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**A practical manual on Introductory Biology**

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**Lab 1. MORPHOLOGY OF FLOWERING PLANTS- The Root**

**The Root :**The root is underground part of the plant and develops from elongation of radicle of the embryo.

Various types of roots		
1. Tap root	2. Fibrous root	Adventitious root

Originates from radicle.	Originates from base of the stem.	Originates from parts of the plant other than radicle.
Dicotyledonous plants	Monocotyledonous plants	
e.g., gram, pea, mango.	e.g., wheat, paddy, grasses.	e.g., Banyan tree (Prop roots) Maize (Still roots) Rhizophora (Respiratory roots)

### Root Cap :

The root is covered at the apex by the thimble-like structure which protects the tender apical part.

### Regions of the root :

- 1. Region of meristematic activity:** Cells of this region have the capability to divide.
- 2. Region of elongation:** Cells of this region are elongated and enlarged.
- 3. Region of Maturation:** This region has differentiated and matured cells. Some of the epidermal cells of this region form thread-like root hairs.

### Modifications of Root :

- 1. For support:** Prop roots (Banyan tree), Stilt roots (Sugarcane, maize), Clinging roots (Orchids), Climbing roots (Betel), Floating/balancing roots (Pistia), etc.
- 2. For storage of food:** Fusiform (raddish), Napiform (Turnip), Conical (Carrot)
- 3. Parasitic roots:** Cuscuta
- 4. For respiration:** Pneumatophores in *Rhizophora* (Mangrove)
- 5. For Nitrogen fixation:** Leguminous roots

Draw the diagrams of above mentioned modifications:

**Lab 2. MORPHOLOGY OF FLOWERING PLANTS- The Stem**

Generally, the stems are aerial and grow above the soil surface. Sometimes, the stem becomes variously modified to perform special functions like perennation, vegetative propagation and food storage. The modified stems may be grouped under three heads viz, underground, subaerial and aerial.

**I. Underground Stem Modifications**

The underground stems, by being situated below the surface of the soil, protect themselves against unfavourable conditions of weather and the attack of animals, and serve as store houses for reserve food, and in vegetative propagation. Their stem nature can be distinguished by the presence of nodes and internodes, scale leaves at the nodes, axillary buds in axils of scale leaves and a terminal bud. Further, the anatomy of the underground stem resembles that of an aerial stem. The underground stems are of four types namely rhizome, tuber, bulb and corm.

**a. Rhizome**

A rhizome is a thick horizontally growing stem which usually stores food material. It has nodes and internodes, scale leaves, axillary buds, adventitious roots and a terminal bud. Scale leaves enclosing the axillary buds are seen arising from the nodal points of the stem. Some of the axillary buds develop into branches which grow upwards into the air and then produce normal green foliage leaves. Usually the growing points of the rhizome continue to remain underground causing an elongation of the rhizome. Roots develop from the lower surface of the rhizome. Eg. Ginger, Turmeric.

**b. Tuber**

Tuber is a swollen end of an underground branch which arises from the axil of a lower leaf. These underground branches grow horizontally outwards in the soil. Each tuber is irregular in shape due to the deposition of food materials (starch). On the surface of each tuber many leaf scars are seen. These leaf scars are the impressions of fallen scale leaves. Each such leaf scar encloses an axillary bud. A leaf scar with an axillary bud is called an eye. These eyes of potato are capable of producing new plants by vegetative propagation. E.g., Potato.

**c. Bulb**

Here, the stem is reduced and represented by a short disc. The lower surface of the stem produces many adventitious roots. E.g., Onion, Garlic.

In bulbs of onion, garlic, etc. the inner leaves are fleshy while the outer ones are dry. This is called as tunicated bulb since the concentric leaf bases form a complete covering or tunic. The apical bud of the bulb produces the shoot. The axillary buds sometimes produce daughter bulbs, as in garlic.

#### **d. Corm**

A corm is a greatly swollen underground basal portion of an erect stem. The swelling is due to the storage of reserve food material. It bears scale leaves and axillary buds. At the end of the growing season, the aerial parts die. With the return of favorable conditions usually one axillary bud (rarely more than one) near the apex develops into a new shoot utilising the food reserve material in the old corm. The new plant produces a new corm at its base. The earlier corm shrivels off. E.g. *Amorphophallus*, *Colocasia*.

### **II. Subaerial Stem Modifications**

In some plants, the sub-aerial stems are modified for the purpose of vegetative reproduction. They are of the following types :

#### **a. Runner**

The runner arises from the base of the stem as a lateral branch and runs along the surface of the soil. It develops distinct nodes and internodes. At each node, the runner produces roots below and leaves above. In this way many runners are often produced by the mother plant and they spread out on the ground on all sides. If any accidental injury results in the separation of a runner, the severed parts are capable of leading an independent existence. E.g., *Oxalis*, *Fragaria*, *Centella asiatica*.

#### **b. Offset**

An offset is a short thick runner like branch which produces a new plant at its tip. The offsets grow in all directions from the main stem of the parent plant. If any accidental injury results in the separation of these units, each is capable of leading an independent existence. E.g., *Pistia*, *Eichhornia*.

#### **c. Stolon**

Here, lateral branches called stolons originate from the underground stem. The stolons grow horizontally outwards for a varying distance in the soil. Ultimately their end (terminal bud) emerges out of the ground and develops into a new plant. A runner, sucker or any basal branch which produces roots is called a stolon. E.g. *Colocasia*.

#### **d. Sucker**

A lateral branch arising close to the ground level, traveling underground for some distance, turning up at its end and producing a new plant is a sucker. Eg. Chrysanthemum

### **III. Aerial Stem Modifications**

In some plants the aerial stem is modified to perform a variety of special functions. The aerial stem modifications are as follows:

#### **a. Stem Tendril**

Tendrils develop as modifications of the stem in certain plants. The terminal bud gives rise to a tendril in *Cissusquadrangularis* and the axillary bud becomes modified into a tendril in *Passiflora*.

#### **b. Stem Thorn**

The thorn is a hard, straight, and pointed structure. In *Bougainvillea* and *Duranta*, the axillary bud is modified into a thorn. In *Carissa* the terminal bud is modified into a pair of thorns. The thorn sometimes bears leaves, flowers and fruits as seen in *Duranta* and Pomegranate. The thorns not only check the rate of transpiration but also protect the plants from herbivore grazing. Eg. *Carissa*, *Duranta*, *Citrus*

Thorns are small, modified stems, spines are modified superficial leaves and prickles are sharp, pointed structures without vascular tissue, arising on stem, petioles and inflorescence.

