स्वाध्याय स्वमन्थन स्वावलम्बन

UTTAR PRADESH RAJARSHI TANDON OPEN UNIVERSITY

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UGBY-03
PLANT DIVERSITY LAB

BLOCK-2B
KEY & GLOSSARY

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UGBY -03
PLANT DIVERSITY LAB

Block

2B

KEY & GLOSSARY

BLOCK 2B KEY AND GLOSSARY

This resource-cum-reference block contains two main components – an 'Identification Key', and a 'Glossary of Taxonomic Terms'. The Identification Key is required particularly for the taxonomy-based exercises, # 22-24. Why we did not include it in Block-2A, you may wonder. There are two reasons for this: *one*, we felt it would be convenient for you to use the key that is either loose, or is in a separately bound block. Thus, the latter form was opted for, as you are required to refer to the key several times for the above-mentioned taxonomy exercises. *Two*, thinking in long term, we thought you could use this block for your reference after you have completed the course. It seemed natural to us that your botanical interests would continue and flourish much beyond this course.

'Glossary of Taxonomic Terms' is the other component forming the major portion of this block. It contains the basic terms that are generally required at this level of study. You are expected to have a clear understanding of these terms not only for the taxonomy-related portion, as the title of the Glossary indicates, but many of these terms are equally important for areas like morphology, anatomy, and economic botany. The Glossary includes both the general terms as well as organ/structure specific terms. To locate any unfamiliar term, first go to the structure of the Glossary , i.e., the index on the pages #11-12, and then look under the 'General Terms' on pages #13-18. These are given in alphabetical order. If your term pertains to a specific organ/structure, then the job becomes very simple. Look for it under the organ/structure concerned.

You can expand this Glossary by noting down the additional new terms, and making their illustrations in the box spaces provided for the purpose.

☺ Hope you will find your study very interesting and rewarding. Our best wishes are with you.

1. AN IDENTIFICATION KEY

Artificial key for the identification of some families of Angiosperms.

This key is based on the Bentham and Hooker's system of classification.

1. Leaves reticulately-veined; flowers 4- or 5-merous; bracteoles (when present) usually 2, lateral; tap root usually present; embryo with two cotyledons ....2. (Class Dicotyledons)

1. Leaves parallel-veined; flowers 3-merous; bracteoles (when present) usually 1, adaxial; tap root usually absent; embryo with one cotyledon ....3. (Class Monocotyledons)

Key to Sub-classes of Dicotyledons

2. Perianth of 2 whorls, usually distinguished into calyx and corolla .... 4.

   4. Inner whorl of perianth (corolla) parts mostly free up to the base (i.e., petals free); stamens not epipetalous ....5. (Sub-Class Polypetalae)

   4. Inner whorl of perianth (corolla) parts mostly united (i.e., petals fused); stamens few and mostly epipetalous ....6. (Sub-Class Gamopetalae)

2. Perianth absent, or of 1 whorl (calyx-like) or 2-whorled with the segments not distinguishable into calyx and corolla ....7. (Sub-Class Monochlamydeae)

Key to Series of Polypetalae

5. Perianth and stamens usually hypogynous; ovary mostly superior; sepals mostly distinct and free ....8.

   8. Conspicuous disc below the ovary not present .... 9. (Series Thalamiflorae)

   8. Distinct disc below ovary present .... (Series Disciflorae)

      Stamens twice as many as sepals; in one or two whorls; gynoecium of many carpels, axile placentation .... Order Geraniales

         Leaves generally smooth, gland-dotted and exstipulate; flowers actinomorphic, 4-, or 5-merous; stamens 3-10, free or united into bundles, in one or two whorls, Obdiplostemonous; gynoecium typically of 4-, 5- or numerous carpels.. *Family Rutaceae*

5. Perianth and stamens mostly perigynous or epigynous; ovary often inferior ....10. (Series Calyciflorae)

Key to Orders and Families of Series Thalamiflorae

9. Gynoecium composed of free carpels (i.e., gynoecium apocarpous); stamens usually indefinite; floral parts in whorls or spirals .... Order Ranales

Herbs or (rarely) climbers; leaves exstipulate; flowers bisexual, actinomorphic (sometimes zygomorphic), floral parts free, generally many and spirally arranged around a torus; placentation marginal or axile; fruit a cluster of achenes or follicles .... ***Family Ranunculaceae***

9. Gynoecium composed of united carpels (syncarpous); stamens usually of definite or indefinite number; floral parts in whorls.........................11.

11. Plants without mucilagenous sacs or cavities; stamens free; gynoecium 2-∞ carpelled; placentation parietal ....12. Order Parietales

12. Herbs with milky or watery latex; flowers actinomorphic or zygomorphic; sepals 2 or 3; petals 4-12; stamens mostly more than 6; fruit not a siliqua or silicula .... ***Family Papaveraceae***

12. Herbs without latex; flowers actinomorphic; sepals 4; petals 4; stamens 6 (rarely lesser) and tetradynamous; fruit a siliqua or silicula .... ***Family Brassicaceae (Cruciferae)***

11. Plants with mucilagenous sacs or cavities; stamens united by filaments; gynoecium many-carpelled; placentation axile ....Order Malvales

Flowers actinomorphic; whorl of bracteoles or epicalyx generally present; stamens indefinite and monadelphous; anthers are single-lobed ....: ***Family Malvaceae***

........*Cont.*
(*Key to Orders and Families of Calyciflorae*)

Key to Orders and Families of Series Calyciflorae

10. Gynoecium of 1 or more carpels; (carpels free in bud, afterwards enclosed within the swollen peduncle); ovary superior or semi-inferior, rarely inferior.. Order Rosales

Flowers actinomorphic or zygomorphic; stamens often united; gynoecium one-carpelled; ovary superior or semi-inferior; often stalked; fruit a legume ....13. ***Family (Fabaceae) Leguminosae***

13. Leaves bipinnate; spines present; flowers actinomorphic; 4- or 5- merous; corolla valvate; stamens 4 to indefinite, in one to many whorls ....***Sub-Family Mimosoideae***

13. Leaves uni- or bi-pinnate; spines generally absent; flowers zygomorphic; 5-merous; corolla imbricate; stamens generally of definite number (5-10) in one or two whorls ....14.

14. Corolla ascending imbricate; stamens usually free, some reduced to staminodes ....***Sub-Family Caesalpinioideae***

14. Corolla descending imbricate, papilionate; stamens usually mono- or di-adelphous, no staminodes........................ ....***Sub-Family Papilionoideae***

10. Gynoecium of many carpels, syncarpous; ovary semi-inferior to inferior... ....15.

15. Flowers bisexual or unisexual; ovary 1-loculed; placentation parietal; inflorescence not an umbel ....Order Passiflorales

Tendrillar herbaceous climbers; flowers unisexual; stamens free or united into 3 bundles or one synandrium; gynoecium of generally 3 (rarely 4 or 5) carpels; fruit a pepo .... ***Family Cucurbitaceae***

15. Flowers bisexual; ovary more than one-loculed; placentation not parietal; inflorescence a simple or compound umbel. .... Order Umbellales

Aromatic herbs; leaves alternate, often pinnately dissected; petioles with sheathing base; sepals reduced, bicarpellary, syncarpous gynoecium; pendulous ovule in each locule; placentation axile; stylopodium present .... ***Family (Apiaceae) Umbelliferae***

Key to Series of Gamopetalae

6. Stamens as many as corolla lobes (rarely fewer); Gynoecium 2-∞ carpelled; ovary inferior .... Series Inferae

Key to Order and Families of Series Inferae

Gynoecium of 2 carpels, ovary 1-loculed with one ovule and basal placentation .... Order Asterales

Herbs or shrubs, often with latex; inflorescence on involucrate head (capitulum); flowers bisexual or unisexual; actinomorphic or zygomorphic; calyx modified to pappus; anthers syngenesious; fruit a cypsella .... ***Family Asteraceae (Compositae)***

6. Stamens as many as or generally fewer than the corolla lobes; Gynoecium 2-∞ carpelled; ovary inferior, ...16. Series Bicarpellatae

Key to Orders and Families of Series Bicarpellatae

16. Latex mostly present; flowers actinomorphic; stamens as many as corolla lobes; gynoecium apo- or syn-carpous ....Order Gentianales

