Exercise 11

Aim: Study and describe flowering plants of families Solanaceae, Fabaceae and Liliaceae.

Principle: Taxonomy deals with identification, nomenclature and classification of organisms. Bentham and Hooker's system of classification is universally used for classification of plants. Field identification of plants is based primarily on morphological features particularly the floral characters.

Requirement: Locally available plant specimens of Solanaceae, Fabaceae and Liliaceae. (minimum 3 species for each family other than the ones described for reference in the manual); each specimen should have at least a small branch with a few inter nodes, leaves, flowers and fruits; glass slides, cover glass, water, 100 ml beakers, petridish, razor, blade, needles, brush, hand lens, dissecting microscope and compound microscope.

Procedure

Keep the twigs in beakers containing water. Make yourself familiar with the terms given to describe the habit of plant, its root system, stem and leaf, inflorescence and flowers. Describe the vegetative and floral features of the plant in the same sequence using terms described therein. Observe the flower bud under dissection microscope or a hand lens and note the aestivation patterns of calyx and corolla, number of sepals and petals (tri, tetra, penta-merous), number of stamens. Cut LS of the flower, place it on a slide and observe under the dissecting microscope to study:

- Position (attachment) of stamens – opposite/alternate to petals; free or epipetalous; extrorse/ introrse anthers (anther lobes in the bud face away from axis – extrorse; anther lobes in the bud face towards the main axis – introrse).
- Number of carpels (mono, bi, tri- carpellary); Position of the ovary (epigynous, perigynous, hypogynous).

Mount a stamen on a slide and study the attachment of filament to anther (basifixed, dorsifixed, versatile, adnate), dehiscence pattern of anther (porous, longitudinal), number of anther lobes (monothecous, dithecous). Mount the pistil and study the ovary, style and stigma. Also cut a TS of the ovary to study the number of locules and placentation. Write the floral formula and

draw the floral diagram of each specimen based on the description. Identify features of the different parts of flower on the basis of descriptions given in Table 11.1.

Observations

Compare the characters with those given in the table and identify the family to which the plant belongs to.

Note: For ready reference some plants are described for each family. The students are required to study the plants other than one described here-under.

Questions

1. Draw the floral diagram and write the floral formula from the below given description of a flower-

   Bisexual, actinomorphic, hypogynous, sepals 5, gamosepalous, petals 5, free, imbricate aestivation, stamens 6, arranged in 2 whorls, ovary superior, trilocular, axile placentation.
2. In which type of placentation would the ovary be always unilocular?
3. If a flower is epigynous what is the position of floral parts?
4. What in the fruit is equivalent to the ovule of the ovary?

Table 11.1 Description of parts of flowers: Calyx/Corolla

Aestivation	**Arrangement of sepals and petals with respect to one another**
Aestivation (Fig 11.1 a–e)	**(i) Valvate:** The sepals/petals close to each other without overlapping or may be in contact with each other. **(ii) Twisted:** Overlapping is regular, i.e., one margin of the sepal/petal overlap the next member and the other margin is overlapped by the previous. **(iii) Imbricate:** Out of five sepals/petals one is completely internal being overlapped on both margins and one is completely external with the rest of the members arranged as in twisted aestivation. **(iv) Quincuncial:** Out of five sepals/petals two are completely internal, two external and one has one margin external and the other margin internal. **(v) Vexillary:** Out of five sepals/petals the posterior one is the largest and external almost completely covering two lateral members which in turn overlap the two small anterior sepals/petals
Number of stamens	**The number of stamens may vary from a few to many in different flowers**
Cohesion (Fig. 11.2 a-e)	Stamens may be free or united. If united they can be of the following type: **(i)** ***Syngenesious:*** Filaments free and anthers united, e.g., Sunflower. **(ii)** ***Synandrous:*** Stamens fused all through their length. e.g., *Cucurbita.* **(iii)** ***Adelphous:*** Anthers remain free and filaments are united. Adelphous condition can be:- (a) Monoadelphous - United to form 1 bundle. e.g., China rose. (b) Diadelphous - United to form 2 bundles. e.g., Pea. (c) Polyadelphous- United into more than two bundles. e.g., Lemon.
Adhesion (Fig. 11.3)	Fusion of stamens with other parts of the flower. **(i)** ***Epipetalous:*** Stamens fused with petals e.g., Sunflower, Datura. **(ii)** ***Epiphyllous:*** Stamens fused with perianth e.g., Lily.
Attachment of filament to anther (Fig. 11.4 a-d)	**(i)** ***Basifixed:*** Filament attached to the base of anther. e.g., Mustard. **(ii)** ***Adnate:*** Filament attached along the whole length of anther. e.g., *Michelia, Magnolia.*

	(iii) ***Dorsifixed:*** Filament attached to the back of anther, e.g., Passion flower. **(iv)** ***Versatile:*** Anther lobes attached with filament in the middle portion with both ends free. e.g., Gramineae family.
Lobes of anther (Fig. 11.5 a,b)	**(i)** ***Monothecous:*** Anther single lobed. **(ii)** ***Dithecous:*** Anther bi-lobed.
Dehiscence pattern (Fig. 11.6 a,b)	**(i)** ***Porous:*** Pollens released through pores, e.g., brinjal, potato. **(ii)** ***Longitudinal:*** Pollens released through the longitudinal slit of anther lobes, e.g., China rose, cotton.

Gynoecium

Position of ovary (Fig. 11.7 a-d)	**(i)** ***Epigynous:*** Position of ovary inferior to other floral parts. e.g., mustard, China rose. **(ii)** ***Perigynous:*** Other floral parts (organs) are attached around the ovary. e.g., apple, guava. **(iii)** ***Hypogynous:*** Position of ovary superior to other floral parts e.g., sunflower.
Cohesion (Fig. 11.8 a-c)	If number of carpels is more than one, they may be **(i)** ***Apocarpous:*** Carpels are free. Each carpel has its own style and stigma. e.g., rose. **(ii)** ***Syncarpous:*** Carpels are united, e.g., lady finger, tomato.
Number of locules in ovary	Vary from one to many **(i)** ***Unilocular:*** One locule, e.g., rose, pea. **(ii)** ***Bilocular:*** Two locules. e.g., datura. **(iii)** ***Multilocular:*** Many locules, e.g., lady's finger, China rose.
Placentation (Fig. 11.9 a-e)	**(i)** ***Marginal:*** The placenta forms a ridge along the ventral suture of the ovary and the ovules are borne on this ridge e.g., pea. **(ii)** ***Axile:*** The ovary is partitioned into several chambers or locules and the placentae are borne along the septa of the ovary. e.g., tomato, China rose. **(iii)** ***Parietal:*** The ovules develop on the inner wall of the ovary or on peripheral part. Ovary unilocular but in some cases becomes two chambered due to formation of a false septum. e.g., mustard. **(iv)** ***Free central:*** Ovules are borne on the central axis and septa are absent. e.g., carnation, chilly. **(v)** ***Basal:*** Placenta develops at the base of the ovary. e.g., sunflower.