#### **c. Phylloclade**

A phylloclade is a flattened stem of several internodes functioning as a leaf. In *Opuntia* the stem is modified into a green flattened structure called Phylloclade. On the surface of the phylloclade, clusters of spines are formed. These spines are the modified leaves of the axillary bud. These spines not only check the rate of transpiration but also protect the plant from herbivores. The phylloclade has distinct nodes and internodes. E.g., *Opuntia*

#### **d. Cladodes and Cladophylls**

A phylloclade of one or two internode is called as a cladode. There are no suitable examples of cladodes because, *Ruscus* and *Asparagus*, which are often considered as cladodes, are in reality, cladophylls. A cladophyll is a flattened leaf like stem arising in the axils of a minute, bract-like, true leaf.

**e. Bulbil**

Bulbil is a special multicellular body essentially meant for reproduction. In Agave the floral buds are modified into bulbils. These bulbils get detached, come in contact with the soil and develop into new plants. In Dioscorea the axillary bud develops into a bulbil. This bulbil detaches from the mother plant and grows up into a new independent one.

**Draw the diagrams of above mentioned modifications.**

**Lab 3. Morphology of flowering plants- The leaf**

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**The Leaf:** Develops from shoot apical meristem, flattened, green structure, manufacture the food by photosynthesis. It has bud in axil. A typical leaf has leaf base, petiole and lamina.

Types of leaf			
1. Simple (Single leaf blade) e.g., mango, peepal	2. Compound (Leaf has number of leaflets)		
	<table border="1"> <tr> <td>i. Pinnately Compound (Neem, rose)</td> <td>ii. Palmately compound (Silk cotton)</td> </tr> </table>	i. Pinnately Compound (Neem, rose)	ii. Palmately compound (Silk cotton)
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**Venation:** The arrangement of veins and veinlets in the lamina of leaf.

**Types of Venation :**

**1. Reticulate :**Veinlets form a network as in leaves of dicotyledonous plants

e.g.: China rose, peepal.

**2. Parallel :**Veins are parallel to each other as in leaves of monocotyledonous plants e.g.: grass,

maize, sugarcane.

**Phyllotaxy :**The pattern of arrangement of leaves on the stem or branch

Types of phyllotaxy		
3. Alternate	4. Opposite	5. Whorled
Single leaf at a node e.g., China rose, Mustard	Two leaves at a node e.g., Calotropis, guava	More than two leaves in a whorl at a node e.g., Nerium

**Modifications of Leaves :**

S.no.	Modification	Function	example
1	Tendrils	Climbing	Sweet wild pea
2	Spines	Protection	Aloe, Opuntia, Argemone
3	Pitcher	Nutrition	Nepenthes
4	Hook	Support	Bignonia

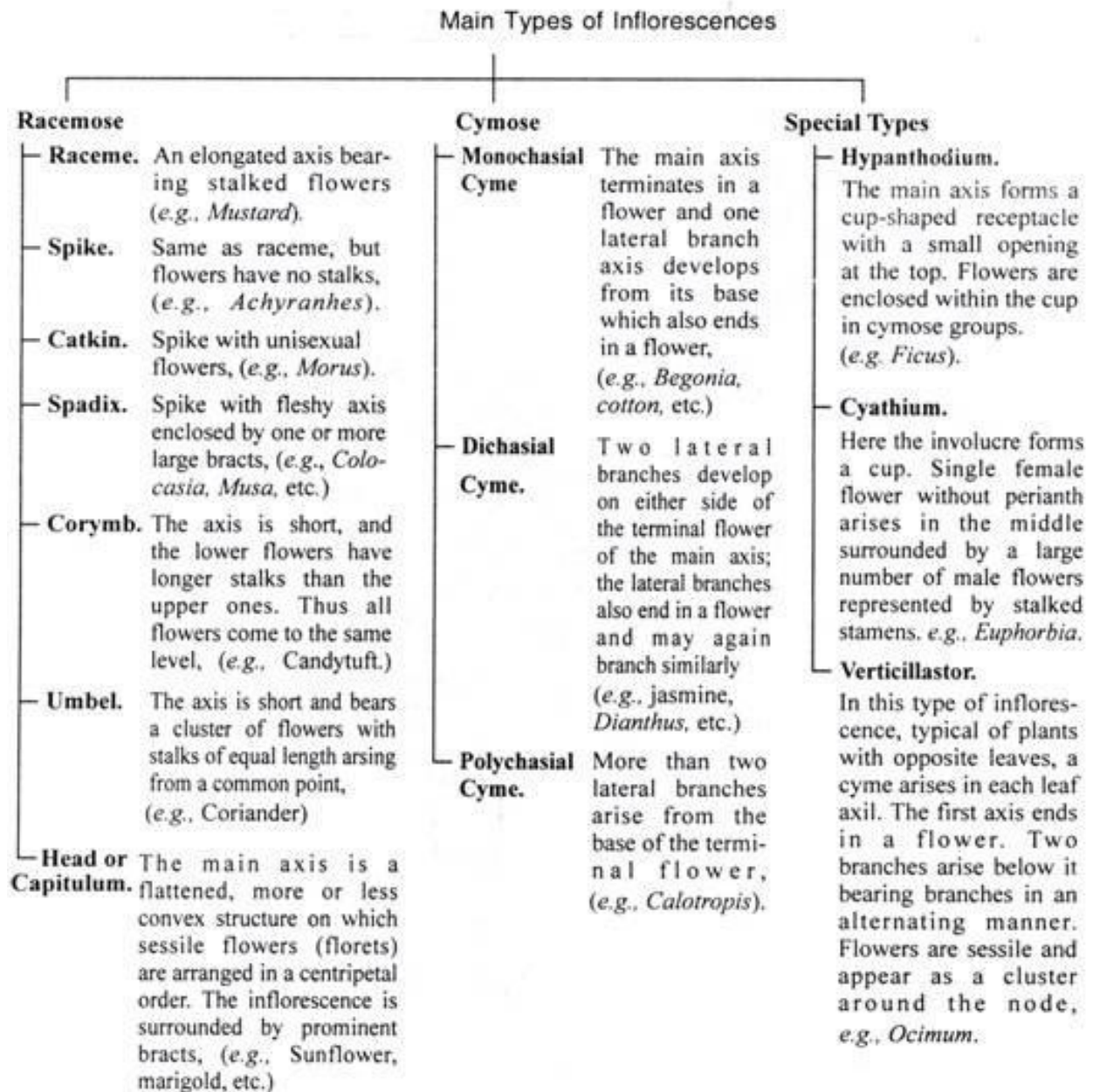
Activity done in the class:

**Draw the diagrams of above mentioned modifications.**

**Inflorescence**, in a flowering plant, is a cluster of flowers on a branch or a system of branches. An inflorescence is categorized on the basis of the arrangement of flowers on a main axis (peduncle) and by the timing of its flowering i.e. determinate (cymose) and indeterminate (racemose).

