functions & structure tissues are of four types :

1. **Epithelium/Epithelial Tissue :** Covering & protective tissue.
2. **Connective Tissue –** To connect structures, provide support to the body and transport substances in the body.
3. **Muscular Tissue –** Helps in contraction & locomotion.
4. **Nervous tissue –** To generate and conduct nerve impulses in body.

HISTORICAL BACKGROUND

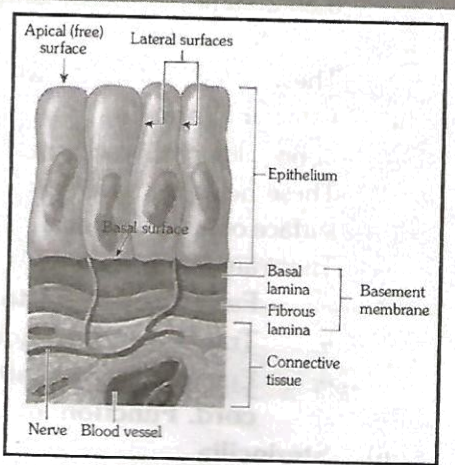
- Word Epithelium was given by – **Ruysch**
- Word animal tissue was coined by – **Bichat** (Plant tissue by - Grew).
- Study of tissue – **Histology.**
- Histology word was given by – **Mayer**
- Father of Histology – **Bichat**
- Detail study of tissue is called **Microscopic anatomy.**
- Founder of microscopic anatomy – **Marcello Malpighi**

EPITHELIUM TISSUE

1. During embryonic development epithelium orginates first.
2. Power of regeneration is present in this tissue while power of regeneration is absent or least power is found in nervous tissue.
3. This tissue faces either a body fluid or outside environment and thus provide a covering or a lining.
4. Word epithelium is composed of two words.

   Epi – Upon **Thelia – growth**

   A tissue which grows upon another tissue is called Epithelium.
5. It always rest upon underlaying connective tissue. Epithelium is the only tissue in which cells are always arranged in uniform layer. Epithelium cells are compactly packed with little intercellular matrix.



6. Due to absence of intercellular spaces blood vessels, lymph vessels & capillaries are unable to pierce this tissue so blood circulation is absent in epithelium. Hence cells depend for their nutrients on underlying connective tissue.
7. **Basement membrane :** Between epithelium and connective tissue, a thin non living acellular basement membrane is present which is highly permeable. Basement membrane consist of 2 layers.
   (a) **Basal lamina :** Towards epithelium and it is made up of glycoprotein, which is secreted by epithelium cells.
   (b) **Fibrous lamina :** Towards connective tissue, in which collagen and reticular fibres are suspended in mucopolysaccharide which is matrix of connective tissue. Mucopolysaccharide is present in the form of Hyaluronic acid.

So basement membrane is secreted by both epithelium and connective tissue.

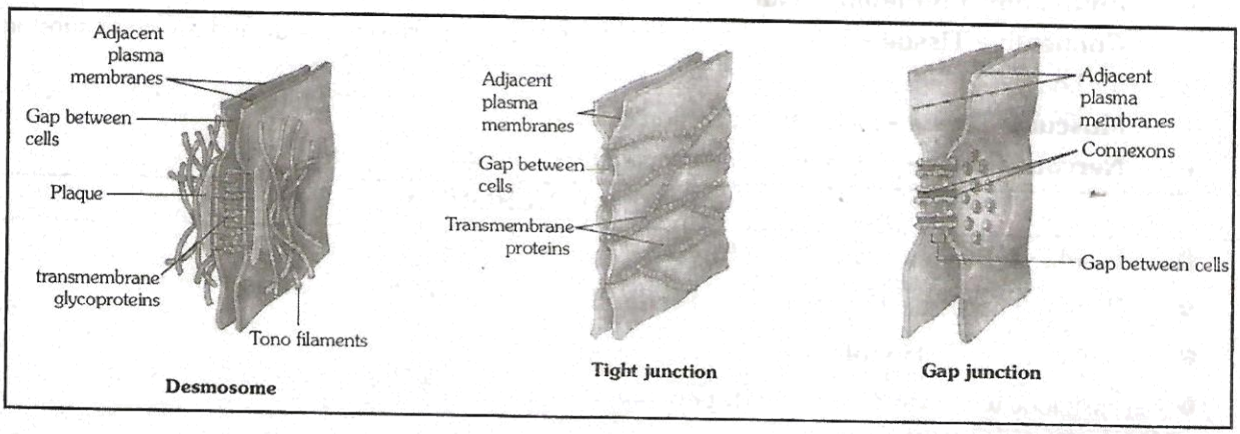
8. **Intercellular junction :** To provide both structural and functional link between its individual cell epithelial cells modify to form following structures (Intercellular Junctions) :

(i) **Interdigitation –** Finger like processes of plasma membrane which enter into cytoplasm of adjacent cell. These structures are mainly found in **transitional epithelium**.

(ii) ***Adhering / Desmosomes –*** This type of (Macula Adherens) Junction consists of disc - like protein plate with intermediate fibre known as tonofibrils composed of keratin like protein. These filaments are deeply situated in the cytoplasm of respective cell. These structures provide mechanical support to **stratified epithelium** or performing cementing to keep neighbouring cell together. e.g. Stratified epithelium

(iii) **Tight Junction –** At some places plasma membrane of adjacent cells become fused to form tight junction to stop substances from leaking across a tissue. These structures are mostly found in **columnar epithelium**.

(iv) **Gap Junction –** Faciliate the cells to communicate with each other by connecting cytoplasm of adjoining cells for rapid transfer of ions, small molecules and sometimes big molecules.



9. **Functional modification of plasma membrane of free end :**

(i) Microvilli

1. These are minute process which are non motile, non contractile. They increase surface area by more than 20 times.
2. They help in absorption, secretion and excretion.

These are present in the **wall of Intestine, Gall bladder, Proximal convoluted tubule etc.**

(ii) Cilia or Kinocilia

1. Long cylindrical process, those are motile and contractile.
2. These helps in movement of particles or mucus in a specific direction. Mainly present in the inner surface of hollow organs.
3. These are found in

e.g. – **Fallopian tube. Uterus (Cilia is only present in patches).**
– **Trachea and Bronchioles**
– **Ependymal epithelium : (Inner lining of ventricles of brain and central canal of spinal cord. Function of cilia is to conduct substances in CSF.)**

(iii) Steriocilia

(i) Long process those are non motile and non contractile.
(ii) Its plasma membrane is thick and rigid.
(iii) They increase surface area and found in

eg. – **Epididymis** – **Vasa deferens**

Origin of Epithelium Tissue

It is the only tissue which originated from all the three primordial germinal layers.

eg. (i) **Ectodermal –** Epidermis (stratified squamous Epithelium)
(ii) **Mesodermal –** Mesothelium (simple squamous Epithelium)
(iii) **Endodermal –** Inner living of gut (simple columnar Epithelium)

BEGINNER'S BOX-1

1. Epithelial tissue origined from :-
(1) Ectoderm (2) Endoderm (3) Mesoderm (4) All of these

2. Basement membrane is composed of :-
(1) Hyaluronic Acid + glycoproteins (2) Only mucopolysacharides
(3) Endodermal cells (4) Epidermal cells

3. Stereocilia present in :-
(1) Epididymis (2) Seminal vesicle (3) Ureter (4) Kidney

4. Lining of brain ventricle & central canal of spinal cord is lined by :-
(1) Ependyma epithelium (2) Endothelium
(3) Mesothelium (4) Neurosensory

5. Desmosomes :-
(1) Connect the Epithelial cells (2) are types of lysosomes
(3) are granules of muscle fibres (4) Found in Bone

6. Ciliated Epithelium found in :-
(1) Oviduct (2) Trachea (3) Brain ventricles (4) All of these

7. Gap junctions :-
(1) help to stop substances from leaking across a tissue.
(2) perform cementing to keep neighbouring cells together
(3) provide stretchability to the epithelium
(4) facilitate the cells to communicate with each other by connecting the cytoplasm of adjoining cells.

8. Condition necessary for the formation of organ system :
(1) presence of all four basic type of tissues (2) Chemical interaction
(3) Physical interaction (4) All of these

9. Tissue which provide support to the body is :
(1) Epithelial tissue (2) Connective tissue (3) Muscular tissue (4) Nervous tissue

10. Intercellular junction which helps in exchange of substances is :
(1) Tight junction (2) Gap junction (3) Interdigitation (4) Desmosome

CLASSIFICATION OF EPITHELIUM TISSUE

Types of Epithelium Tissue

On the basis of number of cell layers

Simple epithelium
- Composed of single layer of cells
- Functions as lining for body cavities, ducts and tubes

Compound epithelium
- Consists of 2 or more cell layers
- It has protective function as it does in our skin

On the bssis of shape / structural modifications of cells

(1) Simple Squamous (2) Simple Cuboidal (3) Simple Columnar (4) Pseudostratified

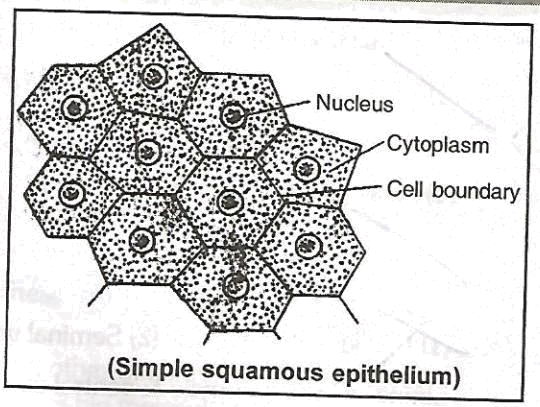
SIMPLE EPITHELIUM TISSUE

1. Simple Squamous epithelium

(i) Single layer of flat, scale like cell with irregular boundries.

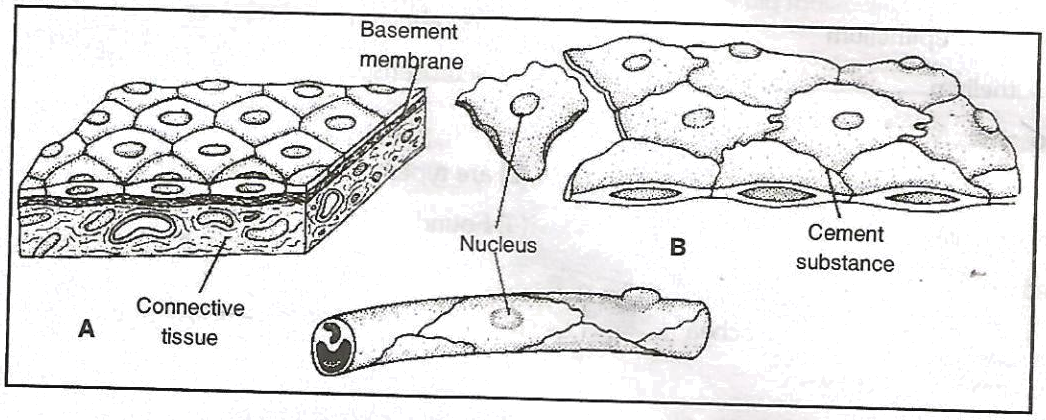
(ii) It is also called **pavement epithelium** due to its tile like appearance.

(iii) It is also called **Tesselated epithelium** due to its wavy appearance.



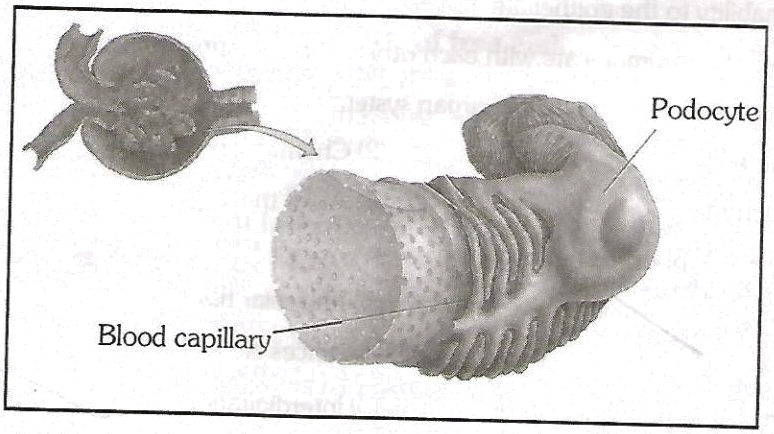
(Simple squamous epithelium)

Functions :

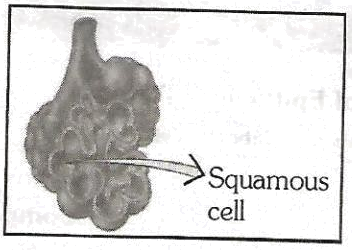


eg. It is found in the lining of :

- **Bowman's capsule (Podocyte)**



- **Alveoli of lungs (Pneumocytes).**



- Mesothelium – Covering of coelom is called as mesothelium.(Tesselated). (Visceral & Parietal peritonium, Visceral and parietal pleura, Visceral and Parietal pericardium).
- Endothelium – Inner lining of blood vessels and lymph vessels. (Tesselated)
- Inner lining of heart wall (Tesselated).

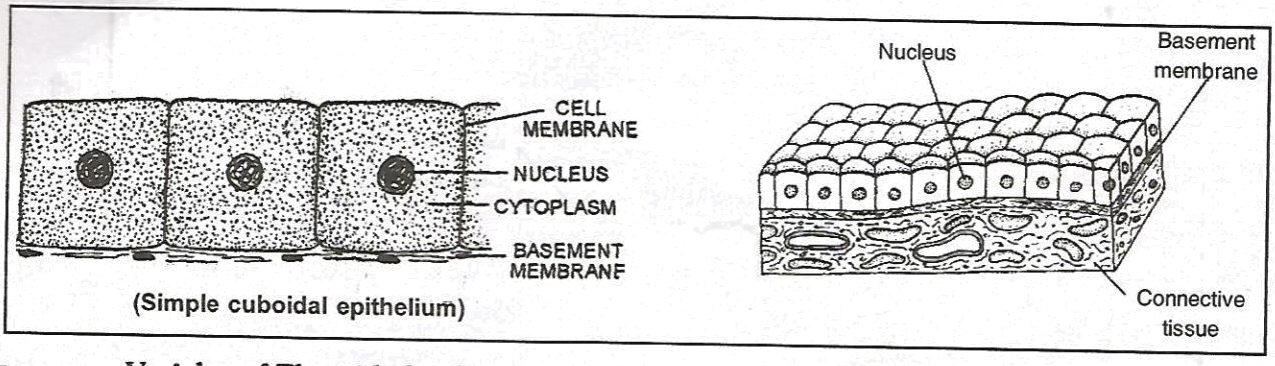
2. Simple Cuboidal Epithelium

(i) Cells are cube like in shape.

(ii) This epithelium is also called **Germinal epthelium** because in gonads (testis & ovaries) cubodial cells divide to form egg & sperm.

Functions :

This epithelium helps in absorption, secretion & excretion.



(Simple cuboidal epithelium)

Eg.
- **Vesicles of Thyroid gland**
- **Acini of Pancreas**
- **Sweat glands**
- **Iris, Choroid, Ciliary body of eye**
- **Tubular part of Nephrons**

Modifications of simple cuboidal epithelium

(i) **Brush bordered cuboidal epithelium :** When microvilli are present on free end of cuboidal cells then it is called as brush bordered cuboidal epithelium. It is found in **PCT of nephron**.

(ii) **Ciliated cuboidal epithelium :** When cilia present on free end of cuboidal cells then it is called as ciliated cuboidal epithelium. It is found in **neck of the nephron** and in **collecting duct**.

3. Simple columnar Epithelium

(i) Cells are pillar like in shape. (Tall and Slender)

(ii) Elongated nucleus is present at the base of cell.

Function : It helps in absorption and secretion.

eg. **Bile Duct, Liver**

Modifications of Simple Columnar epithelium

(a) Brush Bordered Columnar epithelium :

When microvilli are present on free end of columnar epithelium.

e.g. **Gall bladder**

(b) Glandular columnar epithelium :

Unicellular mucous secreting **goblet cells** are also present in between columnar cells.

eg. **Stomach, Colon, Rectum**

(c) Glandular Brushbordered columnar epithelium :

When microvilli present on free end of columnar cells and in between these cells goblet cells are also present.

eg. **Duodenum and Ileum**

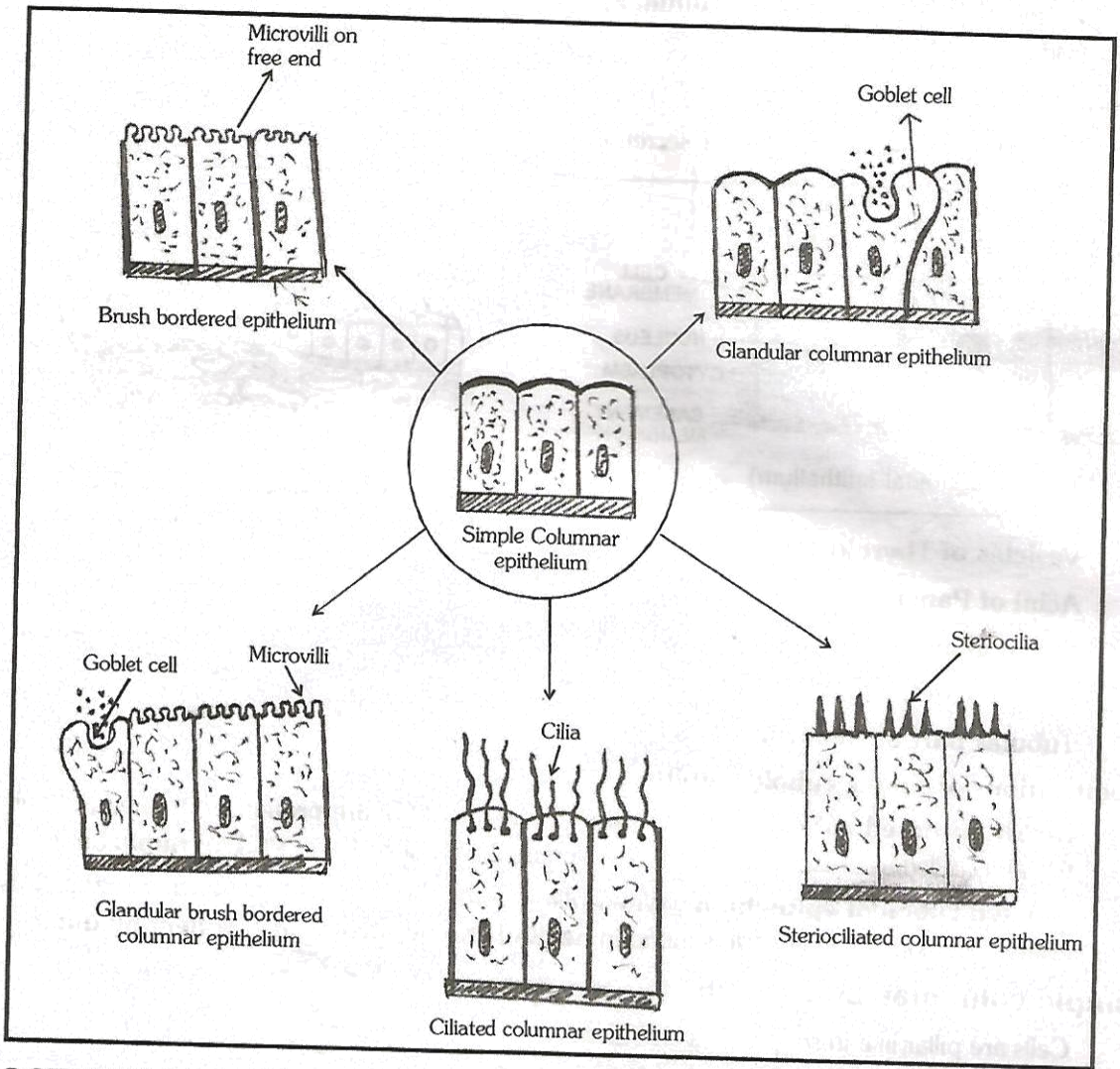
(d) Ciliated Columnar epithelium :

When cilia are present on free end of columnar cells.

Eg. **Fallopian Tube** and **Ependymal epithelium of brain ventricles**

(e) **Sterio ciliated columnar epithelium** : When steriocilia are present on free end of columnar cells.

Eg. **Epididymis** and **Vasa deferens**

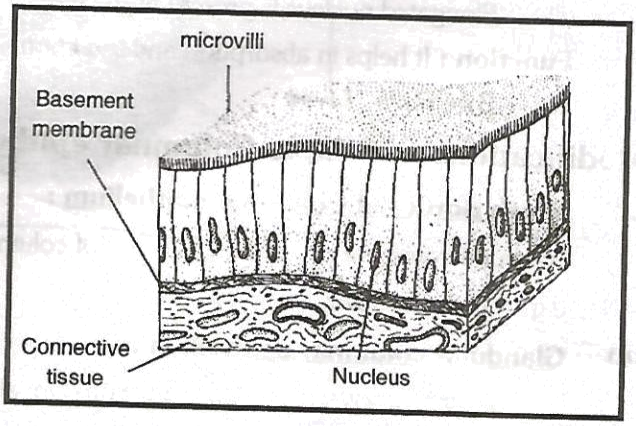


PSEUDOSTRATIFIED EPITHELIUM

(i) These cells are pillar like in shape so it is also a modification of columnar epithelum.

(ii) In this epithelium two types of cells are present i.e.Long cells, Short cells.

(iii) Nucleus in both cells are present on different level so it appears bilayered because few cells are too short to reach the top surface.But all cells are present on single basement membrane so it is unilayered.



Pseudostratified ciliated columnar glandular epithelium [PSCCGE] :

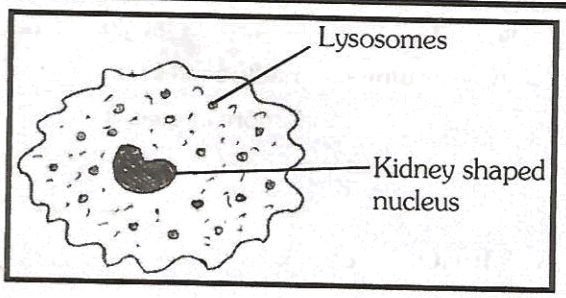
In this epithelium cillia are present of free end of long cells and goblet cells are also present in this epithelium.

eg. **Trachea**

Bronchioles

Respiratory epithelium of nasal chambers.

2. MACROPHAGES (HISTEOCYTE)



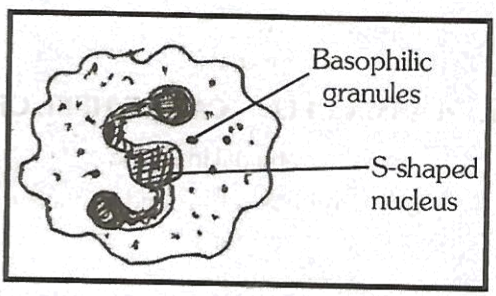
(i) Amoeboid in shape with bean (Reniform) or kidney shaped nucleus.

(ii) Cytoplasm quantity is more and cytoplasm is agranular but due to presence of more number of lysosome it appears granular.

(iii) They are phagocytic in nature. They destroy bacteria & viruses by phagocytosis.

(iv) Also called as **scavenger cells** of connective tissue because they destroy dead or damaged cells to clean connective tissue.

3. MAST CELLS (MASTOCYTES)



(i) Amoeboidal in shape.

(ii) These are like basophils of blood in structure and function.

(iii) In these cells 'S' shaped nucleus is present which is divided into 2 or 3 lobes.

(iv) In their cytoplasm basophilic granules are present which can be stained with basic dye Methylene Blue.

(v) It is important cell of connective tissue proper as they perform important functions.

(a) Histamine :- Histamine is a amino acid derivative. It is a vasodilator which dilate blood vessels and increase blood circulation in affected area.

(i) It also increase permeability of blood capillaries.

(ii) When allergic substance enter into body mast cell stimulate and secrete histamine so a part of blood comes out from blood capillaries with WBC and accumulate in intercellular spaces. This part of blood is called as **exudate** which causes swelling in affected area. This swelling is red, warm & painful. This type of swelling is called **inflammation**.

(b) Serotonin :-

(i) It is also called as 5–hydroxy tryptamine.

(ii) It is a amino acid derivative. It is a vasoconstrictor. It constricts vessels & decrease blood circulation.

(iii) At the site of cut or injury mast cell secrate serotonin which decrease high blood loss.

(c) Heparin :- Heparin is a mucopolysaccharide. It is a natural anti coagulant. It prevents clotting of blood in uninjured blood vessels. (Prevent the conversion of prothrombin into thrombin.)

(d) Matrix is also synthesized by Mast cells.

4. ADIPOSE CELLS

(i) Oval shaped cells which stores fat.

(ii) Fat is collected in the form of fat globule. Fat globule is formed by the fusion of small oil droplets.

(iii) On the basis of number of fat globules adipocytes are of two types.

(a) Monolocular adipocytes :

(i) In these cells single large and central fat globule is present.

(ii) Nucleus and cytoplasm is peripheral and cytoplosm is less in amount.

(iii) Due to compression of fat globule, nucleus become flattened in shape. These adipocytes form **white fat.**

(b) Multilocular adipocytes :- In these cells many small fat globules are distributed in the cytoplasm around nucleus

(i) Cytoplasm is more in quantity.

(ii) Nucleus is rounded & found in the centre.

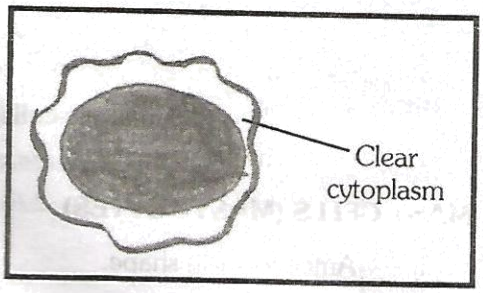
(iii) These adipocytes form **brown fat.** Brown colour is due to the presence of Cytochrome pigment.

5. LYMPHOCYTES

(i) Amoeboidal in shape with a large nucleus and cytoplasm is present as peripheral layer. Cytoplasm quantity is less.

(ii) It's function is to produce, transport & secretes antibodies.

(iii) They divide to form plasma cells of connective tissue proper.

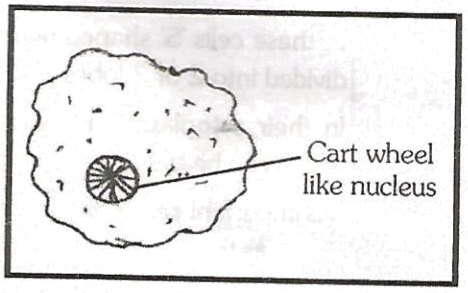


6. PLASMA CELL :- CART WHEEL CELL

(i) Amoeboidal in shape.

(ii) In these cells rounded nucleus is present in which chromatin material is arranged like spokes (radial rows) in a wheel so they are also called as **Cart wheel cells.**

(iii) According to scientists these cells are formed by the division of lymphocytes. So they are also called as **clone of lymphocytes.**



Function : To produce, Secrete & transport of antibody.

(B) FIBRES

I. Collagen fibres (White fibres)

1. They are bright & white fibres composed of collagen protein.
2. It is present in maximum quantity in vertebrates and only collagen fibres constitutes one third part of connective tissue fibres.
3. They are wavy & tough fibres always arranged in bundle. Bundle is called fascia.
4. On boiling they convert into gelatin.

II. Elastic fibres — (Yellow fibres)

1. They are yellow in colour and composed of elastin protein.
2. They are branched fibres but always arranged singly. Branches of these fibres form network.
3. In these fibres maximum elasticity is present.
4. They are highly resistant to chemicals.
5. When boiled they do not dissolve.

III. Reticular Fibres :-

1. Also known as arzyrophil fibre since they can be stained with silver salts.
2. They are composed of reticulin protein.
3. They are highly branched fibres which always form dense network.
4. They are delicate fibres. Elesticity is completely absent.
5. These are mainly distributed in lymphoid organs like spleen or lymph nodes

(C) MATRIX (Ground substance)

– Matrix is compsed of mucopolysaccharide (modified polysaccharide) which is present in the form of hyaluronic acid.

BEGINNER'S BOX-2

1. Pseudostratified epithelium is present in :-
(1) Nephron & Neuron
(2) Larynx & Pharynx
(3) Trachea & Bronchi
(4) Urinary Bladder & Intestine

2. Transitional Epithelium is found in :-
(1) Renal pelvis & Ureter
(2) Urinary bladder
(3) Upper part of male urethra
(4) All of above

3. Columnar Epithelium with microvilli or Brush Border is present in :-
(1) Gall Bladder
(2) Stomach
(3) Appendix
(4) Pharynx

4. The internal lining of blood vessels is called as :-
(1) Mesothelium
(2) Endothelium
(3) Pavement Epithelium
(4) Stratified Epithelium

5. Which of the following tissue covers moist surface of buccal cavity and pharynx?
(1) Cuboidal epithelium
(2) Columnar epithelium
(3) Transitional epithelium
(4) Compound epithelium

6. Non keratinised stratified squamous epithelium is found in :-
(1) Skin
(2) Stomach
(3) Oesophagus
(4) Intestine

7. Inner lining of gut, stomach & liver is made up of :-
(1) Simple squamous
(2) Simple cuboidal
(3) Simple columnar
(4) Pseudo stratified epithelium.

8. Cells of Peritoneum comprise :-
(1) Ciliated Epithelium
(2) Glandular Epthelium
(3) Columnar Epithelium
(4) Squamous Epithelium

9. Stratified squamous Epithelium :-
(1) Outer most layer squamous & Inner most is cuboidal
(2) Outer most layer cuboidal & Inner most is squamous
(3) Outer most layer columnar & Inner most is cuboidal
(4) Outer most layer cuboidal & Inner most is columar

10. The correct statement with respect to epithelial tissue is :-
A – cells are compactly packed
B – cells have no intercellular matrix
C – cells have little intracellular material
D – it is single or multilayered
(1) A & D
(2) B & C
(3) A, C & D
(4) All of these

CONNECTIVE TISSUE

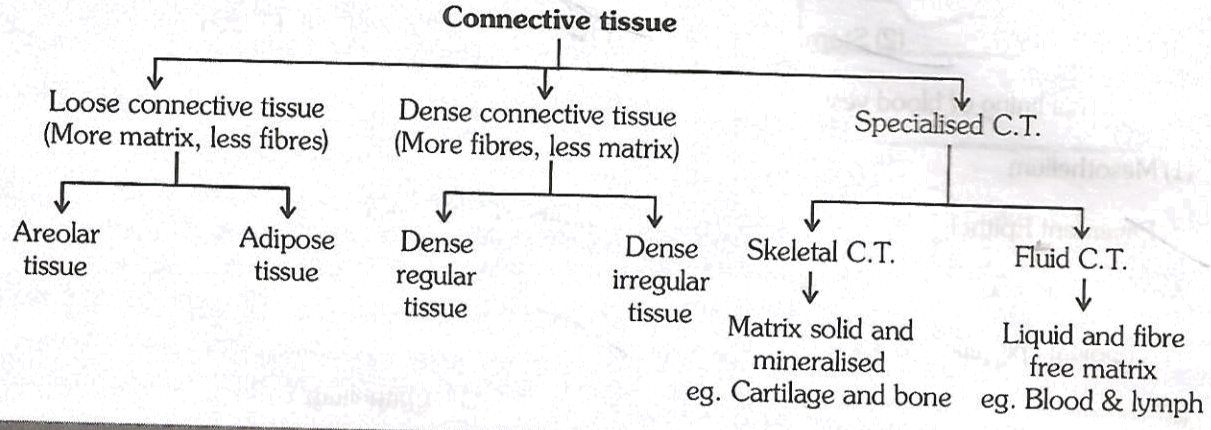
(i) O. Hartwig called them **Mesenchyme** because they originated from embryonic mesoderm

(ii) It is most abundant and widely distributed for linking and supporting.

(iii) On the basis of **matrix** connective tissue is of 3 types.

1. **Connective Tissue Proper :-** Matrix soft and fibrous
2. **Connective Tissue Skeleton :-** Dense and mineralised matrix. Due to deposition of minerals it becomes hard.
3. **Connective tissue Vascular :-** Liquid and fibres free matrix.

In all connective tissue except blood, cells secretes fibres of structural protein (like collagen & elastin) and matrix.



CONNECTIVE TISSUE PROPER

Connective Tissue Proper is composed of three components

(A) Defferent types of cells.

(B) Fibres.

(C) Matrix.

(A) CELLS OF CONNECTIVE TISSUE PROPER

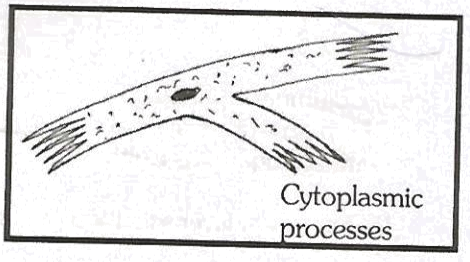
1. FIBROBLAST CELLS

(i) Largest cell of connective tissue proper.

(ii) Maximum in number.

(iii) Branched cytoplasmic process arise from these cells so they appear irregular in shape.

(iv) Main function or primary function of these cells is to produces fibres. Fibres are composed of protein.



(v) They also synthesize most part of matrix of connective Tissue. (Chief matrix producing cell)

(vi) Old fibroblast cells (fibrocyte) are inactive cells and synthesize only little part of matrix.

(vii) Fibroblast cells are also considered as undifferentiated cells of connective tissue because they can be modified into **Osteoblast** & **Chondrioblast** cells to produce bone & cartilage.

Function : (1) To produce fibres (2) To secrete matrix

B. On the basis of nature of secretion :- 3 types of glands are there

(1) **Acrine/Merocrine gland :-** In these glands secretory cells secrete substances by simple diffusion (Exocytosis). No part of cytoplasm is destroyed in secretion.