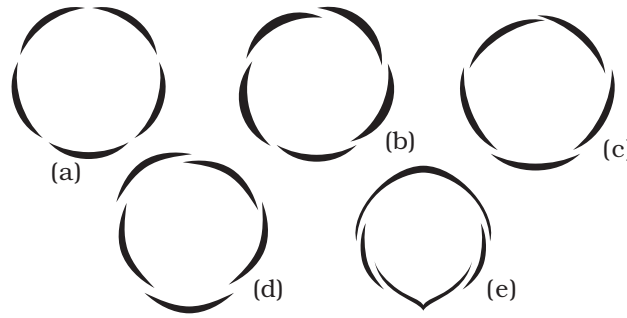


Fig. 11.1 Aestivation (a) Valvate (b) Twisted (c) Imbricate (d) Quincuncial (e) Vexillary

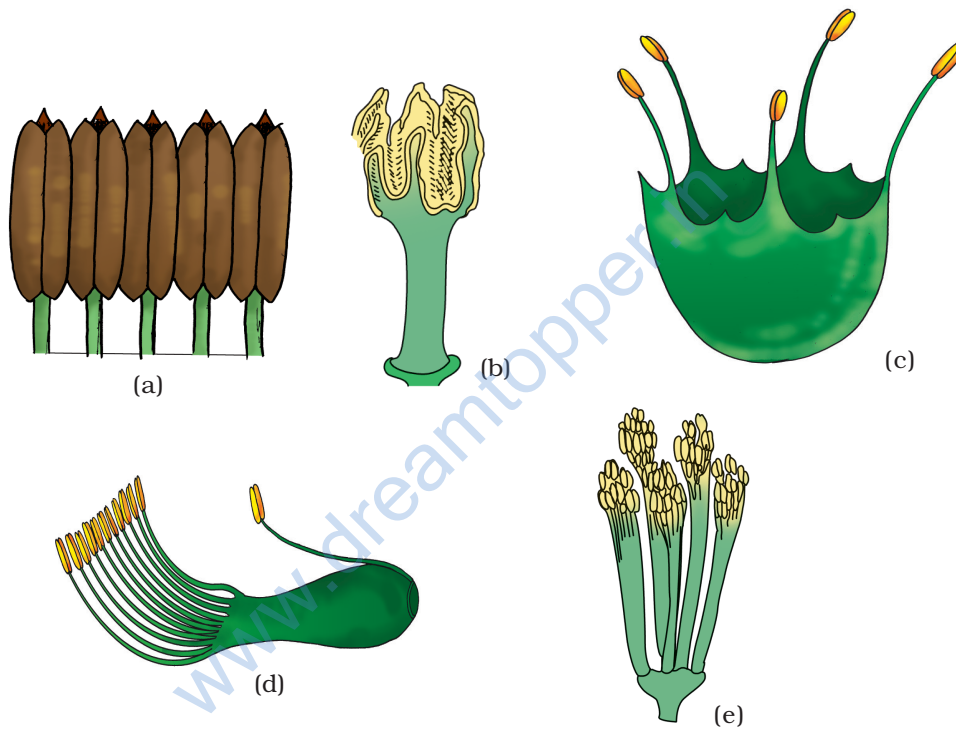


Fig. 11.2 Cohesion of stamens (a) Syngenesious (b) Synandrous (c) Monoadelphous (d) diadelphous (e) Polyadelphous

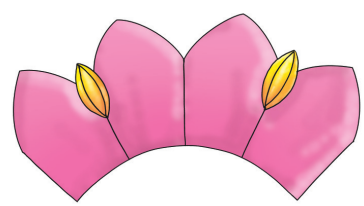


Fig. 11.3 Adhesion of Stamens-Epipetalous/Epiphyllous

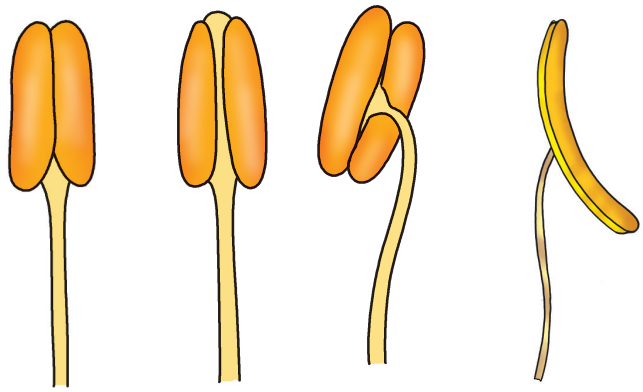


Fig. 11.4 Attachment of filament to anther (a) Basifixed (b) Adnate (c) Dorsifixed (d) Versatile