In **determinate (cymose) inflorescences**, the youngest flowers are at the bottom of an elongated axis or on the outside of a truncated axis. At the time of flowering, the apical meristem (the terminal point of cell division) produces a flowerbud, thus arresting the growth of the peduncle.

In **indeterminate (racemose) inflorescences**, the youngest flowers are at the top of an elongated axis or on the centre of a truncated axis.



**Draw the diagrams of above mentioned modifications.**

**The Flower:** A flower is modified shoot. It is a reproductive unit in angiosperms.

Flowers may be unisexual or bisexual, bracteate or ebracteate. Some features of flower are as given below :

Symmetry of flower	On the basis of no. of floral appendages	On the basis of position of calyx, corolla, androecium with respect of ovary
Actinomorphic (radial symmetry)	Trimerous	Hypogynous(superior ovary)
Zygomorphic (bilateral symmetry)	Tetramerous	Perigynous(half inferior ovary)
Asymmetric (irregular)	Pentamerous	Epigynous (inferior ovary)

**Parts of flower :**

- 1. Calyx:** Sepals, green in colour, leaf like.
- 2. Corolla:** Petals, usually brightly coloured to attract insects for pollination.
- 3. Androecium:** Stamens (filament, anther), male organ and produce pollen grains. Stamens may be epipetalous (attach to petals) or epiphyloous (attach to perianth). Stamens may be monoadelphous (united into one bundle), diadelphous (two bundles) or polyadelphous (more than two bundles).
- 4. Gynoecium:** Made up of one or more carpels, female reproductive part, consists of stigma, style and ovary, ovary bears one or more ovules. Carpels may be apocarpous (free) or syncarpous (united). After fertilisation, ovules develop into seeds and ovary into fruit.

**Gamosepalous** – (Sepals united)

**Polysepalous**– (Sepals free)

**Gamopetalous** – (Petals united)

**Polypetalous** – (Petals free)

**Perianth:** If calyx and corolla are not distinguishable, they are called perianth.

**Aestivation:** The mode of arrangement of sepals or petals in floral bud.

**Types of aestivation:**

- 1. Valvate:** Sepals or petals do not overlap the sepal or petal at margins.
- 2. Twisted:** Sepals or petals overlap the next sepal or petal.
- 3. Imbricate:** The margins of sepals or petals overlap one another but not in any definite direction.
- 4. Vexillary:** The largest petal overlaps the two lateral petals which in turn overlap two smallest anterior petals.

**Placentation:** The arrangement of ovules within the ovary.

**Types of Placentation :**

- 1. Marginal:** Placenta forms a ridge along the ventral suture of ovary.
- 2. Axile:** Margins of carpels fuse to form central axis.
- 3. Parietal:** Ovules develop on inner wall of ovary.
- 4. Free central:** Ovules borne on central axis, lacking septa.
- 5. Basal:** Placenta develops at the base of ovary

**Draw the diagrams of above mentioned modifications.**

It is not easy to define a fruit. For a common man fruit means a sweet, juicy or pulpy, coloured, aromatic structure that encloses seed(s). Botanically, a fruit develops from a ripe ovary or any floral parts on the basis of floral parts they develop, fruits may be true or false.

- (i) **True Fruits:** A true fruit or eucarp is a mature or ripened ovary, developed after fertilization, e.g., Mango, Maize, Grape etc.
- (ii) **False Fruits:** A false fruit or pseudo-carp is derived from the floral parts other than ovary, e.g., peduncle in cashew-nut, thalamus in apple, pear, gourd and cucumber; fused perianth in mulberry and calyx in Dillenia. Jack fruit and pine apple are also false fruits as they develop from the entire inflorescence. False fruits are also called spurious or accessory fruits
- (iii) **Parthenocarpic fruits:** These are seedless fruits that are formed without fertilization, e.g., Banana. Now a day many seedless grapes, oranges and water melones are being developed by horticulturists. Pomology is a branch of horticulture that deals with the study of fruits and their cultivation.

**Morphology of a Typical Fruit:**

A fruit consists of pericarp and seeds. Seeds are fertilized and ripened ovules. The pericarp develops from the ovary wall and may be dry or fleshy. When fleshy, pericarp is differentiated into outer epicarp, middle mesocarp and inner endocarp.

**Types of Fruits:**

**On the basis of the above mentioned features, fruits are usually classified into three main groups:**

- (1) **Simple:** When a single fruit develops from a single ovary of a single flower, it is called a simple fruit. The ovary may belong to a monocarpellary simple gynoecium or to a polycarpellary syncarpous gynoecium. There are two categories of simple fruits—dry and fleshy.
- (2) **Aggregate:** Flowers with polycarpellary and apocarpous gynoecium give rise to a number of fruitlets as there are a number of free ovaries, each giving rise to one fruitlet. Sometimes, these fruitlets coalesce together appearing to be a single fruit but in many other cases, the fruitlets remain free from one another forming etaerio of fruitlets. An aggregate fruit is named according to the nature of fruitlets.
- (3) **Composite or Multiple fruits:** A fruit developing from a complete inflorescence is called a multiple or a composite fruit.

**Draw the diagram of above mentioned modifications.**

The ovules after fertilization, develop into seeds. A seed is made up of a seed coat and an embryo. The embryo is made up of a radicle, an embryonal axis and one (as in wheat, maize) or two cotyledons (as in gram and pea).