Eg. **Sweat glands, Goblet cells, Salivary gland,**

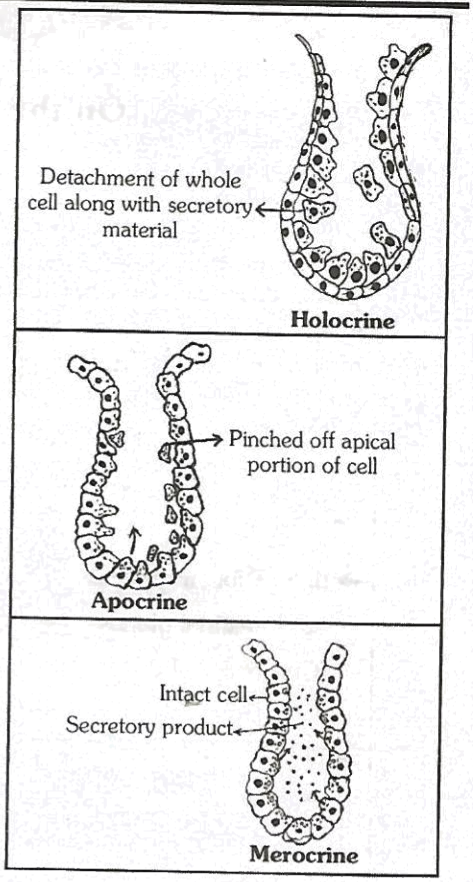
Tear gland, Intestinal glands, Mucous gland.

(2) **Apocrine gland :-** In this type of glands secretory products are collected in apical part of secretory cell and apical portion is also shed alongwith secretory matter. Secretory matter is comparitively concentrate.

– **Mammary glands.**

(3) Holocrine glands :- The production or secretion is shed with whole cell leading to its destruction. i.e Whole cell is shed as secretion (Secretory matter concentrate)

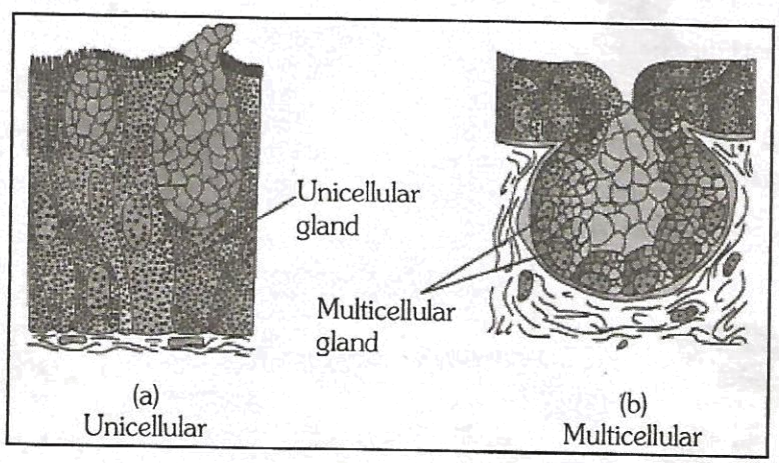
Example : **Sebaceous, meibomian & Zeis gland.**



On the basis of number of cells

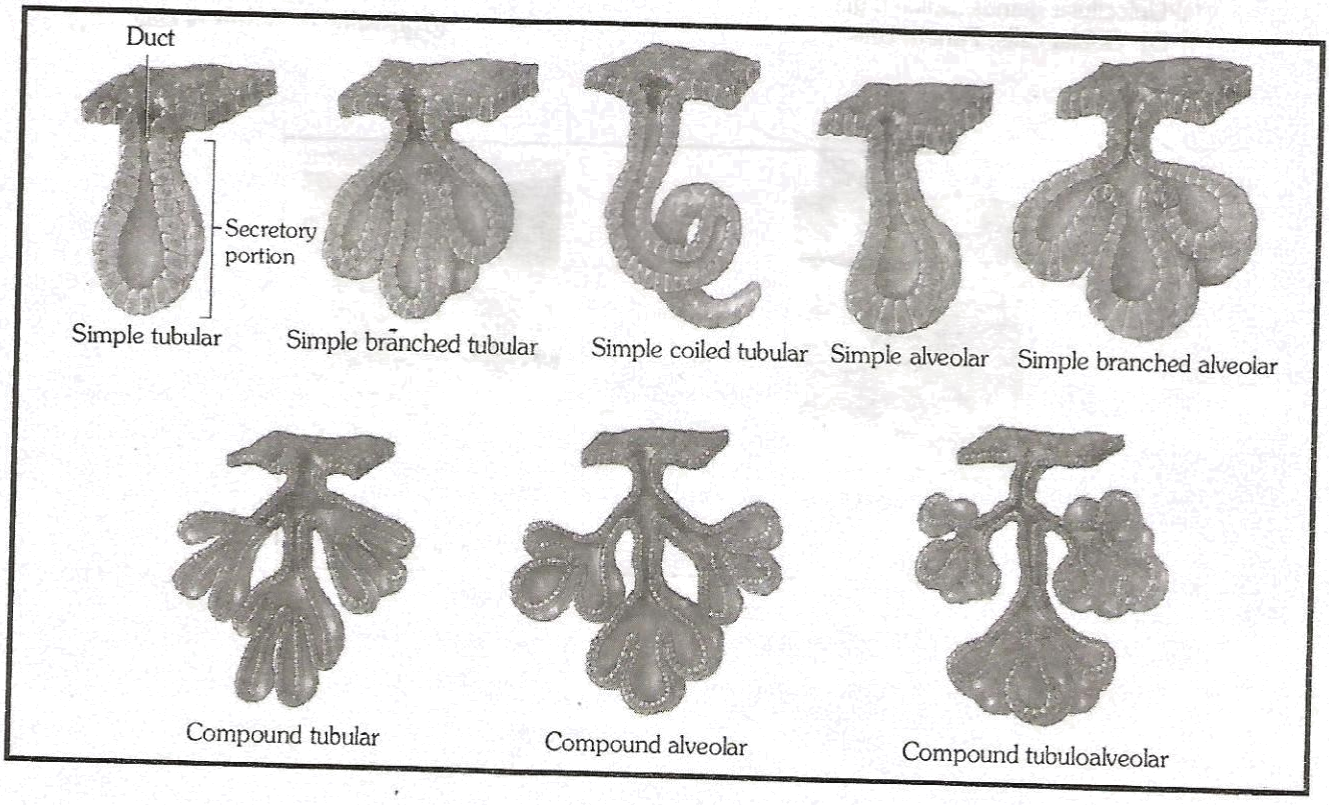
(a) Unicellular glands (Isolated glandular cell)
Eg. Goblet cells, Paneth cells

(b) Multicellular glands
(Consisting of cluster of cell)



On the basis of Shape of secretory unit

- (1) Tubular glands
  - (A) Simple glands
    - (i) S. Tubular glands
      eg. Intestinal glands
      (Crypts of leiberkuhn)
    - (ii) S. coiled tubular
      – Sweat glands
    - (iii) S. branched tubular
      – Gastric glands
  - (B) Compound tubular glands
    eg. - Brunner's gland
    - Mammary glands of Prototheria.
    - Inactive mammary glands of eutheria
- (2) Saccular/Alveolar glands
  - (A) Simple Glands
    - (i) Simple Alveolar
      eg. Cutaneous glands of frog
      - Poison glands
      - Mucous glands
    - (ii) Simple branched alveolar
      eg. Sebaceous glands
  - (B) Compound alveolar glands
    eg. - Sublingual gland
    - Submandibular gland
- (3) Compound tubulo saccular
  - Active mammary glands
  - Parotid gland
  - Pancreas



COMPOUND EPITHELIUM

It is multilayered and have limited role in secretion and absorption. It provide protection against chemical & mechanical stress.

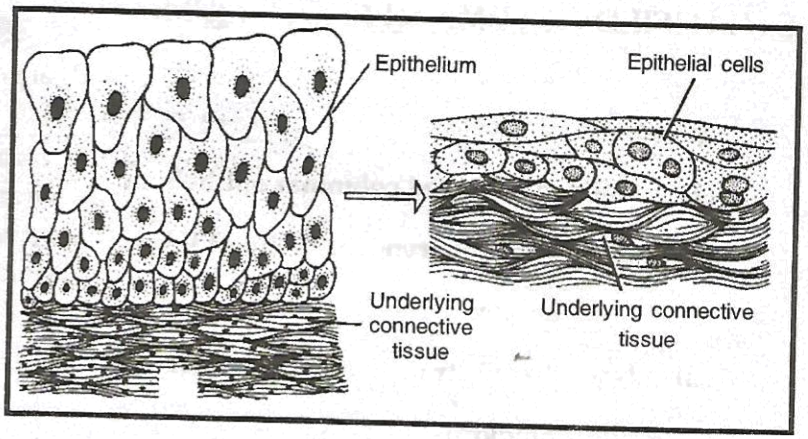
On the basis of stretching ability it is of 2 types –

(1) **Transitional epithelium :–** Stretchable.

(2) **Stratified epithelium :–** Non-stretchable.

1. Transitional Epithelium (Urothelium)

(1) In resting conditions a thin basement membrane is present but on stretching basement membrane almost get disappeared.



(2) In this epithelium 4-6 layers of cells are persent.

- Inner most layer of cell is composed of **cube like cells**.
- Middle 2-4 layers are composed of pear shaped or umbrella shaped cells/Polyheadral cells.
- Outermost 1 or 2 layers are of oval shaped cells.
- These different shape of cells appears only in resting stage. When this tissue is stretched, all the cells become flattened.
- At outermost layer a thin cuticle line is present which makes this tissue water proof.
- Cells are interconnected by interdigitation.

Eg. **Renal Pelvis, Ureter, Urinary Bladder, Proximal part of male urethra.**

2. Stratified Epithelium

On the basis of shape of the cells of outermost layer it is of three types.

(A) STRATIFIED SQUAMOUS EPITHELIUM

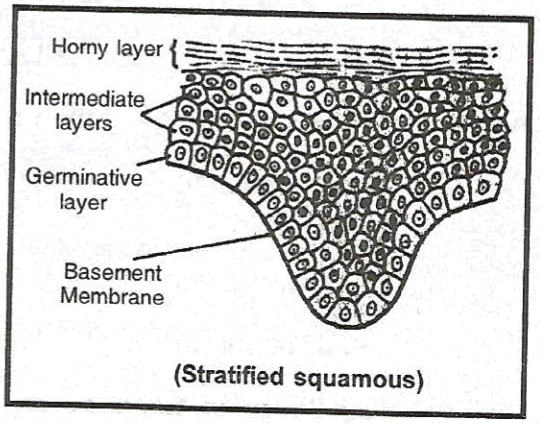
(i) Innermost layer of cells are of cuboidal. These cells have high mitotic index. They get their nutrition from underlaying connective tissue.They divide to from layers of Stratified epithelium so this layer is called as **Germinativum** layer.

(ii) Middle layers are made up of polygonal cells. These cells are interconnected with Desmosomes which provide rigidity or mechanical support.

(iii) Cells of outermost layer are scale like flat cells.

On the basis of presence of keratin protein in the outer most cells this epitheluim is of two types .

1. **<u>Keratinized Stratified squamous epithelium</u>.**
   If keratin protein is present in scaly cells and cells become non nucleated dead cells.
   eg. **Epidermis of skin, Scale, Horn, Nails, Feathers etc.**
2. **<u>Non Keratinized Stratified squamous epithelium</u>.**
   If Keratin protein is absent. Cells are nucleated and Living.
   eg. **– Buccal cavity or oral cavity of mammals**
   – Inner lining of cheeks, lips, hard palate, tonsils,
   – Pharynx, Oesophagus, Anal canal,
   – Lining of vagina
   – Cornea of eye



(Stratified squamous)

STRATIFIED CUBOIDAL EPITHELIUM

1. Inner most layer is cuboidal.
2. Middle layer - polygonal shaped cells.
3. Outermost layer of cells are cube like & cells are nucleated & living.

Eg. Secretory duct of sweat glands, mammary glands and sebaceous gland, pancreas, salivary glands.

STRATIFIED COLUMNAR EPITHELIUM

Outermost layer is composed of pillar shaped cells, cells are nucleated. On the basis of presence of cilia this epithelium is of 2 types

(1) Ciliated stratified columnar epithelium.

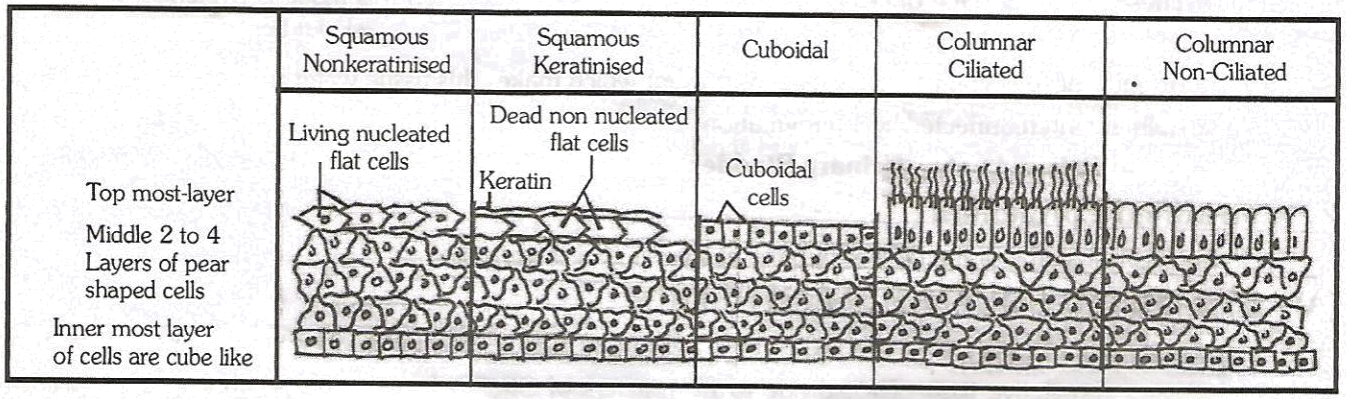
Eg. **Buccopharyngeal cavity of Frog.**

Larynx

(2) Non ciliated stratified columnar epithelium. Cilia absent on free end.

Eg. **Epiglottis.**

STRATIFIED EPITHELIUM



GLANDS

A cell or a group of cells which secretes chemical substances are called glands.

All glands are composed of Epithelium tissue. Some columnar or cuboidal cells get specialised for secretion known as Glandular epithelium.

Glands can be originate from all the three germinal layers.

CLASSIFICATION OF GLANDS

A. On the basis of method of the secretion.

(a) **Endocrine glands :-** Secretory duct absent and secrete hormones. Their products called hormones are secreted directly into the fluid bathing the gland.

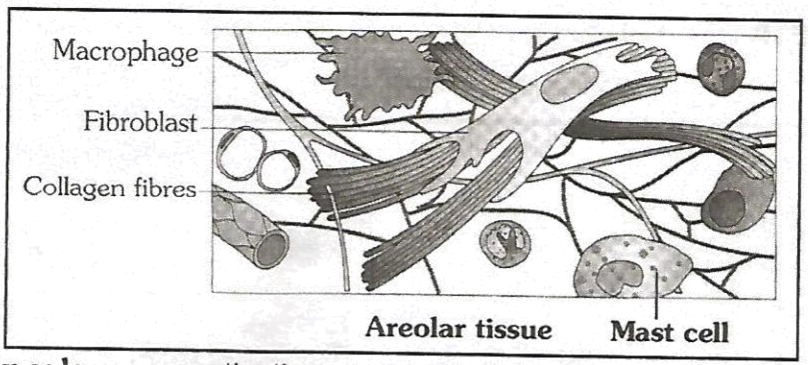
(b) **Exocrine gland :-** Secretory duct present – secretes mucus, saliva, earwax, oil, milk and enzymes.

(c) **Heterocrine/mixed gland :-** Both endocrine & exocrine parts are present.

eg. **Pancreas, Gonads etc.**

TYPE OF CONNECTIVE TISSUE PROPER

1. AREOLAR CONNECTIVE TISSUE

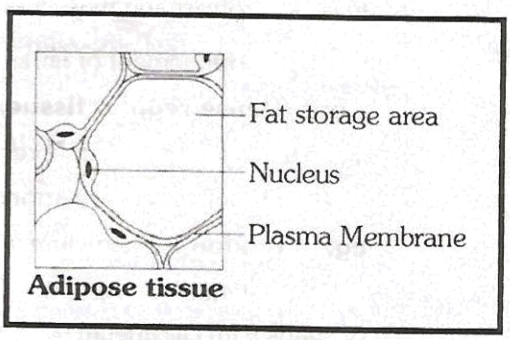


(i) Also known as **loose** connective tissue or **spongy** tissue.
(ii) It is most widely distributed tissue in the body.
(iii) In this tissue maximum intercellular space or substances/matrix is present.
(iv) Due to irregular arrangement of bundle of collagen fibres many gaps are present. These spaces are called **Areolae**.
(v) In areolae other components of connective tissue are distributed like fibres, cells & matrix.
(vi) Few elastic fibres are present but reticular fibres and reticular cells are completely absent.
(vii) In cells mast cells, macrophage & fibroblast are more in number.
(viii) In these areolae blood vessels & nerve fibres are also present.
(ix) It is also present below the skin.

Eg. **Tela Subcutanea:-** A thin continuous layer which connect skin with underlaying skelatal muscles (Panniculas carnosus) . In mammals skin is tightly attached with muscles.

Sub mucosa of Trachea, Bronchi, Intestine

2. ADIPOSE CONNECTIVE. TISSUE



(i) It is a modification of areolar connective tissue (Loose connective tissue). But in areolae major component is adipocytes which store fats. Blood vascular system is also present in this tissue.
It is also present beneath the skin.

(ii) If this tissue is treated with alcohol (organic solvent) Fat will be dissolved completely and adipocytes will become vacuolated.

(iii) On the basis of adipocytes 2 type of fats are found in animals.
(a) White fat (b) Brown fat

(a) **White fat:-** It is composed of monolocular adipocytes in which single large fat globule, peripheral cytoplasm and peripheral nucleus is present. Due to less amount of cytoplasm, Mitochondria are also less in number. So they produce less energy.

Eg. **Panniculas adiposus :-** A thin continuous layer of white fat under the dermis of skin which is also called **hypodermis** of skin.

Yellow bone marow.

Blubber:- Thick layer of white fat found under dermis of skin. Found in whale, seal elephants.

Hump of camel, Tail of marino sheep

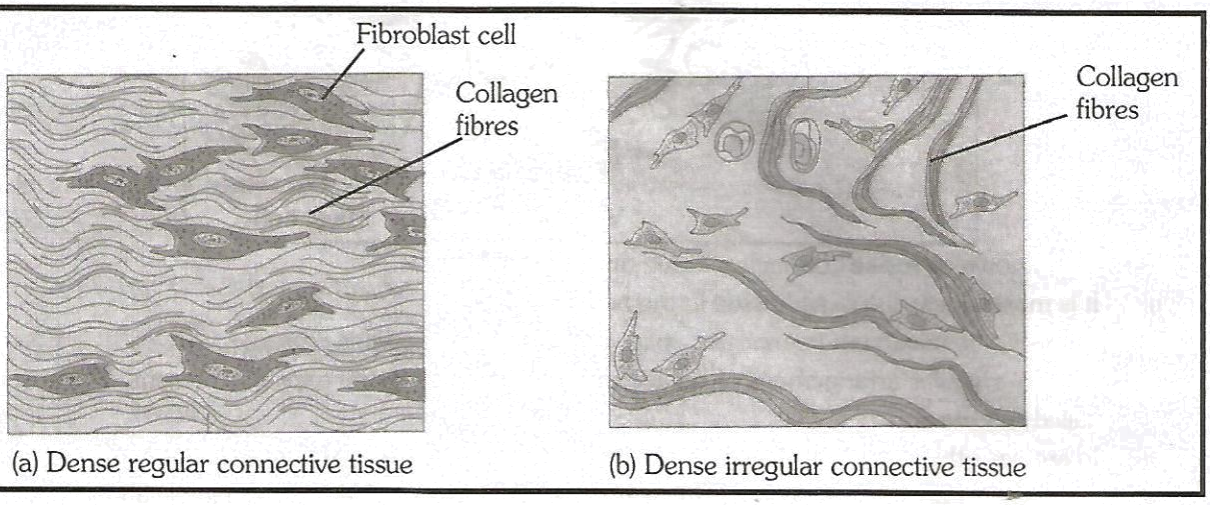
(b) **Brown fat:-** It is composed of multilocular adipocytes in which many fat globules are present. Cytoplasm is more in amount. Due to more number of mitochondria it produces 20 times more energy than white fat. Brown colour of fat is due to presence of cytochrome Pigment.

(i) Cold resistance device in new born baby is due to presence of brown fat.

(ii) Rodents like rat, shrew. They are hibernating animals & during hibernation they obtain energy from stored brown fat.

3. DENSE CONNETIVE TISSUE :

(i) Fibres and Fibroblast are compactly packed.



(a) Dense regular connective tissue (b) Dense irregular connective tissue

(A) WHITE FIBROUS CONNECTIVE TISSUE

(i) In this tissue bundle of collagen fibres are more in quantity & other components of connective tissue proper are less in quantity.

(ii) Yellow fibres & reticular fibres are completely absent.

(iii) In cells fibroblast and mast cells are more in number.

On the basis of arrangement of fibres & matrix this tissue occurs in two forms.

(a) Cord (Dense regular tissue) :-

1. Bundle of collagen fibres & matrix are distributed in regular pattern (alternate pattern).
2. Fibroblast cells are arranged in a series. Mast cells are scattered in matrix.

eg. Tendon :- A structure which connects muscles & bones.

Strongest tendon of the body is **Tendocalcaneal tendon.** This tendon connects gastrocnemius muscle of shank with calcaneum bone of ankle.

(b) Sheath (Dense irregular) :- In this form there is no regular pattern of fibres & matrix. Cells and fibres are criss - crossed arranged.

eg.
- **Pericardium** — Outer covering of heart.
- **Periosteum** — Outer covering of bone.
- **Perichondruim** — Outer covering of cartilage.
- **Epimysium** — Covering of muscle.
- **Renal capsule** — Around kidney.
- **Glisson's capsule** — Around hepatic lobule
- **Duramater** — Outermost covering of brain.
- **Cornea of eye**

(B) YELLOW FIBROUS CONNECTIVE TISSUE

(i) In this tissue yellow fibres are more in quantity but collagen fibres are also present.

(ii) Reticular fibres are absent.

(iii) On the basis of distribution of fibres & matrix they are of two types.

(a) Cord (Dense regular) :- In this form bundle of collagen fibres & matrix distributed in a regular pattern & in matrix yellow fibres form network.

eg. Ligaments — A structure which connects bones.

(i) Strongest Ligament of body is **Ilio femoral ligament**.

(ii) This ligament connects Ilium bone of pelvic girdle with femur bone of hind limb.

(b) Sheath (Dense irregular) :- Irregular distribution of fibres and matrix with elastic fibre.

eg. - **Wall of lymph vessels & blood vessels**
- **True vocal cords**
- **It is also present in the skin**

4. RETICULAR FIBROUS CONNECTIVE TISSUE

(i) It is also called lymphoid Tissue.

(ii) It is mostly found in lymphoid organs.

(iii) Provide support and strength and form the stroma (Frame work) of soft organs.

eg. - **Spleen**
- **Lymph nodes (Tonsils, Payer's Patches).**
- **Endosteum (covering of bone marrow cavity).**

5. MUCOID CONNECTIVE TISSUE

Also called **embryonic** tissue becasue it is mainly found during embryonic life. Its matrix is composed of jelly like material called **Wharton's Jelly.**

eg. - **Umbilical cord (connect placenta with foetus)**
- **Viterous humor — In viterous body of eye.**
- **Comb of cock.**

BEGINNER'S BOX-3

1. Muscles are connected to Bone by means of :-
(1) Cartilage (2) Ligaments (3) Tendon (4) Adipose tissue

2. Brown adipose cells contain :-
(1) Only one fat globule (2) More than one fat globules
(3) Without fat-globules (4) Peripheral nucleus

3. Histeocytes destroy bacteria by :-
(1) Phagocytosis (2) Producing Antitoxins
(3) Producing antibodies (4) Producing antigen

4. Plasma cell :-
(1) Is modified B - lymphocytes of blood (2) Produce antigen
(3) Produce Heparin, Histamine, serotonin (4) Produce matrix & Fibres

5. Yellow , White & Reticular fibres made up of protien
(1) Elastin , Reticulin , Collagen, respectively (2) Reticulin , Elastin, Collagen , respectively
(3) Collagen , Elastin , Reticulin protien (4) Elastin , Collagen, Reticulin protien

6. Which of the following is known as spongy connective tissue :-
(1) Dense fibrous connective tissue (2) Adipose connective tissue
(3) Areolar connective tissue (4) Reticular fibrous connective tissue

7. Which type of connective tissue used to form perimysium :-
(1) Dense fibrous C.T. (2) Adipose C.T. (3) Reticular fibrous C.T. (4) Areolar C.T.

8. a. Monocular b. less mitochondria c. less energy
The above three statements are related to
(1) White fat – rat (2) White fat–new born baby
(3) Brown fat – camel hump (4) White fat – yellow bone marrow

9. Yellow fibrous connective tissue is found in :-
a. Renal capsule b. True vocal cords c. Walls of blood vessels d. Epimysium
(1) a, b (2) b, c (3) c, d (4) a, b, c

10. Lymphocytes are more in :-
(1) White fibrous connective tissue (2) Reticular fibrous connective tissue
(3) Yellow fibrous connective tissue (4) Adipose connective tissue

SPECIALISED CONNECTIVE TISSUE

SKELETON CONNECTIVE TISSUE

(i) Matrix is dense & mineralised. Due to deposition of minerals it becomes hard.

(ii) Also known as **Supporting Tissue** i.e. Provide support to body.

(i)ii It is of 2 types

1. Cartilage 2. Bone

CARTILAGE

(i) Outermost covering of cartilage is called **Perichondrium** which is composed of white fibres connective tissue.

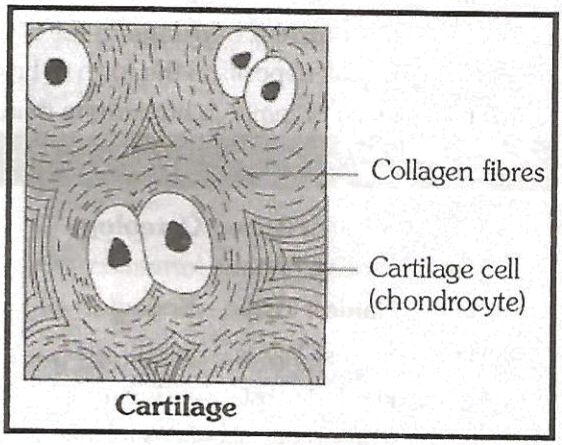
(ii) Cartilage producing cells are arranged on periphery of cartilage known as **Chondroblast**.

(iii) These are active cell & divide to form chondrocytes, and synthesize the matrix of cartilage.

(iv) Mature cells of cartilage is called **Chondrocytes**.

(v) They are found in vacuole like space in matrix called **Lacuna**, In which 1 - 4 Chontrocytes are present.

(vi) **Chondroclast** are cartilage destroying cells.



Cartilage

(vii) Matrix of cartilage is called **chondrin** composed of chondromucoprotein having Chondrotin-6-sulphate and mucopolysacchride (Hyaluronic acid)

(viii) Matrix of cartilage provides rigidity & elasticity to cartilage (matrix solid, pliable and resists compression)

(ix) Blood circulation is absent in the matrix of cartilage but blood supply present in perichondrium.

Type of Cartilage — There are following types of cartilage

1. Hyaline cartilage

(i) It is maximum in human body.

(ii) Most of the part of embryonic skeleton is composed of this cartilage. So maximum bones of body are cartilagenous bones because they are developed from cartilage.

(iii) Outermost covering **perichondirum** is present.

(iv) Matrix of this cartilage is **glass like** clear or hyaline matrix because fibres are completely absent in the matrix of this cartilage.

(v) Colour of matrix is **bluish** & it is transluscent/glass like.

eg. (a) **Nasal septum**.

(b) **'C' shaped rings of trachea and bronchi.** (Incomplete in dorsal surface)

(c) **Sternal part of ribs**.(Coastal cartilage)

(d) **Larynx**

(e) **Articular cartilage :-** At the junction of two long bones on articular surface. At the end of long bone periosteum is absent and Hyaline cartilage is present known as Articular cartilage.

2. Fibrous cartilage

(A) Elastic cartilage

(i) In the matrix of this cartilage yellow fibres form network so it is highly flexible cartilage of body.

(ii) Colour of matrix is pale yellow.

Eg. **a. Tip of Nose** **b. Ear Pinna (Outer ear joint)** **c. Epiglottis** **d. Wall of Eustachian tube**

(B) White fibrous cartilage

(i) Perichondrium is absent because complete WFCT is converted into cartilage.

(ii) In matrix bundle of collagen fibres are more in quantity so it is **strongest cartilage**.

Eg. **(a) Pubic symphysis :** Pubis bone (Half part of pelvic girdle Os innominatum are interconnected by pubic symphysis.

(a) Intervertebral disc : A pad of cushion like structure which absorb mechanical shock & jerks and protect vertebral column. Central part of this disc is soft called as Nucleus pulposus. Slight elongation of body after death or in sleeping posture is due to relaxation of this disc.

3. Calcified cartilage

(i) It is modified hyaline cartilage but due to deposition of calcium salts its matrix becomes hard like bones.

(ii) It is **hardest cartilage** of the body.

(iii) Ca salt deposits in the form of Hydroxy apatite.

Eg. Head of femur & humerus in man.

BONE

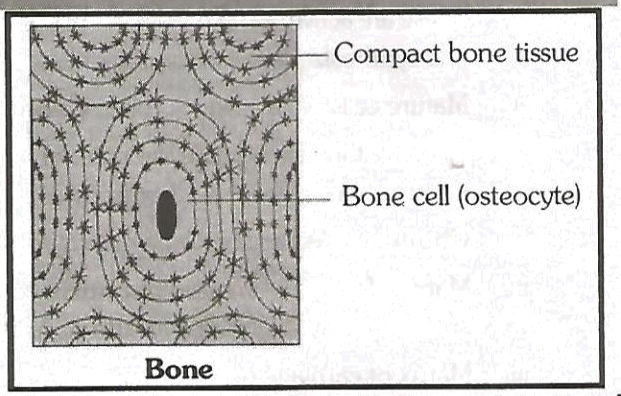
(i) Study of Bone – **Osteology**

(ii) Process of bone formation – **Ossification**

(iii) Hardest Tissue – Bones

(iv) Softest Tissue – Blood.
Hardest substance – Enamel. (It is not a group of cell but it is formed by the secretion of ameloblast cells of teeth.)

(v) Outermost covering of bone is **Periosteum** composed of white fibrous connective tissue.



Bone

(vi) Bone producing cell is called **Osteoblast.** They divide to form **Osteocyte** & synthesize organic part of matrix.

(vii) Mature cell of bone is called as **Osteocyte** which is found in lacuna. Only one osteocyte is found in one lacuna.

(viii) Bone destroying cells are **Osteoclast** cells.

Matrix - Hard and Non-Pliable

It has two parts

Inorganic Part :- 65 - 68%

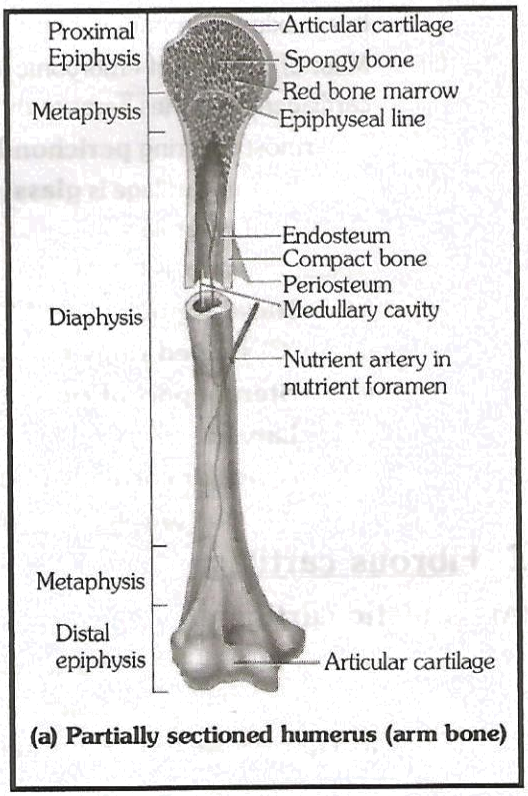
$Ca_3(PO_4)_2$ – 80% max. rest 20% $CaCO_3$ (10%), $Mg_3(PO_4)_2$ (10%), Flourides (very less).

Organic part :- 32 - 35% Ossein in which bundle of collagen fibres suspended in sulphated mucopolysaccharide.

Structure of long bone :

Long bone has three region

(1) Epiphysis (2) Diaphysis (3) Metaphysis



(a) Partially sectioned humerus (arm bone)

Epiphysis

(i) Ends of long bone is called **Epiphysis**. This part is composed of spongy tissue. If this part is present at the joint then on articular surface **periosteum** is absent & articular cartilage (Hyaline cartilage) is present.

(ii) It consist of lamellae that are arranged in an irregular pattern of thin columns called Trabeculae. Between the trabeculae are present spaces filled up with red bone marrow.

(iii) It is composed of myeloid tissue which produce blood corpuscles so epiphysis act as a haemopoietic organ.

Diaphysis

(i) Middle part or shaft of long bone is diaphysis which is composed of **compact bone**.

(ii) In this region hollow cavity is present called bone marrow cavity filled with yellow bone marrow. Function of YBM is storage of fat.

Metaphysis

(i) It formed little part between epiphysis & Diaphysis.

(ii) In this region **epiphyseal plate** is present which is made up of osteoblast cells. They divide to form osteocyte and also synthesize matrix of bone, so epiphyseal plate is responsible for elongation of bone.

(iii) After complete development of long bone this plate is destroyed. So in completely developed bone only 2 regions are found while in a developing bone 3 regions are present.

Special points :

Spongy Bones

(i) Bones in which haversian canal systems are absent. In these bones marrow cavity is present in the form of trabeculae filled with RBM. So all spongy bones of body are haemopoietic.