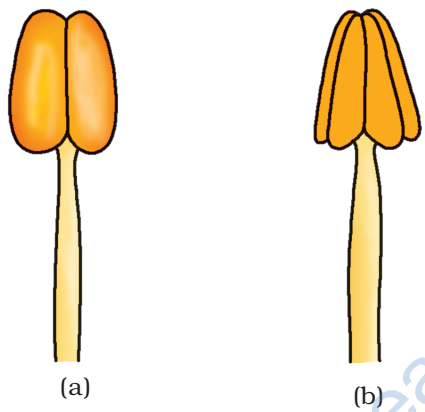


Fig. 11.5 Anther lobes (a) Dithecous (b) Monothecous

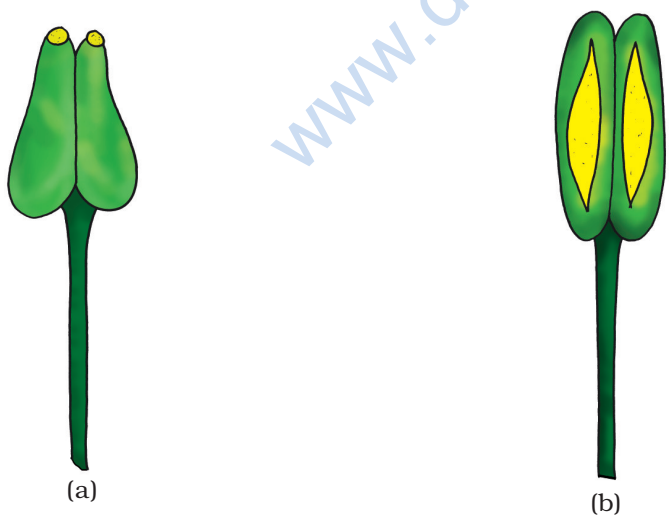
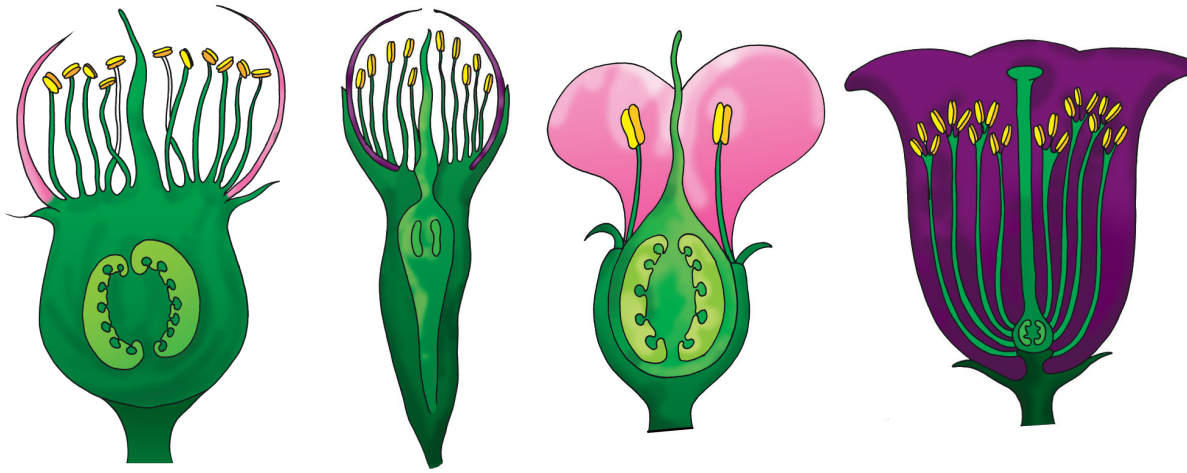


Fig. 11.6 Dehiscence pattern of anther (a) Porous (b) Longitudinal



(a) (b) (c) (d)

Fig. 11.7 Position of ovary (a) Epigynous (b-c) Perigynous (d) Hypogynous

(a) (b) (c)

Fig. 11.8 Cohesion of carpels (a) Apocarpous (b-c) Syncarpous

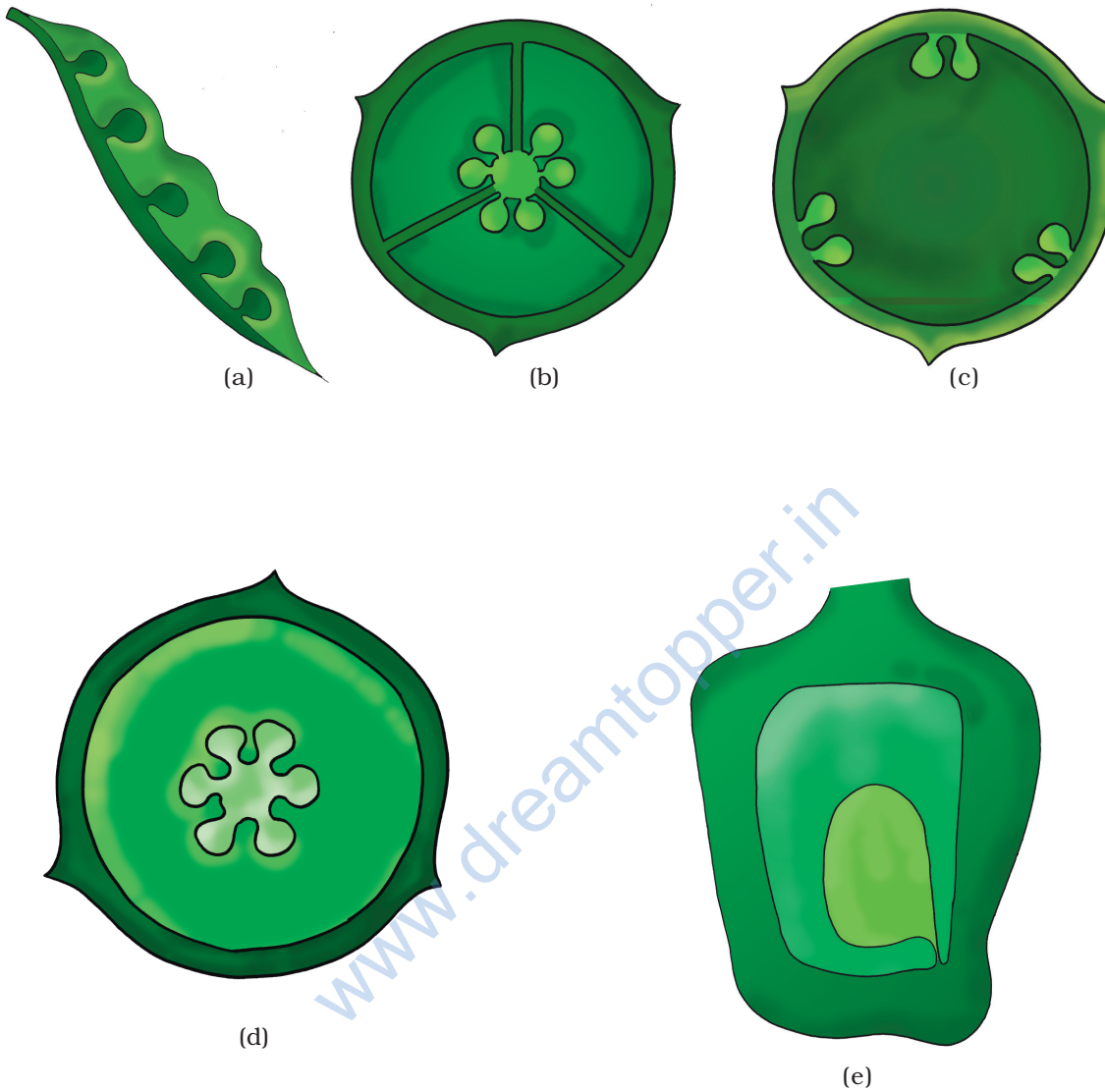


Fig. 11.9 Placentation (a) Marginal (b) Axile (c) Parietal (d) Free central (e) Basal

