

SOPs: BOTANY PRACTICAL EXERCISES OF UNDERGRADUATE STUDENTS

(DBT Life Sciences Star College Scheme, Ministry of Science & Technology, Govt. of India)



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SOP's
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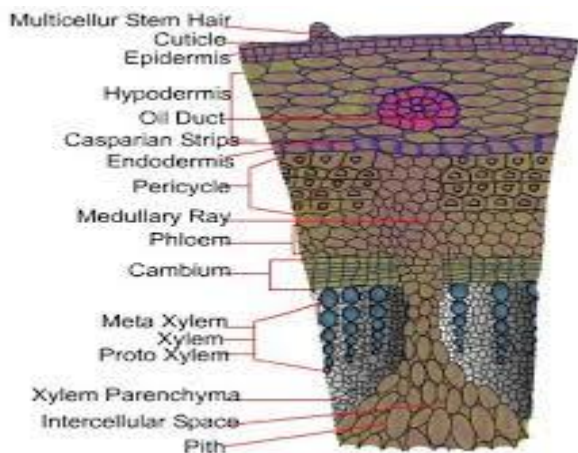
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PLANT ANATOMY

Normal growth of Dicot stem:



Epidermis: This is the outermost layer of the stem which is in direct contact with the external environment so its structural features are related to the functions it plays. It is usually uniseriate and consists of tangentially, flattened cells, made up of parenchymatous cells.

Cortex: The ground tissue that occurs between the epidermis and the vascular system is called the cortex. It is few to several layered thick zone of cells. It can be distinguished into two zones: (i) Hypodermis or outer zone, immediately below the epidermis occurs several layers of collenchymas cells. (ii) inner zone which lies in the inner cortex made of parenchyma cells with or without intercellular spaces.

Endodermis: This is the innermost layer of the cortex which is distinct & wavy in appearance and one cell in thickness. It consists of barrel

shaped, closely fitted cells without intercellular spaces. It consists of abundant starch grains as food reserve.

Pericycle: The zone between endodermis and the vascular cylinder constitutes the pericycle.

Vascular strand: the vascular strand encircles the pith and occurs as a well marked cylinder between the cortex and the pith.

In sunflower, the vascular strand is separated by interfascicular region into smaller and larger units called the vascular bundles. The vascular bundles are discrete, obtusely wedge shaped arranged in the form of a ring. This arrangement of vascular bundles around the pith is known as eustele. Each vascular bundle consists of two types of vascular tissues, the phloem towards the periphery and xylem towards the pith. Cambium occurs between tissues.

Medullary or Pith rays: The ground tissue between the adjacent vascular bundles is known as medullary ray or pith ray. The cells of medullary rays extend outwards from the pith and provide pathways of radial conduction of food and water at any level in the stem. They also transport gases from pith to cortex and vice versa.

Pith or Medulla: Central portion of ground tissue is extensively developed and lies inner to the vascular bundles. The cells of the pith near vascular bundles are comparatively small as compared to the central portion made of large cells.

Anomalous growth of stem of *Boerhaavia diffusa*

Epidermis: This is the boundary of the stem which is made up of single layer of compactly arranged cells with no intercellular spaces. The lateral and outer walls are thickened. Many epidermal cells bear multicellular hairs which are not the outgrowth of the epidermal cells.

Cortex: It is distinguished into two zones. Next to epidermis lies 3-4 layers of collenchymas cells. This layer is not of uniform thickness, as at places it is less developed and is represented by a single layer of cells. Few chloroplast may also be present in the cells of young stem. Next to collenchymas cells lie the zone of chlorenchyma cells. It is made up of 4-6 layers of cells. The cells in this zone are sometimes circular, oval or even polygonal and have abundant chloroplasts. Chlorenchyma cells are characteristics by the deposition of raphides or needle shaped crystals of calcium carbonate.

Endodermis: This is the innermost layer of the cortex which is distinct & made up of thick walled tubular cells without intercellular spaces.

Pericycle: Next to endodermis lies the zone of parenchymatous cells with small isolated patches of sclerenchymatous fibres.