Eg. **Ribs, Pubis, Sternum, Vertebrae, Clavicle, End of long Bones, Scapula**

Compact Bone

In this bone haversian system is present.

Eg. **Diaphysis of long bone.**

Diploic/Heterotypic

☛ In these bones middle part of bone is composed of spongy bone, in which trabeculae is filled with RBM. While this bone is covered by compact bone on upper & lower surface.

Eg. **All flat bones of skull.**

INTERNAL STRUCTURE OF MAMMALIAN BONE

It has following major structures.

1. Periosteum
2. Matrix
3. Endosteum
4. Bone marrow cavity

1. Periosteum

(i) Outermost covering of bone is called **Periosteum**.

(ii) It consists of two layers.

(iii) Outer layer consist of WFCT in which blood circulation is present.

(iv) Inner layer - consists of single layer of osteoblast cells.

(v) They divide to form osteocyte and secrete layers of matrix.

2. Matrix

It is composed of inorganic & organic compounds.

In the matrix of bone two types of canals are present.

1. **Haversian canal**
2. **Volkmann's canal**

Haversian Canal

Longitudenal canals which are arranged parallel to long axis of bone. In these canals one or two blood capillaries and nerve fibres are present.

Volkamann's canal

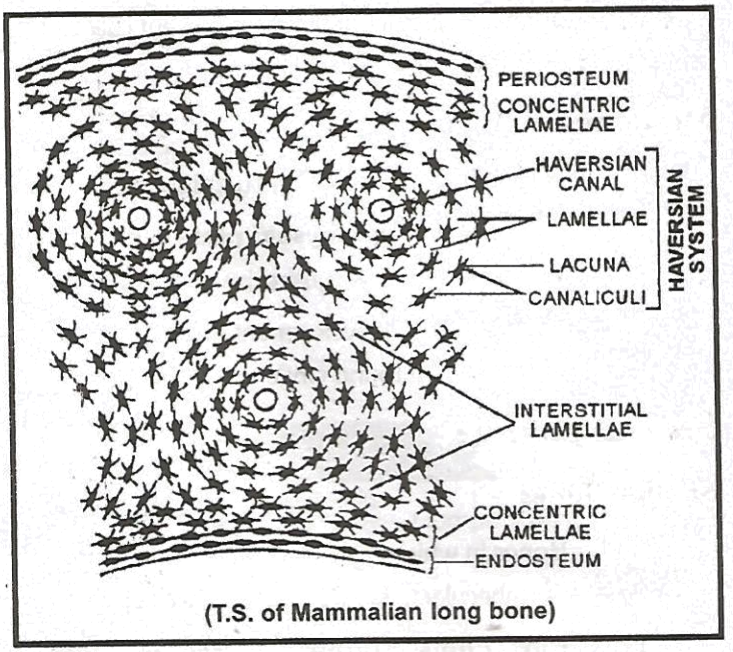
(i) These are transverse/horizontal or oblique canals.

(ii) Haversian canals are interconnected by volkmann's canal.

(iii) Matrix of bone is synthesized in the form of layer. These layers of matrix are called **Lamellae.**

On the basis of arrangement three types of lamellae are present in the matrix.

1. Haversian lamellae
2. Interstitial lamellae
3. Circumferential lamellae.



(T.S. of Mammalian long bone)

Haversian lamellae

(i) Concentric layers of matrix which are present around haversian Canal.

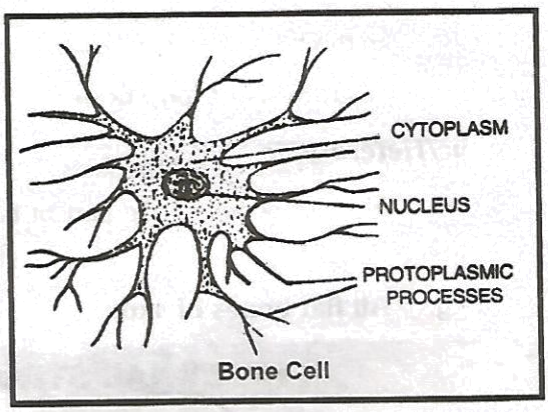
(ii) Between these lamellae layer of osteocyte cells are also present.

(iii) Haversian canal, Haversian lamellae & Osteocyte form **Haversian** system or **Osteon**.

(iv) Presence of haversian canal system is a typical feature of **mammalian** compact bones.

(v) Osteocyte are present in the lacuna. Each osteocyte is inter connected with adjacent osteocyete by their cytoplasmic process.

Cytoplasmic process of osteocyte are present in the canals of lacuna called as **canaliculi**.



Bone Cell

Interstitial Lamellae

These layers of matrix are present in the space between two haversian systems.

Circumferential lamellae

Circumferential layer of matrix are of two types.

1. Outer circumferential lamellae :
   - These are present around all haversian system.
   - These are peripheral layers of matrix.
2. Inner circumferential lamellae :
   - Present around bone marrow cavity.

3. Endosteum

Endosteum consist of two layers.

1. Towards bone marrow cavity layer lined with reticular fibrous connective tissue.
2. Towards matrix of bone endosteum is lined with layer of osteoblast cells. They divide to form osteocyte & synthesize matrix. So growth of bone is bidirectional (Periphery & central region). While Growth of cartilage is unidirectional.

4. Bone marrow cavity

- In the central region hollow cavity is present which is filled with YBM. It is composed of white fat & its function is collection of fats or storage of fats.

TYPES OF BONES

On the basis of development or location of ossification bones are of four types.

1. Cartilagenous bones/Replacing/Endochondral bone

- These bones are developed from cartilage or they are formed by the ossification of cartilage.
- In the formation of these bones two types of cells are required.

1. **Chondroclast:-** Which reabsorb cartilagenous matter.
2. **Osteoblast:-** Which deposit bony matter into cartilage so cartilage is replaced by bone. Hence these bones are also called as replacing bones.

Eg. **Maximum bones of our body like forelimb and hindlimb bones, Ribs.**

2. Membranous bones/Dermal bones/Investing bones

These bones are devloped from the connective tissue of dermis or formed by ossification in the connective tissue of dermis.

Eg. Pubis, Sternum, Clavicle, Scapula bone, Flat bones of skull

3. Sesamoid Bones

(i) These bones are developed by the ossification of tendons at the joints.

Eg. **(a) Pisiform (wrist bone) of man.**

(b) Patella (knee bone) Largest sesamoid bone.

-:Golden Key Points:-

(i) Decalcified Bones :- If a bone is kept in dil HCl for 3 days then complete mineral part of the matrix get dissolved in acid & organic part remain in the bone so bone becomes soft & flexible.

(ii) Dried Bone :- If a bone is kept in sunlight for long time then complete aqueous part of the bone disappear. In these bones empty lacuna & empty bone marrow cavity is present. Shape of bone remain unchanged.

If a bone is burn or kept into very high temp then complete organic part of bone is burn and mineral part of matrix remain as such in the form of ash called dried bone.

(iii) Bright Bone :- If a bone is kept into KOH then complete attached muscle fibres are dissolve in KOH & bone becomes clear & bright called bright bone. Bone will remain unchanged.

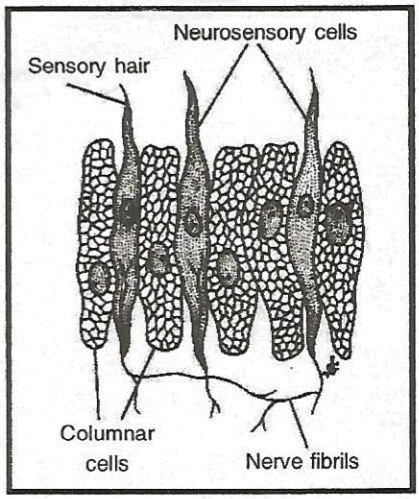
Eg. **Bones of laboratory**

(iv) Special Types of Epithelium

(a) Neuro sensory epithelium :

In the structure of this epithelium in between piller shaped supporting cells modified sensory cells are present. On the free end of sensory cell sensory hair is present by which they receive sensation. Base of these cells is attached with sensory nerve.

Eg.
- **Gustatory Epithelium –** Covering of taste bud of tongue receive taste sensation.
- **Olfactory epithelium –** Schneidarian membrane receive smell sensation.
- **Stato – acoustic –** Lining of internal ear.
- In Retina of eye receive optic sensation.



(b) **Myoepithelium :-** Around mammary and sweat gland (around secretery unit)

(c) **Pigmented epithelium (Cuboidal) :-** In Retina of eye.

(v) **Ilio-femoral ligament** - strongest ligament.

Another strongest ligament is **ligamentum flava**, present between two adjacent vertebrae.

(vi) In quardripeds like cow & buffalo strongest ligament is **ligamentum nuchea** present in the neck between two cervical vertebrae.

(vii) **Sharpey's fibres :-** extra bundle of collagen fibres which are present in the outermost layer of matrix called sharpey fibres. Which provide extra mechanical support to bone.

(viii) ***Visceral Bones***

(a) If ossification takes place in the visceral organs then visceral bones are formed. These are rare bones, found in few animals. In rabbit & man these bones are absent.

Eg.	**Os Cordis**	:	Present in inter ventricular septum of deer's heart.
	Os Palbebrae	:	In the eyelid of crocodile.
	Os Penis (Baculum)	:	In the penis of rodents rat, shrew, bat, whale, tiger.
	Os rostralis	:	In the snout of pig.

BEGINNER'S BOX-4

1. Longitudinal channels of Bone called :-
(1) Haversian canal
(2) Volkmann's canals
(3) Narrow cavity
(4) Lacunae

2. Glass like cartilage is :-
(1) Hyaline cartilage
(2) Fibro cartilage
(3) Calcified cartilage
(4) Elastic cartilage

3. Formation of cartilagenous Bone involves :-
(1) Deposition of Bony matter by osteoblasts & Reabsorption by chondrioclasts
(2) Deposition of Bony matter by osteoblast only
(3) Deposition of Bony matter by osteoclasts & Reabsorption by chondrioblast
(4) None of above

4. Major Inorganic components of Bone :-
(1) Calcium phosphate
(2) Calcium carbonate
(3) Sodium hydroxide
(4) Potassium hydroxide

5. Haversian system is feature of :-
(1) Amphibian Bones
(2) Reptiles Bone
(3) Pneumatic Bone
(4) Mammalian Bone

6. Bone desolving cells :-
(1) Osteoblast (2) Osteocyte (3) Osteoclast (4) Fibroblast

7. Eustachian tube is supported by :-
(1) Elastic cartilage
(2) White fibros cartilage
(3) Calcified cartilage
(4) Hyaline cartilage

8. Perichondrium is :-
(1) Adipose tissue
(2) White fibrous connective tissue
(3) Yellow fibrous connective tissue
(4) Areolar connective tissue

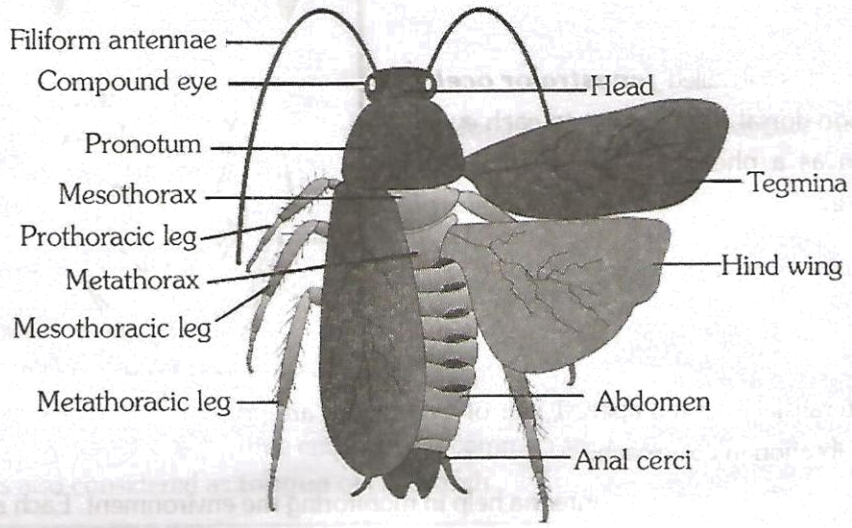
ANSWER KEY

BEGINNER'S BOX-1	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	4	1	1	1	1	4	4	1	2	2
BEGINNER'S BOX-2	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	3	4	1	2	4	3	3	4	1	3
BEGINNER'S BOX-3	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	3	2	1	1	4	3	4	4	2	2
BEGINNER'S BOX-4	Que.	1	2	3	4	5	6	7	8		
	Ans.	1	1	1	1	4	3	1	2		

PERIPLANETA(COCKROACH)

Taxonomic status :-

- **Phylum - *Arthropoda*** (Jointed appendages and chitinous exoskeleton)
- **Class - Insecta** (3 pairs of jointed legs)
- **Order - Dictyoptera/Orthropetra** (Disimilar wings)
- **Genus - *Periplaneta***
- ***Species* - *americana***



External features of cockroach

Introduction :-

- It is also known as **"American** or **common cockroach or ship cockroach".**
- Size is about 34-53 mm long with wings that extends beyond the abdomen of males.
- Cockroach of genus - **Blatta** has small wings in males but **vestigeal in females.**
- It is **omnivorous, nocturnal** and **cursorial** (fast runner) animal.
- Cockroach can run 130 cm/sec at 25°C.
- Number of chromosomes = 34
- It also exhibit **cannabalism**, feeds on their fellows ocassionally.

Morphology :- Body is divisible into 3 parts

Body =	Head	+	Thorax	+	Abdomen		
=	6	+	3	+	11	=	20 segments in embryo.
=	1	+	3	+	10	=	14 segments in adults.

- The entire body is covered by a hard **chitinous exoskeleton** (Brown in colour).
- Exoskeleton of each segment consists of Chitin plate called ***"sclerites".***

Sclerites joined each other by a flexible membrane called ***"articular or arthroidal membrane."***

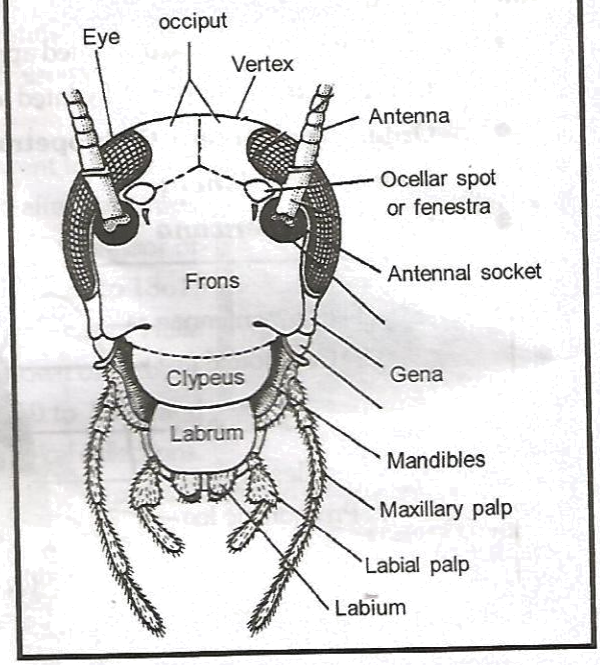
Sclerites of dorsal side - **tergum or tergite**

Sclerites of ventral side - **sternum or sternite**

Sclerites of lateral side - **pleurons or pleurites.**

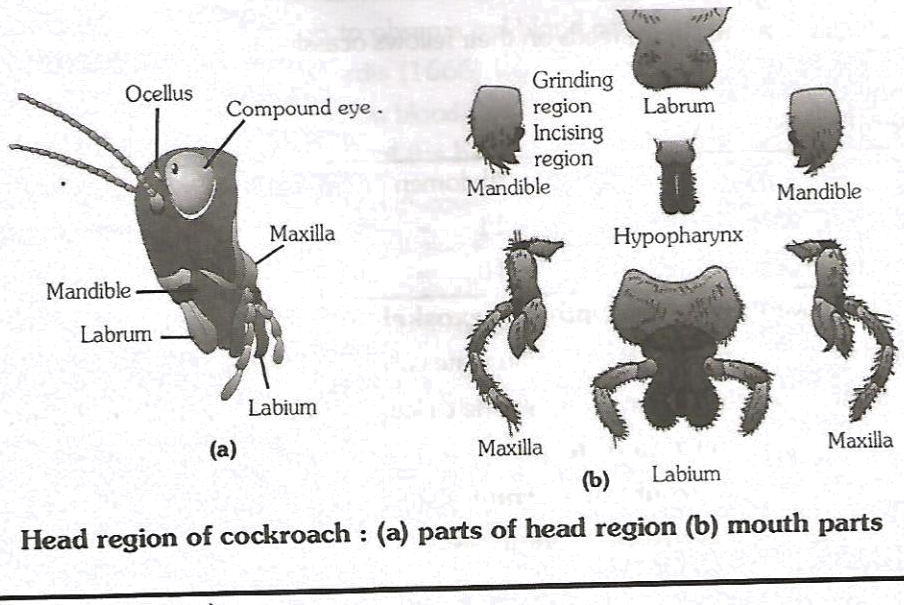
1. HEAD

- It is triangular and **"Hypognathus"**, bent downwards at an angle of 90° from the long axis of body.
- sclerites of the head joined fully and form ***head capsule***.
- Top part of Head is called "Vertex" and on the ***vertex*** a chitin plate present called ***"Occiput"***.
- on the lateral side of head apex 1 pair of compound eye
- each compound eye made up of 2000 units called ***"ommatidia"***
- A small light coloured spot called ***fenestra or ocellar*** spot is located upon dorsal surface close to each eye. In insect it function as a photoreceptor organ but ***in Cockroach,*** it is inactive and called ***"Vestigial simple eye"***.



Antennae :- Lateral side of head apex, 1 pair of ***antennae*** are present, acts as, main receptor of touch, temperature and vibration in cockroach.

- All these sensory receptors present on antenna help in monitoring the environment. Each antenna extending forwards from an antennal socket located dorsally upon head capsule near the compound eye of its side. These are long, filamentous, unbranched and free moving.
- A big chitin plate situated below the vertex called ***frons or forehead.***
- two long flattened chitin plates situated on lateral side called ***"gena" or "cheek"***
- A big chitin plate present in anterior part of frons called ***"Clypeus"***. a movable chitin plate joined with anterior part of clypeus known as ***"labrum" or "Upper lip"***.
- A mouth situated in the anterior side of head which is surrounded by many chitinous structure called ***"mouth parts"***



Head region of cockroach : (a) parts of head region (b) mouth parts

Mouth Parts of Cockroach :-

- **"Bitting and chewing type"**
- A cavity formed due to mouth parts called ***"Preoral cavity" or "cibarium".***

(1) **Labrum or upper lip** :- Broad, flattened and movable sclerite of the dorsal side of head capsule. It dorsally overhangs the mouth and hence referred to as ***"upper lip"***.

(2) **Mandibles** or Jaw

- 1-pair of triangular structure with Chitinous teeth on inner surface.
- They form the lateral wall of preoral cavity and moves horizontally (Grinding)

(3) **First maxillae** :-

- One-pair and form lateral wall of preoral cavity.
- With the help of maxillary palp cockroach pickup its food and put it in preoral cavity for chewing.
- Maxillary palps also used as brush to clean antenna and wing.

(4) **"Labium"or lower lip (Fused 2nd maxillae)**

- Form floor of preoral cavity (Ventral side) and provides a platform for food materials.

(5) **Hypopharynx :- or "lingua"**

- Small, non-chitinous flexible structure that lies on the floor of preoral cavity.
- It bears several sensory setae at its free end, and the common salivary duct opens at the base of hypopharynx, threrefore it is also considered as **tongue** of cockroach.

BEGINNER'S BOX-1

1. Cockroach belong's to phylum :-

(1) Annelida (2) Arthropoda

(3) Porifera (4) Mollusca

2. Which of following tegmata of cockroach fused in adult stage ?

(1) Head (2) Abdomen

(3) Thorax (4) (1) or (2)

3. How many segment found in adult cockroach :-

(1) 12 (2) 15 (3) 20 (4) 14

4. Which movable chitineous plate joined with dorsal part of head :-

(1) Labrum (2) Clypeus

(3) Labium (4) Forhead or frons

5. Which is the correct location of mandibles in mouth of cockroach :-

(1) Upper side (2) Lateral side

(3) Lower side (4) Anterior side

6. Function of arthroidial membrane is _____.

(1) Circulation (2) Respiration

(3) Joining/Articulation (4) Excretion

2. THORAX

- Head is connected with thorax by a short extension of prothorax known as **neck.**
- It has 3 segments - ***Prothorax, Mesothorax*** and ***Metathorax***.

Legs :- One-pair of legs are present on each segment of thorax. (Total 3 pairs)

- Each leg has 5 segments –

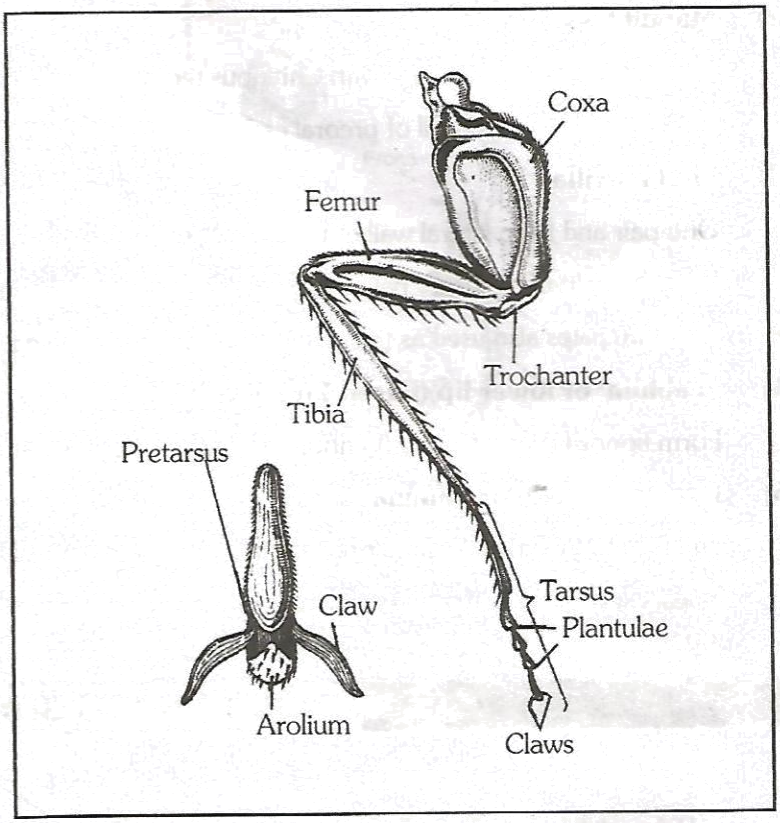
(1) segment-***"Coxa"*** : broadest segment

(2) segment-**trochanter** : small segment

(3) long segment - **femur**

(4) **tibia** - longest segment

(5) **tarsus** - tarsus made up of five segments called tarsomeres and the last one is called ***"pretarsus"***



- Each pretarsus bears one pair of **Claws** and large adhesive pads **Arolium** or **Pulvilus.**
- Cockroach move on the smooth surface by the help of "arolium" and on rough surface with the help of claws. **(In Blatta** - arolium is absent).
- Small adhesive pads present at the junction of tarsomeres are called ***"Plantuli"***
- Cockroach climb on the wall by the help of plantuli and Arolium.
- Tactile setae are present on each segment of legs.

"Wings" :- 2 - pairs

(1) fore wings
↓
on mesothorax
↓
long, narrow, opaque, dark and leathery
↓
fore wings are so long so cover full abdomen and hind wings when at rest.

(2) Hind wing
↓
on Metathorax
↓
small, broad, transparent, membranous and fan like
↓
these wings help in flight

- These are called **Elytra or Tegmina.**
- A network of fine tubules called ***"nurvures"*** is present in the inner side of wings.

3. ABDOMEN

(1) Consists of 10 segments
(2) 9 segment in male
(3) 7 segment in female
} Clearly distinct while remaining segments get modified or reduced.

- All characters of sexual dimorphism in cockroach present in abdomen

- Exoskeleton of each body segment consists of 4 chitinous plates or sclerites one **tergum**, one **sternum** and two **pleurons.**
- 7th tergum largest in male and female and covers 8th and 9th tergite
- Stink gland present in between 5th and 6th tergum

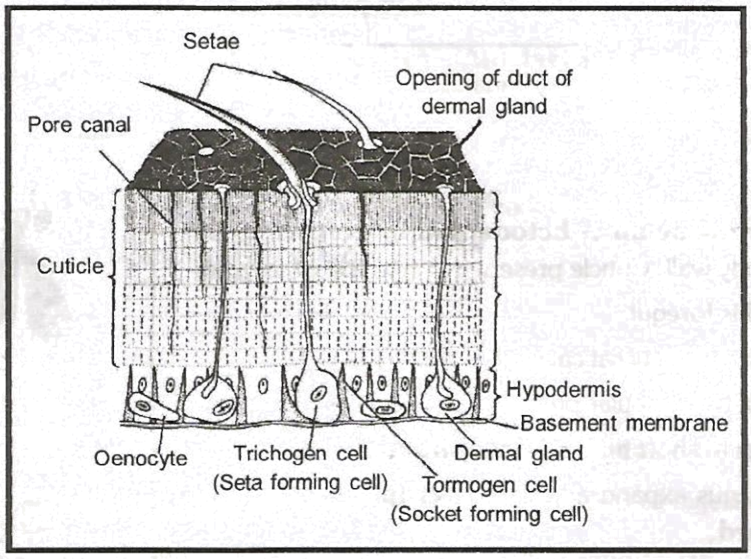
  Smell - repel the enemies.
- 10th tergum - bowl shaped and bifurcated, 10th tergum bears 1 pair of ***"anal cerci"***
- Each ***"anal cerci"*** - "15 segmented", These are main sound receptor.
- **Sternum** - In male - 9 sternum

  In female - 7 sternum
- Projected one-pairs of spine like structure from 9th sternum of male called **"anal styles".**

  These are nonsegmented and help in copulation.
- 7th sternum of female - broad and boat shaped.

  Free end - divided in to two plates called **gynovolvular plates** that surounds oothecal pore.

"Body Wall"



Made up of three layers :-

1. Outermost - **thick cuticle**. A waxy layer occurs on cuticle.

   Cuticle is made up of alternate layer of protein and chitin.
2. **Hypodermis :** Made up of columnar epithelium
3. **Basement Layer :** ***Simple squamous epithelium***

Body cavity or Haemocoel

- All arthropods are ***"True coelomate"*** but coelom is highly reduced and found only in the form of cavity of ***gonads"*** known as gonocoel.
- Body cavities are found as blood-filled sinuses called **Haemocoel**.

BEGINNER'S BOX-2

1. How many segments present in thorax ?
   (1) 2 (2) 4 (3) 1 (4) 3

2. Coxa is the _____ of the leg of cockroach :-
   (1) Small segment (2) Long segment
   (3) Broadest segment (4) Longest segment

3. Cockroach moves on the rough surface by _____.
   (1) Arolium (2) Pulvilus (3) Claw (4) Plantulae

4. Which is the structure act as sound receptor in cockroach :-
   (1) Anal style (2) Anal cerci (3) Antenna (4) Both (2) and (3)

5. What will happened when mandibles remove from mouth part's of cockroach ?
   (1) Only grinding of food will be affected (2) Only incisor of food will be affected
   (3) No incisor and grinding of food take place (4) No effect on Biting & chewing of food

4. DIGESTIVE SYSTEM

Two parts

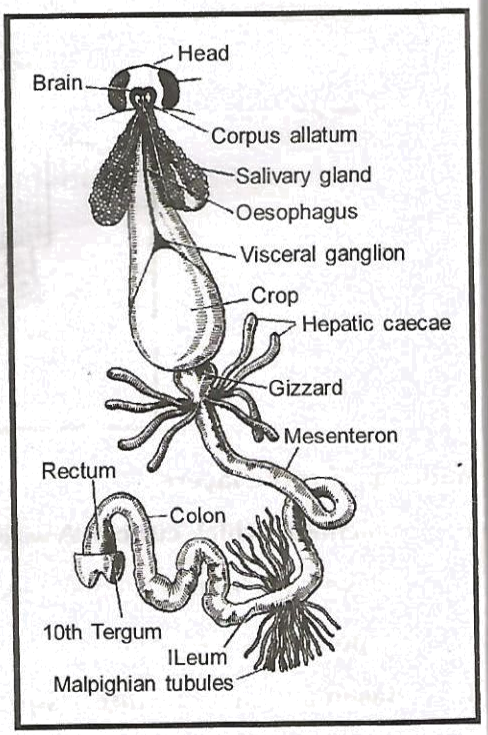
Alimentary canal | Digestive glands

ALIMENTARY CANAL :

- ***It has 3-parts :-***

(1) Fore gut or stomodaeum :- Ectodermal", Formed by the invagination of body wall. Cuticle present in inner side of foregut.

- Mouth to - gizzard is foregut
- Mouth open in the small buccal cavity
- Buccal Cavity - opens in tubular pharynx.
- **Pharynx** - open in to short tubular ***"oesophagus".***
- In thorax oesophagus expand and called **"crop".** It opens into thick walled **gizzard.**
- ***Gizzard*** - "circular muscle layer" well developed.
- **Six cuticular teeth** occur in cavity which are used for fine grinding of food
- Cuticular hairs present in the posterior part of gizzard these form ***"sieve".***
- Gizzard - grinding in upper part - filteration in lower part.



(2) "Mesenteron" or " Mid gut" (endodermal)

- Gizzard open in mesenteron by ***"stomodial valve".***
- 6-8 small and tubular, finger like blind tubules called ***hepatic caeca*** (gastric caecae) project freely into the heamocoel from the anterior part of mesenteron.
- They secrete ***"digestive juice"***
- Wall of mesenteron is muscular.

(3) "Hind gut or Proctodaeum" (ectodermal)

- Thin tubules attached at the junction of hind gut and mid gut called ***"Malpighian tubules"***. these are excretory organ.
- Hind gut - first part - Ileum Its wall is thin and internally folded. Its cuticle bears minute spines, which serve to break the peritrophic membrane.
- **colon** - longest and broader part
- **Rectum** - last part, oval shaped and internally folded wall.

  Its wall - 6 folds - called rectal papillae. These absorb water
- **Anus** :- at the end of 10th abdominal segment.

DIGESTIVE GLANDS :

Salivary gland :-

- 1-pair and attached with oesophagus.
- ***Two parts of each salivary gland.***

  (1) **Reservoir part** :- cylindrical and storage of saliva.

  (2) **glandular part** :- leaf like, synthesis of saliva occurs in this part.
- Common ***efferent salivary duct*** arises from both salivary gland.
- This duct open in preoral cavity at base of hypopharynx.
- **Saliva** contains "Carbohydrate - digestive enzymes". eg. : **Amylase, Cellulase, Chitinase etc.**

Food - "Omnivorous"

(a) Bread, food grain, vegetable, wood , clothes, insects (dead), nymph, moulted exoskeleton.

(b) Identification of food by the help of **antenna.**

Digestion :-

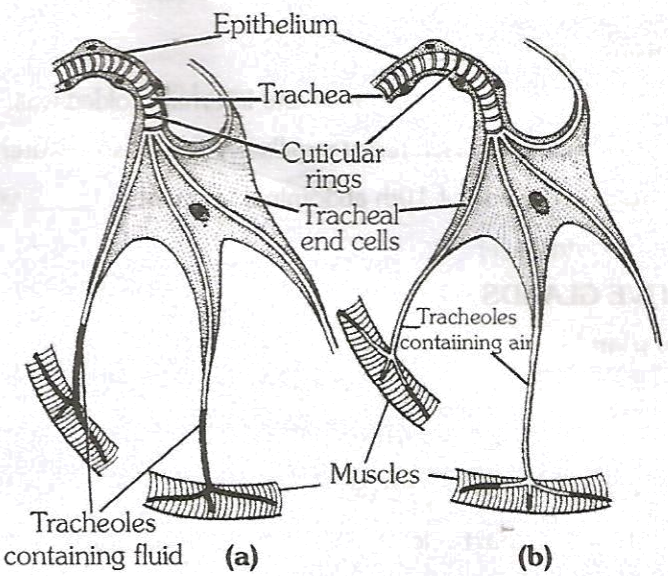
- Start from preoral cavity
- **saliva** - Enzymes of saliva act upon the food till it reaches the crop. Digestion of carbohydrate takes place.
- **In crop :-** Hepatic caeca - Complete digestive juice release in crop. Most of digestion occur in the crop.
- **Gizzard :-** Food throughly grinded into a paste by the thick and sharp edged cuticle of internal folds and grooves.
- Grinded food enter in to the midgut through stomodial valve.
- **Wall of mesenteron** secretes a membrane around the food called ***peritrophic membrane***. It serves to protect the wall of midgut from friction with hard food particles.
- This membrane is permeable to digestive enzyme and digestive food. Bacteria and simbiotic protozoans are present in midgut which are helpful in digestion of cellulose.
- Digestion completes in the anterior part of ***midgut.***
- Absorpiton of digested food mainly occurs in the posterior part of mid gut.
- Distribution of digested food :- by "heamocoelomic fluid"
- Peritrophic membrane and undigested food enter into the Ileum.
- **Spines** of ileum break the peritrophic membrane, so undigested substance release in ileum,
- Maximum absorption of H_2O occured in rectum by rectal papilla.

5. RESPIRATION

- Respiratory organ - ***"respiratory tubules"*** or **Tracheal system.**
- Network of respiratory tubules in body.
- This network open out side the body by the ***"spiracles"***
- 10- pair spiracles , 2-pair on thorax and 8 pairs on abdomen.
- **The spiracles are located on "Pleurone" (Lateral side of body)**

  each spiracles is guarded by a valve and bears cilia like bristles for filtering the incoming air.
- Valve absent in 1st-pair of spiracles of thorax and abdomen both.