Herbs, shrubs or trees, leaves opposite; stamens with short filaments inserted at mouth of corolla tube and often surrounded by hairs, scales, etc. arising from corolla tube; nectar secreting disc present below ovary; ovaries free or united; stigma clavunculate .... ***Family Apocynaceae***

16. Latex absent; flowers zygomorphic; corolla often 2-lipped; gynoecium syncarpous; ovary falsely four-loculed with one ovule in each locule ....Order Lamiales

Herbs, sometimes shrubs; aromatic; stem quadrangular; inflorescence verticillaster; style gynobasic; one ovule in each false locule, fruit carcerulus, a cluster of 4 nutlets .... ***Family (Lamiacae) Labiatae***

Key to Series and Families of Monochlamydeae

7. Flowers unisexual or bisexual or polygamous; embryo curved; latex not present .... Series Curvembryeae

   Herbs or shrubs; leaves exstipulate, covered by hairs; inflorescence with scarious bracts or scales; perianth – membranous, dry, not green, gynoecium 2-3 carpelled, syncarpous; ovary one-loculed, 1 ovule, basal placentation .... ***Family Amaranthaceae***

7. Flowers unisexual; embryo not curved; latex usually present .... Series Unisexuales

   Herbs, shrubs or trees; leaves stipulate; inflorescence racemose or cymose or cyathium; flowers without perianth or without corolla or calyx; gynoecium 3-carpelled with 3-loculed ovary; 1-2 carunculate ovules in each locule, fruit a schizocarpic regma .... ***Family Euphorbiaceae***

........*Cont.*
(Key to Series of Monocotyledons)

Key to Series and Families of Monocotyledons

3. Flowers arranged in spikelets, highly reduced, sessile, in the axils of bracts; perianth absent or reduced to scales (lodicules); ovary superior, one-loculed with one ovule, with a basal placentation; fruit a caryopsis or nut or capsule .... Series Glumaceae

Stem terete or compressed, usually hollow; leaves often ligulate with sheathing leaf bases; each flower or floret enclosed by two glumes, and a bract lemma, and bracteole palea; 1-3 carpelled gynoecium; unilocular ovary with one ovule, basal placentation ....***Family (Poaceae) Gramineae***

3. Flowers not arranged in spikelets; perianth well developed; ovary 3 or more than 3-loculed; fruit not a caryopsis..17.

17. Ovary inferior ....18. Series Epigynae

18. Terminal racemose inflorescence, flowers asymmetrical most of the stamens petaloid, sterile and connate at base, adnate to petals and style; style flat and petaloid, fruit a warty capsule ....***Family Cannaceae***

18. Inflorescence umbellate cyme (rarely racemose) or solitary flower on a scape with spathaceous involucre of bracts; flowers symmetrical; most stamens fertile, epiphyllous; style cylindrical and filiform ....***Family Amaryllidaceae***

17. Ovary superior ....19. Series Coronarieae

19. Leaves basal or cauline; inflorescence racemose often on a scape; perianth homochlamydeous, usually petaloid; staminodes generally absent...***Family Liliaceae***

19. Leaves cauline with closed basal sheaths; inflorescence cymose, perianth heterochlamydeous, staminodes often present................ ....***Family Commelinaceae***

2. GLOSSARY OF TAXONOMIC TERMS

Structure **Page No.**

2.1 GENERAL TERMS

A- : a prefix meaning without, as in asepalous (without sepals)
Abaxial / Dorsal : side of an organ away from the axis or center of axis, lower surface
Abortive : defective, imperfectly developed
Acropetal : arising or developing upward in a longitudinal plane from a lower to a more apical position; the opposite of basipetal
Acyclic : arranged spirally, not whorled
Adaxial / Ventral : side towards the axis, or adjacent to axis, upper surface
Adherent : close proximity of dissimilar organs without fusion of tissues or histological continuity
Adnate : fusion, with histological continuity, of dissimilar organs
Aerial or epigeal : above ground or water, in air
Aestivation / Vernation : arrangement of leaves or perianth parts with respect to each other in a bud
Albumen : nutritive material accompanying the embryo (e.g., endosperm in seed)
Anthesis : flowering; opening of flower for pollination
Anthotaxis : arrangement of sporophylls
Apex (pl. apices) : the tip or distal end
Aphyllous : leafless
Apical / Terminal : at the top, tip, or distal end of a structure
Appendage : an attached, subsidiary or additional part.
Arborescent : tree-like in appearance and in size
Articulate : jointed; with nodes or joints
Attenuate : tapering gradually to a slender tip
Awn / Arista : a bristle-like appendage
Axil : upper angle area formed between the organ and the axis that bears it
Axillary : pertaining to or situated in the axil

Basal : at the bottom or base of a structure
Basicaulus : near the base of stem
Basipetal : developing downward in a longitudinal plane from an apical or distal point towards the base
Bi- : a prefix meaning two or twice, as in bilobed or two-lobed
Bifid : two-clefted or divided apically into two parts
Bifurcate : divided into two forks or branches
Biseriate : in two rows, series or whorls
Bladdery : thin-walled and inflated
Bloom : whitish easily rubbed off powdery covering on a surface
Bristle : short, stiff trichome or hair

Caducous: falling off early or prematurely
Calciform/calyculate : calyx-like
Canaliculate : with a longitudinal channel or groove
Cauline : belonging to main conspicuous stem
Cell : locule or cavity in an organ (this does not refer to the cell – the unit of life)
Centrifugal : developing or progressing from center to periphery
Centripetal : developing or progressing from periphery to center
Circinate : coiled from apex downwards
Coalesced : with like or unlike parts or organs incompletely separated; partially fused in more or less irregular fashion

Coherent : two similar organs in close proximity without fusion or histological continuity
Colpus : an elongated groove
Coma : leafy crown or head (of palms), a tuft of hair
Composite : compound, apparently simple or homogeneous organ or structure made up of several distinct parts
Compound : of two or more similar parts in one organ
Connate : union or fusion of similar structures with histological continuity
Corniculate : terminates in a small horn-like protuberance
Crown : corona; that part of the stem at the surface of ground
Cyclic : whorled

Deciduous : falling at the end of growth season
Definite : a number small enough to make easy an exact count, as opposed to indefinite or numerous
Dehiscence : process of opening or splitting, particularly of a fruit or anther
Deliquescent : to quickly become soft and semi-liquid
Determinate : growth of plant parts limited by cessation of meristematic activity during the year
Di- : a prefix meaning two, as in dicyclic or two-whorled
Dichotomous : forked or divided into two equal parts
Diffuse : spread over a large surface
Digitate : hand-like
Dimorphic : occurring in two different forms (sizes or shapes)
Dissected : irregularly divided into many slender segments
Distal : away from point of origin or attachment
Distichous : organs (leaves, leaflets, flowers) arranged in two opposite rows on a longitudinal axis
Distinct / Free : separate, not fused or closely appressed
Diurnal : opening only during light hours or day
Divided : separated to very near the base
Dorsal : back or abaxial side , pertaining to the surface most distant from the axis
Dorsiventral : flattened surface having distinct dorsal and ventral surfaces

E- or Ex- : a prefix denoting without, as ebracteate meaning without bract
Emergent : with part/s of plant aerial and part/s submerged; rising out of the water above the surface
Emersed : with parts extending above water
Enation : an epidermal outgrowth
Ephemeral : persisting for a short period
Epi- : prefix denoting on or upon, as in epiphytic (on another plant)
Eurypalynous / Multipalynous : a taxonomic group with more than one pollen type
Eusporangiate : type of sporangium which forms from more than one cell
Eustele : cylindrical arrangement of vascular bundles separated by parenchyma tissue
Evident : clearly visible macroscopically
Excrescence : outgrowth on surface
Excurrent : extend beyond the margin or tip;
Exfoliate : to peel off
Exserted : stick out, project beyond
Eye : center of a flower or a bud on tuber

Fasciated : unnaturally and often monstrously connate or adnate, the coalesced parts often unnaturally proliferated in size and number; much flattened; e. g., inflorescence of *Celosia* (cock's comb)
Fertile : with functionally viable gametes
Fertilization : fusion of male and female gametes to give rise to a zygote.
Fetid : having disagreeable smell
Filiform : slender thread-like
Floriferous : flower bearing
Foliaceous : leaf-like
Foliar : pertaining to leaves or leaf-like parts
Frond : large leaf, as that of palms and ferns.
Fruticose : shrubby
Fugacious : falling or withering away shortly after development
Furcate : forked
Furrowed : with longitudinal channels or grooves