Annexure 1

Characteristics	*Solanum nigrum*(Makoi, Black night shade)	*Petunia alba*	*Lathyrus* sp.	*Pisum sativum*	*Asphodelus tenuifolius*
Habit	Herbaceous annual	Herbaceous annual	Herbaceous annual, climber	Herbaceous annual, climber	Herbaceous annual
Root	Tap root	Tap root	Taproot, the lateral roots may have nodules which contain nitrogen fixing *Rhizobium* bacteria	Taproot, the lateral roots may have nodules which contain nitrogen fixing *Rhizobium* bacteria	Fibrous root
Stem	Erect, herbaceous, branched, solid, cylindrical, green	Erect, herbaceous, branched, solid, cylindrical, green	Weak, cylindrical, branched, herbaceous, aerial, climbing with help of leaf tendrils, green	Weak, cylindrical, branched, herbaceous, aerial climbing with help of leaf tendrils, green	Very small but scape formed in reproductive phase
Leaf	Ex-stipulate, petiolate or sessile, simple, alternate, reticulate venation	Ex-stipulate, sessile, simple, alternate in the basal parts and opposite decussate in upper parts, reticulate venation	Stipulate (stipules foliaceous and in pairs), modified into a tendril, simple, alternate, reticulate venation	Stipulate (stipules large, ovate, foliaceous), petiolate, imparipinnately compound, (leaf lets 4 or 6) the common rachis ends in a branched tendril, terminal leaflet is always a tendril; alternate leaflets with reticulate venation	Fistular, slender
Inflorescence	Cymose	Solitary	Racemose	Racemose	Racemose

Characteristics	*Solanum nigrum*(Makoi, Black night shade)	*Petunia alba*	*Lathyrus* sp.	*Pisum sativum*	*Asphodelus tenuifolius*
Flower	Ebracteate, ebracteolate, pedicellate, complete, actinomorphic, bisexual pentamerous, hypogynous	Bracteate, ebracteolate, pedicellate, complete, actinomorphic, bisexual, pentamerous, hypogynous	Bracteate, bracteolate, pedicellate, complete, zygomorphic, bisexual pentamerous, hypo-or perigynous, papilionaceous	Bracteate, bracteolate, pedicellate, complete, zygomorphic, bisexual pentamerous, hypo-or perigynous, papilionaceous	Bracteate, ebracteolate, pedicellate, actinomophic, bisexual, trimerous, hypogynous
Calyx	Sepals 5, persistant, gamosepalous, green, valvate aestivation	Sepals 5, persistant, gamosepalous, green, valvate aestivation	Sepals 5, gamosepalous, ascending imbricate aestivation, odd sepal anterior, green	Sepals 5, gamosepalous, ascending imbricate aestivation, valvate aestivation, odd sepal anterior, green	
Corolla	Petals 5, gamopetalous, white, valvate aestivation	Petals 5, gamopetalous, white/purple, valvate aestivation	Petals 5, polypetatous papilionaceous (The 5 petals are unequal and have a bilateral symmetry. The posterior or outer most largest petal is called **standard,** the lateral pair of petals which are clawed are called the **wings** and the two anterior petals are united to form the **keel** i.e., 1+2+2 arrangement), which encloses the stamens and the carpel descending imbricate (vexillary) aestivation	Petals 5, polypetatous papilionaceous (The 5 petals are unequal and have a bilateral symmetry. The **posterior** or outer most largest petal is called **standard**, the lateral pair of petals which are clawed are called the **wings** and the two anterior petals are united to form the **keel** which encloses the stamens and the carpel, i.e., 1+2+2 arrangement), descending imbricate (vexillary) aestivation	Perianth tepaloid, tepals 6 in two whorls of 3 each (3+3), free, valvate aestivation

Characteristics	*Solanum nigrum*(Makoi, Black night shade)	*Petunia alba*	*Lathyrus* Sp.	*Pisum sativum*	*Asphodelus tenuifolius*
Androecium	Stamens 5, epipetalous, alternate with corolla lobes, polyandrous, anthers dithecous, introrse, dehiscence by apical pores	Stamens 5, epipetalous, alternate with corolla lobes, filaments unequal, polyandrous, anthers basifixed, dithecous, introrse, dehiscence by apical pore	Stamens 10 arranged in a single whorl, diadelphous, (9+1 arrangement, 9 unite at the base and form a tube around the ovary and the 10th posterior stamen is free) anthers basifixed, dithecous, introrse, longitudinal dehiscence	Stamens 10 arranged in a single whorl, diadelphous, (9+1 arrangement, 9 unite at the base and form a tube around the ovary and the 10th posterior stamen is free) anthers basifixed, dithecous, introrse, longitudinal dehiscence	Stamens 6 in 2 alternate whorls of 3 each, epiphyllous opposite to tepals, basifixed, dithecous. introrse, dehiscence by longitudinal slits
Gynoecium	Bicarpellary syncarpous, ovary superior, bilocular, ovary obliquely placed in the flower, ovules many per locule, axile placentation, placenta swollen,	Bicarpellary syncarpous, ovary superior, bilocular, ovary obliquely placed in the flower, ovules many per locule, obliquely transverse septum, axile placentation, placenta swollen,	Monocarpellary, ovary superior, unilocular, ovules many, placentation marginal,	Monocarpellary, ovary superior, unilocular, ovules many, placentation marginal	Tricarpellary syncarpous, ovary superior trilocular, two ovules in each locule, axile placentation,
Fruit	Berry	Capsule	Legume	Legume	Berry
Floral formula	Ebr, Ebrl, ♂,Å, $K_{(5)}\ \overset{\frown}{C_5}\ A_5\ G_{\underline{(2)}}$	Ebr, Ebrl, ♂,Å , $K_{(5)}\ \overset{\frown}{C_5}\ A_5\ G_{\underline{(2)}}$	Br, brl, ♂, %, $K_5\ C_{1+2+2}\ A_{(9)+1}\ G_{\underline{1}}$	Br, brl, ♂, %, $K_5\ C_{1+2+2}\ A_{(9)+1}\ G_{\underline{1}}$	Br, Ebrl, ♂,Å, $\overset{\frown}{P_{(3+3)}}\ A_{3+3}\ G_{\underline{(3)}}$