  So they remain always open.
- Each spiracle open into a large chamber called ***"atrium"*** or tracheal chamber.
- The tracheal chambers are connected with several ***main tracheal trunks*** which repeatedely branch in to a diffuse network of small ***trachea.***



Tracheoles
(a) Filled with fluid in resting cockroach
(b) Filled with air in active cockroach

- last branches of trachea called ***"Tracheal Capillaries" or "tracheoles"***
- Tracheal capillaries develops as cytoplasmic processes of tracheal end cells.
- These process deeply merge in tissues of body
- Each cell of body is directly in contact with processes. Blood is not related with respiration in blood respiratory pigment is absent.
- Exchange of gases take place between the **tracheoles and tissues by simple diffusion**

Breathing :-

- Several ***tergo - sternal muscles*** extend between the tergites and sternites of all abdominal segments.
- When the abdomen expands, atmospheric air gets filled in the tracheal system through spiracles. This is ***inspiration.***
- When the abdomen contracts, the air is forced out. This is ***expiration.***

  expiration takes place through first pairs of spiracles of thorax and first pairs spiracles of abdomen.
- the spiracular valves control and regulate the in and out passages of the air and abdomen.

BEGINNER'S BOX-3

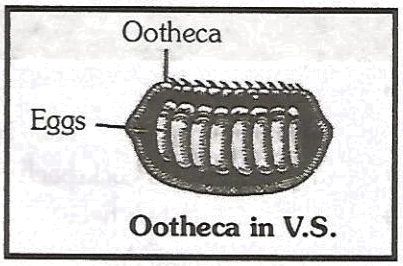
1. In cockroach salivary glands attached with :-

(1) Oesophagus (2) Pharynx (3) Crop (4) Gizzard

2. Which of the main function of tergosternal muscle ?

(1) Respiration (2) Blood circulation (3) Excretion (4) Chewing

- A pair of unequal sized ***"Spermatheca"*** are associated with genital chamber.
- Genital chamber contains female genopore, spermathecal pore and collaterial glands.
- 1-pair of collaterial glands associated with genital chamber. These are branched tubular gland, **left collaterial gland is more branched**
- Both glands open in genital chamber by a common pore
- Three pairs of chitinous processes hanging from the roof of genital chamber into its cavity are the external ganitalia of female cockroach . These are called **ovipositor** or **female gonapophyses** because these serve to arrange the ova in a newly formed ootheca, and possibly help in giving proper shape to the oothecae.



Ootheca in V.S.

Copulation

- **"Breeding season**:- from march to september
- The females secrete a highly odousous and volatile "sex attracting scent from their scent glands called **pheromones or ectohormones.**
- male perceive the smell of this scent with the help of olfactory sensillae located upon their antennae.
- male cockroach opens the ootheca pore with the help of hooks.
- The male insert whole of its phallomeres into the females's gential pouch. then it inserts its pseudopenis into the female gonopore for firm anchorage.
- Sperms are transffered through spermatophores.
- Copulation time ⇒ one hour
- The spermatophore remains inside the body of the female for about 20 hours. during this period all its sperms escape out and fill in the two spermathecae of the female, then the female drops out the case of empty spermatophore.
- Sixteen ova, one from each ovariole of the two ovaries, are dischagred at a time into the genital pouch where these are arranged by the gonapophyses into two parallel row.
- Simultaneously, sperms stored in the spermathecae are also discharged into the genital pouch to fertilize the ova.

Fertilization :

- **Fertilization** is internal and their fertilised are encased in capsules called **oothecae.**
- After fertilization the left collaterial gland secretes a soluble ***"milky protein"*** while the right one secrete dihydroxyphenol. Both secretions mix to form a **brownish scleroprotein.**
- Sclero protein forms a common egg. case, called ***ootheca.***
- Otheca is a dark reddish to blackish brown capsule, about 3/8"(8mm) long.
- They are dropped or glued to a suitable surface, usally in crack or crevice of high relative humidity near a food source.

Development :-

- On an average, female producces **9-10 ootheca,** each containing **14-16 eggs.**
- Development of egg takes place inside ootheca
- Development is **Paurometabolous**, meaning there is development through **nymphal stage.**
- Development time - ***"4 to 8" weeks***
- The nymphs look very much like adults, the nymph grows by moulting about **13 times** to reach the adult form.
- The next to last nymphal stage has wing pads but only adult cockroach have wings.
- Nymph changes into an adult in - 1 year
- time interval between two moulting called ***"stadium.***
- In between moulting nymph called ***"instar"***

GOLDEN KEY POINTS

- Some of the CO_2 leaves the body through tracheae and spiracles. But major part of CO_2 leaves through cuticular covering of body because CO_2 can diffuse more readily through chitin than O_2.
- If the head of a cockroach is cut off, it still survives for as long as one week or more.
- It is because their head holds a bit of a nervous system, while rest of it lies in, i.e., ventral part of the body, i.e, in belly region. Also, their brain does not control breathing and blood does not carry oxygen throughout the body rather the spiracles supply air directly to the tissues through a set of tubes (called trachea) in each segment separately. they are cold-blooded as blood flows in open spaces. i.e., sinuses, so they need much less food which is also one of the reasons for its survival. Without the brain, their body can still perform some functions in terms of very simple reactions.
- Their body ultimately dies due to the dehydration or starvation or from infection of bacteria, viruses etc.

BEGINNER'S BOX-4

1. In cockroach, ootheca is produced by secretion of–

(1) Conglobate gland (2) Prothoracic gland (3) Gonapophyses (4) Collaterial gland

2. Mark the incorrect match w.r.t. function–

(1) Seminal vesicle - Storage of sperm
(2) Phallic gland - Covering of spermatophore
(3) Colleterial gland - Oothecal covering
(4) Phallomeres - Nourishing sperms

3. Heart of cockroach consists of elongated muscular tube lying along–

(1) Mid ventral line of thorax (2) Mid ventral line of abdomen
(3) Lateral to the alimentary canal (4) Mid dorsal line of thorax and abdomen

4. If the head of cockroach is cut-off, it will still live for as long as one week, because–

(1) Head holds a large mass of nervous system
(2) Most of the Nervous system is present in ventral part of its body
(3) Nervous system present only in abdominal part
(4) No control of brain over the body

5. Find out the incorrect pair w.r.t. cockroach–

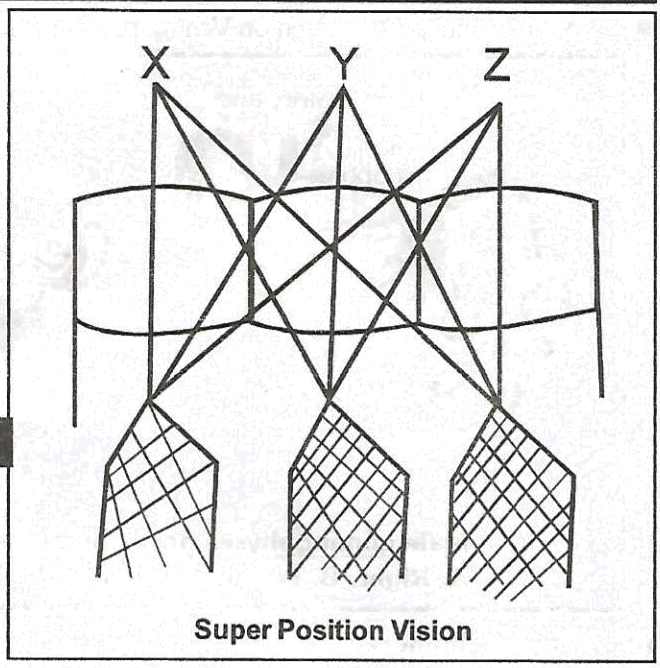
(1) A pair of testis – $4^{th} - 6^{th}$ abdominal segmental
(2) Mushroom gland – $6^{th} - 7^{th}$ abdominal segmental
(3) Titillator – Left phallomere
(4) Innermost layer of spermatophore – Utriculi brevivores

6. Nymph differs from adult cockroach in–

(1) Absence of wings (2) Smaller in size
(3) Absence of mature reproductive organs (4) All of these

(2) "Superposition vision" :-

- In dim light in nocturnal insects.
- In the night, the pigment sheath of ommatidia contracts and shrinks to their bases, hence the light rays can easily cross over from one ommatidium to adjacent ommatidia
- complete images are formed in all ommatidia. This results in the formation of blurred superpostion of the objects.



Super Position Vision

GOLDEN KEY POINTS

- In cockroach only mosaic or apposition images are formed throughout the day and night because there is no power of contraction in pigmented sheath.
- Cockroach is a nocturnal insect, but in it mosaic vision forms during night and therefore it has more sensitivity but less resolution.

10. REPRODUCTIVE SYSTEM

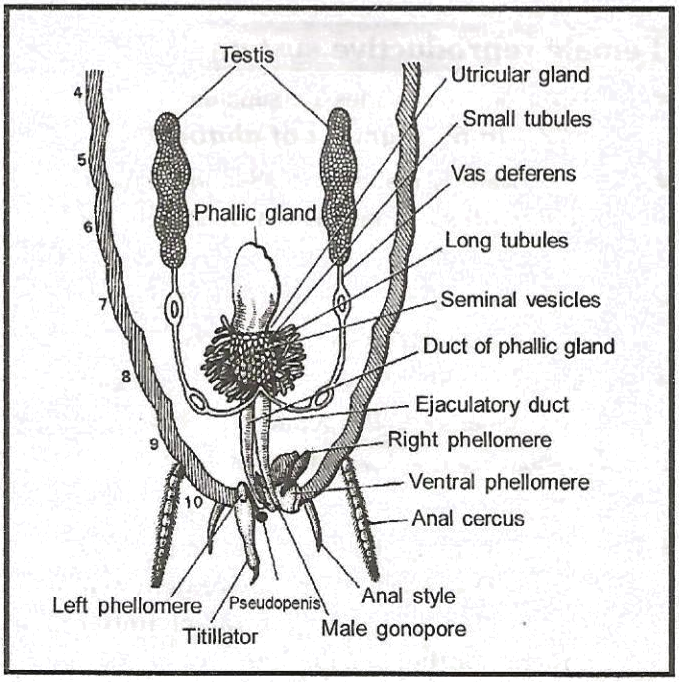
Cockroach - *is dioecious* ***(Unisexual)*** and have well developed reproductive organs.

Male reproduction system:-

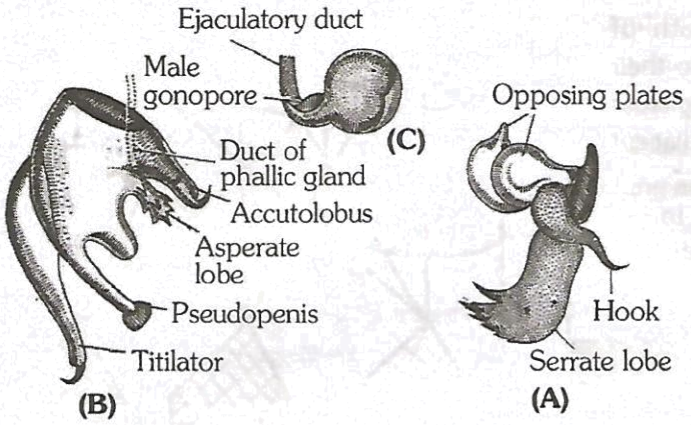
- Consists of 1-pair of testis located on lateral side in "4-6" abdominal segments.
  Each testis formed of ***"3 or 4 lobes"*** and each lobe divided into many lobules that produces sperms.
- **Vasa deferentia** - A vasa deferense arises from each testis, these open in an ejaculatory duct through seminal vesicle.
- **Ejaculatory duct** opens outside by male genital pore situated ventral to anus.
- **Seminal vesicles** are nmumerous sac like structures located at the junction of vas-deferens and ejaculatory duct.
- A gland associated with seminal vesicles called **mushroom gland or utricular gland** having two types of **tubules, (i)** small tubules on inner side - **utriculi brevivores.**

(ii) Long tubules outside - utriculi majores

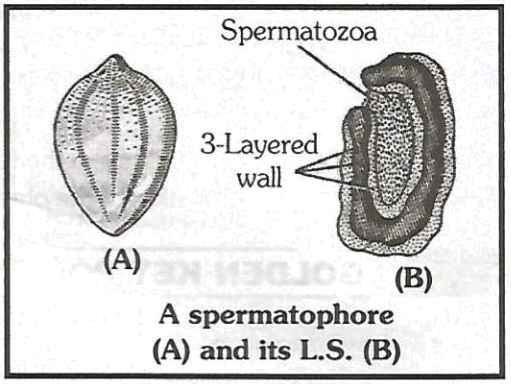
- Tips of these long tubules are also called ***"Uricose gland"*** These absorb excretory material from haemocoel.
- A gland located on mushroom gland called **phallic gland or congloblate gland.** It opens out side by a seperate duct.
- Three irregular shaped Chitinous structures associated with and male genital pore are called ***"phellomeres"*** or **male *gonapophyses*.**"
- **Phellomeres** { (i) Left phellomere; (ii) right phellomere; (iii) Ventral phellomere }
- Phallic aperture present on left phellomeres



- Male genital pore situated on Ventral phellomeres.



Male gonapophyses or phallomeres : A. Right, B. Left and C. Ventral



A spermatophore (A) and its L.S. (B)

(i) Left phellomere :- (Largest)

- Made up of a flat chitinous plate
- It bears **Titilator** (lobe with a hook), **Pseudopenis** (long with bulging tip, **Acute** and **asperate lobe** with spiny surface.

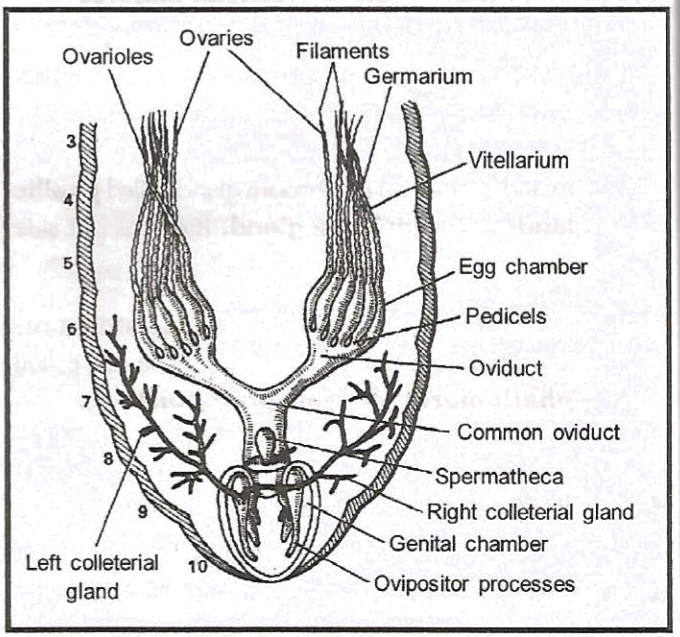
(ii) "Right phellomere" Two large hooks present at apex and a hook present on base of right phellomeres.

(iii) *Ventral - phellomere :* Smallest chitinous plate without hooks.

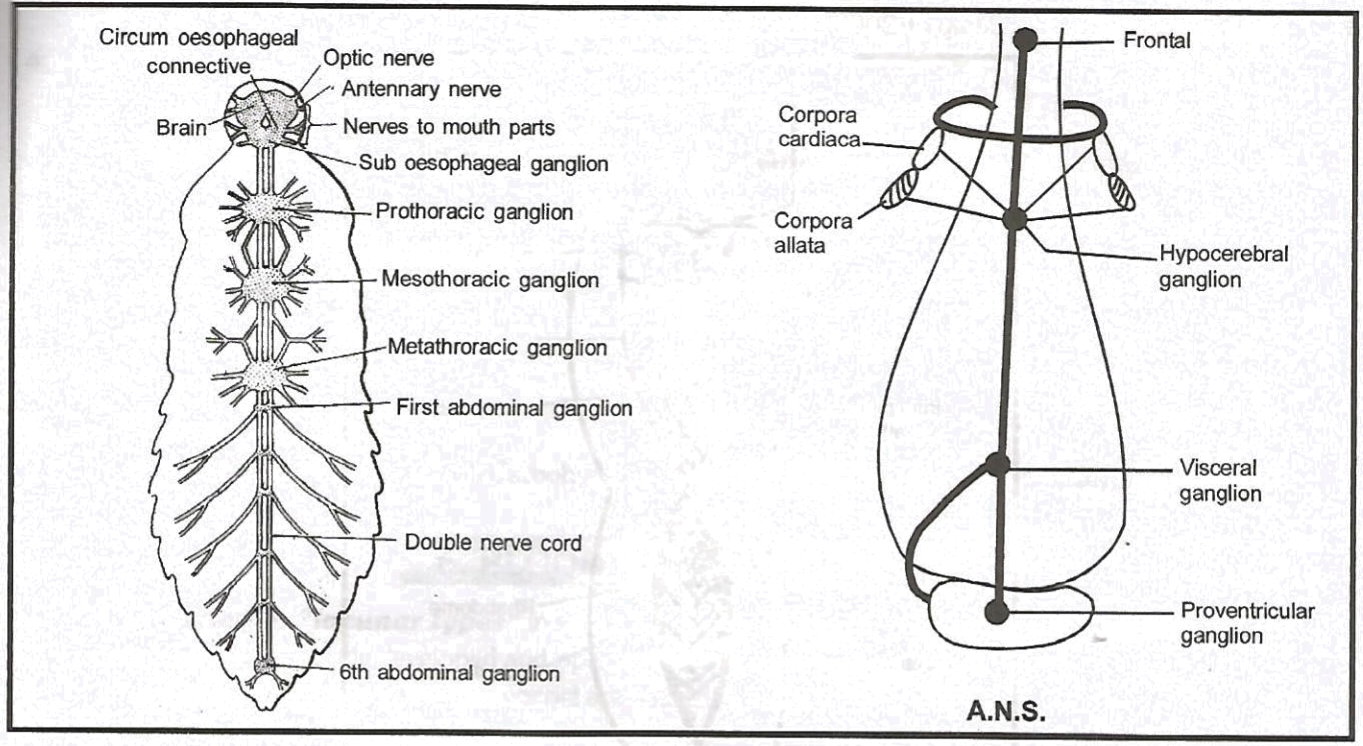
- Hooks help in opening of ootheca pore of female.
- Sperm produced in testes are stored **in Seminal vesicle.**
- All sperms released from seminal vesicles glued together to form a ball called ***"sperm ball"***
- long tubules of mushroom gland secrete a membrane around sperm ball called **spermatophore**
- small tubules :- secrete a nutritive fluid in spermatophore.
- at the time of copulation spermatophore enters into ejaculatory duct.
- Ejaculaotry duct secrete another coat on spermatophore and hence it becomes double layered.
- when it is relaesed outside from male genital pore then phallic gland secretes another layer, so spermatophore becomes **three layered.** They are finally discharged during copulation.

Female reproductive system

- 1-pair of large ovaries are situated on lateral side in ***"2nd to 6th segment of abdomen".***
- each ovary is made up of 8-long tubules called ***"Ovarioles",*** Containing a chain of developing ova.
- Only one egg in each ovariole. It means 16 ova are matured at a time in cockroach.
- Both the oviduct of ovaries fused to form **"vagina",** Which opens into the genital chamber.
- Genital chamber formed by fusion of 3 abdominal sternum.
- The 7 sternum is boat shaped and together with the 8 and 9 sterna forms **brood or genital pouch** whose anteriar part is **genital chamber** and posterior **oothecal chamber.**



8. NERVOUS SYSTEM



(1) Central Nervous system :-

It consists of brain **(Nerve ring)** and **ventral nerve cord** with segmentally arranged paired ganglia.

(a) Brain :- It is represented by ***Supra-oesophageal ganglia*** in head region and their nerve supplies to antenna and compound eyes.

- **Sub-oesophageal ganglion** on ventral side of **oesophagous** remain connected with ***Supra-oesophageal ganglia*** by circumoesophageal connectives.

(b) Nerve Cord :- paired, longitudinal, solid nerve cord is located on ventral side of body

- Nerve cord has **nine segmental ganglia.** i.e. Three large ganglia in thorax and six in abdomen. Last ganglion is located in 7th abdominal segment.
- All ganglia formed in embryo stage by the fusion of 1 pair of ganglia. last segmental ganglion formed by fusion of many ganglia.

(2) "Peripheral Nervous System"

- Several nerves arises from CNS (Nerve ring and Nerve cord) and innervate different part of body.
- All these nerves are **mixed nerves** [motor nerve fibres. / sensory nerve fibres.]

(3) "Autonomous System" (ANS)

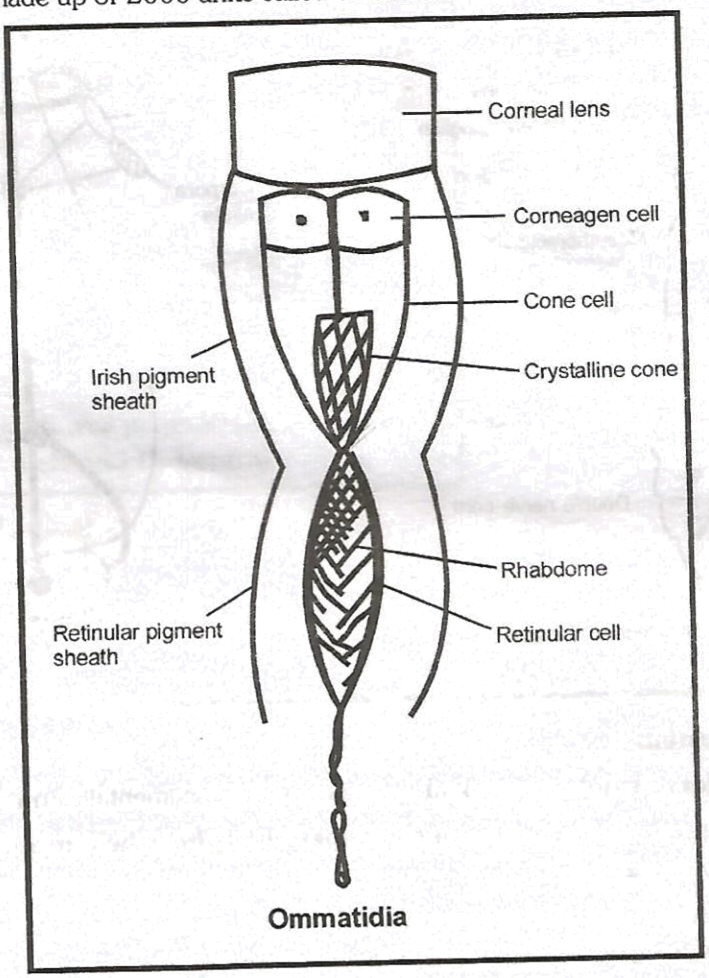
- It consists of 5 ganglia located on different parts of foregut and are inter-connected by nerves. It regulates peristalsis movement in foregut **(involuntary activity)**

GOLDEN KEY POINTS

- The nervous system of cockroach is spread throughout the body. The head holds a bit of nervous system while the rest is situated along the ventral (belly side) part of the body. So, now you understand that if the head of cockroach is cut off, it will still live for as long as one week.
- In cockroach, the sense organs are **antennae, eyes, maxillary palps, labial palps, anal cerci** etc.

9. COMPOUND EYES

- Each compound eye made up of 2000 units called ***ommatidia.***

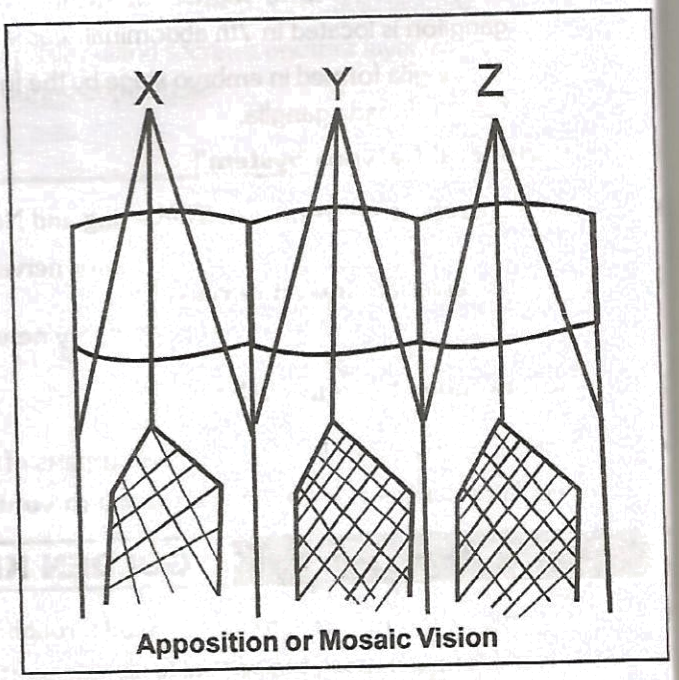


Ommatidia

Mechanism :- two types of vision are found in insects.

(1) Apposition or mosaic vision :-

- Apposition vision form in bright light
- Ommatidia fully covered by pigmented membrane. The light rays reflected from an object enter into a number of ommatidia.
- Only straight light ray enters into an ommatidium and reaches into its receptor region and forms the image of corresponding part of the object, while cross light rays get absorbed.
- Thus several images (Pieces) of an object are received and assembled by brain, thus whole object becomes visible.



Apposition or Mosaic Vision

3. Grinded food enters into the midgut through :-
(1) Sieve (2) Stomodial valve (3) Gizzard (4) Crop

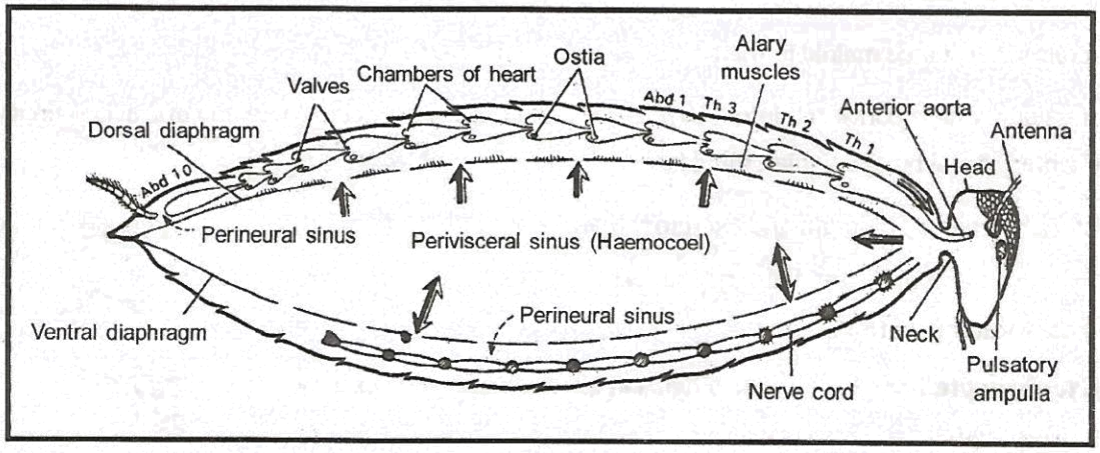
4. Gastric caeca are present at _____.
(1) Junction of fore gut and midgut (2) Foregut
(3) Hindgut (4) Junction of midgut and Hindgut

5. In cockroach which of the following help in exchange of gasas ?
(1) Spiracles (2) Respiratory tubule
(3) Tracheoles (4) Abdomen

6. Cockroach can digest _____.
(1) Protein (2) Carbohydrate (3) Fat (4) All of them

6. BLOOD VASCULAR SYSTEM

- "Open types" or ***"lacunar types"*** in which blood remain filled in tissue spaces or **blood sinuses.**
- Blood vessel are poorly developed and open into tissue space or haemocoel.
- Visceral organs located in the haemocoel are bathed in blood.
- largest blood sinus - "haemocoel"
- Blood of cockroach - "haemolymph" [Colourless - plasma; Blood corpuscles (haematocytes)]
- "Haematocytes" -
  (i) Phagocytosis of bacteria (Protection)
  (ii) related with blood clotting.
- Blood is not related with respiration, because respiratory pigment absent but it helps in transportation of food, hormones and excretory materials.
- Two horizontal septa are present in body cavity.
  (1) Dorsal diaphragm
  (2) Ventral diaphragm
  ] Both have minute pores called ***"fenestrae"/sphincters***



Diaphragms divides the haemocoel in three chambers i.e.

(1) Dorsal sinus - **Pericardial sinus** - It contains heart.

(2) Middle sinus - **Perivisceral sinus** has alimentary canal and fat body.

(3) Ventral chamber - **Perineural sinus** has nerve cord.

Heart of Cockroach :-

- It consists of elongated muscular tube lying along the mid - dorsal line of thorax and abdomen.
- **Dorsal, tubular** and 13 **chambered.**
- It is differentiated into funnel shaped chambers with ostia on either side. These pores act as valve.
- Blood enters from pericardial sinus to heart through ostia when heart chamber relaxes (Diastole)
- Each Posterior chamber of heart connected/related with anterior chamber by a valve like pore.
- Each heart chamber pumps blood into anterior chamber when it contracts (systole), and thus blood reaches into head sinus.
- Special type of cells attached with heart wall are called ***"nephrocytes".*** They probably helps in regulation of HBR (49 beats/minute) and excretion.
- First chamber of heart opens into head sinus through a long tubule called ***"anterior aorta"***
- 12-pair fan like muscles present in pericardial sinus called ***alary muscles***. One end which, is attached to tergum and other end is connected to dorsal diaphragm. These are also fused with heart wall and help in maintaining ***"blood circulation".***
- Tergosternal muscle also help in blood circulation.
- ***"Pulsatile ampulla"*** are present at base of each antennae and wings. These help in blood circulation in antennae and wings.

7. EXCRETORY SYSTEM

- Main excretory organ - **Malpighian tubules**
- These are yellow coloured, thin, filamentous, blind tubules located at the junction of ***midgut*** and **hind gut.**
- Number of malpighian tubules – 100-150
- They are lined by glandular and ciliated epithelium.
- They help in removal of excretory substance from heamolymph.
- Excretory substance mainly in the form of ***"potassium Urate"***
- Potassium urate is converted into ***"Uric Acid"*** and potassium bicarbonate and uric acid is finally relased into alimentary canal by malpighian tubules.
- Water absorbed by hind gut and excretory materials along with undigested food is released outside.
- They are enteronephric and also help in osmoregulation (Water conservation)

(i) **Fat bodies (Urate cells)**
(ii) **Nephrocytes** } Also helps in excretion (Storage excretion)
(iii) **Body wall -**

(iv) **Uricose glands** - These help in excretion in male cockroach only.

- Body wall absorbs excretory materials from Haemocoel and store in cuticle. Then at the time of moulting excretory substances and cuticle separate out from body.

7. In cockroach which of the following features is not associated with conservation of water?
(1) Wall of rectum is provided with six rectal papillae
(2) Uricotelism
(3) Presence of waxy layer above the epicuticle
(4) Presence of thin and transparent chitinous membrane on the inner linning of mesenteron

8. One of the following muscles deal with respiration of cockroach–
(1) Alary muscles
(2) Sternotergal muscles
(3) Intercostal muscles
(4) Adductor muscles

9. During metamorphosis, under the ecodysone hormone moulting occurs_____ times in *Periplaneta*–
(1) 3–5
(2) 15–20
(3) 13
(4) 1–2

10. In male cockroach, outermost layer of spematophore is secreted by–
(1) Ejaculatory duct, during copulation
(2) Phallic gland, during copulation
(3) Mushroom gland, during copulation
(4) Conglobate gland, after copulation

ANSWER KEY

BEGINNER'S BOX-1	Que.	1	2	3	4	5	6				
	Ans.	2	1	4	1	2	3				

BEGINNER'S BOX-2	Que.	1	2	3	4	5					
	Ans.	4	3	3	4	3					

BEGINNER'S BOX-3	Que.	1	2	3	4	5	6				
	Ans.	1	1	2	1	3	4				

BEGINNER'S BOX-4	Que.	1	2	3	4	5	6	7	8	9	10
	Ans.	4	4	4	2	4	4	4	2	3	2

Biology

Target : Pre-Medical

Study Material for PRE-MEDICAL
(Distance Learning Programme)

Chapter # 06

STRUCTURAL ORGANISATION IN PLANTS
(MORPHOLOGY OF FLOWERING PLANTS & ANATOMY OF FLOWERING PLANTS)

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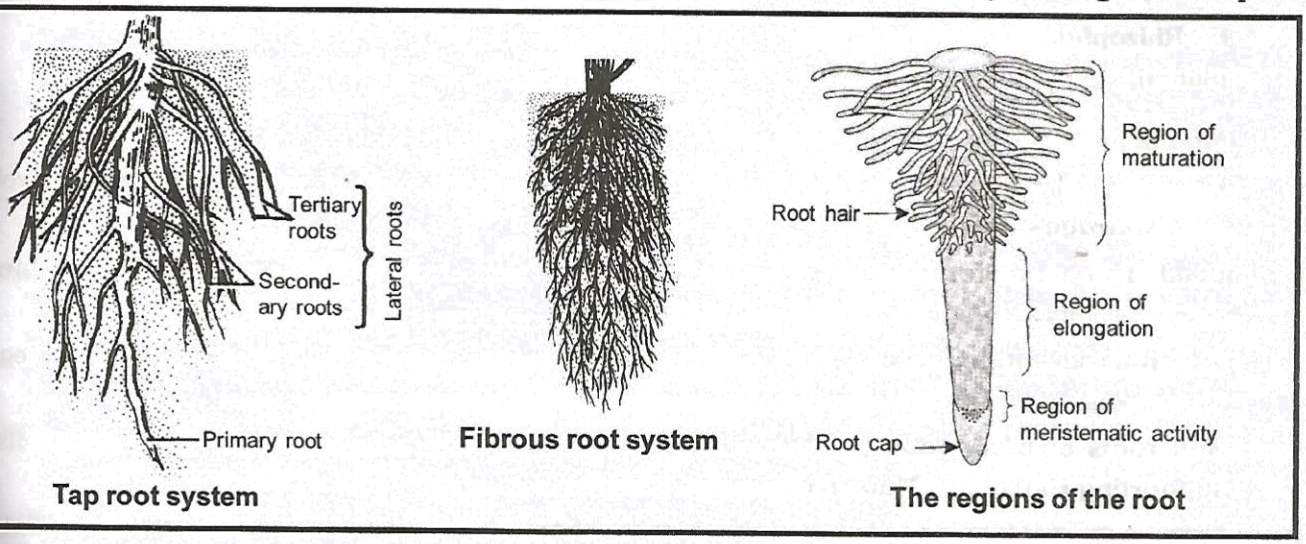
MORPHOLOGY OF FLOWERING PLANTS

ROOT

Roots are (+) vely geotropic, (+) vely hydrotropic, (–) vely phototropic.