Vascular strand: The vascular bundles are present in 3 rings. The outer most ring has 15-20 or more vascular bundles. The ring surrounds a middle of 6-14 vascular bundles. These bundles are smaller in size and oval or rounded in shape. In the innermost ring has 2 large vascular bundles which lie in the pith. These are called medullary bundles. Of all bundles, these are the largest in size and oval in shape. The central bundles are enveloped in thin sheath and lie opposite to each other with xylem facing towards centre and phloem facing outwards.

The vascular bundles are conjoint, collateral, endarch and open.

Anomalous growth of stem of *Mirabilis jalapa*

Epidermis: It is made up of single layer of compactly arranged cells with no intercellular spaces. The cells are thin walled covered with cuticle on the outer side.

Cortex: It is differentiated into two zones. Next to epidermis is present a zone of collenchymatous cortex. This occurs in the form of patches. It constitutes 2-4 layers of cells which are thickened at the corners. Next zone of the cortex is made up of chlorenchyma cells. It is made up of few layers of loosely arranged oval or spherical cells. The cells have abundant chloroplast content.

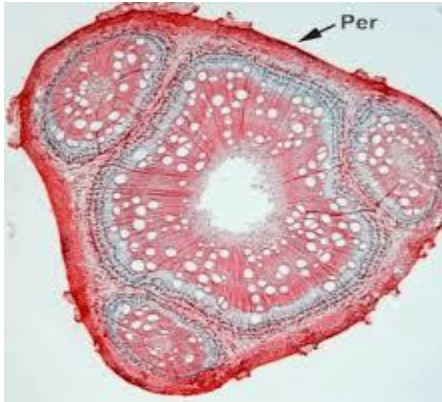
Endodermis: This is the innermost layer of the cortex which is rich in starch content.

Pericycle: Next to endodermis 1 or more layers of thin walled parenchymatous cells constitutes pericycle

Vascular system: Large no. of scattered vascular bundles are present in the pith. These are known as medullary bundles. Of these only 2 are large while others are smaller and scattered. In addition there is a normal ring of vascular bundles next to the pith. There are incomplete dwarf bundles in the outer ring. These contain only phloem.

The vascular bundles in the outer ring are conjoint, collateral, endarch and open. Medullary bundles are larger and developed earlier as compared to other bundles.

Anomalous growth of stem of *Nyctanthes arbortristis*



Epidermis: It is made up of single layer of compactly arranged cells covered by thick cuticle. Multicellular hairs arise from the epidermal cells.

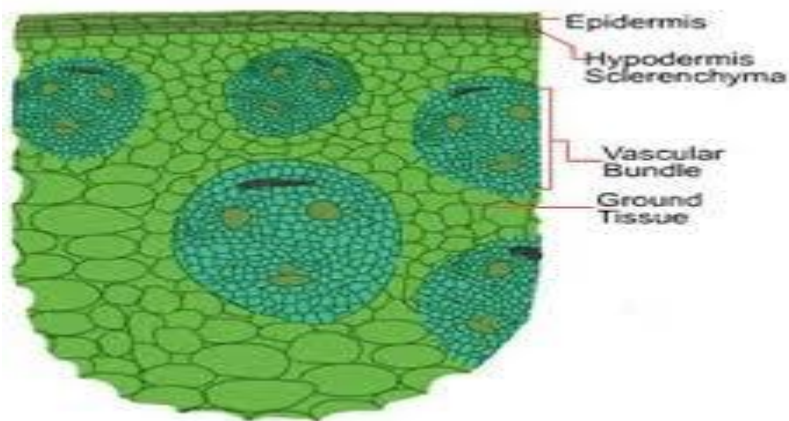
Cortex: It is made up of many layered zone with few collenchymatous layers towards the outside followed by oval or rounded cells constituting the inner zone of the cortex. The main function of cortex is storage.

Endodermis and Pericycle: Endodermis and pericycle are not much distinguishable.