### Structure of a Dicotyledonous Seed

The outermost covering of a seed is the seed coat. The seed coat has two layers, the outer **testa** and the inner **tegmen**. The **hilum** is a scar on the seed coat through which the developing seeds were attached to the fruit. Above the hilum is a small pore called the **micropyle**. Within the seed coat is the embryo, consisting of an embryonal axis and two cotyledons. The cotyledons are often fleshy and full of reserve food materials. At the two ends of the embryonal axis are present the radicle and the plumule. In some seeds such as castor the **endosperm** formed as a result of double fertilisation, is a food storing tissue. In plants such as bean, gram and pea, the endosperm is not present in mature seeds and such seeds are called non-endospermous.

### Structure of Monocotyledonous Seed

Generally, monocotyledonous seeds are endospermic but some as in orchids are non-endospermic. In the seeds of cereals such as maize the seed coat is membranous and generally fused with the fruit wall. The endosperm is bulky and stores food. The outer covering of endosperm separates the embryo by a proteinous layer called **aleurone layer**. The embryo is small and situated in a groove at one end of the endosperm. It consists of one large and shield shaped cotyledon known as **scutellum** and a short axis with a **plumule** and a **radicle**. The plumule and radical are enclosed in sheaths which are called **coleoptile** and **coleorhizae** respectively

**Seed Germination:** Germination in plants is the process by which a dormant seed begins to sprout and grow into a seedling under the right growing conditions.

### Process of Seed Germination

- **Water:** it is extremely necessary for the germination of seeds. Some seeds are extremely dry and need to take considerable amount of water, relative to the dry weight of the seed. But most seeds need enough water to moisten and not soak. It also leaches away a germinator inhibitor in the seed.
- **Oxygen:** It is required by the germinating seed for metabolism. It is used as a part of aerobic respiration until it manages to grow green leaves of its own. Oxygen can be found in the pores of sand particles, but if the seed is buried too deep it will be deprived of this oxygen.
- **Temperature:** This affects growth rate as well as metabolism of the seed. Quite obviously different seeds require different optimum temperatures.
- **Light or darkness:** This can act as an environmental trigger. Many seeds refuse to germinate until sunlight falls on them.

So to summarize, the process of seed germination, under the above mentioned favorable conditions, with suitable triggers the seed undergoes a rapid expansion growth of the embryo, culminating in rupture of the covering layers and emergence of the radical. This radical emergence is considered the completion of germination.

**Draw neat labeled diagram of monocot and dicot seeds**

**Cells** are the basic structural and functional unit of life.

**The Cell Theory** states that:

- 1) All organisms are made up of one or more cells and the products of those cells.
- 2) All cells carry out life activities ( require energy, grow, have a limited size).
- 3) New cells arise only from other living cells by the process of cell division.

**The three main components of any plant or animal cell are:**

**1. Plasma membrane/ cell membrane**

Structure- a bilipidmembraneous layer composed of proteins and carbohydrates. It is fluid like.

Function - the cell membrane separates the cell from its external environment, and is selectively permeable (controls what gets in and out). It protects the cell and provides stability.

Proteins are found embedded within the plasma membrane, with some extending all the way through in order to transport materials.

Carbohydrates are attached to proteins and lipids on the outer lipid layer.

**2. Cytoplasm**

Structure - The jelly-like substance composed of mainly water and found between the cell membrane and nucleus. The cytoplasm makes up most of the "body" of a cell and is constantly streaming.

Function - Organelles are found here and substances like salts may be dissolved in the cytoplasm.

**3. Nucleus**

Structure - The largest organelle in the cell. It is dark and round, and is surrounded by a double membrane called the **nuclear envelope/membrane**. In spots the nuclear envelope fuses to form pores which are selectively permeable. The nucleus contains genetic information (DNA) on special strands called **chromosomes**.

Function - The nucleus is the "control center" of the cell, for cell metabolism and reproduction.

The following organelles are found in both plant and animal cells.

**1. "ER" or Endoplasmic Reticulum**

The Endoplasmic Reticulum is a network of membranous canals filled with fluid. They carry materials throughout the cell. The ER is the "transport system" of the cell.

There are two types of ER: rough ER and smooth ER.

Rough Endoplasmic Reticulum is lined with ribosomes and is rough in appearance and smooth endoplasmic reticulum contains no ribosomes and is smooth in appearance.

**2. Ribosomes**

Ribosomes are small particles which are found individually in the cytoplasm and also line the membranes of the rough endoplasmic reticulum. Ribosomes produce protein. They could be thought of as "factories" in the cell.

**3. Golgi body / apparatus**

Golgi bodies are stacks of flattened membranous stacks (they look like pancakes!). The Golgi Body temporarily stores protein which can then leave the cell via vesicles pinching off from the Golgi.

**4. Lysosomes**

Lysosomes are small sac-like structures surrounded by a single membrane and containing strong digestive enzymes which when released can break down worn out organelles or food. The lysosome is also known as a suicide sac.

## **5. Mitochondria**

The mitochondria are round "tube-like" organelles that are surrounded by a double membrane, with the inner membrane being highly folded. The mitochondria are often referred to as the "powerhouse" of the cell. The mitochondria releases food energy from food molecules to be used by the cell. This process is called respiration. Some cells( muscle cells) require more energy than other cells and so would have many more mitochondria.

## **6. Vacuoles**

Vacuoles are fluid filled organelles enclosed by a membrane. They can store materials such as food, water, sugar, minerals and waste products.

### **Animal cells organelles not found in plant cells:**

#### **Cilia and flagella**

Both cilia and flagella are hair-like organelles which extend from the surface of many animal cells. The structure is identical in both, except that flagella are longer and whiplike and cilia are shorter. There are usually only a few flagella on a cell, while cilia may cover the entire surface of a cell. The function of cilia and flagella include locomotion for one-celled organisms and to move substances over cell surfaces in multi-celled organisms.

### **Organelles and other features found only in plant cells:**

#### **1. Cell wall**

The cell wall is a rigid organelle composed of cellulose and lying just outside the cell membrane. The cell wall gives the plant cell its box-like shape. It also protects the cell. The cell wall contains pores which allow materials to pass to and from the cell membrane.

#### **2. PLASTIDS**

Plastids are double membrane bound organelles. It is in plastids that plants make and store food. Plastids are found in the cytoplasm and there are two main types:

**Leucoplasts** - colorless organelles which store starch or other plant nutrients. ( example - starch stored in a potato)

**Chromoplasts** - contain different colored pigments. The most important type of chromoplast is the **chloroplast**, which contains the green pigment chlorophyll. This is important in the process of photosynthesis.