TYPES OF ROOTS

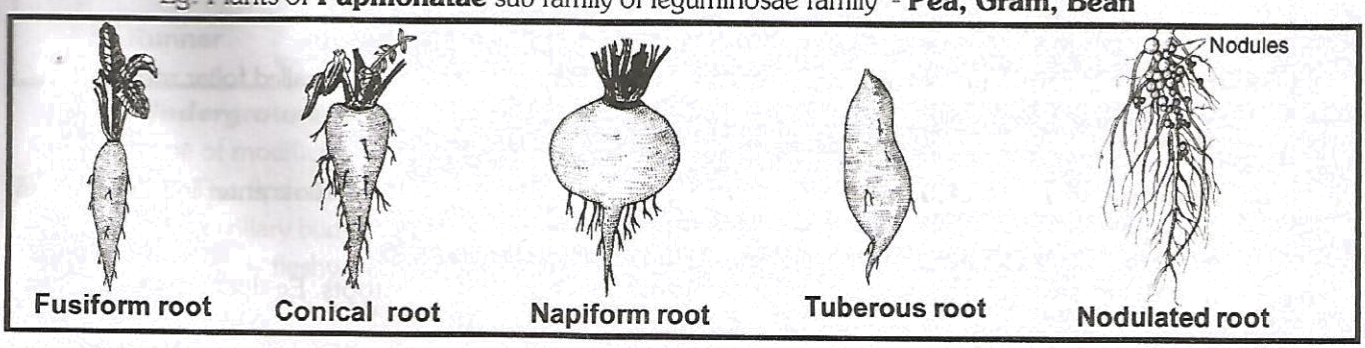
- **Tap roots :–** In most of the **dicot plants**, the direct elongation of the **radicle** leads to the formation of **primary root**. It bears lateral roots of several orders that are referred to as **secondary, tertiary roots,** etc. The primary roots and its branches constitute the **tap root system. Eg. :- mustard plant**
- **Adventitious roots :–** In some plants, like **grass**, ***monstera*** and the **banyan tree**, roots develop from parts of the plant other than the radicle and are known as **adventitious roots.**
- **Fibrous roots :-** In **monocot plants**, the primary root is short lived and is replaced by a large number of roots. These roots originate from the base of the stem and constitute the **fibrous root system. Eg. :- wheat plant**



Functions of the root system :- Absorption of water and minerals, provide a proper anchorage to the plant parts, storage of reserve food material (Carrot, Radish) and synthesis of PGR (plant growth regulators).

MODIFIED ROOTS

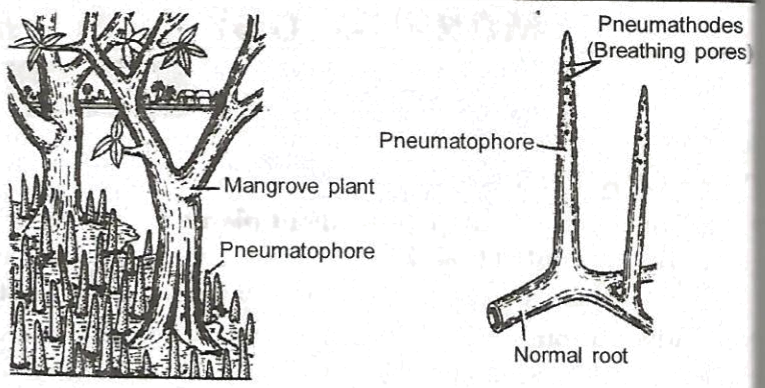
1. **Modified tap root for storage :**
   - (i) **Fusiform roots/Spindle roots** - These root are thicker in the middle and tapering on both ends. ***eg. :-*** **Radish (*Raphanus sativus*)**
   - (ii) **Conical roots** - These roots are thicker at their upper side and tapering at lower side eg. **Carrot (*Daucus*)**
   - (iii) **Napiform roots** - These roots become swollen and spherical at upper end and tapering (like a thread) at their lower end. Eg. **Turnip (*Brassica rapa*),** Sugarbeet = Beet root (*Beta vulgaris*)
   - (iv) **Tuberous roots** - These roots do not have regular shape and any portion of roots become swollen & fleshy. Eg. Mirabilis.
   - (v) **Nodulated roots** - Nodules are formed on branches of roots by nitrogen fixing bacteria (*Rhizobium*). Eg. Plants of **Papilionatae** sub family of leguminosae family - **Pea, Gram, Bean**



2. **Tap root modified for respiration**

In marshy/swampy areas, scarcity of oxygen is found. Some branches of tap root of the plants which grow in this region, grow vertically upward and comes on the surface. These roots are called **pneumatophores** which have minute pores called **pneumathodes** or **lenticels** by which air enters in the plant and plant gets oxygen for respiration Pneumatophores are negatively geotropic

Eg. **Rhizophora,** Heritiera, **(Mangrove plants)**



Respiratory roots (Pneumatophores) of Rhizophora

Modification of adventitious roots :

(i) **Fasciculated roots** - These are adventitious roots occuring in clusters and all of them are swollen Eg. ***Asparagus*, Dahlia**

(ii) **Beaded or moniliform roots** - Root swells up like a bead at different places after a regular interval Eg. *Vitis(Grapes), Momordica (Bitter gourd), Portulaca.*

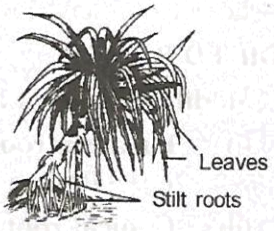
(iii) **Tuberous adventitious roots** : The food is stored in these roots, therefore they become swollen and irregular These roots have no definite shape Eg. **Sweet potato (*Ipomoea batatus*)**

(iv) **Stilt roots or brace roots** - These roots arise from lower node and enter in the soil. These roots are **supporting roots.** Eg. **Maize**, **Sugarcane,** *Pandanus* (screwpine).

Fasciculated roots

Beaded or Moniliform roots

Tuberous roots



Stilt roots

(v) **Prop roots or pillar roots** - These roots arise from branches of plant and grow downward towards the soil These roots **support the tree.** Eg. **Banyan (*Ficus bengalensis*)**

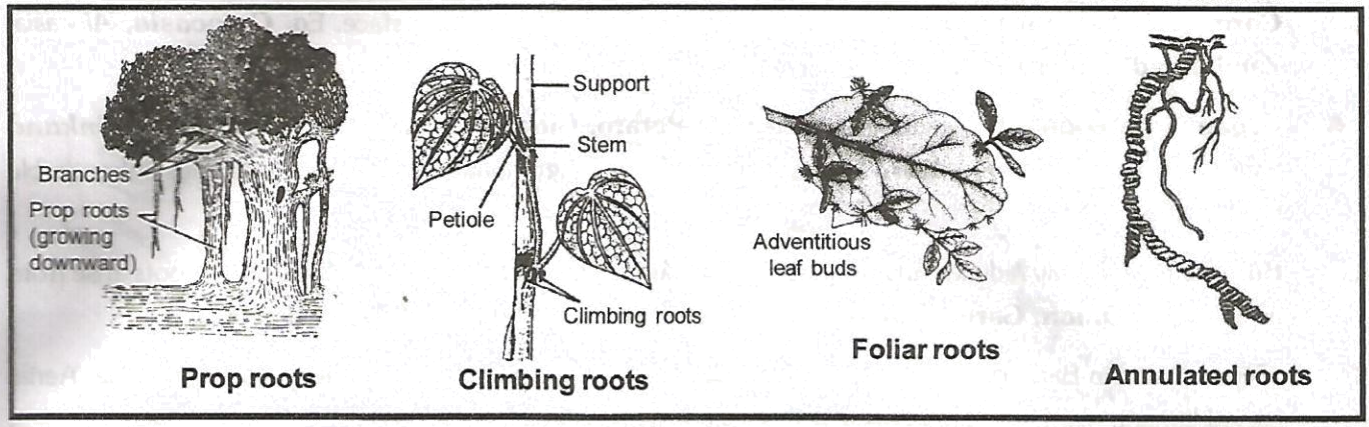
(vi) **Climbing roots** - These roots arise from nodes and help in climbing Eg. **Money plant *(Pothos), Monstera*** Betel (Piper betel), Black pepper.

(vii) **Foliar roots or Epiphyllous roots :–** When roots arise from leaf then they are called foliar roots.

Eg. ***Bryophyllum,*** *Begonia.*

(viii) **Sucking roots or Haustorial roots or Parasitic roots :–** In parasitic plants, roots enter in the host plant to absorb nutrition from the host. Eg. *Dendrophthoe,* ***Cuscuta***, *Viscum.*

(ix) **Annulated roots :** In these roots swelling occurs in a series of rings on the roots. Eg. Ipecac.



STEM

Stem develops from the plumule of the embryo of a germinating seed. The stem bears **nodes** and **internodes.** The region of the stem where leaves are borne are called nodes while the portions between two nodes are called internodes. Stem shows negatively geotropic growth.

The main function of the stem is spreading out branches bearing leaves, flowers and fruits. It conducts water, minerals and photosynthates (food). Some stems perform the function of storage of food, support, protection and of vegetative propagation.

Forms of stem :–

(i) **Caudex/Columnar :–** It is unbranched, erect, cylindrical stem and marked with scars of fallen leaves. ***eg :–*** Palm.

(ii) **Culm :–** Jointed stem with solid nodes & hollow internodes. ***eg :–*** Bamboo (Gramineae).

Modification of stem :–

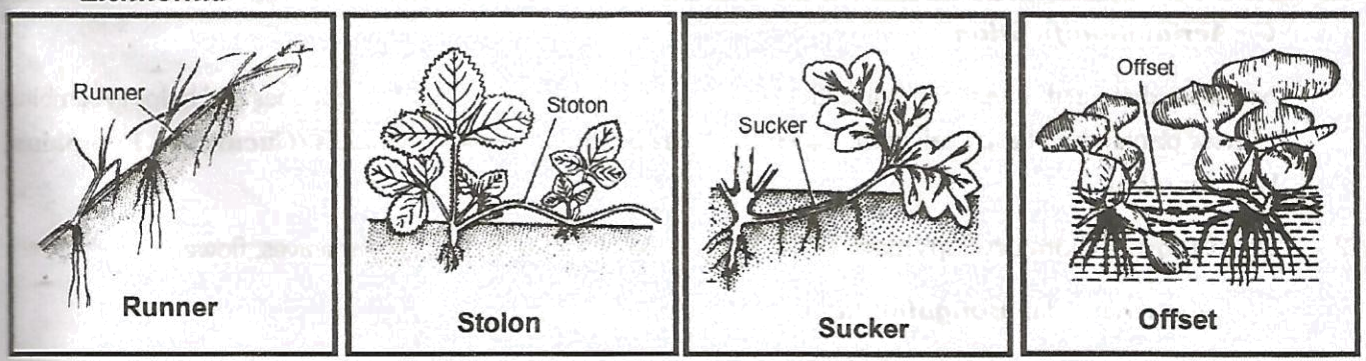
A - sub-aerial modification **-** These are **creeping stems**.

(1) **Runner** - In these stems roots develop at lower side and leaves at upper side from the nodes eg. ***Cynodon dactylon* (Doob grass),** *Oxalis.*

(2) **Stolon** - In it branches develop from the lower part of the main stem and grow for some distance like arch and finally touch the ground to give rise to new shoot. Eg. **Fragaria (**Wild **strawberry) , Jasmine,** Peppermint

(3) **Sucker** - In it the main stem grows in the soil but branches develop from nodes and comesout from the soil. Eg. **Mint, Pineapple, Chrysanthemum, Banana.**

(4) **Offset** - Generally these occur in aquatic plants which have fragile stem. Internodes of offset are small & thicker and each node bears a **rosette of leaves** and a **tuft of roots**. It is also known as **aquatic runner.** Eg. ***Pistia, Eichhornia***



B – Underground modification

This type of modification occurs generally for food storage and vegetative propagation.

(1) **Tuber** - The tips of branches become swollen in the soil. **Eyes are found on tuber which are axillary buds** and axillary buds are covered with scaly leaves. Eg. **Potato**.

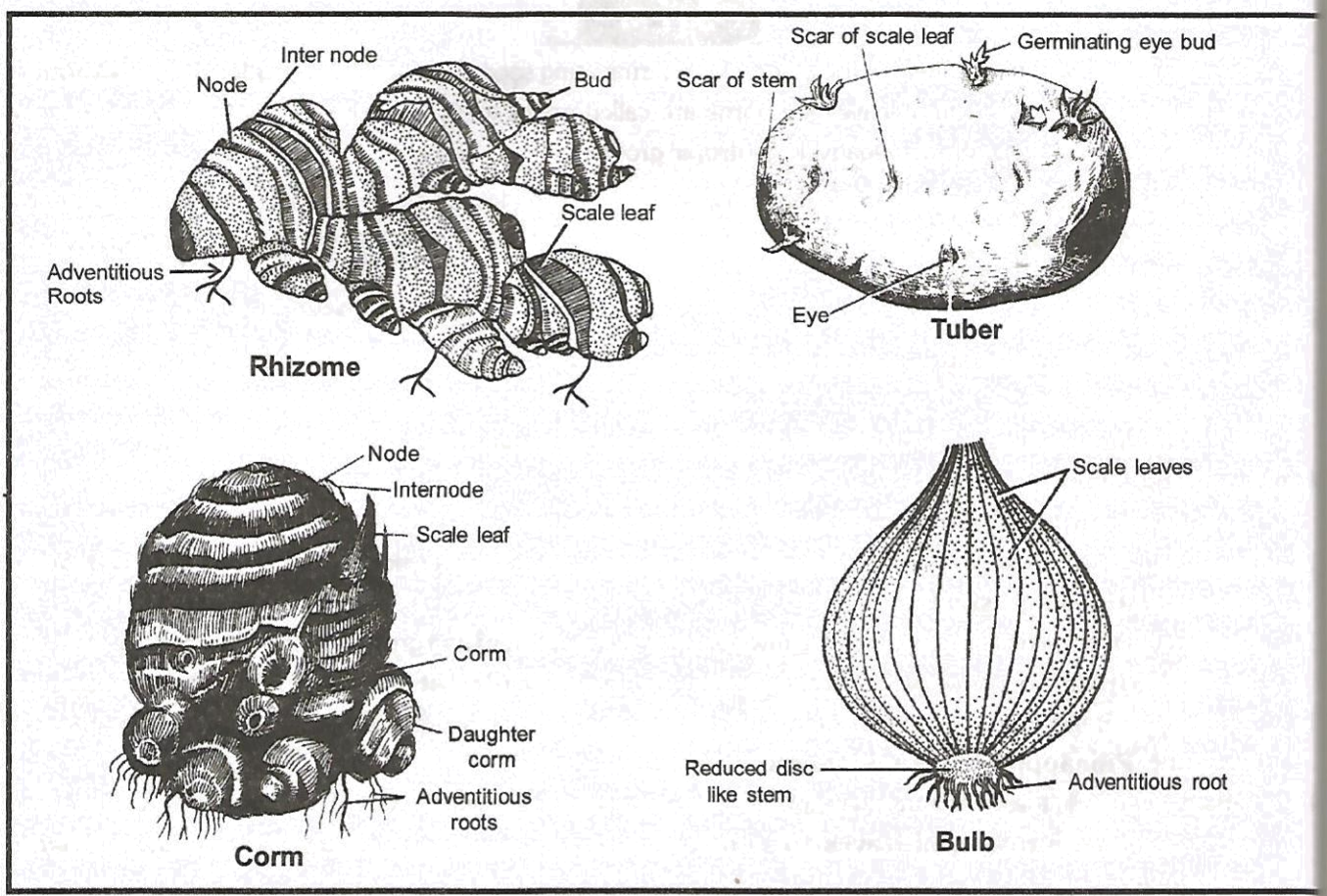
(2) **Rhizome** - It is fleshy stem which grows horizontally in the soil. Nodes and small internodes are found which are covered by scaly leaves. Eg. **Ginger, Turmeric,** Canna, Water lily, **Banana**.

(3) **Corm** - It is condensed structure which grows vertically under the soil surface. Eg. ***Colocasia,*** *Alocasia* **Zaminkand,** Saffron, Colchicum.

- **Organ of perennation** - Underground stems of **Potato, Ginger, Turmeric, *Colocasia, Zaminkan*** are modified to store food in them. They also act as organ of perennation to tide over conditions unfavourabl for growth.

(4) **Bulb** - Stem is highly reduced and disc like and surrounded by numerous fleshy leaves. Many roots arise fro its base. Eg. **Onion, Garlic. The fleshy leaves of onion and garlic store food.**

Note : Type of stem in Banana is rhizome and modification is sucker. Banana propagates through rhizome. Aeri part of banana plant which looks like stem is pseudostem (leaf bases).



C - Aerial modification

(1) **Stem tendril** - In this type of modification axillary bud forms tendril in place of branches and helps in climbin of those plants which have weak stem. Eg. **Grapes/Grapevines,** *Passiflora,* **Gourds *(Cucumber,* Pumpkins Watermelon)**

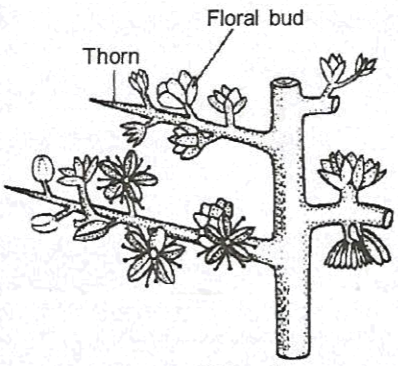
(2) **Stem thorn** - Thorn develops mainly from axillary bud of the stem. It may bear leaves, flowers.

Eg. *Carissa* (Karonda), ***Bougainvillea***, Pomegranate, ***Citrus***

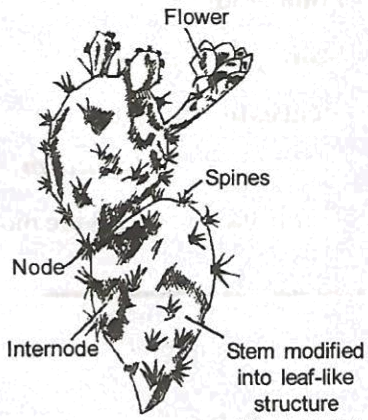
- Thorn protects plant from browsing animals. It is a **woody structure.**

(3) **Phylloclade** - Stem is modified into a fleshy flat ***(Opuntia)*** or fleshy cylindrical ***(Euphorbia)*** and green lea like structure and carries out photosynthesis like leaf. The leaves are modified into spines Eg. ***Opuntia*** **Euphorbia, Cactus.**


Stem tendril



Stem thorn



Phylloclade

LEAF

The leaves develop from the nodes. Their main function is to carry out photosynthesis or food formation, axillary buds are found in the axil of leaves. The axillary bud may develop into a branch. Leaves originate from shoot apical meristems and are **arranged in an acropetal order.**

Leaf is divided into 3 main parts :–

(1) **Leaf base (Hypopodium)** - The part of leaf which is attached to stem is known as leaf base. **Sheathing leaf base** is found in **monocots.** In monocots, the leaf base expands into a sheath covering the stem partially or wholly. **Pulvinus leaf base** found in **some legume plants.**

(2) **Petiole (Mesopodium)** - The part of leaf connecting the lamina with the branch or stem is known as petiole. Petiolated or stalked leaves are known as **petiolate leaves** and when petiole or stalk is absent then leaves are called **sessile**. In *Eichhornia* petiole swells up and in *Citrus* it is winged. The petiole help hold the blade to light. Long thin flexible petioles allow leaf blades to flutter in wind, thereby cooling the leaf and bringing fresh air to leaf surface.

(3) **Lamina (Leaf blade=Epipodium)** - It is a broad and flattened part of leaf. Its main functions are photosynthesis and transpiration.

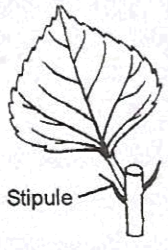
Stipules :–

Leaves of some plants have lateral appendages on either side of leaf base, known as stipules.

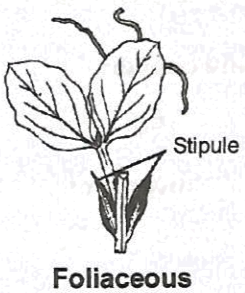
Leaf with stipule is known as **stipulate leaf**, eg. **Fabaceae** Leaf without stipule is called **ex-stipulate leaf** eg. **Solanaceae, Liliaceae**.

Stipules are of various types -

1. **Free lateral**- They are independently present on both sides of leaf base. Eg. *Hibiscus rosasinensis* (China rose).



Free lateral



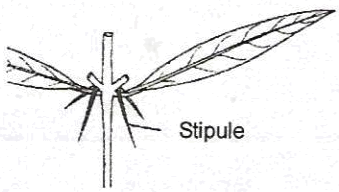
Foliaceous

2. **Foliaceous** - These type of stipules are leaf like. ***Eg. :- Pea***

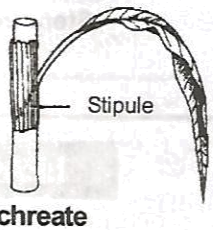
3. **Spiny** - Stipules modified into spine like structures. Eg. *Zizyphus* (Ber)

4. **Ochreate** - When both stipules of a leaf combine together and form a **tube like structure,** then it is call ochreate. Eg. ***Polygonum***

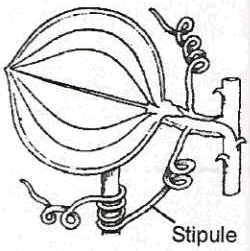
5. **Tendrillar** - Stipules are modified into tendrils like structure. Eg. ***Smilax***



Spiny



Ochreate



Tendrillar

Types of Leaves -

Bracts - These are leaf like structure which may present at base of pedicel of flower.

Bracteoles - These are leaf like structures found on pedicel.

VENATION OF LAMINA

The arrangement of veins and veinlets in leaf lamina is known as venation. It is of 2 - types

(1) **Reticulate**. It is found in **dicots**. Exception – ***Calophyllum*** (It has parallel venation)

(2) **Parallel**. It is found in **monocots**. Exception – ***Smilax*** (It has reticulate venation)

1. **Reticulate venation** - In this type of venation lateral veins are divided into various branches (veinlets) an **vein lets form a net like structure.**

Reticulate venation is of 2 types -

(a) **Unicostate or pinnate** - This type of venation is having only **one principal vein** or midrib that give off many lateral veins which proceed towards margin and apex of lamina of the leaf and form a networ

Eg. :- Mango, Guava, Peepal.

(b) **Multicostate or palmate** - In this type of venation **many principal veins** arising from the tip petiole and proceed upward, this is again of two types -

(i) **Multicostate convergent** - Many principal veins arising from the tip of petiole, converge toward the apex of leaf. ***Eg. :-*** Camphor, *Zizyphus* (plum), Tejpat, Chinarose.

(ii) **Multicostate divergent** - Many principal veins arising from the tip of petiole diverge from on another towards the margin of leaf blade eg. Cotton, Castor, *Cucurbita.*

Unicostate (Pinnate)

Multicostate (Palmate)
Convergent

Multicostate (Palmate)
Divergent

RETICULATE VENATION

2. **Parallel venation** - In this type of venation, **all veins run parallel to each other and they donot form network.**

They are of 2 types -

(a) Unicostate or pinnate : This type of pattern is having only **one principal vein**, that gives off many lateral veins, which proceed toward the margin of leaf blade in a parallel manner but they donot have veinlets.

Eg. Banana, Ginger, Canna

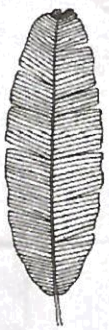
(b) Multicostate or palmate : This type of pattern is having **many principal veins** arising from the tip of the petiole and proceeding upwards.

(i) **Multicostate convergent :** Many principal veins arising from the tip of petiole converge towards the apex of leaf blade.

***Eg.* :–** Wheat, Grass, Sugarcane, Bamboo

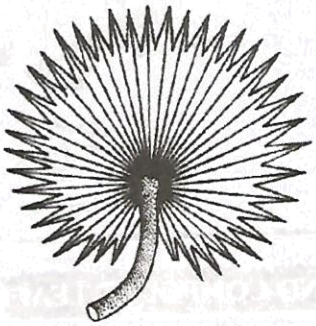
(ii) **Multicostate divergent :** Many principal veins arising from the tip of petiole diverge towards the margin of leaf. They do not divide into veinlets and do not form network.

Eg. :– Coconut, Fan palm.



Unicostate

Multicostate convergent



Multicostate divergent

PARALLEL VENATION

MODIFICATION OF LEAVES When leaves are modified into different structures then it is called modification of leaves.

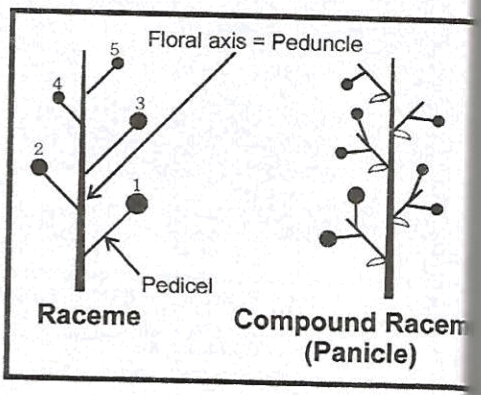
(1) **Leaf tendril** - In some plants whole leaf is modified into a wire like structure which is called leaf tendril Eg. *Lathyrus aphaca* (wild pea) → **Peas**.

(2) **Leaf spine** - Leaves are modified into pointed spines. Eg. ***Opuntia***, ***Cacti,*** *Argemone.*

INFLORESCENCE

The arrangement of flowers on the floral axis is termed as inflorescence.

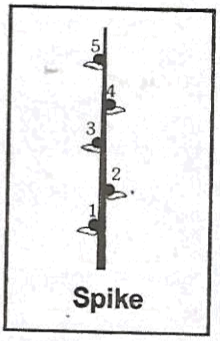
RACEMOSE/INDEFINITE In this type of inflorescence the main axis continues to grow and does terminate in a flower and flowers are borne laterally in an **acropetal order/acropetal succession** (Wh old flowers are arranged at lower side and young flowers are at upper side).
This is of following types :



1. **Raceme** - In this type of inflorescence, peduncle (main axis or floral axis) is elongated and **flowers are pedicellate.**

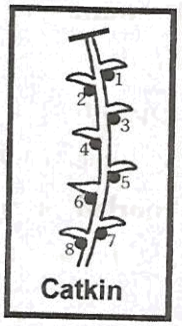
   Eg. **Radish, Mustard**

   - When peduncle is branched and each branch bear pedicellated flowers like raceme and are arranged in acropetal manner then it is known as **compound raceme** or **Raceme of racemes** or **panicle** *Eg.* Gulmohar, Neem.



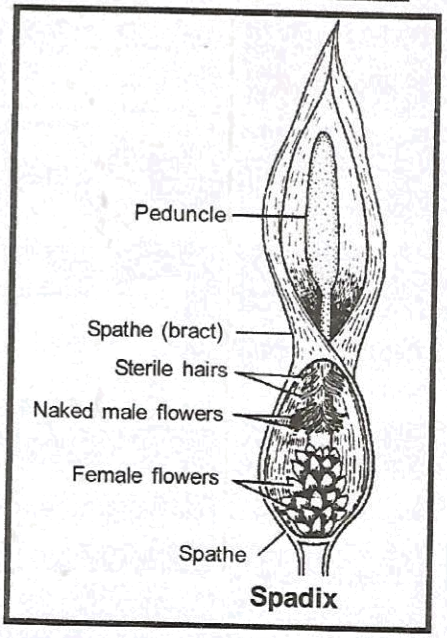
2. **Spike** - In this type of inflorescence peduncle is elongated but **flowers are sessile** (without pedicel). *Eg. Achyranthes.*

   - When peduncle is branched and each branch bears spike like infloresence then the small branch having flowers is called spikelet and this arrangement is called **spike of spikelets.** Eg. **Grass family (Gramineae = Poaceae).**



3. **Catkin/Amentum** - In this type of inflorescence **peduncle is thin, long and weak, and flowers are sessile and unisexual** unisexual flowers develop on separate catkin.

   Eg. **Mulberry (Shahtoot)**, Bhojpatra *(Betula)*, Oak (*Quercus*).

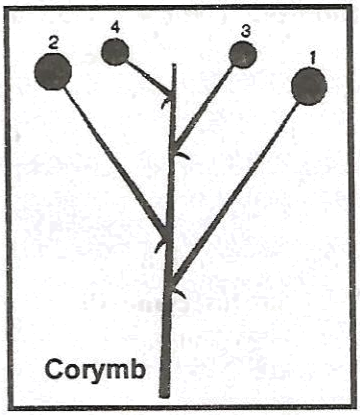


4. **Spadix** - In this type of inflorescence **peduncle is thick, long and fleshy** and it has small sessile and unisexual flowers covered with one or more **large green or colourful bracts (spathe).**

   Eg. Colocasia, **Maize**, Aroids. (Palms - compound spadix)

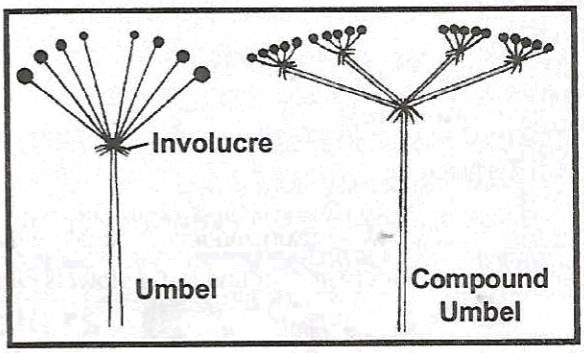
   - **Grain of maize is a fruit (caryopsis).**
   - **Long filamentous threads** (Silky hairs) protruding at the end of a young cob of maize **are styles.**

5. **Corymb** - In this type of inflorescence peduncle is short and all flowers are present at same level because the lower flower has much longer pedicel than the upper once. eg. Candytuft (*Iberis amara*) = Chandani, Capsella.



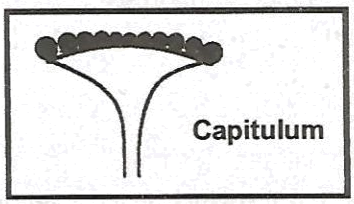
- If peduncle is branched and each branch has flower cluster, then this type of inflorescence is called **compound corymb or corymb of corymbs.** eg *Pyrus terminalis, Pyrus malus,* ***Cauliflower***

6. **Umbel** - An inflorescence in which the flower stalks (Pedicels) are of more or less equal in length, arise from the same point. At the base of flowers stalk, there is whorl of bracts forming the **involucre**. eg. *Centella* (Brahmi)



- If peduncle is branched and each branch has flower cluster then this type of inflorescence is called **compound umbel** or **umbel of umbels** eg. ***Coriandrum (Coriander or* Dhania),** ***Foeniculum*** (Fennel or Saunph), ***Cuminum*** (Cumin or Jeera) **(Umbelliferae or Apiaceae family).**

7. **Capitulum/Racemose head (Anthodium)** - In this type of inflorescence tip of peduncle becomes broad, flattened concave or convex (**receptacle**). On it small sessile flowers are found. These flowers are called **florets**.