Gametophyte : generation or body that produces gametes
Gamo- : a prefix meaning united
Germination : is a process of activation of dormant structure under favourable conditions, as of seed, pollen grain or spore; the process ends with emergence of activated part from the protective coat of the structure
Gland : a secreting body or appendage
Glomerate : in dense or compact clusters
Gregarious : growing in company

Habit : general appearance of plant, and the duration and mode of its life
Hemi- : prefix denoting half
Hetero- : prefix signifying various, as in heterostyly meaning occurrence of styles of different sizes, lengths, and shapes in different populations within a species
Homo- : prefix signifying alike or similar
Hook : a sharp, curved structure; may be modification of inflorescence axis, axillary bud, leaf or leaflet
Hygroscopic : capable of expanding or contracting with changes in humidity

Incised : cut sharply, irregularly and rather deeply
Included : present within, not protruding or exserted
Indefinite : a number large enough to make an exact count difficult
Indehiscent : not regularly opening as a pod or anther
Indeterminate : continual growth of plant parts, not limited by cessation of meristematic activity
Indument : having hairy or pubescent covering
Indurated : hardened, usually ontogenetically
Inflated : blown up
Inflorescence : mode of flower bearing or less correctly arrangement of flowers on the stem
Infra- : prefix signifying below, as in infrafoliar (below leaves)
Inserted : attached to, the point of origin
Intercalary : near the base of an internode or base of a blade
Inter- : a prefix meaning between, as in interfoliar (between leaves)
Interstitial : all over; no localized region

Jointed : with nodes; with points of real or apparent articulation
Jugum : a pair, as of leaflets

Keeled : ridged like the bottom of a boat

Lacerate : torn; irregularly cleft or cut
Laciniate : slashed into narrow pointed and parallel ribbon-like or strap-like projections
Lactiferous : producing or bearing latex
Lacuna : a cavity, hole, or gap
Lamellate : provided with many fin-like blades or cross-partitions
Lateral : on or at the side
Latex : milky sap
Lax : loose, not congested
Leptosporangiate : type of sporangium development where the sporangium forms from one initial cell
Lineate : lined, bearing thin parallel lines
Lobe : any part or segment of an organ
Locule / Loculus (pl. Locules / Loculi) : a compartment or cavity

Marcescent : withering but the remains persisting
Marginal : pertaining to the border or edge
Medial : upon or along the longitudinal axis
Megaspore : the spore which on germination gives rise to female gametophyte from which develops female gamete or the egg cell
Megasporophyll : a sporophyll that bears megasporangia, often produced in the axil of a bract; a carpel in an angiosperm
Meristem : undifferentiated tissue whose cells are capable of developing into various organs or tissues
-merous : a suffix indicating the number of parts in a whorl of stems, leaves or floral organs, as a tri-merous flower having perianth parts in sets of three
Microsporangium : sporangium containing only microspores
Microspore : the spore which on germination gives rise to male gametophyte from which differentiate the male gamete or sperm cell
Mono- : a prefix meaning one or once, as in monocyclic (one whorled)
Mucilage : sticky and slimy substance produced by glandular cells in plant tissues
Multi- : a prefix meaning several or many, as in multicellular (many-celled)

Nectary : a secretory gland producing sugary liquid that attracts pollinators
- Floral : present in the flower
- Extra-floral : present in organs of plant other than the flower, as in leaf, bract

Nodose : knobby; knotty

Ob- : a prefix usually signifying inversion, as in obovate (inverted ovate)
Oligo- : a prefix signifying few, as in oligospermous (few seeded)
Operculum : a lid or cover produced by circumscissile dehiscence
Ortho- : a prefix indicating straight
Ovuliferous : bearing ovules

Palmatifid : cut palmately
Palmatisect : sectioned or divided palmately into distinct segments
Pectinate : having closely parallel tooth-like projections; comb-like
Penta- : a prefix meaning five, as in pentacyclic (five-whorled)
Perennate : lasting the whole year through, self-renewing by lateral shoots from the base
Persistent : remaining attached; not falling off
Perulate : scale-bearing, as most buds
Phyllotaxis / Phyllotaxy : arrangement of leaves
Pinnatifid : cut pinnately
Pinnatisect : sectioned or divided pinnately into distinct segments
Placentation : the arrangement of ovules within the ovary
Poly- : a prefix meaning many, as in polycyclic (many-whorled)
Prefoliation : form and arrangement of young leaves and perianth parts in bud condition; comprises of ptyxis and aestivation/vernation
Prickle / Emergence : a sharp-pointed outgrowth of epidermal, or epidermal and sub-epidermal origin of any organ, lacks vascular supply
Proximal : near the point of origin or attachment
Pseud- / Pseudo- : A prefix meaning false, not genuine, not the true or the typical
Ptyxis : form of an individual part in a bud; the way a part is folded and rolled in the bud
Pulvinate : cushion shaped

Quadrifid : cut or divided into four lobes or parts

Radiate : spreading outwards from a common center.
Ramiform : branched
Rank : a vertical row; leaves that are 2-ranked are in two vertical rows, and may be alternate or opposite
Rostrate : having a beak or beak-like projection
Rudimentary : imperfectly developed and non-functional

Sac : a pouch or baggy cavity
Sapling : a young tree
Scale : a small, dry, scarious to coriaceous flattened structure
Scar : the mark left on stem or axis after detachment of organ
Seasonal : occurring during a seasonal cycle, or each season
Seedling : a young plant developed from a seed
Semataxis : arrangement of semaphylls (sepals, petals, tepals)
Septate : divided by internal partitions into locules or cells
Seriate : in series, usually in whorls or apparent whorls
Serrated : cut into saw-like teeth
Sigmoid : said of a structure that is curved sidewise in opposing directions; S-shaped
Sperm : a male gamete or reproductive cell
Spine : a small, stiff and pointed outgrowth lacking vascular supply, may be a modified stipule or leaf
Sporophyte : the organ or plant which can bear sporogenous tissue
Stenopalynous : a taxonomic group with only one pollen type
Sterile : lacking functional sex organs or gametes

Stoma / Stomate (pl. stomata / stomates) : an aperture or pore in epidermis bounded by two guard cells which provide regulated gas exchange between the tissue and atmosphere
Stomatal apparatus / Stomatal complex : stoma together with the subsidiary cells, if present
Sub- : a prefix signifying somewhat, slightly or rather as in sub-basal or near the base
Subtend : to stand below and close to, as a bract underneath a flower
Subterranean / Hypogeous : below the surface of the ground
Suppressed : vestigial to the degree of not being evident superficially or macroscopically, but whose presence in ancestral forms may be indicated by other features, such as anatomical
Surficial / Epigeous : upon or spread over the surface of ground

Tapering : gradually becoming smaller or diminishing in diameter or width toward one end
Tendril : slender twisting appendage, an organ for support
Terrestrial : of the ground
Tetra- : a suffix signifying number four or 4-times, as in tetracyclic (four-whorled)
Thallus : a flat leaf-like organ without differentiation into stem and foliage
Tri- : a suffix signifying number three or 3-times, as in trigonous (three-angled)
Trichome : a hair or bristle; surface appendage of diverse form, structure and function represented by hair, scale, and papilla, of epidermal or sub-epidermal origin
Tunic : a loose membranous outer skin other than epidermis; the loose membrane about a corm or bulb

Unarmed : without prickles or spines
Uni- : a prefix meaning one or single, as in uniseriate (one-rowed)

Venation : disposition or arrangement of veins
Ventral : adaxial; top or upper side of a surface, adjacent to axis
Verticil : a whorl
Vesicle : a small bladdery sac or cavity filled with air or fluid
Vesture / Vestiture : anything on or arising from a surface causing it to be other than glabrous
Vivipary : development of seedling on the parent plant; seed germinates inside fruit while still on the parent plant
Voluble : twining

Xylem : the wood elements of a vascular cylinder; a water conducting complex tissue of tracheary elements, parenchyma and fibers

Zygote : the first cell of new sporophytic generation that gives rise to the embryo