#### **3. Central vacuole**

The central vacuole is a large fluid-filled vacuole found in plants.

**Draw a neat labeled diagram of a plant cell**

A Tissue is a cluster of cells, that are alike in configuration and work together to attain a specific function, forms a tissue. Different types of plant tissues include permanent and meristematic tissues.

**Meristematic tissue:** These tissues have the capability to develop by swift division. They assist in the major growth of the vegetation. Growth in length and growth in diameter of the plant are carried about by these cells. The Meristematic cells are cubical, living cells with a big nucleus. These cells are meticulously crammed with no intercellular spaces. Depending on the section where the meristematic tissues are existing, they are categorized as meristems intercalary, lateral and apical.

- Apical meristem is existent at the growing tips or apical of stems and roots. Apical meristem upsurges the length of the plant.
- Lateral meristem is existent in the radial portion of the stem or root. Lateral meristem upsurges the thickness of the plant.
- Intercalary meristem is found at the internodes or at the base of the leaves. Intercalary meristem upsurges the size of the internode.

Old meristematic cells lose the capability to distribute and convert into permanent tissues. This procedure of capturing up a permanent function, size, and shape is termed as differentiation.

**Permanent tissues:** Those cells which have lost their ability to distribute but are specialised to offer elasticity, flexibility and strength to the plant. These tissues can be additionally categorised into:

- Simple permanent: They can be classified into sclerenchyma, collenchyma and parenchyma based on their purpose.
- Complex permanent Tissue: These tissues include of phloem and xylem. Xylem is valuable for the transportation of water and solvable constituents. Xylem is made up of xylem parenchyma, fibres, vessels and tracheids. Phloem is valuable in the transportation of food particles. Phloem consists of phloem parenchyma, phloem fibres, companion cells, sieve cells and sieve tubes.

**Parenchyma** – These are alive, polygonal cells with a big central vacuole, and have intercellular spaces amidst them. Parenchymatous cells create the ground tissue and pith.

- Parenchyma comprising of chloroplasts are termed as chlorenchyma. The chlorenchyma helps in photosynthesis.
- Parenchyma which comprise of big air voids are called aerenchyma. Buoyancy is the main purpose the aerenchyma serves.
- Some parenchymatous cells perform as storage chambers for starch in vegetable and fruits.

**Collenchyma** – These are stretched out living cells with minute intercellular gaps. Their cell walls are made up of pectin and cellulose. Collenchyma is found in the marginal regions of leaves and stems and offers flexibility with the structural framework and mechanical support in plants.

**Sclerenchyma** – These are elongated, dead cells with a lignin deposits in their cell wall. They have no intercellular gaps. Sclerenchyma is found in the covering of seeds and nuts, around the vascular tissues in stems and the veins of leaves. Sclerenchyma provides strength to the plant.

**Xylem** – It helps in the transport of dissolved substances and water all through the plant. The diverse components of the xylem include vessels, tracheids, xylem fibres and xylem

parenchyma. Xylem fibres and Tracheids are made up of lignin, which provides structural support to the plant.

Phloem – This tissue helps in the transportation of food all through the plant. The diverse elements of phloem include phloem fibres, sieve tubes, phloem parenchyma and companion cells.

**Protective tissues:** These provide fortification to the plant. They include the cork and epidermis.

Epidermis – Its a layer of cell that makes up making up an outer casing of all the structures in the plant. The stomata perforates the epidermis at certain places. The stomata help in loss of water and gaseous exchange.

Cork – This is the external protective tissue which substitutes the epidermal cells in mature stems and roots. Cork cells are lifeless and lack intercellular gaps. Their cell walls are coagulated by suberin which makes them impervious to gas and Water Molecules

**Draw neat labeled diagrams of various types of plant tissues.**

**Cell Cycle:** The sequence of events by which a cell duplicates its genome, synthesis the other components of the cell and eventually divides into daughter cell.

**Phases of cell cycle:**

**Interphase:**

- **G<sub>1</sub> phase:** Cell metabolically active and grows continuously
- **S phase:** DNA synthesis occurs, DNA content increases from 2C to 4C. but the number of chromosomes remain same.
- **G<sub>2</sub> phase:** Proteins are synthesized in preparation for cell division, while cell growth continues.

**Multiplication phase (M phase):** starts with nuclear division, corresponding to separation of daughter chromosomes (karyokinesis) and usually ends with division of cytoplasm (cytokinesis).

**Quiescent stage (G<sub>0</sub> stage):** cells that do not divide and exit G<sub>1</sub> phase to enter an inactive stage called G<sub>0</sub> stage. Cell at this stage remain metabolically active but do not proliferate.

**Mitosis:**

- **Prophase:**
  - i. Replicated chromosomes, each consisting of two chromatids, condense and become visible.
  - ii. Microtubules are assembled into mitotic spindle.
  - iii. Nucleolus and nuclear envelop disappear
  - iv. Centriole moves to opposite poles
- **Metaphase**
  - i. Spindle fibres attached to kinetochores of chromosomes.
  - ii. Chromosomes line up at the equator of the spindle to form metaphase plate.
- **Anaphase**
  - i. Centromeres split and chromatids separate
  - ii. Chromatids move to opposite poles.
- **Telophase**
  - Chromosomes cluster at opposite poles.
  - Nuclear envelop assembles around chromosome cluster.
  - Nucleolus, golgi complex, ER reform.

- **Cytokinesis:** is the division of protoplast of a cell into two daughter cells after karyokinesis.

**Animal cytokinesis:** Appearance of furrow in plasma membrane which deepens and joins in the centre, dividing cell cytoplasm into two.

**Plant cytokinesis:** Formation of new cell wall begins with the formation of simple precursor- cell plate which represents the middle lamella between the walls of two adjacent cells.

### **Significance**

- Growth
- Maintenance of surface/volume ratio.
- Maintenance of chromosome number.
- Regeneration
- Reproduction in unicellular organisms.
- Repairing and wound healing.

### **Meiosis**

- Specialized kind of cell division that reduces the chromosomal number by half, resulting the formation of 4 haploid daughter cells.
- Occurs during gametogenesis in plants and animals.
- Involves two sequential cycles of nuclear and cell division called Meiosis I and Meiosis II
- Interphase occurs prior to meiosis which is similar to interphase of mitosis except the S phase is prolonged.