If all the flower of capitulum are same, then it is called homogamous head eg. Vernonia. The flowers which are present in centre are small & called **disc florets** and flowers which are present at periphery are large & called **ray florets,** it is known as centripetal order and this type of head is called **heterogamous head**. In this type of inflorescence florets may be unisexual, bisexual and sterile. This inflorescence is surrounded by one or more involucre. It is **most advanced type of inflorescence,** because all flowers are pollinated at the same time and **due to surity of pollination.** Eg. **Compositae/Asteraceae family [Sunflower**, *Zinnia*, **Marigold (*Tagetes*)].**

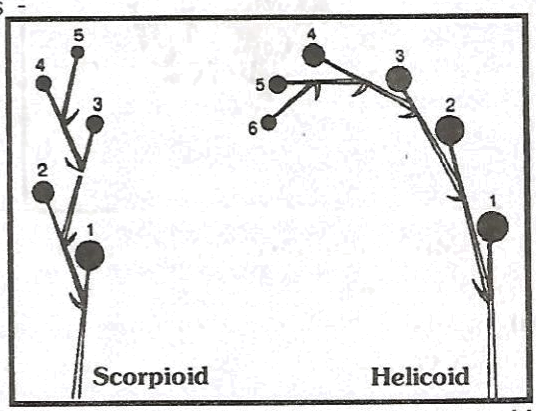
CYMOSE/DEFINITE

In this type of inflorescence, the main axis/peduncle terminates in a flower. In it the older flowers are present at upper side and young flowers are arranged towards the base. This type of arrangement is called **basipetal succession/basipetal order.** It is of following types -

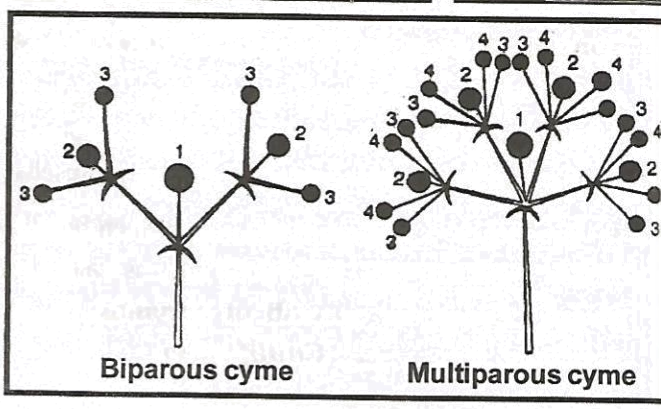
1. **Uniparous cyme/Monochasial cyme** - The peduncle ending in a flower producing one lateral branch at a time which also ending in a flower. It is of two types -

(a) **Helicoid cyme** - When all lateral branches develop on the same side on peduncle forming a sort of helix, then it is called helicoid cyme. Eg. *Heliotropium, Drosera.*

(b) **Scorpioid cyme** - In this type one lateral branch develops on one side and the other branch develops opposite to first one, i.e. they lie alternate to each other. Eg. *Begonia*



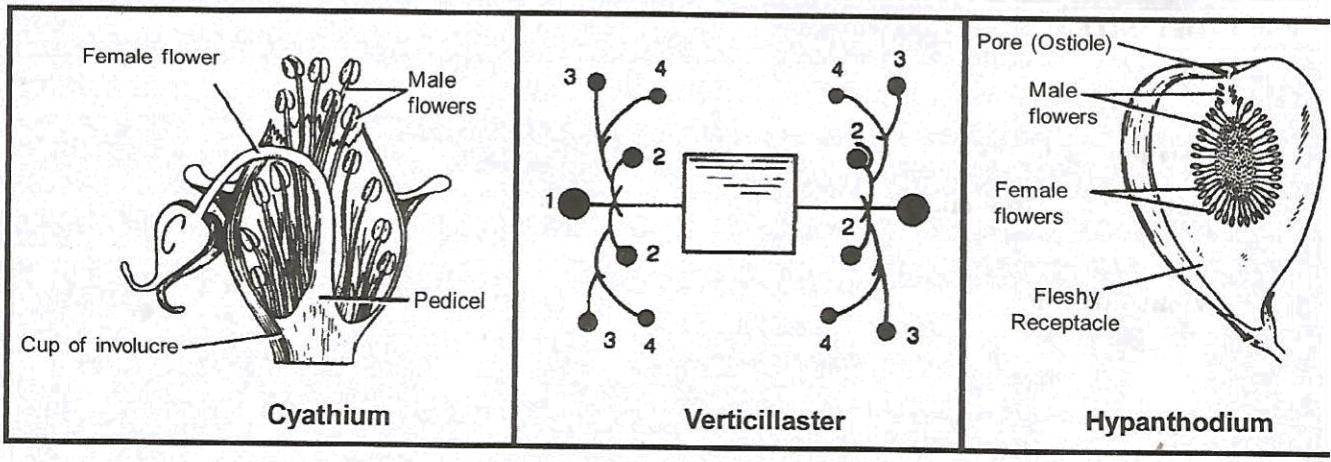
2. **Biparous cyme / Dichasial cyme** - In this type of inflorescence peduncle ends in a flower and from the basal part of peduncle two lateral branches arise which also end in a flower, now this same arrangement occurs on these lateral branches.
   Eg. Bougainvillea, Jasmine, Teak.
3. **Multiparous cyme/Polychasial cyme** - In this type of inflorescence peduncle ends in a flower and from the base of it many lateral branches arise, which also terminate in flower, this arrangement now also occurs on these lateral branc
   eg. *Calotropis* (madar), *Asclepias.*



SPECIAL TYPE OF INFLORESCENCE

1. **Cyathium** - The bracts or the involucres become fused to form a **cup shaped structure,** on the mar of it secretory gland is found. In the central part of cup shaped structure a female flower is found, wh matures earlier. Due to the growth of pedicel this flower comes out from the cup shaped structure. Achlamydo female flower is surrounded by small achlamydous male flowers. The male flowers, which lie towards centre mature earlier than the flowers which lie towards the periphery. Male flowers are represented stamens
   This type of inflorescence is found in **Euphorbiaceae family** - *Euphorbia, Poinsettia, Pedilanthus.*
   Ratio of female & male flowers → One : many
2. **Verticillaster** - This type of inflorescence is found in **Labiatae/Lamiaceae family**. In this type of inflorescer leaves are arranged in opposite manner on stem. From the axil of each leaf inflorescence develops. Fr the main axis, lateral axis arises, on which flowers are found. Now from these branches lateral branc develop also which bear flowers. In this type of inflorescence each **dichasial cyme changes into monochas (scorpioid) cyme.** Eg. **Labiatae/Lamiaceae family-*Salvia, Ocimum* (Tulsi), Coleus .**
3. **Hypanthodium** - In this type of inflorescence upper part of peduncle is modified into a narrow c like structure having a pore (ostiole). At the base of cup female flowers develop while towards the mou male flowers develop. **All three types of flowers (male, female, sterile female) are present** this inflorescence. Eg. ***Ficus* species - Banyan, Fig, Peepal**

Note : Cyathium & hypanthodium inflorescence are similar in having unisexual flowers.



- **Mixed inflorescence** – Some times flowers are arranged in both racemose and cymose manner on sam peduncle called mixed inflorescence.

(i) **Mixed spadix – Banana**

(ii) **Cymose raceme or thyrsus** – Grapes (*Vitis*).

BEGINNER'S BOX-1

ROOTS TO INFLORESCENCE

1. In which of the following type of underground modification of stem, storage of food does not occur in stem ?
(1) Bulb (2) Rhizome (3) Corm (4) Tuber

2. Fasciculated roots are found in :-
(1) *Asparagus* (2) *Colocasia* (3) Ginger (4) Turmeric

3. Lamina is also known as :-
(1) Phyllopodium (2) Epipodium (3) Mesopodium (4) Hypopodium

4. Phyllode & clalode are :-
(1) Homologous (2) Analogous (3) Vestigial organs (4) Homoanalogous organs

5. Name the inflorescence in which only unisexual flowers are present.
(1) Cyathium (2) Capitulum (3) Raceme (4) Umbel

GOLDEN KEY POINTS

- Tap roots arise from radicle whereas adventitious roots arise from any other part of plant other than radicle.
- Root cap is thimble like structure.
- Gladiolus is an example of corm.
- *Opuntia* and *Euphorbia* are examples of phylloclade.
- In *Nepenthes*, only lamina is modified into pitcher like structure.
- In Achlamydous flower, accessory whorls are absent.

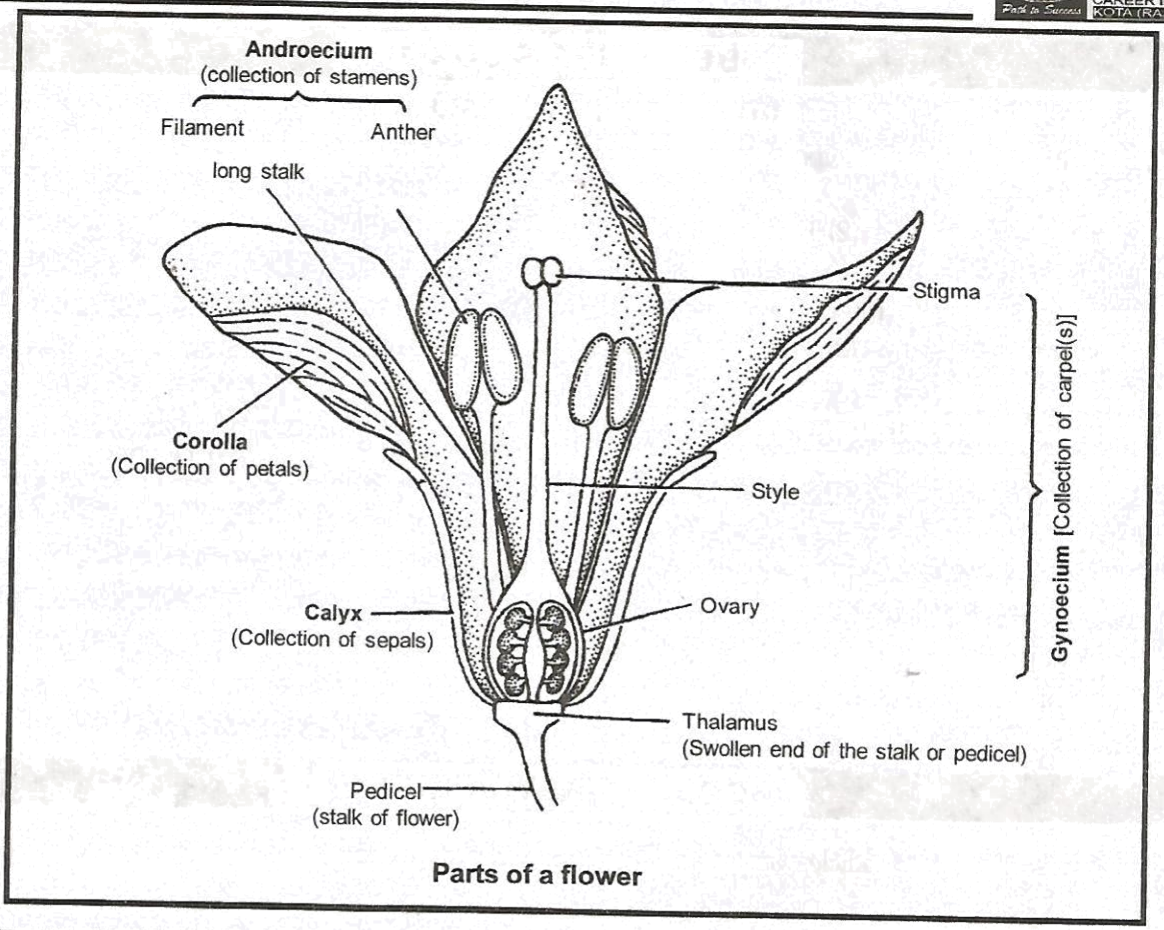
FLOWER

A flower is a modified shoot where in the shoot apical meristem changes to floral meristem. Internodes do not elongate and the axis gets condensed.

Generally flower has a short or long stalk which is called **pedicel**. The upper part of pedicel is swollen, which is called **thalamus**. Floral leaves are present on it.

There are 4 types of floral leaves.
(1) Sepal (2) Petal (3) Stamen (4) Carpel

- A typical flower has four different kinds of whorls arranged successively on thalamus. These are calyx, corolla, androecium and gynoecium.
- **Calyx and corolla are accessory organs or accessory whorls while androecium and gynoecium are reproductive organs or reproductive whorls or essential whorls.**
- **Complete flower** : All four whorls are present.
- **Incomplete flower** : Any whorl is absent e.g. Unisexual flower
- **Bisexual flower** : Perfect flower
- **Unisexual flower** : Imperfect flower
- A flower may be trimerous, tetramerous or pentamerous when the floral appendages are in multiple of 3,4 or 5 respectively. **In dicots flowers are usually pentamerous while in monocots flowers are trimerous.**



Parts of a flower

SYMMETRY OF FLOWER

1. **Actinomorphic/Radial/Regular** - When a flower can be divided into two equal halves by any vertical plane or radial plane passing through the centre, then it is said to be actinomorphic flower **eg. Mustard, *Datura*, Chilli.**

2. **Zygomorphic/Bilateral** - When a flower can be divided into two equal (similar) halves only by one particular vertical plane, then it is said to be zygomorphic flower. **eg. Pea, Bean, Gulmohur, *Cassia*.**

3. **Asymmetrical/Irregular** - When a flower cannot be divided into two equal (similar) halves from any vertical plane passing through the centre, then it is said to be asymmetrical flower. **eg. Canna.**

- **The part of flower which lies near to the mother axis is posterior part while the part which is far from the mother axis is anterior part of flower.** Floral organ arises from thalamus.

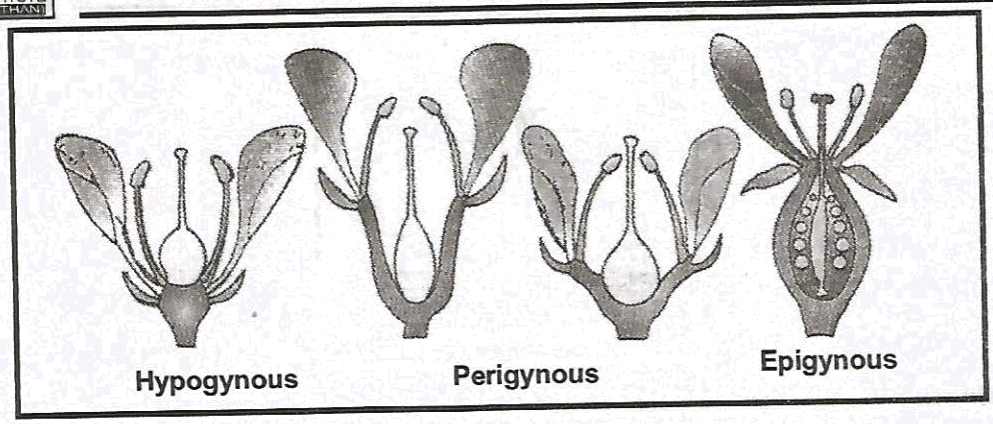
TYPES OF FLOWERS ON THE BASIS OF INSERTION OF FLORAL LEAVES

The relative position of gynoecium changes with respect to floral parts and on this basis it is divided into three types.

(1) **Hypogynous flower** - When petals, sepals and stamens are situated below the ovary, then the flower is called hypogynous and in this condition **ovary** will be **superior**. **eg. Mustard, China rose, Brinjal, Mango.**

(2) **Perigynous flower** - In it thalamus grows upwardly and form a cup shaped structure. On the margin of thalamus floral parts are attached except gynoecium, which lies at the basal part. So in this condition gynoecium is situated below the other floral parts. But **ovary** in this condition is said to be **half inferior**. **Eg. Rose, Plum, Peach.**

(3) **Epigynous flower** - When petals, sepals & stamens are situated above the ovary, then the **ovary** is said to be **inferior** and rest of the floral parts superior. Eg. **Guava**, **Apple**, **Cucumber** and the **rayflorets of Sunflower.**



BRACT -

Bracteate flower - The flower with bract is called bracteate flower.

Ebracteate flower - Flower without bract is known as ebracteate flower.

Involucre - The whorl of bracts is called involucre.

Spathe - When large bract completely encloses whole inflorescence, then it is called spathe.
Eg. **Banana, Maize**

Petaloid bract - When the size of bract is greater than the size of flower and it is of various coloured like petals, then it is called petaloid bract. Eg. ***Bougainvillea***.

Glumes - Small, dry, scaly bracts are called glumes. Eg. Wheat, Grass (**Gramineae family**).

CALYX -

The outermost whorl of flower is called calyx. Each member of this whorl is called **sepal**, when all the sepals are free from each other, then it is called **polysepalous condition** eg. Mustard, Radish. When the sepals are fused with each other then this condition is called **gamosepalous condition**. Eg. Cotton, *Datura*, Brinjal.

- Sepals are green leaf like and protect the flower in the bud stage.
- In calyx of ***Mussaenda,*** one of the sepal enlarges and forms a leaf like structure. It may be brightly coloured. It attracts the insects and thus acts as **advertisement flag/advertising flag.**
- In Trapa, Calyx is modified into spines and helps in protection of fruits.
- In the **family of sunflower (compositae)** sepals are modified into hairy structure which is known as **pappus**. The pappus is modified calyx and helps in dispersal of fruit.
- If sepals do not fall and remain attached to fruit, then they are called **persistent sepals**.

Eg. **Tomato**, Chilli, **Brinjal**, Cotton, Datura

COROLLA -

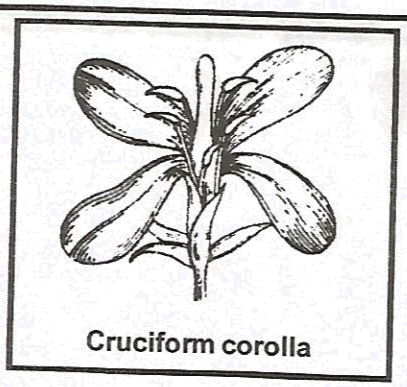
The second whorl of flower is called corolla and each member of corolla is called petal. When all the petals are free, then it is called **polypetalous condition** and when petals are fused, then it is called **gamopetalous condition**.

- Petals are usually of brightly coloured to attract insects for pollination.

FORMS OF COROLLA -

(A) Actinomorphic Polypetalous Corolla

(1) **Cruciform** - In cruciform corolla 4 petals are found. These **petals are arranged crosswise.** The lower narrow part of petal is called **claw** while the upper broad part is called **limb**. Eg. Radish, Mustard **(Cruciferae)**



Cruciform corolla

(B) *Actinomorphic* Gamopetalous Corolla

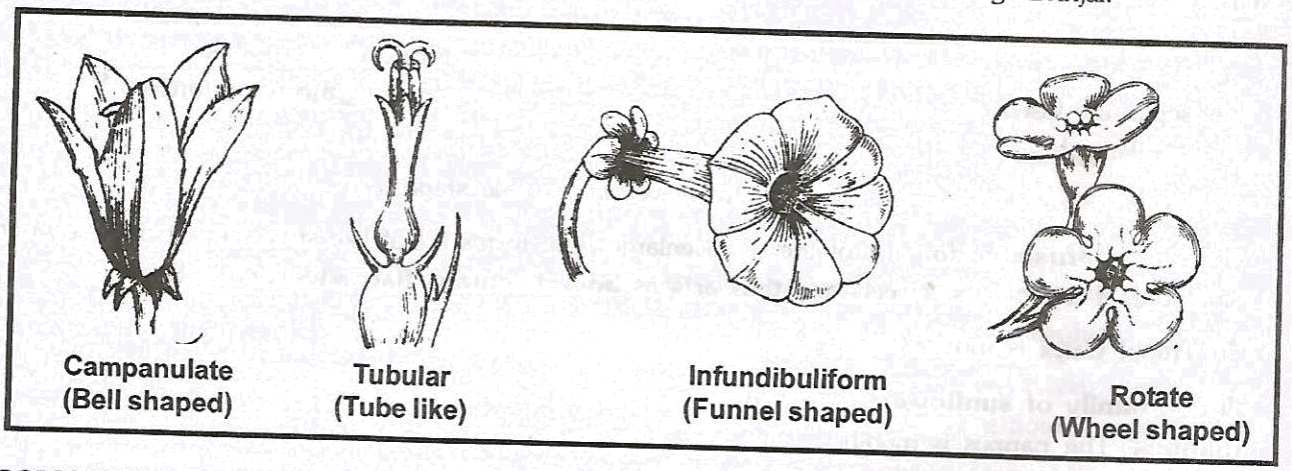
(i) **Campanulate/Bell shaped** - In this type of corolla 5 fused petals are present. It's shape is simi to bell. Eg. Tobacco, Raspberry, *Campanula.*

(ii) **Tubular** - In this type 5 fused petals form tubular (tube like) or cylindrical structure.

Eg. Disc florets of sunflower.

(iii) **Funnel shaped or infundibuliform** or coheel shaped - In this type 5 fused petals are foun It's shape is similar to funnel. Eg. ***Datura***, Railway creeper, **Petunia**

(iv) ***Wheel shaped/Rotate*** - In this type 5 gamopetalous petals are found and the fused parts for small tube and the petals are arranged in a whorl above the tube. *Eg.* Brinjal.



Campanulate (Bell shaped) | Tubular (Tube like) | Infundibuliform (Funnel shaped) | Rotate (Wheel shaped)

ZYGOMORPHIC POLYPETALOUS COROLLA -

***Papilionaceous* (Butter fly shaped corolla)** - In this type of corolla five petals are found. Posterior petal is largest and is known as **standard or vexillum**. Vexillum covers two lateral petals which are called **wings or alae** and the innermost anterior petals are united to form a **keel or carina**. Both lateral petals cover the keel. Eg. Pea, Bean, Gram, Arhar (**Papilionatae**).

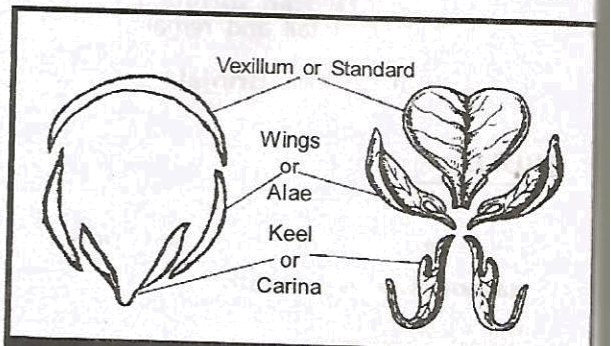
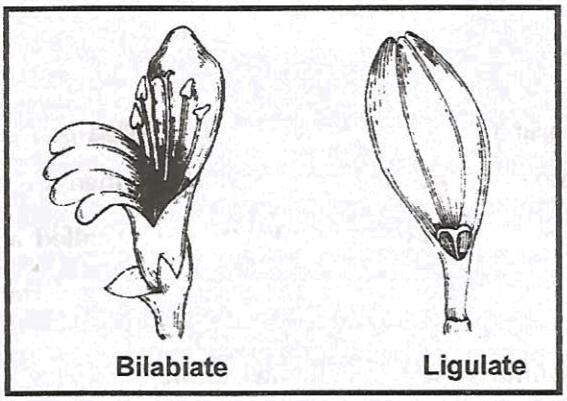


FIG : (COROLLA)

ZYGOMORPHIC GAMOPETALOUS COROLLA

(i) ***Bilabiate*** - The petals of gamopetalous corolla are divided into two lips. The place between two lips is called corolla mouth Eg. *Ocimum* (Holy basil = Tulsi), *Salvia (Labiatae family)*

(ii) ***Ligulate*** - The upper part of corolla is long, flattened tongue like which is attached with short narrow tube. Eg. Ray florets of sunflower.



AESTIVATION

The mode of arrangement of sepals or petals in floral bud with respect to the other members of the same whorl is known as aestivation. It is of following types :-

(1) ***Valvate*** - When the petal of a whorl lie adjacent to other petal and just touch one another at the margin without overlapping then it is known as valvate aestivation. Eg. ***Calotropis plant*, Cruciferae, Solanaceae & Liliaceae family.**

(2) ***Twisted*** - In this type one margin of a petal covers adjacent petal and the other margin is covered by another petal. One margin of the petal overlaps that of the next one, and the other margin is overlapped by the another one. Eg. **Cotton**, **Ladyfinger**, **China rose** (**Malvaceae family**).

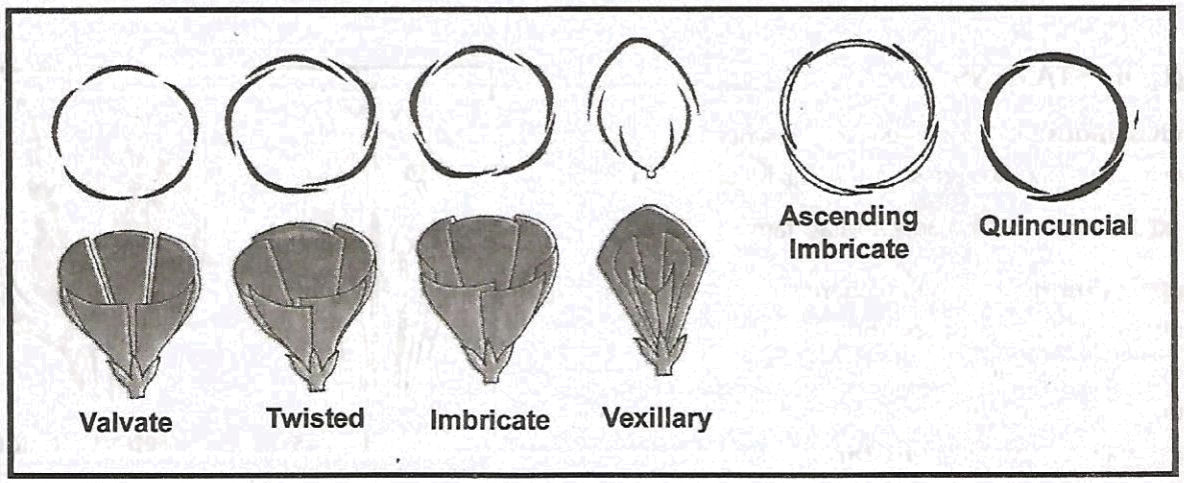
(3) ***Imbricate*** - When both margins of the one petal are covered by the other two petals and both margin of another one, covers other. Rest are arranged in twisted manner. OR If the margins of sepals or petals overlap one another but not in any particular direction, then it is known as imbricate aestivation.

Eg.: **Cassia, Gulmohur.**

- Ascending imbricate :- The posterior petal is innermost i.e., its both margins are overlapped. e.g. Caesalpinoidae sub-family of leguminosae.

(4) ***Vexillary or Descending imbricate or Papilionaceous*** - The posterior petal is outermost & largest and is known as **standard** or **vexillum** which overlaps the two lateral petals **wings** or **alae**. These two laterals petals overlaps two smallest anterior petals i.e. **keel or carina**. Vexillary arrangement is found in pea family. Eg. **Pea, Bean** (**Papilionatae sub-family of leguminosae family**).

(5) ***Quincuncial :-*** Out of the five petals, two are completely internal, two are completely external and in the remaining petal, one margin is internal and the other margin is external. e.g. Murraya.



ANDROECIUM

COHESION OF STAMENS :-

When the floral parts of similar whorl are fused, then it is called cohesion.

When the stamens of an androecium are free from one another, then it is called **polyandrous** conditi

(1) **When stamens are united by their filaments only, then it is called adelphy.** It is of following ty

(a) ***Monoadelphous*** - In this type of cohesion all the filaments are united into a single bundle or bunch but anthers remain free. In this type of cohesion a tube is formed arround the gynoecium wh is called staminal tube Eg. **China rose (Malvaceae family)**.

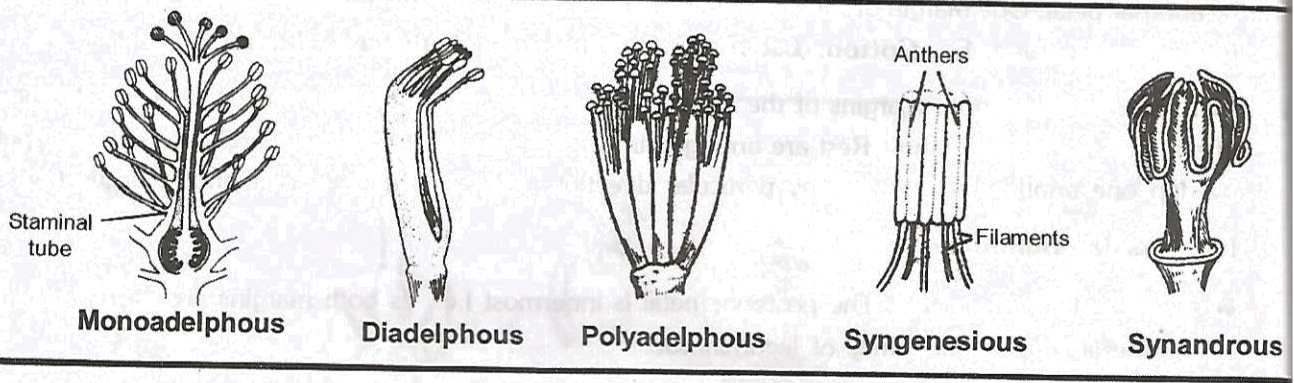
(b) ***Diadelphous*** - In this type of cohesion filaments are united into two bundles but the anthers rem free Eg. **Pea (Papilionatae)**.

In these plants out of 10 stamens, 9 stamens are united into a bundle while 1 stamen remains fr

(c) ***Polyadelphous*** - Filaments are united into more than two bundles. Eg. **Citrus**.

(2) ***Syngenesious*** - Only anthers are united in bundle, but filaments remain free eg. **Compositae fami**

(3) ***Synandrous*** - Anthers as well as filaments of stamens are united through their whole leng Eg. *Colocasia, Alocasia,* Cucurbitaceae family.



ADHESION OF STAMENS -

When the stamens are attached to other parts of flower, then it is called adhesion of stamens.

(1) ***Epipetalous*** - Stamens are attached to the petals. Eg. **Brinjal. (Solanaceae)**

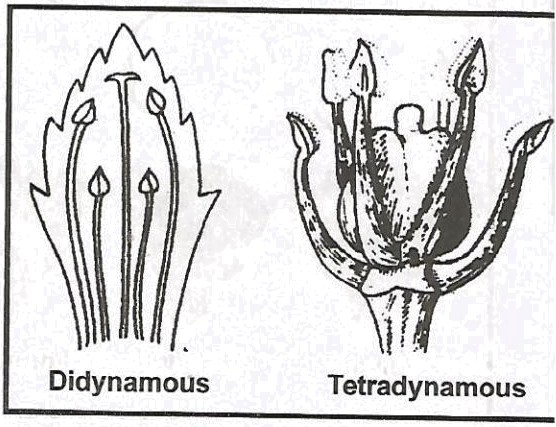
(2) ***Epiphyllous or Epitepalous*** - Stamens are attached to the tepals. Eg. Onion, **Lily. (Liliaceae)**

(3) ***Gynandrous*** - Complete stamens or only anthers are attached to the gynoecium. Eg. Calotropis, Aristoloch

LENGTH OF STAMENS -

(1) **Didynamous** - If four stamens are present and out of them two are long and two are short, then it is called didynamous condition. Eg. Lamiaceae/Labiatae family (***Salvia***)

(2) ***Tetradynamous*** - When there are six stamens and they are arranged in two whorls. In outer whorl, there are two short stamens while in inner whorl, there are four long stamens, this condition is called tetradynamous. Eg. Cruciferae family (**Mustard**, *Capsella*).



GYNOECIUM

- If only one carpel is present in gynoecium then this condition is called **monocarpellary** condition.
- If more than one carpel is present in gynoecium then this condition is called **polycarpellary**.
- When all the carpels in polycarpellary/multicarpellary condition are free, then this condition is called **apocarpous**. **eg. Lotus, Rose, Michelia.**
- When all the carpels are fused, then this condition is called **syncarpous**. **eg. *Papaver, Hibiscus*, Mustard, Tomato.**

PLACENTATION

The ovules are attached on ovary walls on one or more cushion like structure called **placenta**. The manner in which placenta or ovules are arranged on ovary wall is known as placentation or **The arrangement of ovules within the ovary is known as placentation**. It is of following types:

(1) **Marginal** : This type of placentation is found in monocarpellary gynoecium. In this type of placentation. **placenta forms a ridge along the ventral suture of the ovary and the ovules are borne on this ridge forming two rows as in Pea.** There is no true placenta. Eg. **Pea (Leguminosae family).**

Tamarind, Cassia, Gulmohur, Acacia

(2) **Axile** : This type of placentation is found in multicarpellary, syncarpous gynoecium. **Ovary is multilocular and the ovules are borne on the central axis.** Number of chambers are equal to the number of carpels fused. Eg. **China rose**, **Lemon**, **Tomato**.

(3) **Parietal** : This type of placentation is found in unilocular syncarpous ovary. **The ovules develop on the inner wall of the ovary** or on peripheral part. Eg. **Mustard** and ***Argemone.***

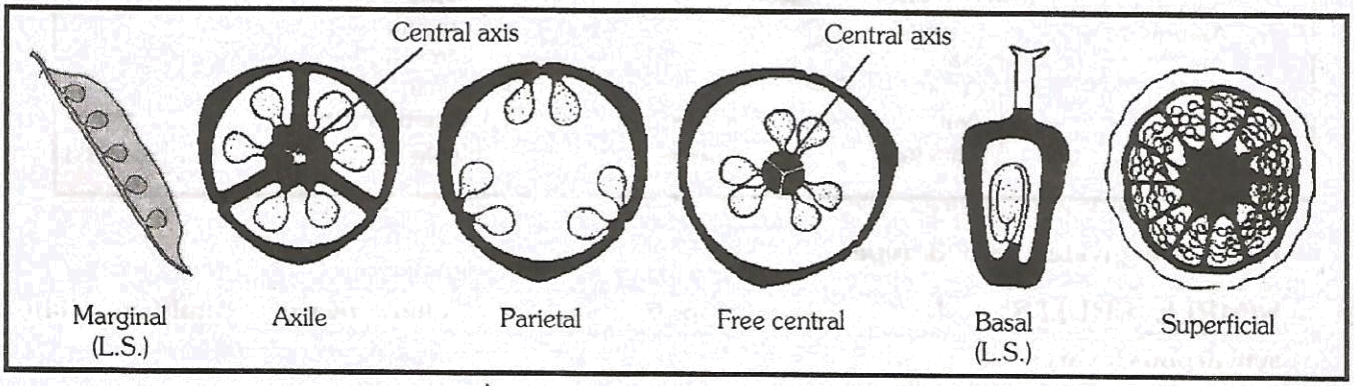
- **In some plants, ovary is one chambered but it becomes two chambered due to formation of false septum or replum. Cruciferae family (**Eg. **Mustard,** Capsella**) and Argemone.**

(4) **Free central/Central** : This type of placentation is found in syncarpous gynoecium. In it, the **ovary is unilocular (septa are absent)** and **the ovules are borne on the central axis.**

eg. ***Primrose, Dianthus***

(5) **Basal :** The ovary is unilocular and a **single ovule is attached at the base of ovary. Eg. Marigold, Sunflower *(Asteraceae / Compositae family), Gramineae / Poaceae family.***

(6) **Superficial** - This type of placentation is found in multicarpellary, syncarpous, multilocular gynoecium. The ovules are attached on the entire inner surface or walls of loculii Eg. Nymphaea (Water lily)



FRUIT

The seeds are protected inside the fruit. But in some fruits like grapes, banana seeds are not found a such type of fruits are called **parthenocarpic** or **seedless fruits.**

PERICARP (Fruit wall) : After ripening, the ovary wall changes into pericarp. This pericarp may thick and fleshy or thick and hard or thin and soft.