Vascular system: Normal vascular bundles occur in a ring in the central region. These are conjoint, collateral, endarch and open. In addition to the normal ring of vascular bundles, there are 4 inversely oriented vascular bundles in the cortex, at the 4 ridges of the stem. The phloem of such bundles are directed towards the inner side and xylem towards the epidermis. These bundles show exarch condition. The cambium present in the cortical bundles adds a small amount of secondary vascular tissue in a normal manner. The cambium of the normal ring of vascular

bundles function in normal way and produce secondary phloem towards the outer side and secondary xylem towards the inner side. In the centre of the stem. There is a broad pith which is composed of thin walled cells.

Normal growth of Monocot stem:



Epidermis: This is the outermost boundary layer of the stem which is in direct contact with the external environment. It is made up of single layer of compactly arranged elongated and rectangular, barrel shaped, transparent parenchymatous cells.

Hypodermis: There are 2-3 layers of sclerenchymatous cells lying below the epidermis. Their walls are lignified. These cells provide rigidity and mechanical strength to the stem. It also acts as a heat screen.

Ground tissues: It is not differentiated into cortex, endodermis, pericycle & pith. It is a mass of parenchymatous cells lying next to the hypodermis. It is largely made up of thin walled, angular, compactly arranged cells without intercellular spaces towards the hypodermis but become larger and oval in the inner region, enclosing small intercellular

spaces. The outer cells of ground tissue may synthesize food due to the presence of chloroplast in stem.

Vascular strand: The vascular strand is made up of discrete vascular bundles showing a widely spaced and scattered arrangement in *Zeamays*. Each vascular bundle is oval, rounded or wedge shaped in outline, surrounded by a sheath of sclerenchymatous fibres. The vascular bundles are collateral, conjoint & closed. As there is no cambium, so no secondary growth takes place in monocot stem.

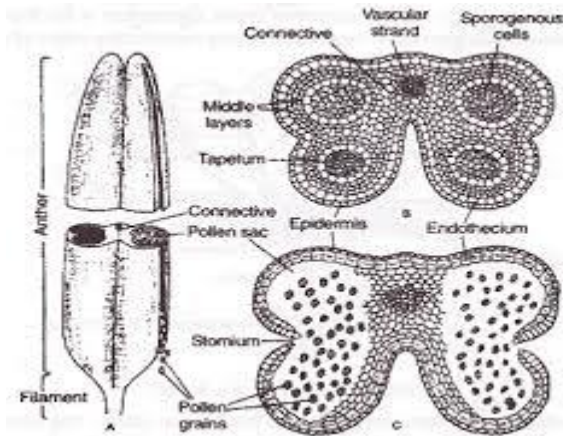
Xylem: It consists of both protoxylem and metaxylem vessels, tracheids and xylem parenchyma. The elements of the xylem are arranged in the form of letter 'Y'. The oval metaxylem elements are present on the divergent ends of 'Y'. The protoxylem positioned radially towards the lower arm of 'Y' which consists of few smaller vessels with annular and spiral thickenings. Hence xylem is endarch.

Phloem: It consists of sieve tubes and companion cells. Phloem parenchyma between the arms of the xys absent. The phloem is situated outer to the xylem. The sieve tubes conduct organic food.

In Maize, the phloem is distinguished into outer protophloem and inner metaphloem. The protophloem may be absent in smaller vascular bundles while metaphloem forms the functional part of the phloem in young as well as in mature vascular bundles.

PLANT EMBRYOLOGY

Structure of Anther



Epidermis: It is the outermost layer of the anther. The cells become stretched and shriveled off at maturity.

Endothecium: The microsporangial wall consists of an outer layer of larger cells are called endothecium. It is hygroscopic and helps in the dehiscence of pollen grains. In the shallow groove present between the two microsporangia of an anther lobe the hypodermal cells lying at the level of endothecium remain thin walled . This constitutes the stomium or line of dehiscence.

Tapetum: The innermost layer of the anther is called Tapetum. It is derived from the primary parietal cells. The tapetum is of 2 types:

1. Provide nourishment to the developing microspore mother cells and pollen grains.
2. Production of ubiquitin granules coated with sporopollenin for increasing the thickness of exine of pollen grains.

3. Secretion of pollenkit in case of entomophilous pollen grains.
4. Secretion of proteins for the exine of pollen grains to recognize compatibility.
5. Secretory tapetum secretes callase to dissolve callose.