Additional terms

2.2 SHAPES (Plate – 1)

Acerose : needle-shaped; sharp
Angular : many angled
Annular : ring-like

Botuliform : sausage-shaped

Capitate : head-like
Clavate : club-shaped
Compressed / Complanate / Flattened : compressed on two sides, flat
Conical : cone-like
Cruciform / Cruciate : cross-shaped
Cylindrical / Terete : long-tubular with circular cross-section
Cymbiform / Navicular : boat-shaped

Discoid : orbicular with convex faces

Falcate / Seculate : sickle-shaped
Fistulose : hollow, as a culm without a pith
Fusiform : spindle-shaped; broadest in middle and tapering to each end

Globose : nearly spherical

Lenticular : biconvex, usually elongate and flat; lens-shaped
Ligulate : strap-shaped

Napiform : turnip-shaped
Nodiform / Nodulose : knotty or knobby, as the roots of most of the Fabaceae

Pyriform : pear-shaped

Spiral : twisted like a corkscrew
Stellate : star-shaped

Torose : cylindrical with contractions at intervals
Turbinate : top-shaped; obconic
Turgid / Tumid : swollen or inflated

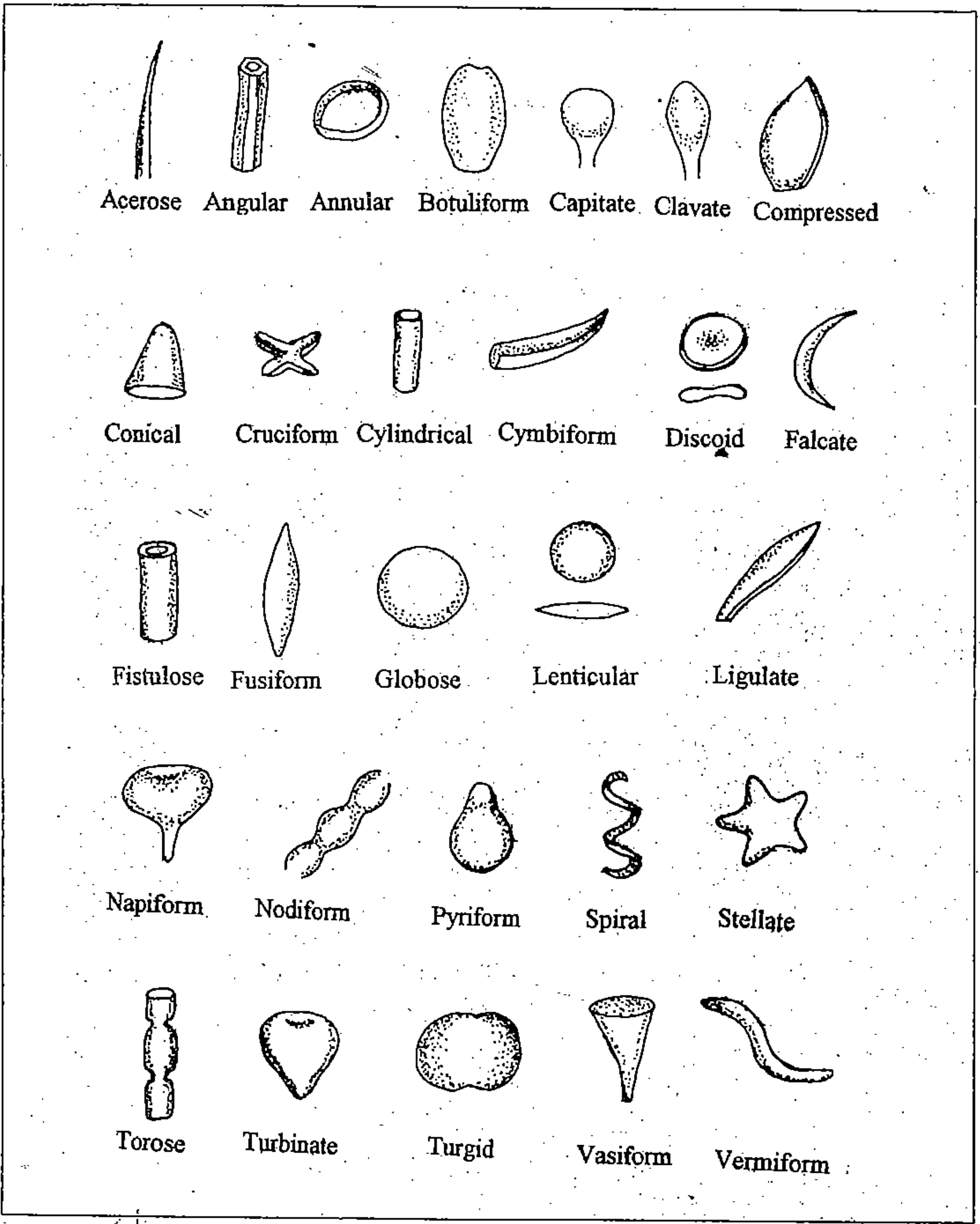
Vasiform : elongated funnel-shaped

Vermiform : worm-shaped

Also see leaf shapes

Additional terms

Plate – 1: Different shapes.



2.3 ORIENTATION OF PARTS (Plate – 2)

Agglomerate / Conglomerate / Crowded / Aggregate : dense structures with varied angles of divergence
Adpressed / appressed : pressed closely to axis upwards
Ascending : directed upward

Cernuous : drooping
Conduplicate : folded together lengthwise, upward or downward along the central axis
Connivent : convergent apically without fusion
Contorted : twisted around a central axis

Deflexed : bent abruptly downward
Depressed : pressed close to axis downward
Descending : directed downward
Dextrorse : rising helically from right to left, a characteristic of twining stems
Divergent : spreading away

Eccentric : one-sided; off-center

Geniculate : Abruptly bent like a knee

Incurved : curved inward or upward
Inflexed : bent abruptly upward
Involute : margins or outer portion of sides rolled inward over upper or ventral surface

Pendulous : hanging loosely or freely
Plicate : with series of longitudinal folds; plaited

Recurved / Retrorse : curved or bent outward or downward
Revolute : margins or outer portion of sides rolled outward or downward over lower or dorsal surface

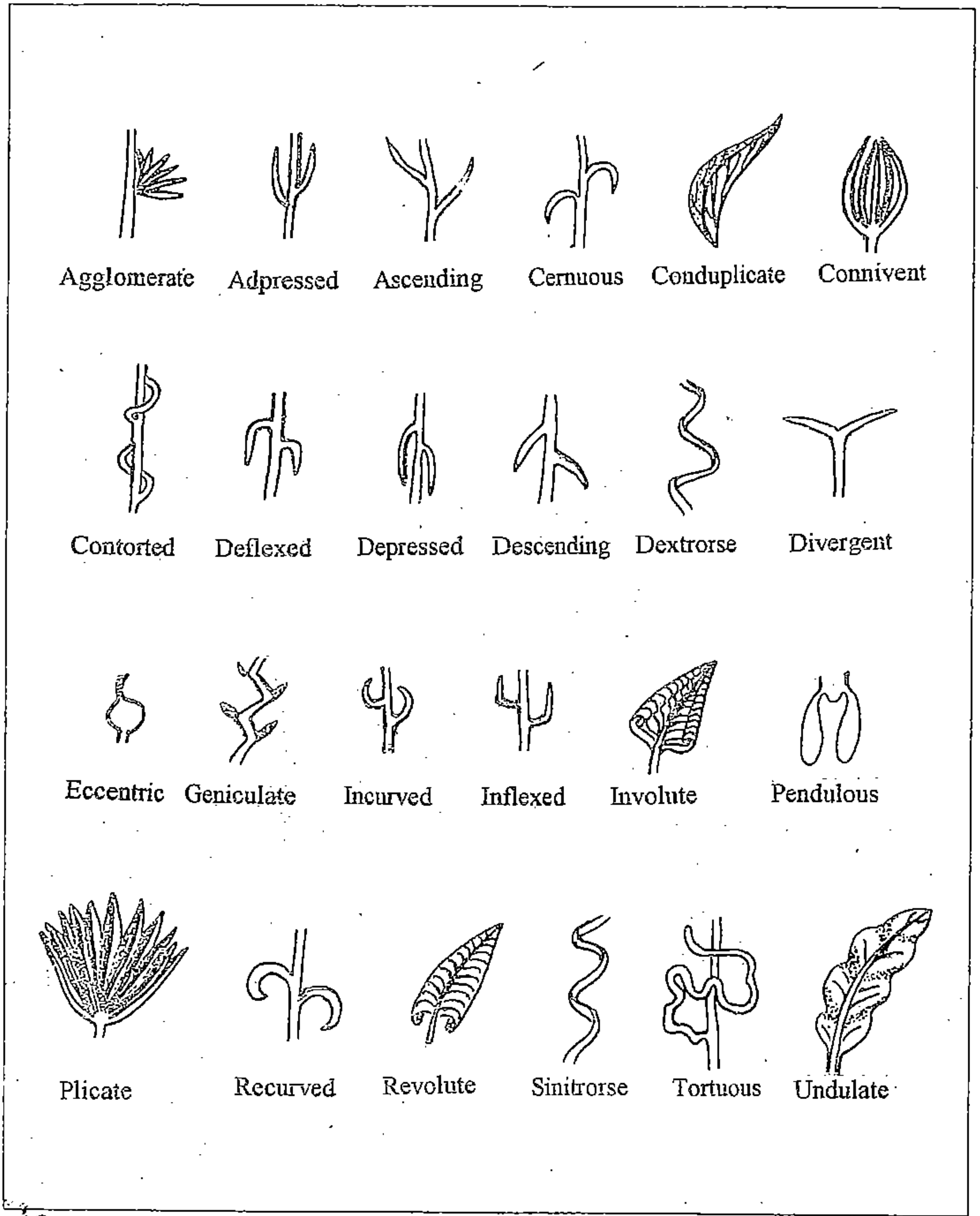
Sinistrorse : rising helically from left to right, a characteristic of twining stems