Pericarp is made up of 3 layers :-

(a) Outermost layer = Epicarp
(b) Middle layer = Mesocarp
(c) Innermost layer = Endocarp

(a) **Epicarp** - It is the outermost layer, it may be thick or thin and hard or soft. It forms outermost la of fruit which is also called rind

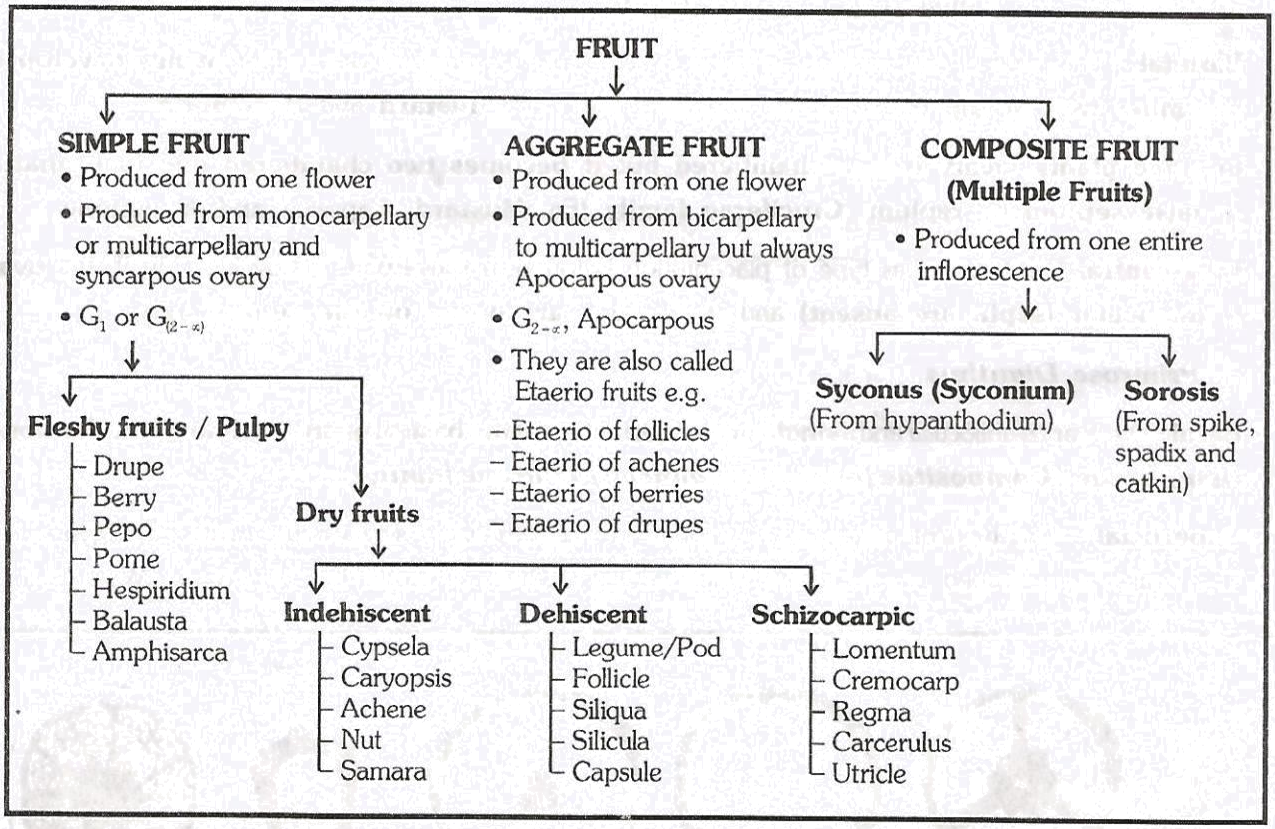
(b) **Mesocarp** : It is the middle layer which is thick and fleshy in **mango**, peach and date palm. In **cocon** this layer is made up of fibres which is also called coir

(c) **Endocarp** : It forms the innermost layer, it may be thin membranous (eg. Orange, Datepalm) or th and hard (eg. Mango, Coconut)

TRUE FRUIT OR EUCARP OR EUCARPIC FRUIT : When the fruit is developed only from t ovary then the fruit is called true fruit. Eg. Mango, Coconut, Zizyphus

FALSE FRUIT OR PSEUDOCARP OR PSEUDOCARPIC FRUIT : In some fruits, in place of ova some other parts of flower like thalamus, calyx and inflorescence are modified into fruit or a part fruit. Eg. **Apple, Strawberry, Pear, Mulberry, Fig, Cashew nut**

CLASSIFICATION OF FRUITS :



Fruits are divided into 3 types :

1. **SIMPLE FRUITS** These fruits **develop from monocarpellary ovary or multicarpellary syncarpous ovary** and only one fruit is formed by the gynoecium.

Simple fruits are of two types :

(a) Fleshy fruits **(b) Dry fruits**

(a) FLESHY FRUITS In fleshy fruits, **fruit wall (pericarp) is differentiated into epicarp, mesocarp and endocarp.** These fruit develop from superior or inferior syncarpous gynoecium. These may be unilocular or multilocular, these fruits are indehiscent.

Fleshy fruits are of following types :

(1) DRUPE FRUITS : These fruits develop from monocarpellary, superior ovaries. In these fruits **endocarp is hard and stony,** so these fruits are **also called stony fruits**. Eg. **Mango, coconut, almond,** peach, **walnut,** plum. In **mango** the outermost cover or rind is called epicarp. Middle edible fleshy part is mesocarp and the inner stony hard endocarp. In plum (Ber), epicarp and mesocarp both are edible while endocarp is stony.

The hard covering of almond and walnut is endocarp and their edible part is seed. In **coconut** epicarp is hard and thin while mesocarp is thick and fibrous. The endocarp is hard and seed is proteced in it. The sweet water and edible part of coconut are liquid and solid endosperm respectively.

(2) BERRY : These fruits develop from mono or multicarpellary, syncarpous ovary. Ovary may be superior or inferior. **Placentation is axile. Generally epicarp is thin membrane like and seeds are embedded in fleshy part. Initially seeds are attached with placenta of fruit but after maturation these seeds are detached from placenta** and are spread randomly in fleshy part.

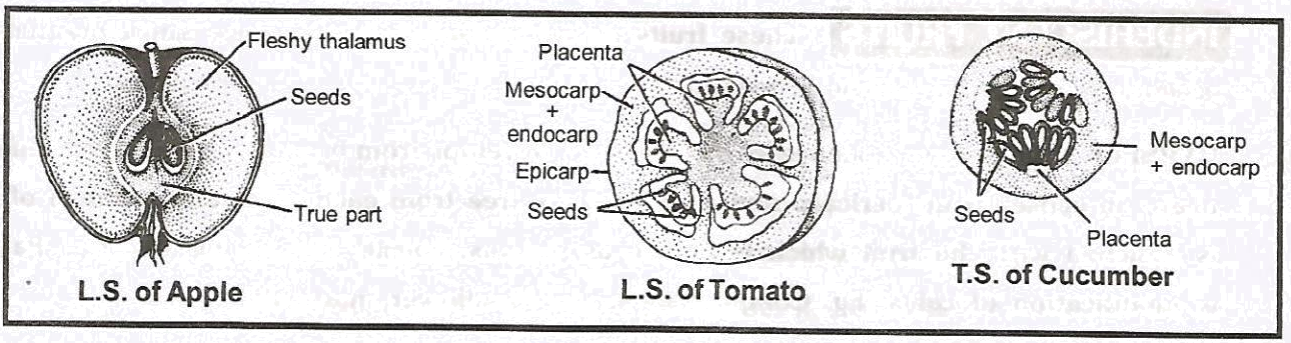
(i) Plants with superior ovary (True berry) = **Tomato,** Grapes, **Brinjal.**

(ii) Plants with inferior ovary (False berry) = Guava, Banana

Date palm and Betelnut are single seeded berry.

(3) PEPO : These fruits develop from tricarpellary, syncarpous and **inferior ovaries.** These fruit are unilocular and **have parietal placentation but looks like axile due to swelling of placenta.** These fruits are fleshy and spongy. Eg. fruits of **cucurbitaceae family** like cucumber (Khira), water melon (Tarbooz), *Cucurbita maxima* (*Pumpkin*), bitter gourd (Karela), muskmelon (Kharbuja).

(4) POME : This fruit develops from bi or multicarpellary, syncarpous, **inferior ovary. The rind and sponge are made up of thalamus.** The main part of the ovary is like to cartilage. It remains inside the fruit and seeds are present in it. Eg. **Apple**, **Pear**. These are **false fruits**. Fleshy swollen **thalamus** of these fruits is **edible** part.

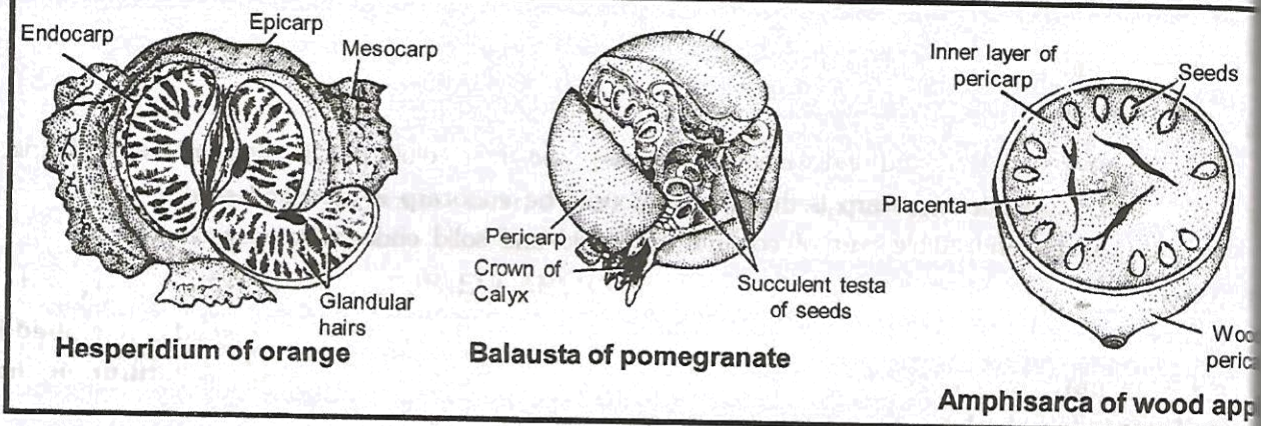


(5) HESPERIDIUM : This fruit develops from multicarpellary, syncarpous, superior ovary and **axile placentation.** This fruit is specially found in the plants of Rutaceae family. Eg. **Orange, Lemon.**

Epicarp of these fruits is made up of thick rind which is having many oil glands. Mesocarp is the white fibrous structure which is attached with epicarp. Membranous endocarp projects inward and forms many chambers. Many glandular hairs are present on the inner side of endocarp. These **glandular juicy hairs** are **edible**.

(6) **BALAUSTA** : This is a multilocular, multiseeded fruit, which **develops from inferior ovary.** It's pe is hard. **Calyx is persistent which is arranged in the form of crown.** Seeds are irregularly arr on placenta. **Epicarp is hard. Testa of seed is fleshy and juicy. Testa** is the **edible par Pomegranate (*Punica granatum*) = Anar.**

(7) **AMPHISARCA** : This fruit is multichambered which develops from multicarpellary superior ovary. **part of pericarp is woody and placenta is fleshy.** The inner part of pericarp and placenta is e Eg. wood apple/beel (*Aegle marmelos*), elephant apple/kaith (*Feronia*).



Hesperidium of orange **Balausta of pomegranate** **Amphisarca of wood app**

DRY-FRUITS

Pericarp (fruit wall) of simple dry fruits is not diffrentiated into epicarp, mesocarp and endoc

In some dry fruits, pericarp dehisces/ruptures after ripening and seeds are dispersed, such fruits are c **dehiscent fruits.** In some fruits, pericarp breaks/splits into one or more seeded segments, such f are called **schizocarpic fruits.** In some fruits, pericarp does not dehisce even after maturing/ripen such fruits are called **indehiscent fruits.**

Simple dry fruits can be divided into following three groups :

(i) Indehiscent (ii) Dehiscent (iii) Schizocarpic

i. **INDEHISCENT FRUITS** **These fruits do not dehisce/rupture.** These simple dry fruits generally of small sized and single seeded.

(1) **CYPSELA** : This is a small, one seeded dry fruit which **develops from** bicarpellary, syncarpous, **infer ovary. In cypsela fruit pericarp and seed coat are free from each other and a bunch of h is attached with the fruit which is known as pappus.** Pappus helps in fruit dispersal. **Papp is modification of calyx.** Eg. **Compositae family (Sunflower, marigold).**

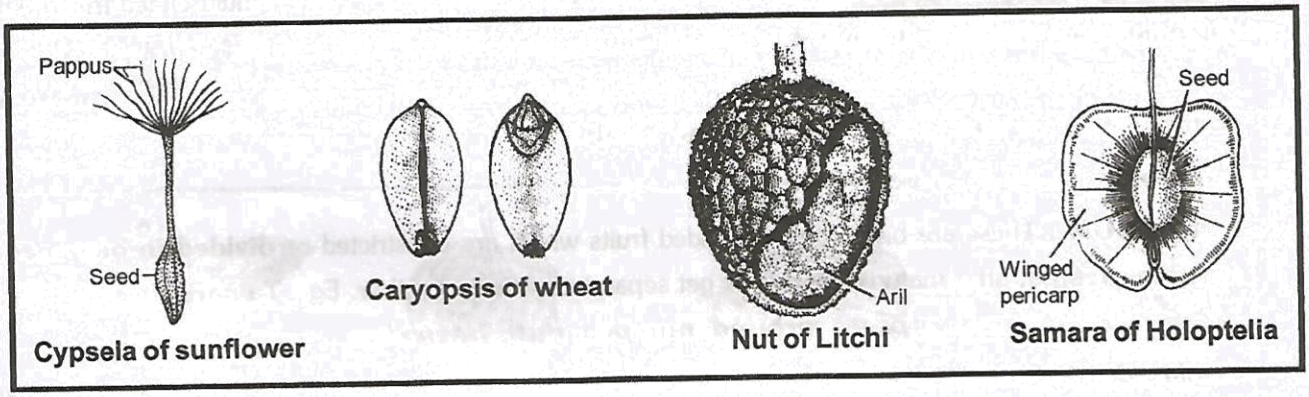
(2) **CARYOPSIS** : These are small, one seeded dry fruits, which develop from monocarpellary, superior ova In these fruits **Pericarp is fused with the seed coat and form a joint surface.** These fruits present in **family Gramineae.** Eg. **wheat, rice, maize etc.**

(3) **ACHENE** : These are single seeded fruits which develop from monocarpellary, superior ovary. **In the fruits pericarp is free from the seed coat & pappus are absent.** Eg. *Clematis, Mirabilis, Boerhaa*

(4) **NUT** : **This is a single seeded** fruit which develops from bi or multicarpellary, syncarpous, superior ovary. In it **pericarp is hard.** Eg. *Quercus* (oak), *Anacardium occidentale* (Cashewnut), **Trapa (Water chest-nut), Litchi.**

In **Litchi** epicarp and mesocarp is fused and give leathery appearence. Endocarp is membrane like thin. An additional coat arround the seed is formed which is called **aril**. Actually it is a sort of third integument. In mature fruit, this **aril is fleshy and is only edible part**.

(5) **SAMARA :** These are dry indehiscent one seeded **winged/feathery fruit**. It develops from bi or tri carpellary, syncarpous and superior ovary. The main character of these fruits is that **wing like structure develops from pericarp** which helps in dispersal of fruits. Eg. *Holoptelia* (Chil-bil), *Dioscorea.*



In *Shorea robusta* wing develops from calyx instead of pericarp and these fruits are called samaroid.

ii. **DEHISCENT FRUITS** **Pericarp of these fruits gets ruptured after ripening and seeds are dispersed outside.** These fruits are mainly of 5 types:

(1) **LEGUME OR POD** : These fruits develop from monocarpellary, unilocular, superior ovary with **marginal placentation**. They are generally long and multiseeded fruits. Dehiscense of fruit occurs at both sutures i.e. dorsal and ventral suture. **Dehiscence starts from apex/tip and reaches to basal part.** Eg. **Pea, Beans, Gram.**

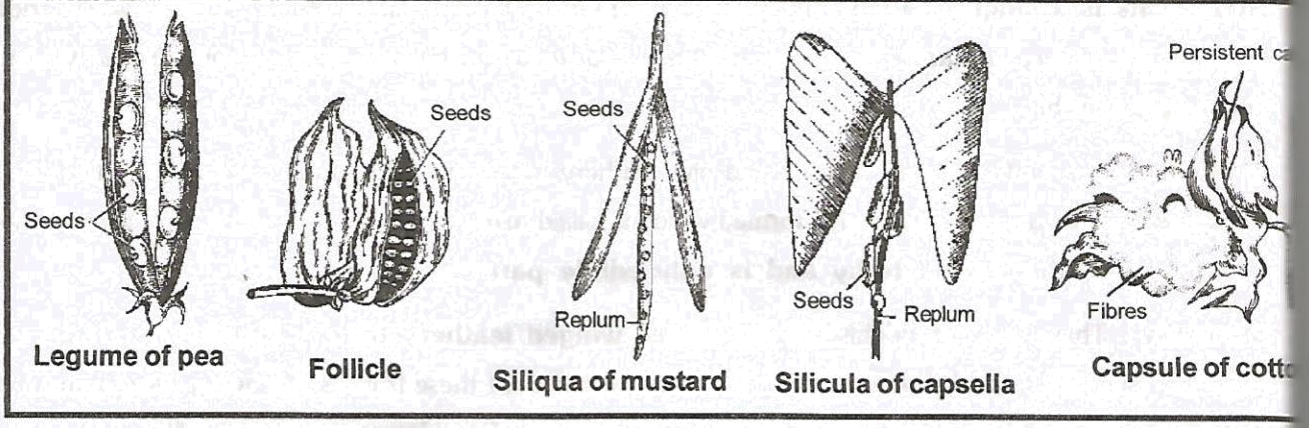
(2) **FOLLICLE** : It is also multiseeded fruit which develops from superior unilocular, monocarpellary ovary but the **dehiscence occurs only from ventral suture.** Eg. *Asclepias, Rauwolfia, Periwinkle* or Vinca, *Delphinium.*

(3) **SILIQUA** : This fruit develops from bicarpellary, syncarpous, superior ovary and ovary has **parietal placentation**. Dehiscence occurs from both dorsal and ventral suture, **Dehiscence starts from lower part and proceeds upward (from base to the apex).** Initially ovary is unilocular but due to formation of **false septum/replum** ovary becomes bilocular later on. On false septum seeds are attached. This type of fruit is found in **Cruciferae family**. Eg. ***Brassica* (Mustard).**

(4) **SILICULA : Small, broad siliqua is known as silicula.** It is reduced form of siliqua. It's dehiscense is similar to siliqua. It is found in some members of Cruciferae family. Eg. Candytuft *(Iberis amara),* ***Capsella***

(5) **CAPSULE** - This is dry, multichambered and multiseeded fruit and it develops from multicarpellary, syncarpous, superior ovary. In it, **axile placentation** is found and **dehiscence occurs by various methods.** Poricidal (Porous), loculicidal, septifragal, septicidal.

Eg. ***Papaver* (Poppy=opium plant)**, *Gossypium* **(Cotton)**, **Datura**, *Abelmoschus* **(Lady finger)**, **Onion**



iii. **SCHIZOCARPIC FRUITS = SPLITTING FRUITS :** These are generally multiseeded fruits. A **ripening, they break/split and divide into mericarps** and after destruction of pericarp seed co out. These fruits develop from mono or bi or multicarpllary superior or inferior ovary. **Each meric contains one or two seeds (Usually one seed).**

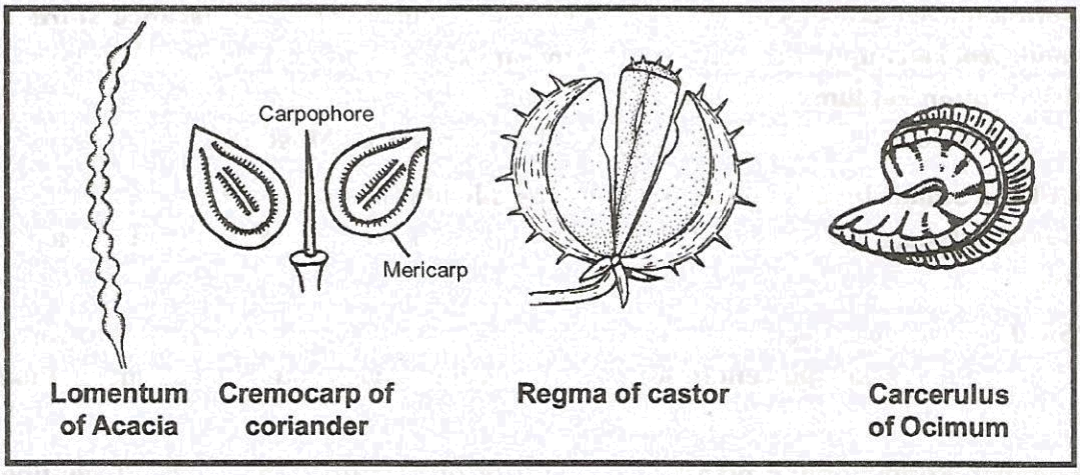
Schizocarpic fruits are of five types:-

(1) ***LOMENTUM*** : These are bisutural multiseeded fruits which are constricted or **divided in one see many mericarps,** after maturity mericarps get separated with each other. Eg. **Tamarind**, *Cassia fis Mimosa pudica, Arachis hypogea* (***ground nut/pea nut***), *Desmodium*, *Acacia* **(babool).**

(2) **CREMOCARP** : This is a double seeded fruit it develops from bicarpellary, syncarpous, inferior ov It is generally found in umbelliferae family. On maturation, it splits from apex to the base in such a that **two mericarps are formed** and each mericarp contains one seed. These mericarp are attac with carpophore. **Carpophore** is the extended part of thalamus. Eg. Coriander (**dhania**), *Daucus* (car Cuminum (**jeera = cumin**), Foeniculum (**saunph=fennel**).

(3) **REGMA** : This fruit develops from tri to pentacarpellary, syncarpous, superior ovary. In it **3 to 5** loc are present and **it breaks/splits into 3 to 5 one seeded parts.** Each part is known as coccus the outer side of pericarp, **spines are found.** Eg. Euphorbiaceae family (Arand=castor/*Ricinus*) three cocii and Geranium has 5 coccus.

(4) **CARCERULUS** : This fruit develops from multicarpellary or bicarpellary, syncarpous, superior ovary **divides into four one seeded mericarps / locules & spines are absent.** Eg. ***Ocimum*** (tu ***Salvia***.



AGGREGATE FRUITS

These fruits develop from multicarpellary, apocarpous gynoecium. In apocarpous condition each carpel is free from each other and it forms a fruitlet. Aggregate fruits are made up of a bunch of fruitlets which is known as etaerio.

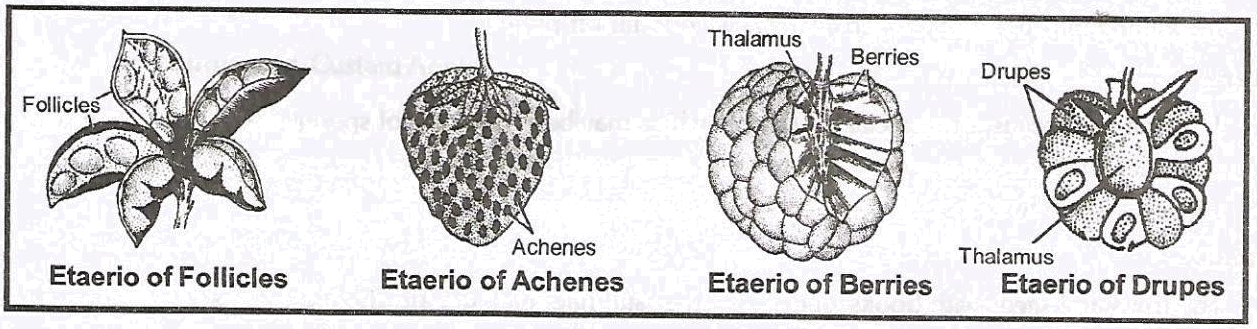
(1) **Etaerio of follicles** : Each fruitlet of etaerio is follicle. Eg. ***Calotropis,*** *Catharanthus, Magnolia, Michelia.* Only two follicles are present in etaerio of *Calotropis.* In *Catharanthus* and *Magnolia* etaerio develops from many follicles.

(2) **Etaerio of achenes** : In this type of aggregate fruit, each fruitlet is an achene. Eg. *Rananculus*, **Strawberry, Rose, Lotus.**

In **lotus**, thalamus becomes spongy and some achenes are embedded in it. **In strawberry, thalamus is fleshy and small achenes are found on its surface.** In rose, many achenes are present on a saucer (cup) like inner surface of fleshy thalamus.

(3) **Etaerio of berries** : It is an aggregation of small berries. Eg. *Polyalthia,* ***Annona*** *squamosa* (**Custard-apple=sitaphal**). In etaerio of **Anona** all the berries are arranged densly on thalamus.

(4) **Etaerio of drupes** : In this type of fruit, many small drupes develop from different carpels. Eg. **Raspberry, Blackberry**.



Etaerio of Follicles **Etaerio of Achenes** **Etaerio of Berries** **Etaerio of Drupes**

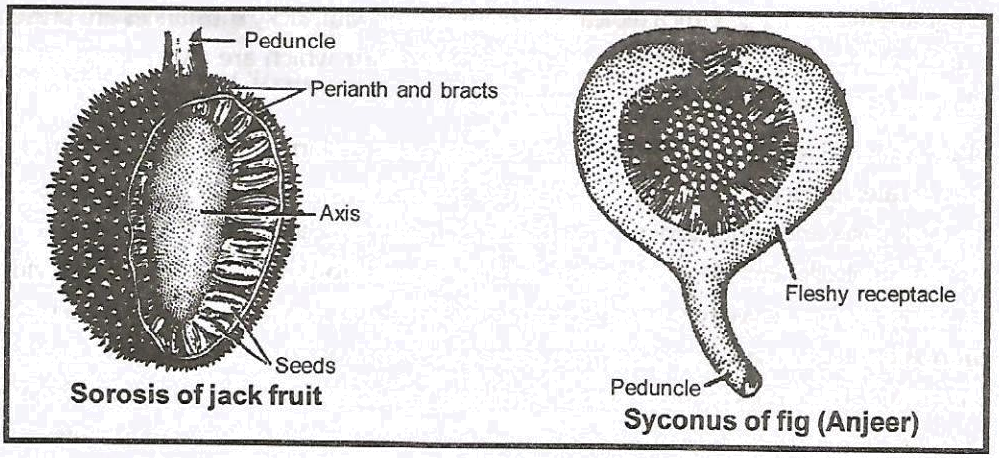
COMPOSITE FRUITS = Multiple fruits

All composite fruits are false fruits.

This type of fruit differ from aggregate fruit that in place of single ovary, many ovaries of many flowers and other floral parts combine together to form a fruit. In composite fruits, **generally whole inflorescence is modify into fruit**. These are of two types :

(1) **SOROSIS** : This fruit **develops from spike, spadix or catkin inflorescence.**
Eg. : **Pineapple (Annanas) Jack fruit (Kathal), Mulberry (Shahtoot).**

(2) **SYCONUS OR SYCONIUM** : This fruit **develops from hypanthodium inflorescence.** Many achenes develop from the pistillate flowers. Eg. ***Ficus*** species like **Fig** [Anjeer (*Ficus carica*)], **Peepal** (*Ficus religiosa*)



Sorosis of jack fruit **Syconus of fig (Anjeer)**

- **Geocarpic fruits : Underground fruits** are called geocarpic fruits. **eg. *Arachis* (groundnut)**

Dispersal of fruits and seeds

We know that most of the plants do not move from one place to another. They grow, produce flower and f while remaining fixed at one and the same place. The seeds falling directly under the mother plant hav germinate and develop under limited food supply and space. To overcome this problem, the fruits and se have developed several special devices for wide dispersal. The natural agents like wind, water and animals even mechanism of dehiscence in some fruits, help the seeds and fruits to disperse from one place to anot and to long distances from the parent plant.

Wind –

In the species where the seeds are light in weight or have some accessory part to help dissemination, dispersed by the air current. The seeds of Drum–stick and Cinchona, and fruits of yam, maple and sal tree, provided with one or more appendages in the form of thin, flat and membranous wings, which help ther float in the air and be carried away to long distances. In the members of Asteraceae, the calyx is modified i hair–like structures called pappus. They persist in fruit and open out like umbrella, helping the seeds to flo the air. In poppy and prickly poppy (*Argemone*), the fruit dehisces and seeds are thrown out to a distan away from the parent plant. The seeds of Calotropis, Alstonia and cotton are provided with hair and c sufficient distances alongwith the wind. The seeds of orchids and some grasses are very small and ligh weight and may be easily carried away by wind to far off places.

Water –

The fruits and seeds with specialised devices which may be in the form of spongy and fibrous outer walls a coconut and spongy thalamus as in lotus, and small seeds with airy aril as in water lily, float very easily in w and are carried away to long distances with the water current.

Animals –

The fruits and seeds with hooks, spines, bristles, stiff hair, etc., get attached to the body of hairy and wo animals and are carried away by them to distant places. For instance fruits of Xanthium and Urena bear cur hooks, spear grass has a bunch of stiff hair, Tribulus has sharp and rigid spines **Boerhaavia** has sticky h which help their dispersal by animals. The edible fruits like guava, grape, fig and plum are dispersed by b and even human beings, either by feeding on them and passing out undigested seeds with faeces or by carry them to other places for later feeding.

Defense mechanism in plants

Plants have developed special organs or devices to repulse or avoid the attack of their enemies. Some pla like lemon, pomegranate and Duranta have **thorns** ; pineapple, datepalm, Agave and Yucca have sha pointed **spines** at the leaf ends ; silk cotton tree and rose have prickles ; Opuntia and other cacti have spi for their protection from animals. The **stinging hair** with sharp and siliceous apex occur on all parts of body in nettles (Laportea spp) and Urtica dioica. **Glandular hair** with sticky substances are present in Jatrop Boerhaavia and tobacco. The dense coating of hair or **stiff hair** which are always repulsive to animals found in cud-weed (Gnaphalium) and in many cucurbits.

There are other defense devices like the presence of poisonous and irritating substances in the plants. Th are in the form of latex in Ficus, Nerium and Euphorbia ; alkaloids in poppy, Datura and tobacco, and irritat substances in Colocasia and other aroids. The plants of neem and karela have a bitter taste. Productior tannin, resin, essential oils, etc., in some plants and the **geophilous** habit in others (e.g. zinger , turme colocasia and onion) are protective measures. Some plants like guava, mango and litchi have a habit of harbou ants (**myrmicophily**), which save the plant from damage by other animals. **Mimicry** is a habit of imitating general appearance, colour, shape of other plants or animals, generally disliked by attackers. The aroids (Caladi and Sansevieria resemble spotted snakes and are thus able to scare away plant-eating animals.

EDIBLE PARTS OF SOME IMPORTANT FRUITS

	PLANT	TYPE OF FRUIT	EDIBLE PARTS
1.	***Abelmoschus esculentus***/Lady's Finger/Okra/Bhindi	Capsule	Whole fruit (vegetable)
2.	***Achrus sapota***/Sapodilla/Cheeku	Berry	Mesocarp and endocarp
3.	***Aegle marmelos***/Wood Apple/Bel	Amphisarca	Pulpy endocarp (inner pericarp) and placenta.
4.	***Anacardium occidentale***/Cashewnut/ Kaju	Nut	Cotyledons and Peduncle
5.	***Ananas comosus*** = ***A. sativus***/Pineapple	Sorosis	Fleshy axis, bracts fused perianth & Pericarp
6.	***Annona squamosa***/Custard Apple/ Sitaphal	Etaerio of Berries	Mesocarp & Thalamus
7.	***Arachis hypogea***/Ground nut/Peanut	Lomentum	Seeds/Cotyledons
8.	***Areca catechu***/Betel nut or Areca nut	Berry	Endosperm/Seed
9.	***Artocarpus integrifolia***/Jack Fruit/Kathal	Sorosis	Bracts, perianth and seeds (as vegetable and fruit)
10.	***Carica papaya***/Papaya/Papita	Berry	Mesocarp and Endocarp
11.	Cereals, ***Avena sativa*** (Oat), ***Oryza sativa*** (Rice), ***Hordeum vulgare*** (Barley), ***Triticum durum*** (Durum Wheat), ***Triticum aestivum*** (Bread Wheat), ***Zea mays*** (Maize)	Caryopsis	Whole fruit (Endosperm and embryo)
12.	***Citrus reticulata***/Orange, ***Citrus sinensis***/Sweet Orange, ***Citrus aurantifolia***/Lime	Hesperidium	Glandular hair
13.	***Cocos nucifera***/Coconut	Drupe	Endosperm
14.	***Cucumis melo***/Musk Melon/Kharbuja	Pepo	Mesocarp, Endocarp & seeds
15.	***Cucumis vulgaris***/Water melon/Tarbooj	Pepo	Mesocarp, Endocarp & seeds
16.	***Cucumis sativus***/Cucumber/Kheera	Pepo	Mesocarp, Endocarp and Young seed

17.	***Ficus carica***/Fig/Anjeer	Syconus	Fleshy receptacle
18.	***Fragaria vesca***/Strawberry	Etaerio of achenes	Fleshy thalamus
19.	***Grewia asiatica***/Dhamin/Phalsa	Drupe	Mesocarp
20.	***Juglans regia***/Walnut	Drupe	Lobed cotyledons of seed
21.	***Litchi chinensis***/Litchi	Nut	Aril
22.	***Lycopersicon esculentum***/Tomato	Berry	Whole fruit (Pericarp and placenta
23.	***Pyrus malus*** (M. sylvestris)/Apple	Pome	Fleshy thalamus
24.	***Mangifera indica***/Mango	Drupe	Mesocarp
25.	***Morus alba, M. nigra***/Mulberry	Sorosis	Whole fruit (Fleshy perianth,Fleshy
26.	***Phoenix dactylifera***/Date/Khajoor	Berry	Pericarp
27.	***Prunus amygdalus***/Almond	Drupe	Seed (Cotyledons and embryo)
28.	***Musa paradisiaca***/Banana	Berry	Less developed Mesocarp and well developed endocarp
29.	***Psidium guajava***/Guava	Berry	Whole fruit (Thalamus, pericarp and placenta)
30.	Pulses	Pod/Legume	Seed
31.	***Punica granatum***, Pomegranate/Anar	Balausta	Fleshy testa of seeds
32.	***Pyrus communis***/Pear	Pome	Fleshy thalamus
33.	***Solanum melongena***/Brinjal	Berry	Whole fruit (Pericarp & Placenta)
34.	***Tamarindus indica***/Tamarind	Lomentum	Pericarp (Mesocarp)
35.	***Trapa bispinosa***/Water Chestnut /Singhara	Nut	Seed
36.	***Vitis vinifera***/Grapes	Berry	Pericarp and placenta (whole fruit)
37.	***Zizyphus mauritiana/Z.jujuba***/Jujube /Chinese Dates/Ber	Drupe	Epicarp and mesocarp

EXTRA POINTS

1. **Cladode** : In this modification branches of limited growth become green and flat like a leaf and perform photosynthesis. Eg. ***Asparagus*** (one internode long) ***Ruscus*** (2 internode long).
2. **Bulbil :** It is modified vegetative bud with stored food, meant for vegetative reproduction. Eg. ***Agave, Oxalis, Dioscorea* (Yam).**
3. **Cabbage** represents the **largest bud.**
4. **Pistillode** : Sterile pistil is known as pistillode eg. Some ray florets of compositae.
5. **Staminode :** Sterile stamen is called staminode. eg. Salvia, Caesalpinoidae (Cassia, Gulmohur, Tamarind)
6. Ptyxis : Folding of lamina in bud condition.
7. Vernation : Arrangement of leaves in bud condition.
8. Isomerous flower : When each whorl has an equal number of parts or its multiple.