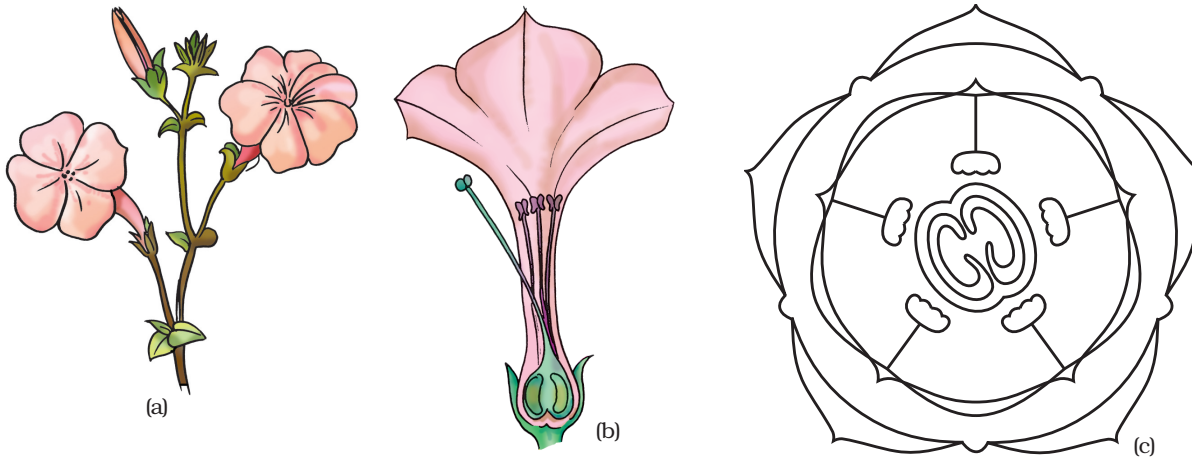


Fig. 11.10 *Petunia* (a) A twig (b) LS of flower (c) Floral diagram

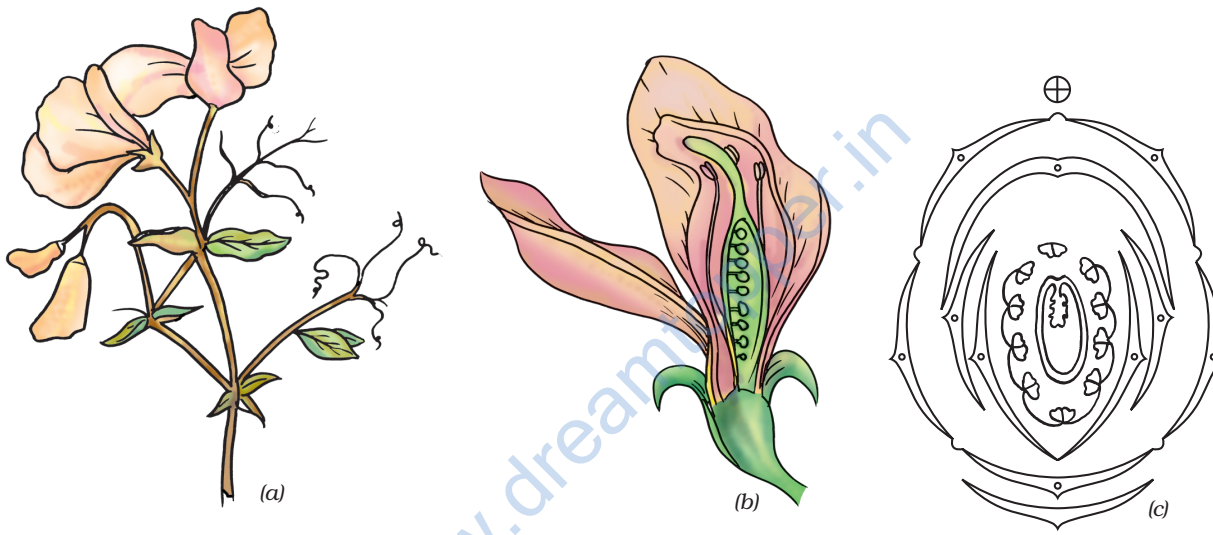


Fig. 11.11 *Lathyrus* (a) A twig (b) LS of flower (c) Floral diagram

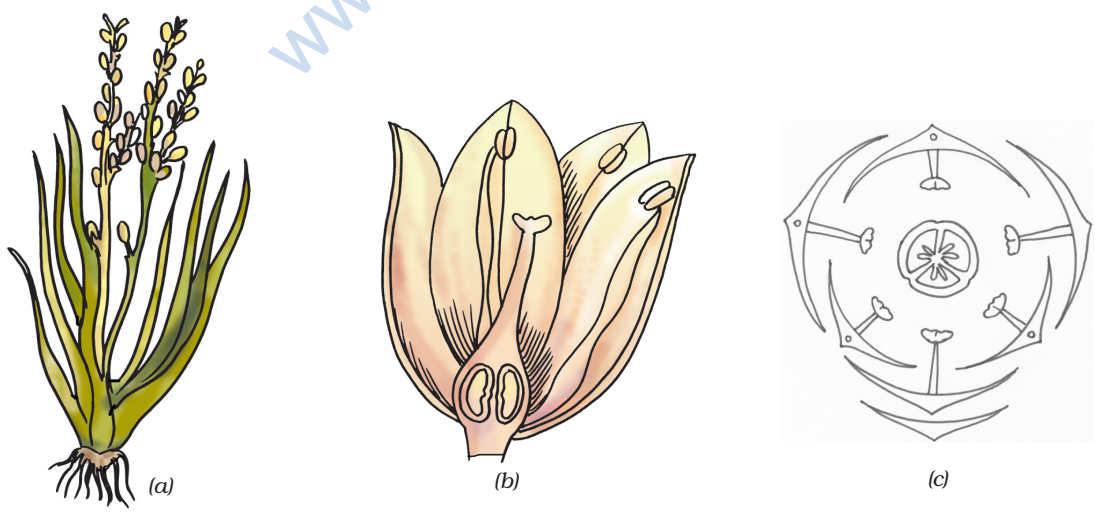


Fig. 11.12 *Asphodelus* (a) A twig (b) LS of flower (c) Floral diagram

Other Examples

Family : Solanaceae	Family : Fabaceae	Family : Liliaceae
Physalis *Solanum xanthocarpum* *Solanum melongena* *Solanum tuberosum* *Nicotiana tabacum* *Hyocyamus* *Atropa belladonna* *Withania somnifera* *Cestrum nocturnum* *Datura*	*Phaseolus moong* (Urad) *P. vulgaris* (Kidney bean, French bean) *P. aureus* (Moong) *Trigonella* (Fenugreek) *Cajanus cajan* (Arhar, pigeon pea) *Dolichos lablab* (Sem, Hyacinth bean) *Cicer arietinum* (chana, gram, chickpea *Indigofera* (Indigo) *Abrus* (Ratti) *Arachis hypogea* (groundnut) *Medicago sativa* (Alfalfa)	*Allium cepa* (onion) *Gloriosa superba* *Aloe barbendesis* *Heterosmilax* *Asparagus officinale* *Yucca gloriosa* *Lilium candidum* *Smilax spp*

Identification and systematic Position- Family : Solanaceae

1.	Leaves reticulate venation, flowers tetra or pentamerous, tap root system.	**Dicotyledons**
2.	Petals fused,	**Gamopetalae**
3.	Ovary superior, carpels usually two, stamens alternate with the corolla lobes, number of stamens equal or fewer to the number of corolla lobes.	**Bicarpellatae**
4.	Herbs or twiners, leaves alternate, flowers actinomorphic, stamens epipetalous, ovary superior two carpels, bilocular, axile placentation, ovules few or many in each carpel.	**Polemoniales**
5.	Herbs and shrubs, leaves simple, alternate, gamosepalous, stamens 5, epipetalous, ovary superior, bicarpellary syncarpous, bilocular, sometimes four locules due to false septum, many ovules in each locule, swollen placenta, ovary obliquely placed in the flower, axile placentation, fruit a berry or a capsule.	**Solanaceae**

Identification and systematic Position - Family : Fabaceae

1.	Leaves with reticulate venation, flowers tetra or pentamerous, tap root system.	**Dicotyledons**
2.	Petals free or not united.	**Polypetalae**
3.	Flowers hypo or perigynous; regular or irregular (vexillary).	**Calyciflorae**
4.	Flowers zygomorphic and *papilionaceous*, descending imbricate aestivation of corolla, 1 standard, 2 wings and 2 keels; stamens10, mono or diadelphous (9+1) ovary superior, marginal placentation, ovules many.	**Fabaceae**

Identification and systematic Position - Family : Liliaceae

1.	Leaves usually with parallel venation, flowers trimerous, fibrous root system, embryo with one cotyledon	**Monocotyledonous**
2.	Ovary superior, trilocular, 6 tepals in 2 whorls of 3+3, petaloid	**Coronariae**
3.	Perianth petaloid, 6 tepals free or connate below. stamens 6 in two whorls of 3+3, opposite to tepals, epiphyllous, ovary tricarpellary, syncarpous, trilocular, 2 or more ovules per locule fruit 3 celled berry or capsule.	**Liliaceae**

Exercise 12

Aim: To study anatomy of stem and root of monocots and dicots.