Microspores or Pollen grains: The separated mother cells round off and undergo sporic meiosis to produce tetrads of haploid microspores or pollen grains.

Microsporogenesis:

It is the process of development of haploid microspores from diploid microspore mother cells in the microsporangium. The pollen sacs are developed in anther from a strip of archesporial cells.

Microgametogenesis:

Structure of Pollen grain:

Pollen grain is actually an immature and partially developed male gametophyte. Pollens are yellow due to flavanoids and carotenoids in their exine commonly globular in outline. Its protoplasm is rich in starch and unsaturated oils. The latter protect the chromosomes from radiation damage. It has 2 wall layers- outer exine and inner intine. Exine is made up of highly resistant fatty substance called sporopollenin, an oxidative polymer of carotenoids and carotenoid esters due to which pollens are well preserved for long time in fossils.

Development of Male gametophyte:

The pollen grain nucleus grows in size & shifts to one side near the wall. The protoplast divides to 2 unequal cells – small generative cell and large tube or vegetative cell. A callose layer develops around generative cell which separates the cell from pollen grain wall. Later on callose

dissolves & naked generative cell comes to lie freely in the cytoplasm of the tube cell. Nucleus of tube cell rich in proteins and RNA and generative nucleus rich in DNA, poorer in proteins and without RNA. The 2 male gametes develop from the generative cell and represents male gametophyte.

Megasporogenesis:

The process of development of haploid megaspores from diploid megaspore mother cell is called Megasporogenesis. Megaspore mother cell is diploid and undergoes sporic meiosis to form linear tetrads of 4 haploid megaspores. Normally the chalazal megaspore in the tetrad remain functional while remaining 3 degenerate. The functional megaspore is also called embryo sac cell.

Megagametogenesis:

The development of embryo sac or female gametophyte from functional haploid megaspore is called Megagametogenesis. Embryo sac is 7 celled and 8 nucleated.

Types of Ovules:

Depending upon the configuration & orientation of the body of the ovule in relation to the funiculus, 6 types of ovules are found in angiosperms.

1. **Orthotropous ovule:** This ovule is straight in position with funicle, micropyle and chalaza all in same straight line.
2. **Anatropous ovule:** In this ovule, the funicle is elongated and the body of the ovule is inverted at 180° so that micropyle & hilum come close to each other and chalaza lies to the opposite side.

3. **Hemitropous ovule:** The ovule is turned through 90° so that body of the ovule makes a right angle with the funicle. Micropyle & chalaza lies in a transverse line.
4. **Campylotropous ovule:** It is similar to Hemitropous in being placed at right angle to funicle but body of the ovule is curved so that hilum, chalaza and micropyle come nearby.
5. **Amphitropous ovule:** In this ovule, body of the ovule as well as embryo sac both get curved in semicyclic way and embryo sac and body of the ovule assume a horse shoe shaped.
6. **Circinotropous ovule:** The funicle is very large & coiled around ovule by more than 360° and micropyle faces upwardly.

Endosperm:

It is the food laden tissue formed by triple fusion of double fertilization.

Endosperm is of 3 types:

1. **Nuclear endosperm:** In this endosperm, nucleus divide repeatedly without wall formation. The multinucleate cytoplasm undergoes cleavage & give rise to multicellular tissue.
2. **Cellular endosperm:** In this endosperm, every division of the primary endosperm nucleus is followed by cytokinesis. Therefore endosperm is cellular.
3. **Helobial endosperm:** In this endosperm, the first division of the primary endosperm nucleus is followed by transverse cytokinesis to form 2 unequal cells – large micropylar and smaller chalazal.