   Just oppsite to isomerous is heteromerous.
9. Polygamous : A plant bearing bisexual, unisexual and even neutral flower is said to be polygamous. Eg. *Polygonum*, Mango
10. Position of style :
    (a) Terminal : Arising from the tip of the ovary.
    (b) Lateral : Arising from the side of ovary. Eg. Mango,
    (c) **Gynobasic style** : Arising from the depressed centre of the four-lobed ovary or directly from the thalamus. Eg. **Tulsi (*Ocimum*)**, ***Salvia***.
11. **Clove (*Syzygium aromaticum*) = Unopened floral bud**
12. **Saffron (*Crocus sativus*) = Stigmas + Styles.**

FAMILIES OF ANGIOSPERMS

Following symbols are used for floral formula:-

Bracteate	=	Br
Ebracteate	=	Ebr
Actinomorphic	=	$\oplus$
Zygomorphic	=	% or Φ or $+$ or $\div$
Bisexual	=	$\varnothing$
Unisexual male (staminate)	=	σ
Unisexual female (Pistillate)	=	φ
Epicalyx	=	Epi or EpiK
Calyx	=	$K \nearrow K_n$ - Polysepalous condition $K \searrow K_{(n)}$ - Gamosepalous condition
Corolla	=	$C \nearrow C_n$ - Polypetalous condition $C \searrow C_{(n)}$ - Gamopetalous condition
Perianth	=	$P \nearrow P_n$ - Polyphyllous or polytepalous condition $P \searrow P_{(n)}$ - Gamophyllous or gamotepalous condition
Androecium	=	$A \nearrow A_n$ - Polyandrous condition $A \searrow A_{(n)}$ - Cohesion condition
Gynoecium	=	$G \nearrow G_n$ - Apocarpous condition $G \searrow G_{(n)}$ - Syncarpous condition
Superior ovary	=	Hypogynous flower = $\underline{G}$
Inferior ovary	=	Epigynous flower = $\overline{G}$
Ovary half inferior or half superior	=	Perigynous flower = G–

Adhesion

Epiphyllous condition	=	$\overset{\frown}{P\,A}$
Epipetalous condition	=	$\overset{\frown}{C\,A}$
Gynandrous condition	=	$\overset{\frown}{A\,G}$

1. CRUCIFERAE [= BRASSICACEAE] = Mustard family

1. Systematic Position:-

Class	=	Dicotyledonae	
Sub-Class	=	Polypetalae	
Series	=	Thalamiflorae	Flower - Hypogynous
Order	=	Parietales	Placentation - Parietal

2. Distinguishing Features of Cruciferae:-

(i) The plant organs have **pungent odour**. This odour is due to presence of **sulphur containing glucosides compound.**

Myrosin enzyme (present in secretory cells) hydrolyse them into glucose & different isothiocyanates (Various oils)

(ii) **Inflorescence-** Typical raceme.

Exceptions:-

(i) *Iberis amara* = Candytuft (chandani) has corymb type of inflorescence in which lower flower have much longer pedicels than the upper ones.

(ii) The edible compound corymb inflorescence is present in cauliflower in which main axis (floral axis) is branched. Each branch is a corymb. It is a corymb of corymbs (compound inflorescence)

3. The common Characteristics of flower:-

(i) **Flower**- Ebracteate

Bisexual or hermaphrodite

Actinomorphic but sometimes zygomorphic e.g. Iberis amara (**Candytuft = Chandani**)

Flower- Hypogynous and tetramerous.

(ii) **Calyx-** Sepals 4, polysepalous, calyx arranged in two whorls 2 outer and 2 inner, imbricate aestivation.

(iii) **Corolla-** Petals 4, polypetalous, **valvate aestivation and cruciform/cross form**.

- The each petal in cruciferae is divided into two parts -long **claw** and broader (spreading) lamina-**limb**. i.e clawed petals.
- The corolla is absent in *Lepidium* and *Coronopus*.
- Some petals are transformed into stamens in *Capsella*.

(iv) **Androecium:- Stamens 6,** arranged in two whorls - in which **two outer stamens are small** (antisepalous) **and inner four stamens are long** (antipetalous). **This condition is known as tetradynamous**. **Nectaries** are present at the base of the anthers

- Polyandrous condition is found.
- Anthers are dithecous.
- Stamens introrse i.e. stamens bending towards the gynoecium.

* Exception :- 2 Stamens in Coronopus, 4 stamens in Lepidium and Cardamine and 16 stamens in Megacarpea.

(v) Gynoecium:- Bicarpellary, syncarpous.

* **The ovary is unilocular in the begining but it becomes bilocular later on due to the fo of a false septum (replum).** Replum is developed from the thalamus inplace of wall of the

* **Placentation is parietal.**

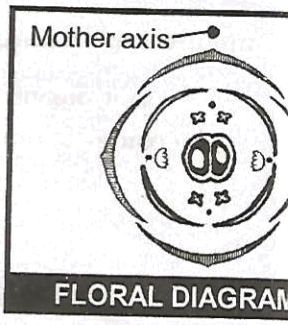
(vi) Fruit:- Usually siliqua (eg. Mustard)

Silicula fruit is found in *Capsella,* *Iberis* (Chandani), *Lepidium* and *Alyssum.* The smal siliqua is known as silicula.

(vii) Seed :- Non endospermic

(viii) Floral Formula:-

$$\text{Ebr} \oplus \female K_{2+2}\, C_{4x}\, A_{2+4}\, \underline{G}_{(2)} \quad \textbf{OR} \quad \oplus \female K_{2+2}\, C_{4}\, A_{2+4}\, \underline{G}_{(2)}$$



FLORAL DIAGRAM

(4) **Economic Importance:-** The family includes a large number of plant species which are of in importance to mankind as follows:-

[A] Food Stuff

(i) Radish (Muli) = ***Raphanus sativus*** - Fusiform root.

(ii) Turnip (Shaljam) = ***Brassica rapa*** - Napiform root

(iii) Cauliflower (Phool gobhi) = ***Brassica oleracea*** var. botrytis, **immature inflorescence is**

(iv) Cabbage (Patta gobhi) = ***Brassica oleracea*** var. capitata, fleshy leaves of bud are edi

(v) Knol-Khol (Ganth gobhi) = ***Brassica oleracea*** var. caulorapa, thickened stem is edible.

(vi) Mustard (Sarson) = ***Brassica campestris*** (yellow); ***B.napus*** (black)

(vii) Rai = **Brassica nigra** (Black Rai), ***Brassica-alba*** (white Rai); ***Brassica juncea*** (Local Rai)

(viii) Taramira = ***Eruca sativa*** - oil is obtained.

[B] Medicinal uses:-

(i) Halima = ***Lepidium sativum*** - garden cress- Its seeds are used in **liver dise** asthama, cough and bleeding piles.

(ii) Wall flower = ***Cheiranthus cheiri*** - Its **seeds** are used in **fever cough, paralysis, bron**

(iii) Chandani (Candy tuft) = ***Iberis amara*** - It is used in rheumatism disease.

[C] Ornamental plants:-

(i) **Chandani (Candy tuft)** = ***Iberis amara***

(ii) Wall Flower = ***Cheiranthus cheiri***

(iii) **Shepherd's purse** = ***Capsella bursa -pestoris***

2. MALVACEAE = Cotton family, Mallow family

[1] Systematic position:-

Class - Dicotyledonae

Sub class - Polypetalae

Series - Thalamiflorae

Order - Malvales

Family - Malvaceae

[2] Diagnostic features of malvaceae:-

The **mucilage is present in various plant organs** like flower, fruit. Stellate (star shaped) hairs are present on the shoot.

Inflorescence:- Cymose or solitary – solitary axillary or solitary terminal (Abutilon).

Exception:- The racemose inflorescence is present in Althaea (holly hock)

- Most of the economically important fibre yielding plants belong to family malvaceae.

[3] General characteristics of flower:-

(i) Flower:- Bracteate- Bracts are big and green in colour because simple leaves function as bracts.

Flowers are bisexual, actinomorphic, hypogynous and **pentamerous**.

(ii) Epicalyx:- Epicalyx (Bracteoles) are 3- 7; free and green in colour. They are the transformed bracteoles. The structure of the bracteoles are like as bracts which is present on pedicel.

Valvate aestivation.

Epicalyx is absent in some genera of the malvaceae such as *Abutilon*, *Sida*, and *Bombax*.

(iii) Calyx:- sepals 5, gamosepalous, valvate aestivation. In some of the plants persistant calyx are present, it means they are present on fruit eg. *Abelmoschus* (Bhindi) and *Gossypium* (Cotton).

- The odd sepal is posterior in malvaceae.

(iv) Corolla:- Petals 5, polypetalous, **twisted aestivation,** mucilagenous and attractive.

(v) Androecium:- Stamens infinite, monoadelphous means filaments united together in one bundle and anthers remain free.

- **Anthers kidney shaped, Monothecous**
- **The filaments are united together to form a long staminal canal** or **staminal tube** around style.
- **Staminal tube is united with the petals at the base of the flower, so stamens are epipetalous.**
- The stamens are extrorse.

Exception : *Julostylis* contains 10 stamens in which 5 stamens are sterile and remaining 5 are fertile.

(vi) Gynoecium:- Pentacarpellary or polycarpellary, syncarpous but stigma's are free, so gynoecium is incompletely syncarpous.

The number of locules are equal to the number of carpels, so ovary is pentalocular or multilocular

The ovary and style are enclosed in staminal tube but stigma remains outside.

Axile placentation

Exception:- Three carpels are present in the flower of *Kydia.*

(vii) Fruit:- Loculicidal **capsule** e.g. **Lady finger, Cotton.**

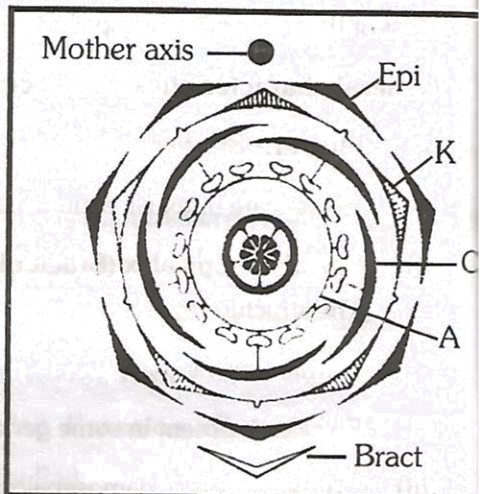
Exception:- The carcerulus fruit is found in holly hock = *Althaea, Abutilon, Sida.* This is a typ schizocarpic fruit.

(viii) Seed:- Non endospermic, a dense hairy seed coat is present on cotton seed [*Gossypium*]

(ix) Floral formula:-

$$Br \oplus ⚥ \; Epi_{3-7} \; K_{(5)} \; \overbrace{C_5 \; A_{(\infty)}} \; \underline{G}_{(5-\infty)}$$

[4] Economic importance:- The family includes many plants of great economic importance e.g. food, fibres, oils, medicine and ornamentals:-



FLORAL DIAGRAM

(a) Food:- (i) Okra/bhindi **(Lady's finger)** = ***Abelmoschus esculentus*** or ***Hibiscus esculentus*** used as vegetable.

(b) Oils:- From **Cotton seeds (*Gossypium* seeds).** The seeds of ***Gossypium*** are used for obtaining oil which is hydrogenated to prepare vegetable ghee. Volatile oil known as Musk seed oil used in perfumary is obtained from *Hibiscus abelmoschus* seeds.

(c) Fibres:- Most of the economically important fibre yielding plants belong to the family malvaceae

[i] Surface fibres:- These fibres are obtained from the surface of the seeds.

(a) Cotton = *Gossypium*.

(b) Red Silk cotton = ***Salmalia malabaricum*** (Semal)

(c) White Silk cotton = *Eriodendron* or Ceiba [Kapok]

[ii] *Soft fibre or Bast fibres* :-

(a) Patua = ***Hibiscus sabdariffa*** (Rosella hemp)

(b) China Jute = ***Abutilon asiaticum*** = Indian mallow.

(c) Patsan [Deccan hemp] = ***Hibiscus cannabinus***

[D] Timber:-

(i) ***Ochroma lagopus*** = Balsa wood, **lightest wood**

(ii) *Malva sylvestris* = Mallow wood

[E] Medicine:-

[i] ***Urena repanda*** - These **roots** are useful in **hydrophobia.**

[F] Ornamental:-

[i] **China rose [Shoeflower]** = ***Hibiscus rosasinensis*** - **Red shoes polish** is obtained from the **petals** of this flower.

[ii] **Holly hock [Gul- e - khera]** = ***Althaea rosea*** (Blue colour is obtained from its leaves)

[iii] Cotton rose = *Hibiscus mutabilis* (Changeable rose)

[iv] Mallow [Khatmi] = ***Malva sylvestris***

[v] Umbrella tree = *Thespesia populnea*

[vi] ***Pavonia odorata*** - from roots **hina perfume** is manufactured.

[G] Vitamins:- ***Gossypium*** seeds are rich in **vitamin A, D, E, and B- complex.**

3. SOLANACEAE = Potato family

[1] Systematic position:-

Class	-	Dicotyledonae
Subclass	-	**Gamopetalae**
Series	-	Bicarpellatae
Order	-	Polymoniales
Family	-	Solanaceae

It is distributed in tropics, subtropics and even temperate zones.

Many ovules are present in the ovary so many seeds are formed as in tomato, brinjal etc.

- Most of plants of this family are herbs, some of them are shrubs , rarely trees.

- **Stem herbaceous** rarely woody, aerial, erect, cylindrical, branched, solid or hollow, **hairy or glabrous (Smooth).**

- The tap root system is present in these plants.

- **Leaves are simple** rarely pinnately compound and **exstipulate, alternate, venation reticulate**. Bicollateral vascular bundles are present in stem

[2] **Inflorescence:- Solitary axillary, or cymose** inflorescence as in ***Solanum***.

Monochasical cyme is of two types:-

[A] Helicoid cyme:- sp. of Solanum.

[B] Scorpioid cyme :- species of *Atropa* plants.

Exception :- Solitary terminal inflorescence is found in *Datura*.

[3] **Flower:-** Flowers are bracteate or ebracteate, **bisexual**, complete, hypogynous, **pentamerous actinomorphic**.

[4] **Calyx:- Sepals 5, gamosepalous (united), valvate aestivation** and **persistent. (eg. Tomato, Bri**

When sepals grow with the growth of the fruit and become thickened and elongated then they are kno accrescent sepals. eg. Brinjal

[5] **Corolla:- Petals -5, gamopetalous (united), aestivation valvate**

[6] **Androecium:- Stamens -5,** polyandrous, **epipetalous stamens**, introrse, filaments basifixed and anthers dith

[7] **Gynoecium:- Bicarpellary, syncarpous, bilocular and axile placentation, ovary superior.**

Special features:- Swollen placenta and oblique septum. Ovaries arranged obliquely on thala carpels move at $\angle 45^0$ in clock wise direction. posterior carpel turns on right side and ant carpel turns on left side.

- **Multilocular ovary is formed in tomatoes** and Datura **due to formation of false septum.**

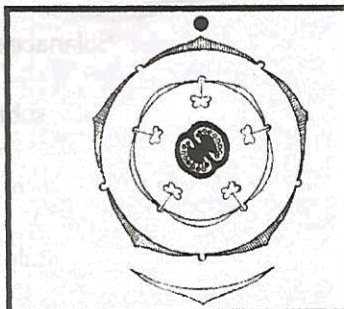
[8] **Fruit:-** Fleshy fruit - **berry (Tomato, Brinjal)** sometimes **capsule** (*Datura*).

The fruit of the Datura is septifragal capsule.

[9] **Seeds :- Many and Endospermic.**

[10] **Floral formula :**

Br or Ebr $\oplus$ δ φ $K_{(5)}$ $\overset{\frown}{C_{(5)}\ A_5}$ $\underline{G}_{(2)}$



FLORAL DIAGRAM

[11] Economic Importance:-

[A] **Food : (a) Vegetable :-**

(i) **Potato** = ***Solanum tuberosum*** - edible part **under ground stem- tuber**

(ii) **Tomato** = ***Lycopersicum esculentum***

(iii) **Brinjal** (Egg plant) = ***Solanum melongena***

(iv) Makoi = ***Solanum nigrum***

(v) **Chilli** = ***Capsicum annuum* (used as spice)**

(vi) Shimala Mirch = ***Capsicum frutescence***

(vii) Rasbhary (Goose berry) = ***Physalis- peruviana*** (fruits are eaten)

[B] Medicines:-

(i) ***Atropa belladonna*** (Deadly night shade) The **roots** are used in the manufacture of **drug belladonna**. Atropine alkaloids is obtained from the roots **Atropine is used to dialate the pupil of the eye**.

(ii) *Stramonium* is obtained from the seeds of Datura (Thorn apple) in which Scopolamine alkaloid is present. It is pain reliever and sedative.

(iii) Henbane medicine (containing hyoscyamine alkalloid) obtained from the leaves of Hyoscyamus niger. It is used in the treatmet of asthama and whooping cough.

(iv) **Nicotine** & anabasin **alkaloid** obtained from the leaves of **Nicotiana tabacum (Tobacco)** & *N. rustica*. It is nerve stimulent and are also used as insecticide.

(v) Solanum xanthocarpum = (Nelee Kanteli) the juice of its used in rheumatism and cough.

(vi) ***Withania somnifera*** = Asvagandh/**Ashwagandha** - Its root used as nerve tonic, leaves used in fever.

(vii) *Solanum nigrum* = (Makoi) - The fruit are laxative.

[C] Ornamental Plants :- Many plants of the family are cultivated for their beautiful flower and fragrance as follows:-

(i) ***Petunia alba*** and *Petunia hybrida.*

(ii) ***Cestrum nocturnum*** = Rat - Ki - Rani (Night Jasmine)

(iii) ***Cestrum diurnum*** = Din - Ka - Raja (Day Jasmine)

(iv) *Schizanthus* = Poor man's orchids

(v) *Brunfelsia hopeana* = Kal - Aaj - Kal

[D] Fumigatory :- Tobacco (*Nicotiana tabacum*)

4. LEGUMINOSAE

[1] SYSTEMATIC POSITION

Class	-	Dicotyledonae
Sub class	-	Polypetalae
Series	-	Calyciflorae
Order	-	Rosales
Family	-	Leguminosae

MAIN CHARACTERISTICS

Flower	-	Hypogynous G
Gynoecium	-	**Monocarpellary**
Ovary	-	**Unilocular**
Placentation	-	**Marginal**

Leguminosae family is devided into 3 - subfamilies

1. Papilionatae/Papilionoideae/Lotoideae **2. Caesalpinoideae** **3. Mimosoideae**

SUB - FAMILY → PAPILIONATAE

= Pea family = Pulse family

= FABACEAE FAMILY

IMPORTANT FEATURES

It is distributed all over the world.

Trees, shrubs, herbs are found in this family.

Sleeping movements commonly occurs in this family.

[1] **Roots** :- Roots are branched and tap root system is present. **Root nodules** are present. In root no **N-fixing bacterium *Rhizobium leguminosarum*** is present.

[2] **Stem – Erect or climber**

[3] **Leaves** :- **Stipulate**, **simple or pinnately compound**-unipinnate, imparipinnate, **leaf base pulvin pulvinus, venation reticulate, Alternate**

[4] **Inflorescence :-** Typical raceme (**racemose**).

[5] **Flower** :- Bracteate, **bisexual**, hypogynous, penta merous and **Zygomorphic** symmetry. The zygomor symmetry is due to presence of different (odd) petals (dissimilar petals & androecium).

[6] **Calyx** :- **Sepals 5, gamosepalous**, **aestivation imbricate** or **valvate** (mainly valvate), anterior sepals is

[7] **Corolla** :- **This is the first main diagnostic character for the subfamilies of leguminosae. Petals 5, papilionaceous (Butterfly shaped), polypetalous**, one petal is odd out of 5–petals, towards the mother axis - means **posterior** in position. It is the **largest and outer most petal** which is called **standard or vexillum.**

→ Below the vexillum, two small free lateral petals present which are known as **wing** or **alae**. **(lateral in position)**

→ **Anterior two petals fused together to form a boat like structure called keel or carina which encloses the essential organs. i.e. stamens and pistil/carpel.**

Such type of **aestivation** is called **vexillary or descending imbricate.**

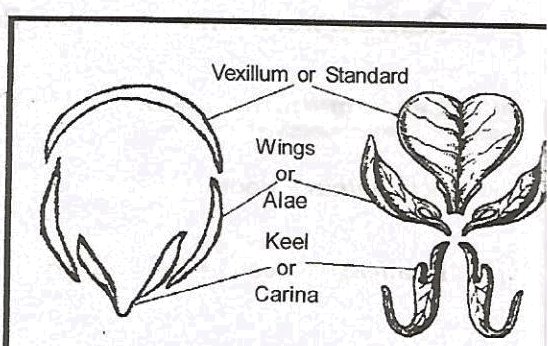


FIG : (COROLLA)

[8] ANDROECIUM

This is the second main diagnostic character for the subfamilies of Leguminosae.

Stamens - 10; diadelphous (9) + 1

9 stamens fused together to form a sheath around the pistil while the tenth posterior one is free

* **Anther dithecous**

[9] GYNOECIUM :- Gynoecium is **monocarpellary, unilocular with many ovules, superior ovary, style single** and **marginal placentation.**

[10] FRUIT :- **Legume or pod** (dry, dehiscent, one chambered fruit).

Sometimes lomentum is also found eg. ***Arachis*** **(mungphali)**

[11] SEED :- Non-endospermic, one to many

[12] FLORAL FORMULA :-

Br ⊕ ⚥ $K_{(5)}\ C_{1+2+(2)}\ A_{1+(9)}\ \underline{G}_1$ **or** Br % ⚥ $K_{(5)}\ C_{1+2+(2)}\ A_{(9)+1}\ \underline{G}_1$

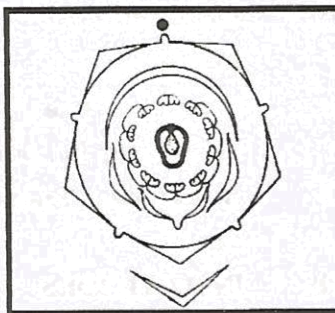


FIG : FLORAL DIAGRAM

[13] ECONOMIC IMPORTANCE

[A] FOOD PLANT

[i]	**Arhar** (Pigeon pea) - **Pulse**	=	***Cajanus cajan (indicus)***
[ii]	**Chana (Gram) - Pulse**	=	***Cicer arietinum***
[iii]	**Mattar (Pea)**	=	***Pisum sativum***
[iv]	Urad (Blak gram) - Pulse	=	***Phaseolus mungo*** **or** ***vigna mungo***
[v]	**Mung** (green gram) - **Pulse**	=	***Phaseolus*** **radiatus (esculentus)** ***or vigna*** **radiatus**
[vi]	Masoor - Pulse	=	***Lens esculenta or L. culinaris or Ervum lens***
[vii]	French bean or Kidney bean (Rajma)	=	***Vigna/Phaseolus vulgaris***
[viii]	**Soyabean - Pulse**	=	***Glycine max (G. soja) – Soyabean contains more protein than meat***
[ix]	Gwar (cluster bean)	=	***Cymopsis tetragonoloba***
[x]	Methi	=	***Trigonella foenum graecum***
[xi]	**Mungphali(Ground nut)**	=	***Arachis hypogea.***
[xii]	**Sem- Pulse**	=	***Dolichos lablab***
[xiii]	Agast tree	=	***Sesbania grandiflora*** Its flowers are edible
[xiv]	Cowpea (chowla)	=	***Vigna sinensis***
[xv]	**Khaseri dal**	=	***Lathyrus sativus*** The **lathyrism disease** is produced by the use of this dal.

[B] FODDER

[i]	Alfalfa (Rijka)	=	***Medicago sativa***
[ii]	**Berseem**	=	***Trifolium alexandrium.*** *Used as green mannure*
[iii]	Bankla	=	***Vicia faba***
[iv]	**Dhaincha**	=	***Sesbania***

[C] FIBRES

[i]	**Sunhemp**	=	***Crotalaria juncea (ternatea)***

[D] TIMBER

[i]	Shisham	=	***Dalbergia sissoo (Indian Red Wood)***
[ii]	Kala shisham	=	Indian rose wood = ***Dalbergia latifolia***

[E] DYES

[i] **Neel (Blue dye)** = ***Indigofera tinctoria*** (dye is obtained from leaves)

[ii] Fire of the forest = ***Butea monosperma*** orange, yellow dye is obtained from the flower

[F] MEDICINAL PLANTS

(i) **Mulaithi (Liquorice)** = ***Glycyrrhiza glabra***

Its **roots** are used in **cough & cold.**

[G] ORNAMENTAL

(i) Butterfly pea = ***Clitoria ternatea***

(ii) Indian coral tree = ***Erythrina indica***

(iii) Indian telegraph plant = ***Desmodium gyrans***

(iv) ***Sweet pea* (Phool matar)** = ***Lathyrus odoratus***

(v) ***Lupin*** = ***Lupinus albus***

[H] INSECTICIDES :-

(i) Deris elliptica → Rotenone insecticide - rotenone is obtained.

[I] GUM

(i) Bengal kino gum = It is obtained from the **butea** (dhak).

(ii) Astragalus gummifer

[J] EDIBLE OIL → **Soyabean, Groundnut**

[K] OTHER USES :-

(i) ***Abrus precatorius*** = **Crab's eye = Ratti = Jweller's weight** - jwellers use it's seeds as weight

(ii) Silk worm lives on the stem of *Butea.*

(iii) *Alhagi pseudoalhagi* = Camel's fodder. From twigs screens (chiks) are manufactured

5. LILIACEAE = Lily family

[1] **SYSTEMIC POSITION**

Class - Monocotyledonae

Series - Coronarieae

Family - Liliaceae

It is distributed world wide.

Liliaceae is a monocot family.

Perianth is present in this family, It means there is no difference in between calyx and corolla. If perianth is green in colour then it is called **sepaloid** as in **onion.**

If perianth is coloured other than green then it is known as **petaloid** as in **Lily.**

[2] **DIAGNOSTIC FEATURES**

(1) **HABIT** :-

Perennial herbs with underground bulbs/corms/rhizomes.

sometimes **abnormal secondary growth** is found in trees such as - ***Dracaena, Yucca.***

(2) **ROOT**

Usually adventitious/fibrous. Fasciculated roots are found in *Asparagus* (satawar).

(3) **STEM**

The aerial stem is present in few plants. (*Dracaena, Yucca, Smilax* etc.)

Majority of the plants have underground stem. It is of following types -

[i] **BULBS** eg. - **Onion, Garlic.**

[ii] **CORM** - eg. - ***Colchicum.***

[iii] **RHIZOME** - eg. ***Aloe.***

* **MODIFICATION OF AERIAL STEM**

Cladode - eg. ***Asparagus, Ruscus***

(4) LEAVES

→ **Mostly basal, linear, alternate, exstipulate with parallel venation.**

→ Radical leaves are present in few plants such as in *Asphodelus.*

→ **Exceptionally reticulate venation is found in *Smilax,*** *Paris*

→ The stipule of *Smilax* and leaf tip of *Gloriosa* are modified into tendrils.

(5) **INFLORESCENCE :- Solitary / Cymose; Often umbellate clusters.**

(i) **Scapigerous umbel or Cymose umbel or Umbellate clusters** - e.g. **Onion** and **Garlic**

In this type of inflorescence, a axis called scape arises from the underground stem and on its top cluster of flowers develop, this bunch of (cluster) flowers looks like an umbel. But, truely speaking it is not umbel. The flowers are arranged in compact scorpioid cyme order.

(ii) Panicle = Compound raceme e.g. *Yucca* and *Dracaena*

(6) **GENERAL CHARACTERS OF FLOWER**

Bracteate, ***bisexual,*** complete, ***actinomorphic,*** hypogynous and **trimerous.**

* The flowers in *Ruscus* and *Smilax* are unisexual and incomplete.

(7) **PERIANTH**

Tepals 6, arranged in two whorls 3 + 3, **Often united into tube, Valvate aestivation**

(8) **ANDROECIUM**

6 stamens, epiphyllous, arranged in two whorls 3 + 3, polyandrous.

(9) **GYNOECIUM**

Tricarpellary, **syncarpous**, **trilocular with many ovules,**

axile placentation, **superior ovary.**

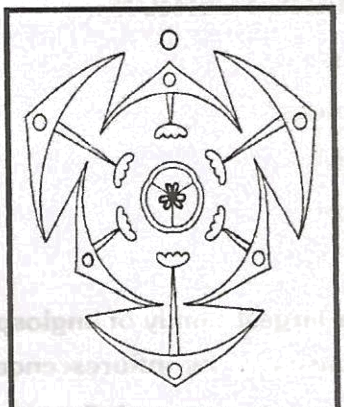
(10) **FRUIT**

Capsule (Onion), rarely berry (Lily).

(11) **SEED :- Endospermic/Endospermous**

(12) **FLORAL FORMULA**

$Br \oplus ⚥ \overbrace{P_{(3+3)} A_{3+3}} \underline{G}_{(3)}$



FLORAL DIAGRAM

(13) **ECONOMIC IMPORTANCE**

[A] **FOOD**

(i) **Onion = *Allium* cepa** - Foul odour is due to an oil like organic compound of sulphur - allyl sulphide formed in Fleshy leaves of bulb.

(ii) **Garlic = *Allium sativum*** - Antidiabetic property is due to sulphur containing AA- S - Allyl - Cystine Sulphoxide (SACS) in Fleshy leaves of bulb.

(iii) **Satawar = *Asparagus* - used as vegatable.**

10. **FLORAL FORMULA**

(A) **Ray florets** → $Br\ \%\ ♀\ K_p\ C_{(5)}\ A_0\ \overline{G}_{(2)}$

(B) **Disc florets** → $Br\ \oplus\ ⚥\ K_p\ \widehat{C_{(5)}\ A_{(5)}}\ \overline{G}_{(2)}$

(C) **Sterile florets** → $Br\ \oplus\ K_p^s\ C_{(5)}\ A_0\ G_0$

(It is a type of ray florets)

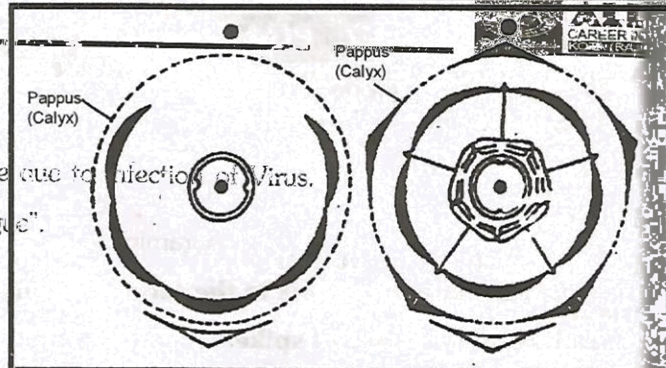


FIG. FLORAL DIAGRAM RAY FLORET

FIG. FLORAL DIAGRAM DISC FLORET

ECONOMIC IMPORTANCE :-

[A] **Food :-**

(1) *Lactuca sativa* = Salad (Garden lettuce) – Leaves edible

(2) *Intybus* (kasani) = Cichorium – chicory powder is prepared which mixed with coffee powder.

(3) **Helianthus tuberosus** - Their **tubers** are eaten which contain **inulin crystals**.

(4) ***Helianthus annuus*** = **Sunflower (Suraj mukhi)** – The seeds of this yiedls valuable **oil** which is used for cooking purposes.

(5) *Carthamus tinctorius* = Kusum (Safflower) – Oil obtaining from these seeds which reduced the level of cholesterol. Orange red colour obtains from the petals of the flowers.

[B] **Medicinal plants :-**

(1) *Artemisia obsinthium* - Santonin medicine obtains from Artemisia which is useful for removal of worms.

(2) ***Arnica montana*** - **Arnica** medicine is obtained which is used in healing of wound and as **hair oil**.

(3) ***Eclipta alba*** **(Bhring Raj)** - Juice is used as **hair tonic**.

(4) ***Chrysanthemum cinerariaefolium*** = **Guldaudi** – **Pyrethrum** named **insecticide** is obtained.

(5) Species of *Blumea* produce "Kapoor" which is a useful medicine.

(6) *Taraxacum officinale* - 'Taraxacum' medicine is obtained which is purgative and diuretic.

[C] **Ornamental :-**

(1) ***Helianthus annuus*** = **Surajmukhi**

(2) ***Chrysanthemum*** = **Gul–Daudi**

(3) ***Tagetes*** = **Genda (Marigold)**

(4) *Zinnia*

(5) *Dahlia*

(6) *Aster*

[D] **Other Values :-**

(1) ***Ambrosia artemissifolia*** = **Rug weed** - **Hay fever** is due to its pollen grains.

(2) ***Parthenium hysterophorus/P.argentatum*** = **Carrot grass** or **Congress grass** – skin allergy develops from its pollen grains.