Principle: The study of internal morphology, i.e., cells of various tissues in an organ of a living body is called Anatomy. Tissue, which is a group of cells performing a common function, may be simple (parenchyma, collenchyma and sclerenchyma) or complex containing more than one type of cells (xylem and phloem). The tissues may be temporary (meristematic) or permanent (sclerenchyma, parenchyma, collenchyma).

The internal organisation of these tissues differ in root, stem and leaves. These differences are given in tabular form for easy identification. Various tissues which constitutes roots and stems are described briefly.

Requirement: Samples of stem and root of sunflower, *Cucurbita*, maize, *Canna*, etc., or any other locally available plant, safranin stain, dilute acid water, glycerine, watch glass, slide, cover slip, brush, razor/scalpel blade, blotting paper, microscope.

Procedure

- Collect a few thin green branches of recent growth (i.e., non-woody/herbaceous without any secondary growth) from the examples given above, preferably of the thickness of a tooth-pick.
- Use pith of potato piece/*Calotropis* stem/raw papaya fruits for embedding the material to be sectioned. It is advisable to first stain roots before sectioning. If material is thick like that of maize, it can be directly sectioned without embedding them in pith.
- Hold the material between the thumb and index finger in such a way that the tips of the finger and smooth cut surface of the material are in a line, while the tip of the thumb is just a few mm below the upper surface of the material.
- Wet the surfaces of razor blade/scalpel blade.
- Carefully move the blade horizontally over the surface of material in quick succession in a manner that a very thin and complete slice of the material is cut and obtained over the surface of razor blade.
- After cutting several sections in this manner, transfer all these into a watch glass containing water.

- Make a visual observation of the sections cut and pick the thinnest possible and complete sections from the lot and transfer it into a watch glass containing safranin and allow these to remain there for about 2 mins.
- With the help of a brush gently transfer the section into another watch glass containing water to remove excess of safranin stain. Keep the material for few minutes and transfer it into a watch glass containing a few drops of dilute acid in water to remove excess of safranin stain. Wash with water and transfer the section on to a clean slide containing 1 drop of glycerine. Place a cover slip over it avoiding air bubbles.

Observation

Note all tissues which are lignified (as in sclerenchyma, collenchyma) are stained red with safranin. Observe the outline of the cut sections. Make a note of the presence and composition of various tissues (epidermis, cortex, endodermis, pericycle, vascular bundle) and characteristics of vascular bundle. List the differences between root and stem of monocots and dicots. Use the information given in Annexure 3 for identification.