Tortuous : irregularly twisted

Undulate : with a series of vertical curves at right angles to central axis

Additional terms

Plate – 2: Different orientations of plant parts.



2.4 SURFACE CHARACTERS

2.4.1 Texture Types

Asperous : having a rough surface

Baccate / Succulent : fleshy or juicy and resistant to drying

Cartilaginous : hard and tough but flexible
Coriaceous : thick and leathery
Corneous : horny
Crustaceous : hard, thin, and brittle

Fibrous : fiber-like; having loose, woody fibers
Flaccid : lax and weak; limp

Gelatinous : jelly-like; soft and semi-solid
Glutinous / Viscid : sticky

Herbaceous : soft and succulent, not woody
Hyaline : thin and translucent or transparent

Ligneous / Woody / Sclerous : hard and lignified

Membranous / Membranaceous : membrane-like; thin and semi-translucent
Mucilaginous : gummy or gelatinous

Scabrous : rough
Scarious : thin and dry, appearing shrivelled
Shining / Nitid / Laevigate : lustrous, polished
Spongy : soft / sponge-like
Suberous : corky

Velutinous : velvet-like

2.4.2 Surface Types Based On Epidermal Vestures (Plate – 3)

Aculeate : Prickly; covered with prickles

Barbed : with short, rigid, reflexed (pointing backward or down) bristles or processes
Bristly : covered with bristles

Ciliate : with conspicuous marginal trichomes
Comose : with a tuft of trichomes, usually apical

Echinate / Spiny : covered with spines

Farinaceous / Farinose / Mealy : covered by white or bluish mealy powder or bloom
Floccose : covered with dense, appressed, woody trichomes in patches or tufts

Glabrous : smooth; devoid of outgrowths
Glandular : covered with glands or trichomes with enlarged tips
Glaucous : covered with a bloom or smooth, waxy coating that rubs off
Glochidiate : with barbed trichomes, glochids, usually in tufts

Hairy : covered with epidermal hair or trichomes; generally used when type of hair not specified
Hirsute : covered with long, rather stiff trichomes
Hispid : covered with very long, bristly, stiff trichomes
Hoary : covered with very short dense trichomes giving a whitish appearance to the organ

Paleaceous : with small membranous scales; chaffy
Pannose / Felted : with matted, felt-like layer of trichomes
Papillose / Papillate : covered with minute tubercules
Pubescent : with straight, slender trichomes

Scabrous / Scabrid : having a harsh surface, often due to very stiff hairs or projections
Spiculate : with crystals in or on the surface
Strigose : covered with sharp, coarse, bent hairs usually with a bulbous base

Tomentose : covered with dense, woolly, matted , interwoven trichomes
Tuberculate / Verrucose : with a warty surface

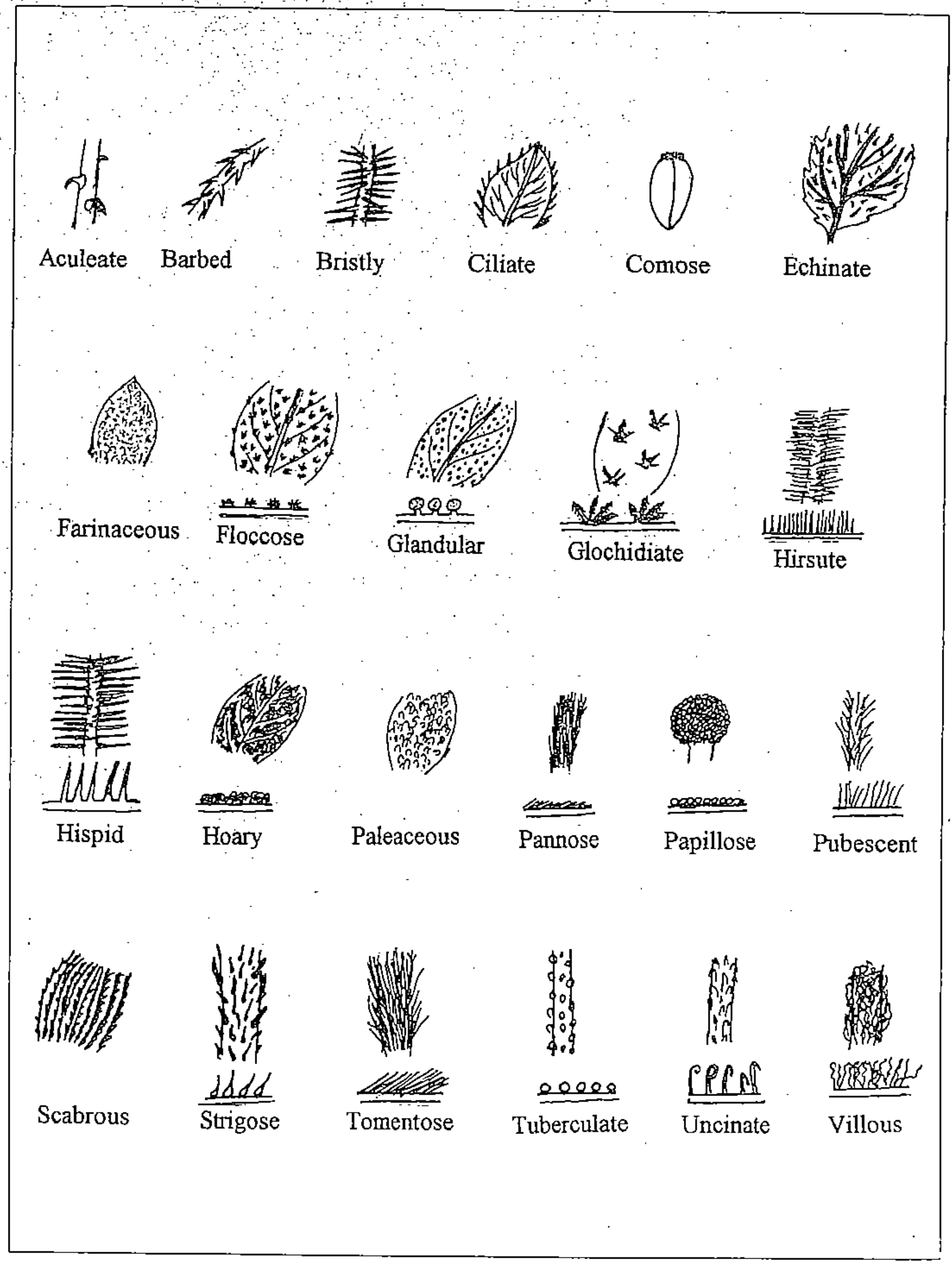
Uncinate : covered with trichomes having hooked tips

Villous / Villose : covered with long, soft, crooked trichomes
Viscid : sticky or glutinous; covered with glandular hair exuding a sticky liquid

Waxy / Ceraceous / Ceriferous : covered with wax or wax-like coating

Additional terms

Plate – 3: Surface types based on epidermal vestures.