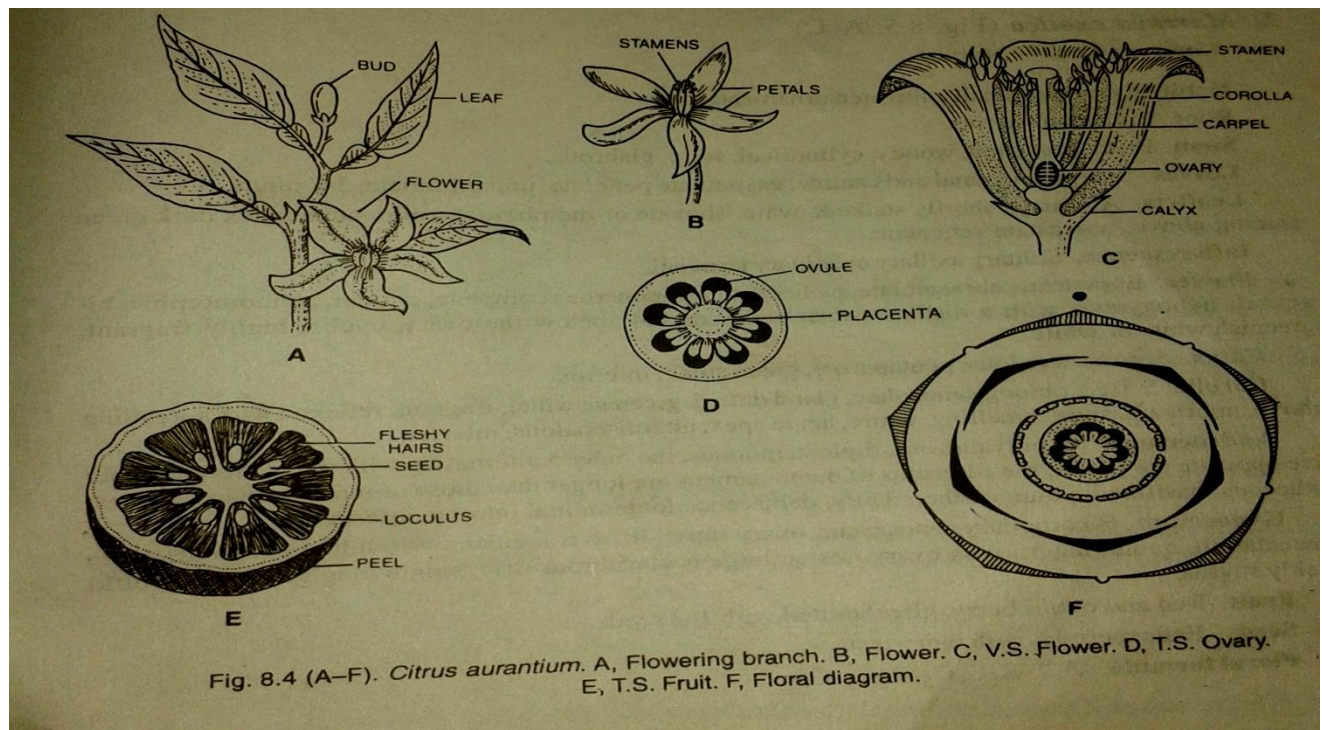
Further development in both the cells occurs like nuclear endosperm.

PLANT TAXONOMY

Citrus aurantium (orange)

Classification

Division	:	Spermatophyta
Sub division	:	Angiospermae
Class	:	Dicotyledonae
Sub class	:	Polypetalae
Series	:	Disciflorae
Order	:	Geraniales
Family	:	Rutaceae
Genus	:	<i>Citrus</i>
Species	:	<i>aurantium</i>



Citrus aurantium (orange)

Habit : A small tree cultivated in India for its edible fruits & medicinal properties.

Root : Branched tap root.

Stem: Aerial, erect, branched, solid, woody green, glabrous.

Leaves :Evergreen, cauline and ramal , alternate exstipulate, petiolate , winged petiole, compound unifoliate actually trifoliate but the two lateral leaflets fall off leaving a scar, terminal leaflet unicostate reticulate, gland dotted, glaucous. A spine is present in the axil of each leaf which is the modified first leaf of the suppressed axillary shoot.

Floral characters

Inflorescence : Solitary axillary or group of flowers in axillary position.

Flower: Ebracteate, ebracteolate, pedicellate, complete, regular, actinomorphic, bisexual, pentamerous, hypogynous, cyclic, white & scented.

Calyx: 5, gamosepalous, cup shaped, pentafid, green , gland dotted, reflexed, inferior.

Corolla: 5, polypetalous, petals lanceolate, sweet scented, gland dotted, white, imbricate; alternating with the sepals; inferior.