Anatomically root differs from stem by the following points:

S.No.	Root	Stem
1.	Cuticle absent	Cuticle present
2.	Epidermis does not have stomata	Epidermis contains stomata
3.	Unicellular root hairs present	Epidermal hairs are usually multicellular
4.	Collenchyma absent	Collenchyma present
5.	Green plastids absent (achlorophyllous)	Green plastids present (chloropyllous)
6.	Vascular bundles are radial in arrangement (xylem and phloem are on different radii)	Vascular bundles are conjoint and collateral in arrangement (xylem and phloem are on the same radius)
7.	Xylem development is centripetal and protoxylem is exarch, i.e., lies towards the periphery	Xylem development is centrifugal and protoxylem is endarch, i.e., lies towards the center

Annexure 3

Anatomy of the Root

The most distinguishing anatomical characters of the root are:

1. **Epidermis:** It is the outer most layer of thin walled parenchymatous cells with many unicellular root hairs. It does not have stomata and cuticle.
2. **Cortex:** It is multilayered and well developed. The cells are thin walled, parenchymatous and may contain leucoplasts. The intercellular spaces are well developed. Collenchyma is absent. The inner most layer of the cortex is called **endodermis**. The endodermis is a definite ring like layer consisting of barrel shaped cells compactly arranged without any intercellular spaces. **Casparian** thickenings in the form of strips are present on the radial and inner walls of the endodermal cells. Also, **passage cells** are present. The passage cells are thin walled and are usually located opposite the protoxylem.
3. **Pericycle:** The outer most layer of the **stele** (vascular tissue) is called pericycle. It is single layered and consists of compactly arranged thin walled parenchymatous cells with no intercellular spaces. The pericycle cells alternate with the endodermal cells suggesting that these two layers differ in their origin. The endodermis is derived from periblem initials of the apical meristem, whereas the pericycle is derived from the pleurome initials. Pericycle encloses the vascular system.
4. **Vascular system:** Bounded by the endodermal and pericycle layers, vascular system consists of xylem, phloem and the associated parenchyma tissue called conjunctive tissue.

   The vascular bundles are arranged in a ring. The bundles are radial and there are equal number of separate bundles of xylem and phloem. The number of xylem and phloem bundles varies from two to six (diarch, triarch, tetrarch, pentarch, and hexarch) in dicots and more than six, i.e., polyarch in monocots.

   The xylem consists of **protoxylem** which lies towards periphery and **metaxylem** which lies towards the centre or pith. This type of arrangement of xylem is called **exarch** (protoxylem is exarch in root and endarch in shoot). The protoxylem consists of annular and spiral vessels with narrow lumen (in cross section) and the metaxylem consists of reticulate and pitted vessels with broad lumen. (Recall the xylem maceration experiment)

   The phloem consists of sieve tubes, companion cells and phloem parenchyma.

   The parenchyma present in between the xylem and phloem bundles is known as **conjunctive** tissue.
5. **Pith:** It occupies the central area and may be large, small or even, absent. Generally in dicot roots the pith is small or absent. Total obliteration of pith occurs sometimes when metaxylem elements grow and meet in the centre. In monocot roots pith is large in size. Pith consists of parenchymatous cells with intercellular spaces.

Anatomy of the Shoot

The central ascending portion of the plant axis is called the shoot. It develops from the plumule of the embryo. The shoot bears lateral appendages called leaves.

The anatomical feature of stem are:

1. **Epidermis:** It is the outermost layer of cells, generally parenchymatous rectangular in shape. Multi-cellular **trichomes** or epidermal hairs, (no epidermal hairs in monocots) are generally present. The epidermis has an outer layer of cuticle made up of waxy material.
2. A multilayered **hypodermis** is present just below the epidermis. The hypodermis is generally collenchymatous in dicots and sclerenchymatous in monocots.
3. Cortex and pith are well defined in cases of dicots whereas in monocots only ground tissue is present. In dicots well defined endodermis and pericycle below the cortex are present. In monocots the endodermis is present around each vascular bundle. Distinction into cortex, pericycle, and pith is not seen. Vascular bundles are present in the ground tissue.
4. Each vascular bundle consists of xylem, phloem, cambium (absent in case of monocots) and associated parenchyma tissue. The vascular bundles are conjoint and collateral. They are open (i.e., cambium present between xylem and phloem) in dicot stems and thus show the secondary growth. Cambium is absent in monocot stems and therefore there is no secondary growth with a few exception.

   The vascular bundles are arranged in a ring in dicots whereas they are scattered in ground tissue in monocots. Each vascular bundle is surrounded by a sclerenchymatous bundle sheath.

   The vascular bundles are usually of equal size in dicots whereas in monocots they are of unequal size. In monocot stem the bundles near the periphery or closer to epidermis are smaller in size and the bundles nearer to the center are larger in size.
5. The protoxylem is endarch, i.e., towards the centre. The phloem consists of sieve tubes, companion cells and phloem parenchyma.

   In dicot stems, in between the xylem and phloem of the vascular bundle a procambium strip of 2-3 cells thickness (fascicular cambium) is present. The procambium between two adjacent vascular bundles is called interfascicular cambium. In young stems the cambial strips are confined only to the vascular bundles but as the stem becomes older, the interfascicular cambium develops and a continuous ring of cambium is formed. The secondary growth (formation of secondary phloem and secondary xylem) is due to the activity of cambium.
6. In dicot stem the central region of the stem is called pith (medulla). The pith consists of thin walled parenchymatous cell with intercellular spaces. The pith is well developed in dicot stem whereas in monocots it is absent.

From the anatomical point of view the monocot and dicot roots differ from each other in the following features (Fig. 12.1 and 12.2):

S. No.	Monocot Root	Dicot Root
1.	Polyarch condition	Diarch to hexarch (2-6 vascular bundles) condition
2.	Pith well developed	Pith is very small or absent
3.	Secondary growth absent	Secondary growth occurs due to the activity of vascular cambium