#### **a. Meiosis I**

**Prophase I:** subdivided into 5 phases.

##### **i. Leptotene**

- Chromosomes makes their as single stranded structures.
- Compaction of chromosomes continues.

##### **ii. Zygotene**

- Homologous chromosomes start pairing and this process of association is called **Synapsis.**

- Chromosomal complex is associated with the formation of synaptonemal complex.
- Complex formed by a pair of synapsed homologous chromosomes is called bivalent or tetrad.

**iii. Pachytene:** Crossing over occurs between non sister chromatids of homologous chromosomes.

**iv. Diplotene:** Dissolution of synaptonemal complex occurs and the recombined chromosomes separate each other except at the sites of crossing over. These X-shaped structures are called Chiasmata.

**v. Diakinesis**

- Terminalization of chiasmata.
- Chromosomes are fully condensed and meiotic spindles assemble.
- Nucleolus disappear and nuclear envelope breaks down.

### **Metaphase I**

- Bivalent chromosomes align on the equatorial plate.
- Microtubules from opposite poles of the spindle attach to the pair of homologous chromosomes.

**Anaphase I:** Homologous chromosomes separate, while chromatids remain associated at their centromeres.

### **Telophase I:**

- Nuclear membrane and nucleolus reappear
- Cytokinesis follows.

**Interkinesis:** Stage between Meiosis I and Meiosis II

### **Meiosis II**

#### **Prophase II**

- Nuclear membrane disappears
- Chromosomes become compact

#### **Metaphase II**

- Chromosomes align at the equator
- Microtubules from opposite poles of the spindle get attached to kinetochores of sister chromatids.

### **Anaphase II**

- Simultaneous splitting of the centromere of each chromosome, allowing them to move towards opposite poles of the cell.

### **Telophase II**

- Two groups of chromosomes get enclosed by a nuclear envelope.
- Cytokinesis follows resulting in the formation of 4 haploid cells.

### **Significance:**

1. Formation of gametes in sexually reproducing organisms.
2. Genetic variability
3. Maintenance of chromosomal number

**Draw neat labeled representation of mitosis and meiosis in plant cell.**

## Lab 11. Internal structure of Root Page No.....

### Dicot Root

Internal structure of a typical dicotyledon root shows following features:

**1. Epiblema:** It is uniseriate outermost layer. It comprising tubular living components. Cuticle and stomata are absent. Unicellular root hairs are formed due to elongation of some cells of epiblema. Epiblema also known as Rhizodermis or Piliferous layer. Root hair are present in maturation zone of root.

**Note:** Cells of epiblema which develop root hair called trichoblast.

**2. Cortex:** It is made up of parenchymatous cells.

Chloroplast is absent so they are nonphotosynthetic but chloroplast is present in roots of *Tinospora* and *Trapa* so they are photosynthetic.

**Note:** The cells of outer part of cortex -are suberized in old root. It is called exodermis.

Exodermis is found in some dicotyledonae roots and most of the monocotyledonae roots'.

**3 Endodermis:** This layer is situated between the pericycle and cortex. Casparian strips are present on radial and tangential wall of endodermis. These strips are made up of lignosuberin (mainly suberin).

Casparian strips are discovered by Caspari.

The cells of endodermis which are situated in front of protoxylem cells lack of casparian strips.

These are called passage cells/ transfusion cells. The number of passage cells is equivalent to the protoxylem cells. Passage cells provide path to absorbed water from cortex to pericycle.

**4. Pericycle:** It is single layered. It is composed prosenchyma.

Lateral roots are originated from the part of pericycle which is lying opposite to protoxylem. Thus lateral roots are endogenous in origin. A few mature cells of pericycle usually opposite to protoxylem, become meristematic. These cells divide by periclinal divisions and form some layers of cells. These divisions are followed by anticlinal divisions forming a primordium which grows to form a lateral root.

**5. Vascular Bundles:** Vascular bundles are radial and exarch, xylem and phloems are separate and equal in number. The number of xylem bundles are two to six (diarch to hexarch).

But exceptionally, *Ficus* (Banyan tree) root is polyarch.

Parenchyma which is found between xylem and phloem is called conjunctive tissue.

**6. Pith:** In dicot root pith is less developed or absent.

### **Internal Structure of Monocotyledon Root**

The internal structure of a typical monocotyledon root is similar to dicotyledon root:

- (1) Number of xylem bundles are more than six (Polyarch) in monocotyledon root (exceptionally the number of xylem bundles are two to six in onion).
- (2) Pith is well developed in monocotyledon root.

**Draw the internal structure of typical monocot and dicot roots.**

### Internal Structure of Dicot Stems

Internal structure of a typical dicot stem shows following features:

#### 1. Epidermis:

- Epidermis is the outermost layer of the stem.
- It is single layerd and lack of chloroplast.
- Multicellular hairs (trichomes) and stomata are found on epidermis.
- Outer side of epidermis a layer is present which is made up of cutin is called cuticle.
- Epidermis plays a significant role in protection

#### 2. Cortex:

In dicotyledon stem cortex divided into three parts:

(a) **Hypodermis:** It is present just below the epidermis. It provides additional support to epidermis. It is thick multicellular layer. This layer is composed of collenchyma and their cells contain chloroplast. So hypodermis is green and photosynthetic.

(b) **General Cortex:** This part is composed 01 parenchyma. Storage of food is the main function of the cortex. Resin canal/ mucilage canal are present in it. These are schizogenous in origin. The innermost layer of the cortex is called endodermis.

(c) **Endodermis:** It is single celled thick layer. The cells of endodermis are barrel shaped. These cells accumulate more starch in stem of dicot. Thus it is known as "Starch sheath".

#### 3. Pericycle:

This layer is situated in between the endodermis and vascular bundles. The perieycle of stem is multilayered and made up of sclerenchyma. Sclerencymatousperieyle is also known as Hardbast.

#### 4. Vascular Bundle:

The vascular bundles (wedge shaped) are arranged in a ring. Each vascular bund is conjoint, collateral and open. Each vascular bundle is made of phloem, cambium and xylem. Eustele is present in dicotyledon stems.

#### 5. Pith:

This is well developed region, spreading from ring of vascular bundle to the centre. The cells of this region mainly made up of parenchyma.

**Function of pith:** Storage of water and food.

## **Internal Structure of Monocotyledon Stem**

**1. Epidermis:** Epidermis is the outer most single celled thick layer. It is covered with thick cuticle. Multicellular hairs are absent & stomata are also less.