Androecium: Many in one whorl, polyadelphous filaments united into groups at the base. Bitheous, dorsifixed anthers, introse longitudinal dehiscence, yellow anther lobes, inferior.

Gynoecium : Polycarpellary syncarpous, superior , multilocular ovary with axile placentation , style short, stigma capitate, a large honey secreting disc present below the ovary. Ovules many in each loculus.

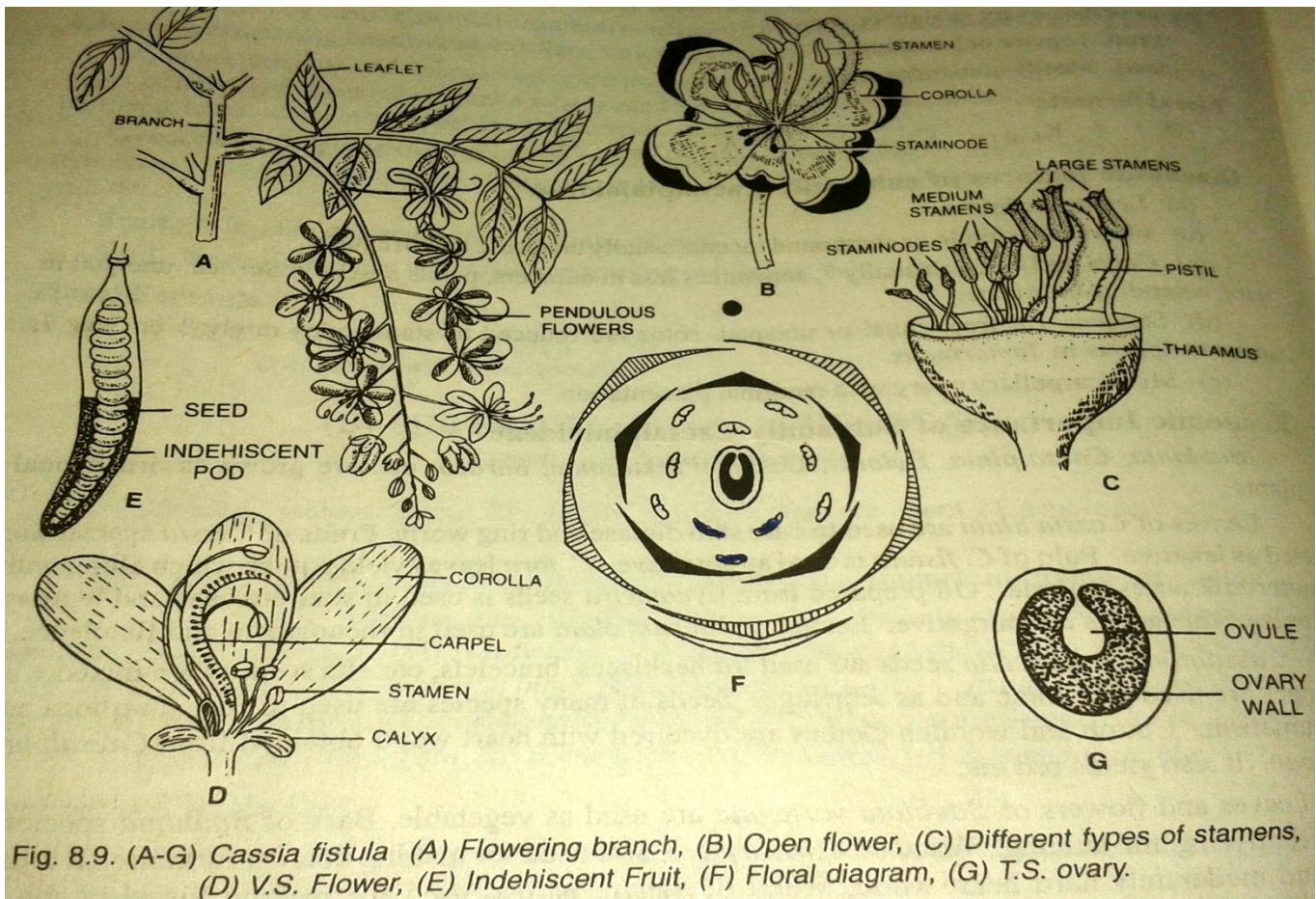
Fruit : A berry(Hesperidium).