2.5 TRICHOMES (Plate – 4)

2.5.1 Glandular : unicellular or multicellular trichomes involved in secretion of various substances such as chalk, digestive enzymes, mucilage, nectar, poisons or tissue irritants (stinging hairs), salts, terpenes or essential oils, aqueous solution of organic and inorganic substances (stigmatic papillae, trichome, hydathodes), and sticky substances (colleters)

2.5.2 Non-glandular : unicellular or multicellular trichomes not involved in secretion

Barbed : trichome with short, reflexed projections

Candelabra : candelabrum-like
Clavate : club-shaped

Dendroid / Dendritic : branched and tree-like

Echinoid : spiny, multicellular

Falcate : sickle-shaped
Forked : bifurcated

Hirsute : long and somewhat stiff
Hooked : unicellular with tip bent like a hook

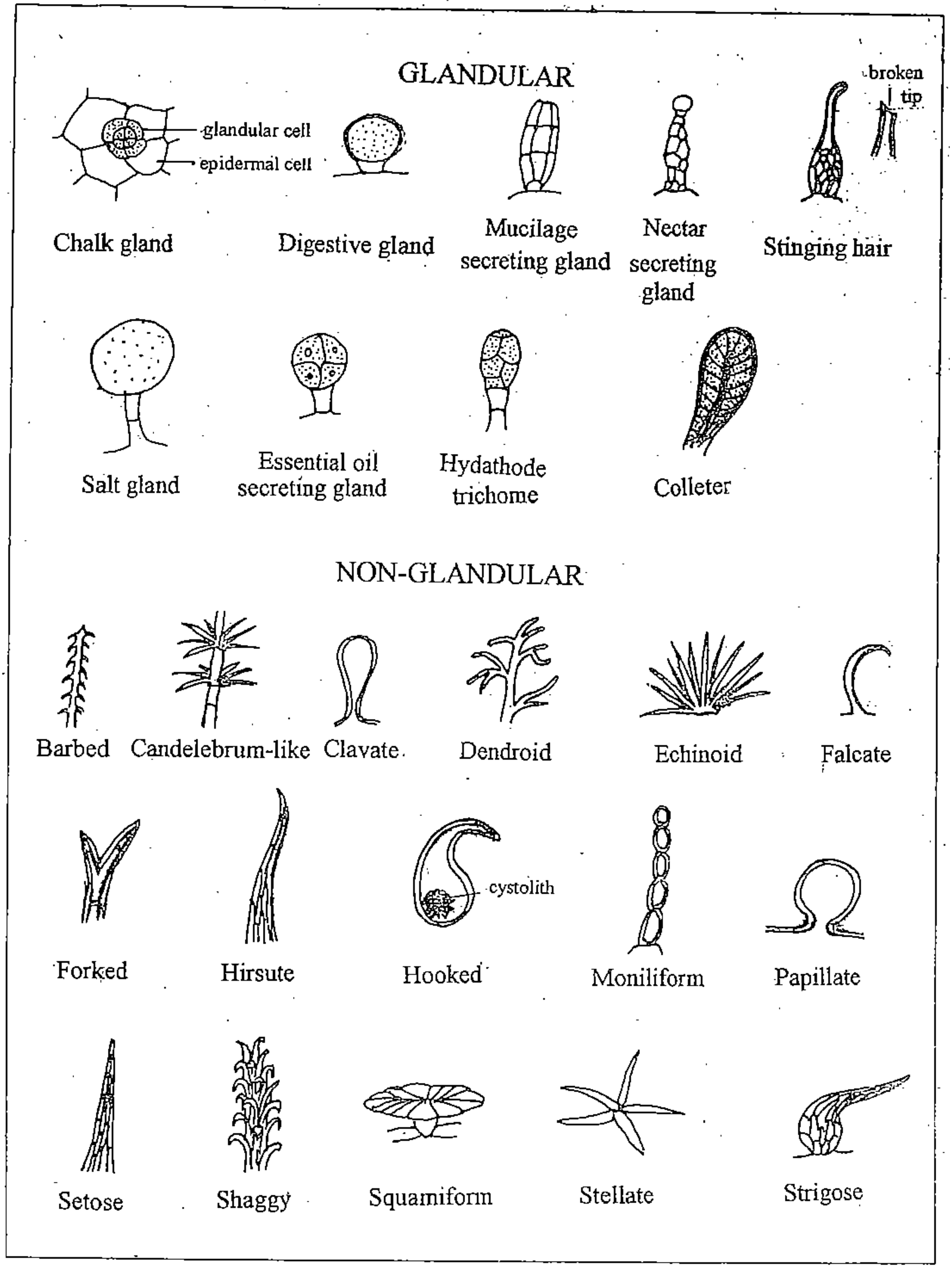
Moniliform : like stringed beads

Papillate : short and blunt

Setose : stiff and bristle-like
Shaggy : multicellular and rough
Squamiform : flattened and multicellular
Stellate : star-shaped
Strigose : sharp, coarse, bent with a bulbous base

Additional terms

Plate – 4: Different types of trichomes.



2.6 SPECIAL CHARACTERS OF PLANT AND ITS PARTS

2.6.1 The Plant

A. Plant Parts (Plate – 5)

Bud : immature vegetative or floral shoot or both, often covered by scales

Flower : reproductive shoot of flowering plants bearing sporophylls with or without protective envelopes, the calyx and corolla

Fruit : mature fertilized ovary of flowering plants, with or without the accessory parts

Leaf : a photosynthetic organ developed from leaf primordium in the bud and borne on the stem of a plant

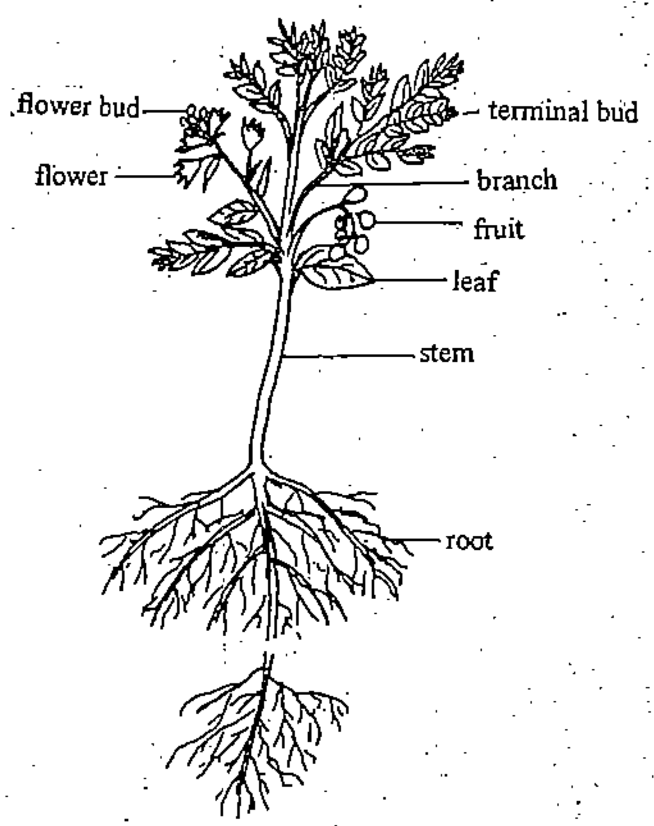
Root : an absorbing and anchoring organ , usually positively geotropic and initially developed from the radicle

Seed : mature, fertilized ovule of seed-plants

Shoot : part of plant developed from the shoot apical meristem and it generally consists of parts of plant other than roots

Stem : a supporting and conduction organ developed initially from the epicotyl, and is negatively geotropic

Plate – 5: Different parts of a seed plant.