**2. Hypodermis:** Hypodermis of monocotyledon stem is made up of sclerenchyma. It is 2-3 layered monocot stem rigidity is more in hypodermis whereas in dicot stem elasticity is more. It provides mechanical support to plant.

**3. Ground tissue:** The entire mass of parenchyma cells next to hypodermis and extending to the centre is called ground tissue. There is no differentiation of ground tissue in monocotyledon stem. It means ground tissue is not differentiated into endodermis, cortex, Pericycle etc.

Note: Sometimes in some grasses, wheat etc. the central portion of ground tissue becomes hollow and is called Pith cavity.

### **4. Vascular Bundle:**

- Many vascular bundles are scattered in the ground tissue and V.B. are generally oval shape.
- Vascular bundles towards the centre are large in size and less in number.
- Vascular bundles situated towards the periphery are small in size but more in number.
- Each vascular bundle is conjoint, collateral and closed.
- Vascular bundles surrounded by the layer of sclerenchymatous fibre are known as bundle sheath.
- So vascular bundles are called fibro vascular bundles.

**(a) Xylem:** In xylem number of vessels is less. In metaxylem there occur two large vessels while in protoxylem there occur one or two small vessels. Vessels are arranged in V or Y shape. Just beneath protoxylem vessels, there occur a water cavity which is schizolysigenous in origin but major part of water cavity is lysigenous. This cavity is formed by disintegration of the element present below the proto xylem and neighbouring parenchyma.

**Exception:** In Asparagus water cavity & bundle sheath are absent.

**(b) Phloem:** It consists of sieve tube elements and companion cells. Phloem parenchyma is absent.

**5. Pith:** Pith is undifferentiated in monocotyledon stems. Atactostele is found in monocotyledon. This is highly developed stele.

**Draw internal structures of typical monocot and dicot stems.**

**Internal Structure of Dorsiventral Leaves**

- Cuticle is present on both surfaces but cuticle of upper surface is more thick.
- Dorsiventral leaves are mostly hypostomatic i.e. stomata present on lower surface.
- In amphistomaticdorsiventral leaves stomata are more on lower surface as compared to upper surface.
- Mesophyll of these leaves is divided into two regions - Palisade tissue and spongy tissue.
- Palisade tissue is found towards upper surface.
- These cells have more chloroplasts and spongy tissue is found towards lower surface.

**Internal Structure of Isobilateral Leaves**

- The thickness or cuticle on the both surface is equal.
- Distribution of stomata on both surface are equal.
- Isobilateral leaves are Amphistomatic i.e. stomata present on both sides.
- Mesophyll of isobilateral leaves is not differentiated into palisade and spongy tissues.
- It is completely made up of spongy tissues. Palisade tissue are absent.

**Note:**

- In isobilateral leaf, two distinct patches of sclerenchyma are present above and below each of the large vascular bundles and extend up to the upper and lower epidermal layers, respectively.
- In dorsiventral leaf, two distinct patches of parenchymal sclerenchyma are present above and below each of the large vascular bundles and extend up to the upper and lower epidermal layers, respectively.

**Vascular Bundles of Leaves**

- Similar types of vascular bundles are found in both dorsiventral and isobilateral leaves.
- Vascular bundles of leaves are conjoint, collateral and closed.
- Protoxylem is situated towards the adaxial surface and protophloem towards the abaxial surface in the vascular bundle.
- Leaves are devoid of endodermis and pericycle.
- Vascular bundles are surrounded by a bundle sheath.

- Bundle sheath in C-4 - plants is chlorenchymatous and remaining plants have parenchymatous or sclerenchyrnatous (mainly parenchymatous) bundle sheath.

**Note:**

**1. Bulliform cells:** Large cells are found in the epidermis of psammophytic (desert) grasses which are filled by liquid or empty (mostly) and colourless are called bulliform cells or motor cells. Upward folding of leaves during the sunny day takes place due to the presence of these specific cells. This is an adaptation to reduce the transpiration.

**Example:** Ammophila, Poa, Empectra and Agropyron etc. are Psammophytic grasses.

**2.** Epidermis of Nerium (both upper & lower) and Ficus (only upper epidermis) becomes multilayered. This is an adaptation to reduce transpiration.

**Draw neat labeled diagrams of internal structure of isobilateral and dorsi-ventral leaves.**

## **Lab 14. Plant systematic: Poaceae, Fabaceae, and Brassicaceae**

### **Characters of Poaceae:**

Mostly herbs, stem jointed, fistular, cylindrical; leaves simple, alternate, sheathing, sheath open, ligulate; inflorescence compound spike; flowers zygomorphic, hypogynous, protected by palea; perianth represented by 2 or 3 minute scales (lodicules); stamens 3, versatile; carpel one, style 2 or 3, stigmas feathery, basal placentation; fruit caryopsis; testa fused with pericarp.

### **A. Vegetative characters:**

#### **Habit:**

Herbs, annuals or perennials or shrubs, sometimes tree like (Bambusa, Dendrocalamus).

#### **Root:**

Adventitious, fibrous, branched, fascicled or stilt (*Zea mays*).

#### **Stem:**

Underground rhizome in all perennial grasses, cylindrical, culm with conspicuous nodes and internodes, internodes hollow, herbaceous or woody, glabrous or glaucous, vegetative shoots are arising from the base of aerial stem or from underground stems are called tillers.

#### **Leaves:**

Alternate, simple, distichous, exstipulate, sessile, ligulate (absent in *Echinochloa*), leaf base forming tubular sheath, sheath open, surrounding internode incompletely, ligule is present at the junction of the lamina and sheath, entire, hairy or rough, linear, parallel venation.

### **B. Floral characters:**

#### **Inflorescence:**

Compound spike which may be sessile or stalked. Each unit of inflorescence is spikelet. The spikelets are arranged in various ways on the main axis called rachilla. A compound inflorescence may be spike of spikelets (*Triticum*), panicle of spikelets (*Avena*).

The spikelet consists of a short axis called rachilla on which 1 to many sessile or short stalked flowers are borne. The florets may be arranged in alternate or opposite manner on the central axis.