Seed: Many endospermic, testa mucilaginous.

Cassia fistula (Amaltas)

Classification

Division	: Spermatophyta
Sub division	: Angiospermae
Class	: Dicotyledonae
Sub class	: Polypetalae
Series	: Calyciflorae
Order	: Rosales
Family	: Leguminosae
Sub family	: Caesalpinoideae
Genus	: <i>Cassia</i>
Species	: <i>fistula</i>



Cassia fistula (Amaltas)

Habit : Ornamental, cultivated tree with beautiful yellow pendulous racemes.

Root : Highly branched tap root.

Stem: Aerial, erect, solid, cylindrical, woody , branched.

Leaf : Ramal , stipulate, stipules small and caducous , alternate, petiolate, compound, paripinnate, 6-10 leaflets arranged opposite to each other.

Leaflets: Opposite, ovate, entire margin, acute apex, subsessile with pulvinus at the base, margin of leaflets slightly wavy, unicostate reticulate, glabrous, leathery when old, green.

Floral characters

Inflorescence : Long, pendulous raceme, panicle or compound.

Flower: Bracteate, pedicellate, ebrcteolate, irregular, zygomorphic, complete, bisexual, perigynous, pentamerous in outer 3 whorls, cyclic, yellow.

Calyx: 5, polysepalous, imbricate, odd sepal anterior, inferior, green or greenish yellow.

Corolla: 5, polypetalous, ascending imbricate, the posterior petal small and innermost in the bud, postero-lateral petals cover it, ovate, entire, distinctly veined, yellow, inferior.

Androecium: 10, polyandrous, unequal, anterior, **3 stamens are long and sickle shaped and fertile** bitheous anthers with longitudinal dehiscence. The **4 stamens are medium sized fertile** and bitheous but have dehiscence by apical pores, the **3 small posterior stamens are sterile and are called staminodes**, anthers basifixed, medium sized anthers sometimes bend after dehiscence.

Gynoecium : Monocarpellary, ovary superior, slightly stalked, curved, marginal placentation , short style, terminal and hairy stigma, ovules many.

Fruit : Cylindrical, indehiscent pod with one seeded transverse compartments.

Seed: Endospermic.

ECONOMIC BOTANY

Mustard

Botanical name : *Brassica campestris*

Vernacular name: Sarson

Family : Brassicaceae

Morphology :

1. The plant is small attaining a height of 2 feet.
2. Pods contain smooth and dark brown seeds.
3. Crude mustard oil is edible. Also used in lamps, oiling wooden goods, in the manufacture of soap and rubber substitutes.
4. It is known to be a good lubricant.
5. The seeds and oil are used in pickles and for flavouring curries and vegetables.
6. The oil cake is mostly used as a cattle feed.

Wheat

Botanical name : *Triticum aestivum*

Vernacular name: Gehun, Kanak

Family : Gramineae

Morphology :

1. The wheat plant is annual herb with height of 2-4 feet.
2. Inflorescence is terminal spike bears 15-20 spikelets.
3. Each individual spikelet contains 1-5 sessile & bracteates flowers.
4. The spikelets are arranged in zig-zag axis.
5. The mature grain has an outer husk, proteinaceous aleurone layer of embryo & starchy endosperm.
6. The grain is dry, one seeded, indehiscent fruit called caryopsis.

Cotton

Botanical name : *Gossypium hirsutum*

Vernacular name: Rui

Family : Malvaceae

Morphology :

1. The stem of the plant is monopodial with spirally arranged leaves and branches but no flowers.
2. Plant bears dimorphic branches- vegetative (monopodial) and fruiting (sympodial).
3. Leaves are large, palmately lobed & covered with multicellular hairs.
4. Flowers are large and showy.
5. The fruit (boll) is spherical or ovoid leathery capsule consisting of 3-5 locules.
6. The cotton fibres represent epidermal prolongation layer coated with cutin.