Acaulescent : plant apparently stemless; with extremely condensed stem as in some monocots
Aerophyllus : with leaves in air, above ground or water
Amphicarpous : with fruits in two environments, viz., aerial and subterranean from chasmo- and cleisto-gamous flowers, respectively
Annual : with life cycle of one season duration or living for one year or less
Arhizous : without roots

Biennial : with life cycle of two years duration, usually flowering in the second year

Calcifuge : a plant that dislikes lime or chalk, e.g., rhododendron
Caulescent : plants with distinct stem
Caulocarpic : with stem living for many years, bearing flowers and fruits directly on the main stem
Climber : a weak-stemmed, mostly herbaceous, annual or perennial plant which climbs up a support
Creeper : a herbaceous plant which creeps horizontally on the support, giving rise to roots and shoots intermittently

Deciduous : with leaves falling at the end of growing season; not evergreen
Diclinous : plant with imperfect flowers; stamens and carpels in separate flowers
- Dioecious : male (staminate) and female (carpellate) flowers borne on different plants
- Monoecious : male and female flowers borne on same plant

Epiphyte : plant growing on another plant
Evergreen : bears leaves throughout the year

Female / Carpellate / Pistillate : bearing flowers without functional stamens

Halophyte : tolerant of excess amounts of salts (usually sodium chloride) in the soil solution
Heliophyte : can grow only in well-lighted places
Herb : a usually short and soft plant with annual, above-ground stems lacking definite woody structures
Hermaphroditic / Monoclinous : plant with all perfect flowers
Heterocarpic : bearing two types of fruits, both above ground
Heterotroph : cannot manufacture food on its own and is dependent on other sources of nutrition
- Parasite : dependent on another living plant (host) for nutrition partially or totally
    - Partial root parasite : obtains partial nutritional requirement from the roots of host, e.g., *Santalum album*
    - Partial stem parasite : obtains partial nutritional requirement from the stem of host, e.g., *Viscum album*
    - Total root parasite : obtains entire nutritional requirement from roots of host, e.g., *Rafflesia*
    - Total stem parasite : obtains entire nutritional requirement from stem of host, e.g., *Cuscuta*

- Saprophyte : a plant (usually lacking chlorophyll) that draws its nutrition from dead and decaying organic matter of vegetable or animal origin

Hydrophyte : plant growing in water or in very wet place
- Amphibious : with roots and stem embedded in water or water saturated soil and foliage of plant raised above water surface, e.g., in *Typha*
- Floating : foliage of plant floating on the surface of water, plant may or may not be anchored to the substratum
- Submerged : plant completely under water, may or may not be anchored to substratum

Hygrophyte : plant which grows in constantly moist places

Insectivorous : which derives nutrition partially from insects; trap and digest insects

Male / Staminate : plant with staminate flowers only

Mesophyte : plant growing in normal environment, i.e., in average conditions of temperature, light, soil and water

Monocarpic / Hapaxanthic : fruiting once; perennial, biennial or annual, flowering and fruiting once, then dying; usually applied to perennials that grow for several years before flowering and dying

Perennial : plant that persists for more than two years
- Herbaceous : a non-woody perennial with the aerial shoot system dying after each growing season, persists with the help of a perennate underground shoot system
- Woody : a tree or shrub, the shoot system remains above ground

Polygamous : plant with perfect and imperfect flowers

Sciophyte : plant which grows only in shady places; shade-loving plants

Shrub : a much-branched woody perennial plant usually without a single trunk

Straggler : plant with a weak stem which climbs other supports with the help of hooks

Subshrub / Shrublet : a suffrutescent perennial (the stem basally woody) or a very low shrub of less than 30 cm tall, often creeping over ground

Tree : a tall woody perennial plant usually with a single trunk

Trioecious : plants with staminate, pistillate or perfect flowers

Undershrub : a perennial plant having stems that are woody only in the basal parts, the upper part dying back

Vine / Liana : an elongate, weak-stemmed, often climbing annual or perennial plant, with herbaceous or woody texture

Xerophyte : a plant of dry, arid habitat, such as the desert

Additional terms

2.6.2 The Root

A. Root Parts (Plate – 6)

Region of elongation : part of root where cells undergo rapid elongation and enlargement
Region of maturation : part of root where cells undergo differentiation into various kinds of primary tissues, and where root hairs are present
Root cap : parenchymatous, protective, cap-like tissue at the apex of the root
Root hair : lateral, single-celled, absorbing outgrowth of the epidermal cell
Root pocket : a type of root cap which does not regenerate, found in water plants

Secondary root / Lateral root : root branch with root cap and hairs, derived endogenously from the pericycle of main root

B. Root Types (Plate – 7)

Adventitious : arising from organ other than embryonic root or radicle
Annulated : root with a series of ring-like swellings
Assimilatory : green roots of some plants which help in photosynthesis

Buttress : root with board-like or plank-like growth on upper side, a supporting structure

Climbing : above-ground, fibrous, adventitious root arising from node, some times from internode, frequently with an adhesive disk; a crampon
Clinging : aerial root of epiphyte which enters the crevices of support to keep the plant in place
Contractile or Pull : root capable of shortening, usually drawing the plant or plant part deeper into the soil, generally has a wrinkled surface

Epiphytic : root of epiphyte, with a special spongy velamen layer, concerned with absorption of moisture

Fibrous : fine, thread-like or slender, generally adventitious root

Haustorial : absorbing root within host of some parasitic species
Holdfast / Haptera : root which helps in attaching plant to surface on which it is growing

Nodulated : root with nodular outgrowths, as roots of legumes with nitrogen fixing nodules

Pneumatophorous : aerating, apogeotropic or negatively geotropic root with lenticels/pores/pneumathodes which help in gaseous exchange , usually found in marsh plants
Primary / Seminal : which develops from the radicle of embryo
Prop : adventitious, supporting root, usually arises from the horizontal lower branches of trees and grows vertically down, gets anchored in soil, becomes thick, strong, and pillar-like

Reproductive : contain buds that readily develop into new individuals, aid in vegetative propagation

Respiratory / Floating : adventitious, soft, light, spongy, colourless, and above water roots of aquatic plants which help to store air and also function as air float

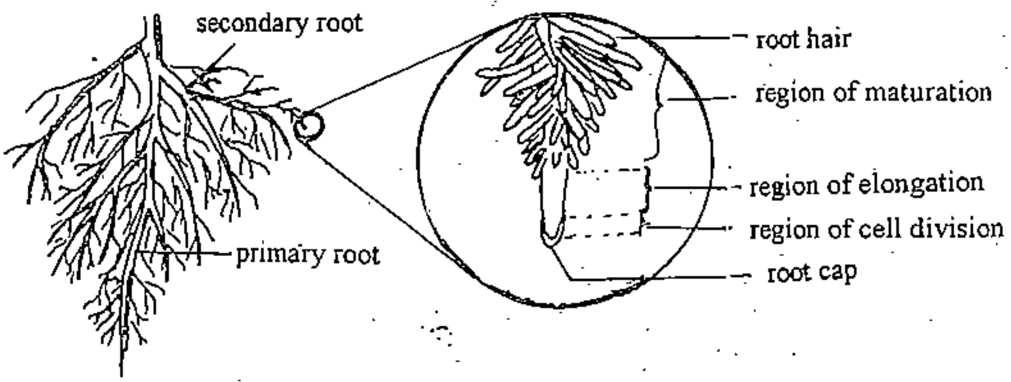
Stilt : supporting root which arises from the lower portions of stem, grows obliquely down, gets anchored in soil and provides additional support to main stem

Storage : swollen, fleshy root which functions as storage and may be perennating organ

- Conical : a tap root with a broad upper part gradually tapering below like a cone, as in carrot
- Fascicled / Fasciculated : fleshy or tuberous roots in a cluster, a modification of adventitious roots
- Fusiform : a tap root where the middle part of root is swollen and it tapers towards both ends gradually; spindle-shaped
- Moniliform / Beaded : elongated roots with regularly arranged swollen areas
- Napiform : a modification of tap root, upper part considerably swollen and tapers suddenly downward
- Nodulose : slender root with swollen tip
- Tuberous : fleshy root resembling a tuber, generally modification of adventitious root