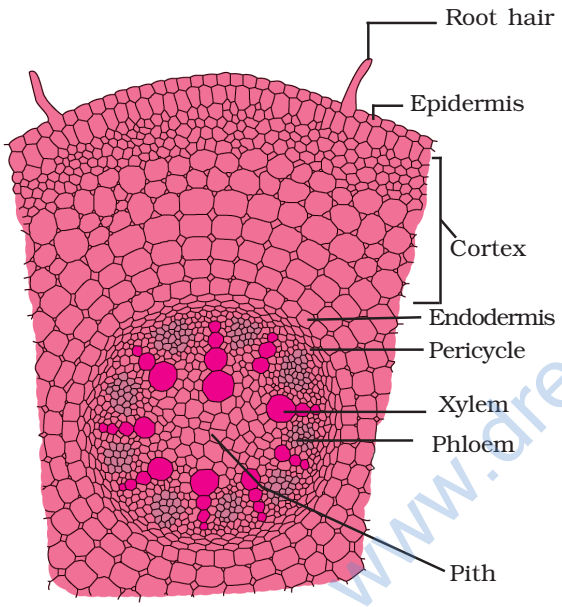


Fig. 12.1 TS of a monocot root

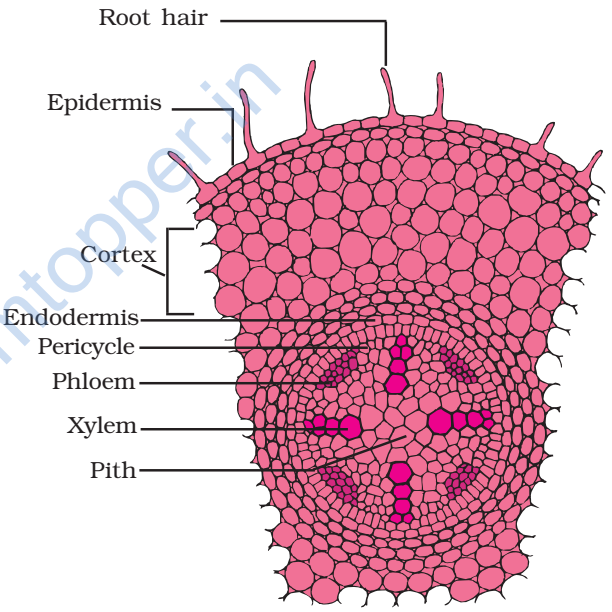


Fig. 12.2 TS of a Dicot root

A few examples of dicotyledonous and monocotyledonous roots which can be selected for anatomical study are given in the following table.

Dicotyledonous Roots	Monocotyledonous Roots
Phaseolus radiatus	*Canna*
Ranunculus	*Zea mays*
Cicer	*Smilax*
Ficus	*Allium cepa*

Anatomically, the dicot and monocot stems differ in the following features (Figs. 12.3 and 12.4):

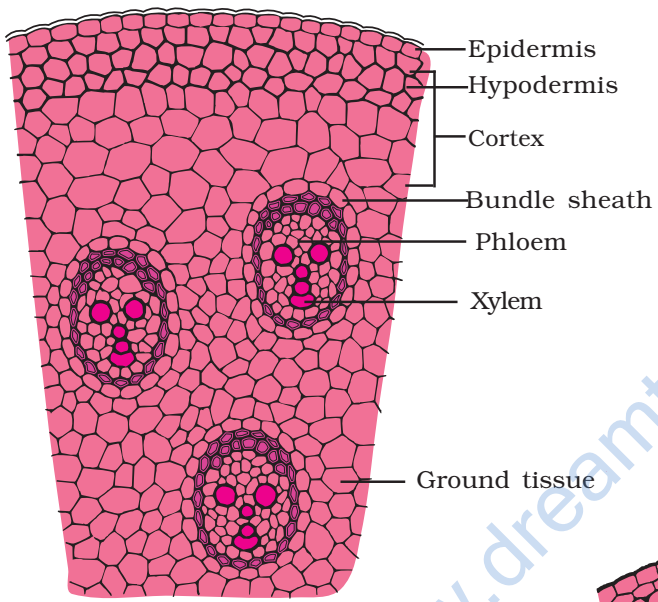


Fig. 12.3 TS of a monocot stem

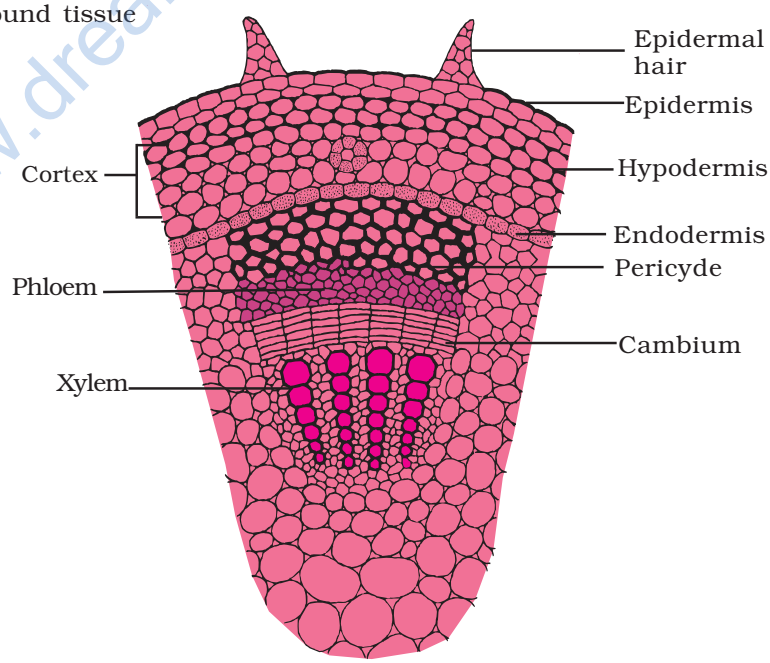


Fig. 12.4 TS of a dicot stem

S. No.	Monocot Stem	Dicot Stem
1.	Epidermis single layered and no epidermal hairs	Epidermis single layered and epidermal hairs are present
2.	Hypodermis sclerenchymatous	Hypodermis collenchymatous
3.	The vascular bundles are scattered in arrangement	The vascular bundles are arranged in a ring
4.	The vascular bundles at the periphery are smaller in size than those at the center	The vascular bundles are of the same size
5.	The vascular bundles are conjoint, collateral and closed; the sclerenchymatous bundle sheath is present; the vessels are arranged in V- or Y-shape; water cavity is present	The vascular bundles are conjoint, collateral and open; the bundle sheath is absent; the vessels are arranged in rows; water cavity is absent
6.	Only ground tissue is present	A well defined cortex, endodermis, pericycle and pith are present

A few typical dicotyledonous stems and monocotyledonous stems that can be selected for study of anatomical are given in the following table.

Dicotyledonous Stems	Monocotyledonous Stems
Helianthus (sunflower)	*Zea mays* (maize/corn)
Tinospora	*Canna*
Ricinus (castor)	*Asparagus*
Xanthium	*Cynodon dactylon* (*Doob* grass)

Questions

1. Arrange the following sequentially as you would see in a TS of a dicot stem-pericycle, epidermis, pith, cortex, xylem, phloem.
2. Where do you find radial, conjoint, collateral and open vascular bundles?
3. What type of xylem arrangement would be seen in TS root of lily plant?
4. Which part of dicot stem is meristematic?