At the base of rachilla two sterile scales, called glumes, are present. The glumes are placed one above the other on opposite sides. The lower one is called first glume and the upper is called second glume. Both the glumes are boat shaped and sterile. Above the glumes a series of florets are present. Each floret has an inferior palea or lemma and above it a superior palea. The lemma frequently bears a long, stiff hair called awn.

#### **Flower:**

Bracteate and bracteolate, sessile, incomplete, hermaphrodite, or unisexual (*Zea mays*), irregular, zygomorphic, hypogynous, cyclic.

**Perianth:**

Represented by membranous scales called the lodicules. The lodicules are situated above and opposite the superior palea or may be absent, or many (*Ochlandra*), or 2 or 3.

**Androecium:**

Usually stamens 3, rarely 6 (*Bambusa*, *Oryza*) and one in various species of *Anrostis*, *Lepturus*; polyandrous, filaments long, anthers ditheous, versatile, linear, extrorse; pollen grains dry.

**Gynoecium:**

Monocarpellary, according to some authors carpels 3, of which 2 are abortive, ovary superior, unilocular with single ovule, basal placentation, style short or absent; stigmas two feathery or papillate and branched.

**Fruit:**

Caryopsis (achene with pericarp completely united or adherent with the seed coat) or rarely nut (*Dendrocalamus*) or berry (*Bambusa*).

**Seed:**

Endospermic and containing a single cotyledon called scutellum, which is shield shaped and pressed against the endosperm.

**Floral formula:**

**Floral formula** –  $0 | 0 \text{ } \overline{\text{P}}_{0 \text{ or } 2} \text{ (Lodicules)} \text{ A}_{3 \text{ or } 6} \text{ G}_{\underline{1}}$ .

**Characteristics of Fabaceae**

Family Fabaceae is large family including plants which are economically important. The family Fabaceae also was known as Leguminosae or Papilionaceae since it is the pea or legume family. It consists of around 5000 species of dicotyledons which are widely distributed all over the world.

**b. Vegetative Characters**

**Root:** Dicotyledons with taproot with root nodules.

**Stem:** Erect or climber; Fabaceae include shrubs, herbs, trees and majorly climbers.

**Leaves:** Petiolate, pinnately compound or simple; pulvinus leaf base, stipulate; reticulate venation

**• Floral Characters**

**Inflorescence:** Racemose.

**Flower:** Complete, bisexual, zygomorphic, perigynous, bracteate/ ebracteate.

**Calyx:** Five sepals, gamosepalous; imbricate aestivation.

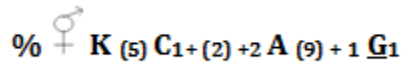
**Androecium:** Ten stamens (9+1), diadelphous, anther ditheous.

**Gynoecium:** Superior ovary, monocarpellary, unilocular, marginal placentation, single, sort - style and flat, hairy-stigma.

**Fruit:** Legume.

**Seed:** One or more, non-endospermic.

**Floral formula:**



### **Characters of Brassicaceae:**

Flowers actinomorphic rarely zygomorphic, hermaphrodite; sepals four in two whorls of two each, petals four, diagonally arranged-cruciform; stamens six, tetradynamous; gynoecium bicarpellary, syncarpous, parietal placentation, bilocular due to the formation of false septum (replum); fruit siliqua or silicula.

### **A. Vegetative characters:**

#### **Habit:**

Generally herbs, annual (Brassica, Capsella) or biennial or shrubs. Common Indian herbs are Eruca, Alyssum, Nasturtium, Lepidium, Coronopus etc. Vegetative reproduction is by bulbils (Dentariabulbifera) or by coral roots.

#### **Roots:**

Tap root, swollen on account of stored food materials. It may be conical (Radish), fusiform or napiform (Turnip).

### **ADVERTISEMENTS:**

#### **Stem:**

Herbaceous, erect, cylindrical (Iberis, Brassica) rarely woody or some times reduced (Raphanus & Brassica species), glabrous or hairy, solid and branched.

#### **Leaves:**

Alternate or sub-opposite, simple, exstipulate (Brassica campestris). May be cauline or radical (Raphanus), generally sessile, hairy, entire and with unicostate reticulate venation.

### **B. Floral characters:**

#### **Inflorescence:**

Raceme (Brassica campestris) corymbose raceme (Iberis) or corymb.

**Flower:**

Pedicellate, ebracteate, hermaphrodite, actinomorphic rarely zygomorphic (Iberis and Teesdalia), hypogynous, complete or incomplete (Lepidium) and tetramerous.

**ADVERTISEMENTS:****Calyx:**

Sepals 4 arranged in two whorls of two each, polysepalous (2 antero-posterior and 2 lateral), 2 lateral sepals may be saccate, imbricate aestivation, inferior.

**Corolla:**

Petals 4, alternate with sepals, polypetalous, petals arranged in the form of across known as cruciform. This arrangement is characteristic of the family Petals usually clawed, petals generally equal rarely unequal (Iberis, Teesdalia) or sometimes petals may be replaced by stamens (Capsella bursa pastoris).

**Androecium:**

Stamens 6, arranged in two whorls, outer two stamens short and inner four long (2+4), tetradynamous, polyandrous, anthers dithecousbasifixed, introrse. Disc like nectaries, variable in number, present at the base of stamens. In some cases the number of stamens is variable – 16 (Megacarpaea), 4 (Cardaminehirsuta), 2 (Coronopus) etc.

**Gynoecium:**

Bicarpellary rarely tricarpellary (Lepidiumsativum), syncarpous, ovary superior, unilocular, becomes bilocular due to the development of false septum called replum: parietal placentation, ovules many, style short, stigma simple or bifid. The crucifer carpel has been a puzzling subject for the morphologists and their attention attracted towards its for a long time. According to some there are only two carpels while others hold that there are four carpels.

**Fruit:**

Siliqua or silicula, sometimes lomentum (Raphanus); when the valves separate in a siliqua the seeds remain attached to the replum.

**Seed:**

Ex-albuminous. The germination of seed is epigeal.

**Pollination:**

Self or cross pollinated; flowers are visited by insects due to the presence of nectaries.  
Cleistogamy is found in *Cardamine chenopodiifolia*. Anemophilous pollination is found in *Pringlea*.

**Floral formula:**

$\oplus \text{ } \overline{\text{K}}_{2+2} \text{ } \text{C}_{4x} \text{ } \text{A}_{2+4} \text{ } \underline{\text{G}}_{(2)}$ .

Draw neat labeled floral diagrams of above mentioned families.