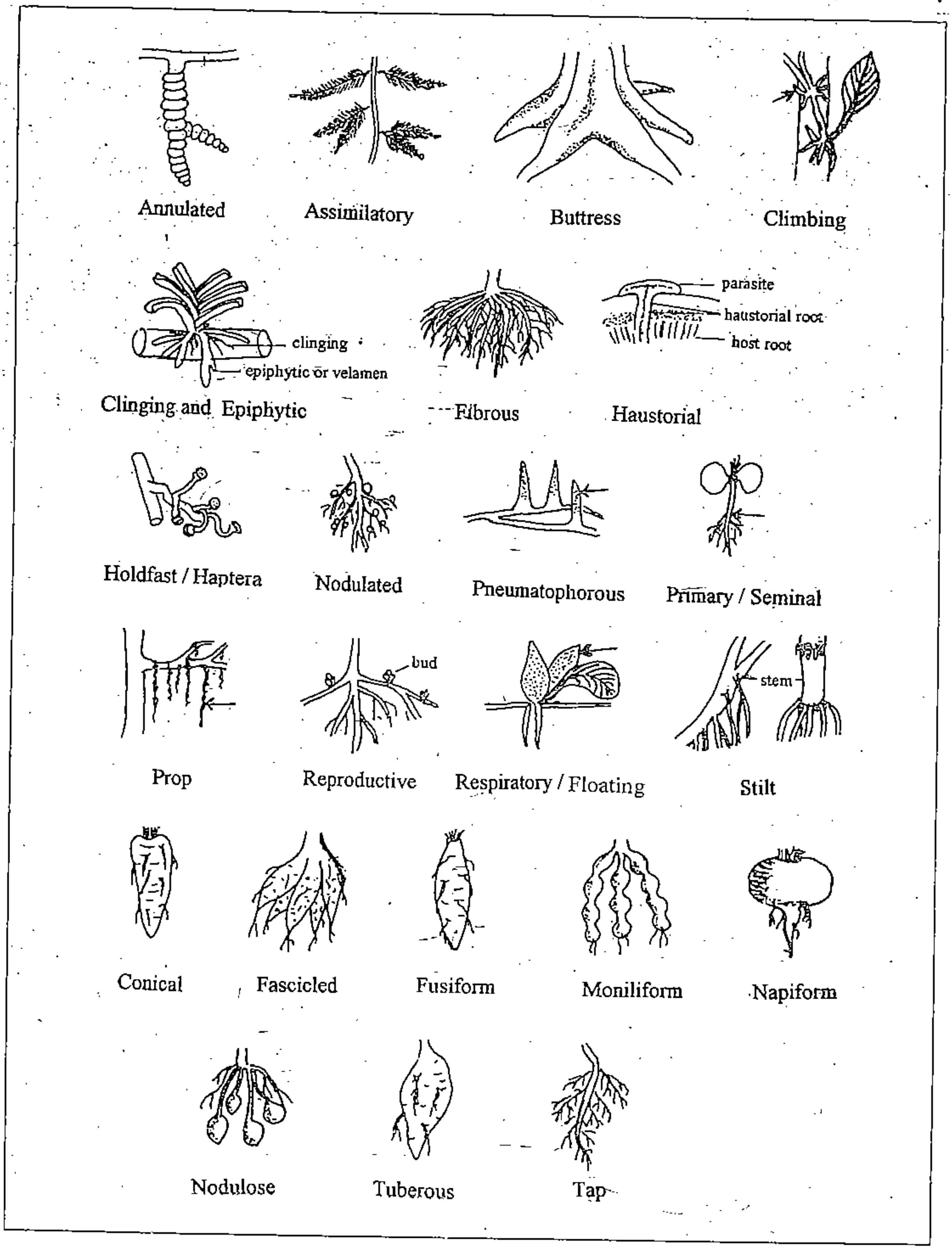
Tap : persistent well-developed primary root

Plate – 6: The parts of root.



Root system

Plate – 7: The types of root.



2.6.3 The Bud (Plate –8)

A. Bud Parts (Plate – 8)

Apical meristem : meristematic tissue that gives rise to other bud parts

Bud primordium : meristematic tissue that gives rise to a bud consisting of leaf or flower primordia and apical meristem

Flower primordium : meristematic tissue that gives rise to a flower

Leaf primordium : meristematic tissue that gives rise to a leaf

Scale : protective leaf surrounding the bud

B. Bud types (Plate – 8)

Adventitious : bud arising from more or less mature tissues of organs other than the node
- Epiphyllous / Foliar : buds arising from leaves
- Radical : buds arising on roots

Axillary : in the axil of leaf or leaf scars, generally gives rise to branches

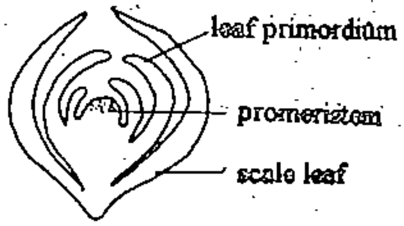
Flower / Floral : bud which will give rise to one or more flowers

Protected / Covered / Scaly : shoot and/or flower primordia surrounded by scales

Terminal : situated at apex or end of stem

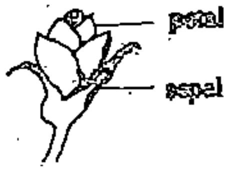
Vegetative / Leaf : an immature shoot consisting of a short stem, apical meristem and young leaves covering meristem; gives rise to a branch with leaves

Additional terms



L.S. Protected vegetative bud

Adventitious Epiphyllous

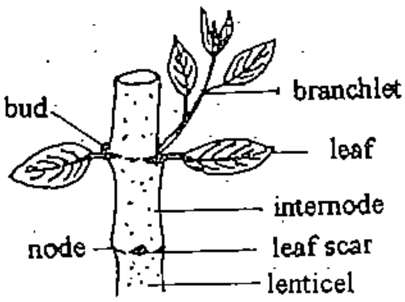


Flower

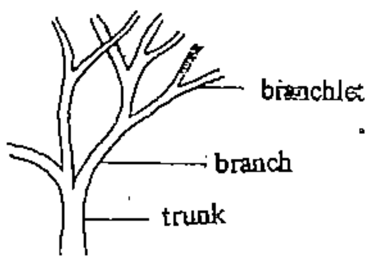
Axillary

Terminal

Adventitious Radical



Twig



Aerial, Arborescent

A. Stem Parts

Bark : tissues of plant outside wood or xylem
Branch : lateral shoot of main stem, generally arises from an axillary bud
Branchlet : lateral shoot of a branch

Internode : a section or region of stem between successive nodes

Lenticel : lens-shaped or wart-like patches of parenchymatous tissue or a 'breathing' pore on the surface of stem and branches, sometimes on fruit

Node : region of stem from which leaf, leaves, or branch(es) arise

Pith : soft, spongy, central cylinder of tissue inner to wood, usually parenchymatous

Scar : a mark indicating former place of attachment, may be of bud scale, leaf or stipule

Trunk : wide lower part of stem bearing the branches, especially of a tree
Twig : a young woody stem; more precisely, the shoot of a wood plant represented by growth of the current season

Wood: central part of stem consisting of xylem

B. Stem Types (Plate - 9)

Aerial : above ground stem
Angular : many-angled in cross-section
Arboresent : tree-like in appearance and size

Branched Ramose : possessing branches or lateral shoots
Bulb : a short. erect. condensed, underground stem surrounded by fleshy leaves
Bulbil : a small bulb or bulb-like body produced on above-ground parts; a vegetative bud.
Bulblet : a small bulb, irrespective of origin

Caudex : a slow growing, upright, woody underground or subterranean base of a herbaceous perennial that each year gives rise to leaves and flowering stems
Cespitose / Caespitose : a short, much-branched stem growing in a clump and forming a cushion
Cladode: greem cylindrical main stem of xerophyte bearing flattened branches of limited growth, usually with single internode, resembling leaf in form and function

limbing : growing upward by means of tendrils, petioles, or adventitious roots
olumnar : a tall, woody, unbranched stem, usually with a crown of leaves
orm : underground, upright, enlarged, fleshy stem with scale leaves; a storage stem
ormel : small corm produced at the base of parent corm

Culm : jointed stems (flowering and fruiting) of grasses and sedges with swollen and solid nodes and hollow internodes
Cylindrical : circular in cross-section

Decumbent : reclining or lying on the ground with the tips ascending

Erect : upright

Fruticose : shrubby, woody throughout, commonly with several main stems but no main trunk

Herbaceous : soft and succulent
Heterophyllous : bearing more than one type of leaves
Hollow / Fistular : without pith, generally in the internode

Innovations : sterile shoots of grasses and sedges

Offset : a short, stout, horizontal branch which grows to a limited extent and produces at the apex a tuft of leaves above and a cluster of small roots below

Phylloclade / Cladophyll : green, flattened or cylindrical stem and branches of many internodes of certain xerophytic plants resembling a leaf in form and function
Procumbent / Prostrate / Reclining / Humistrate : trailing or lying flat, not rooting at the nodes

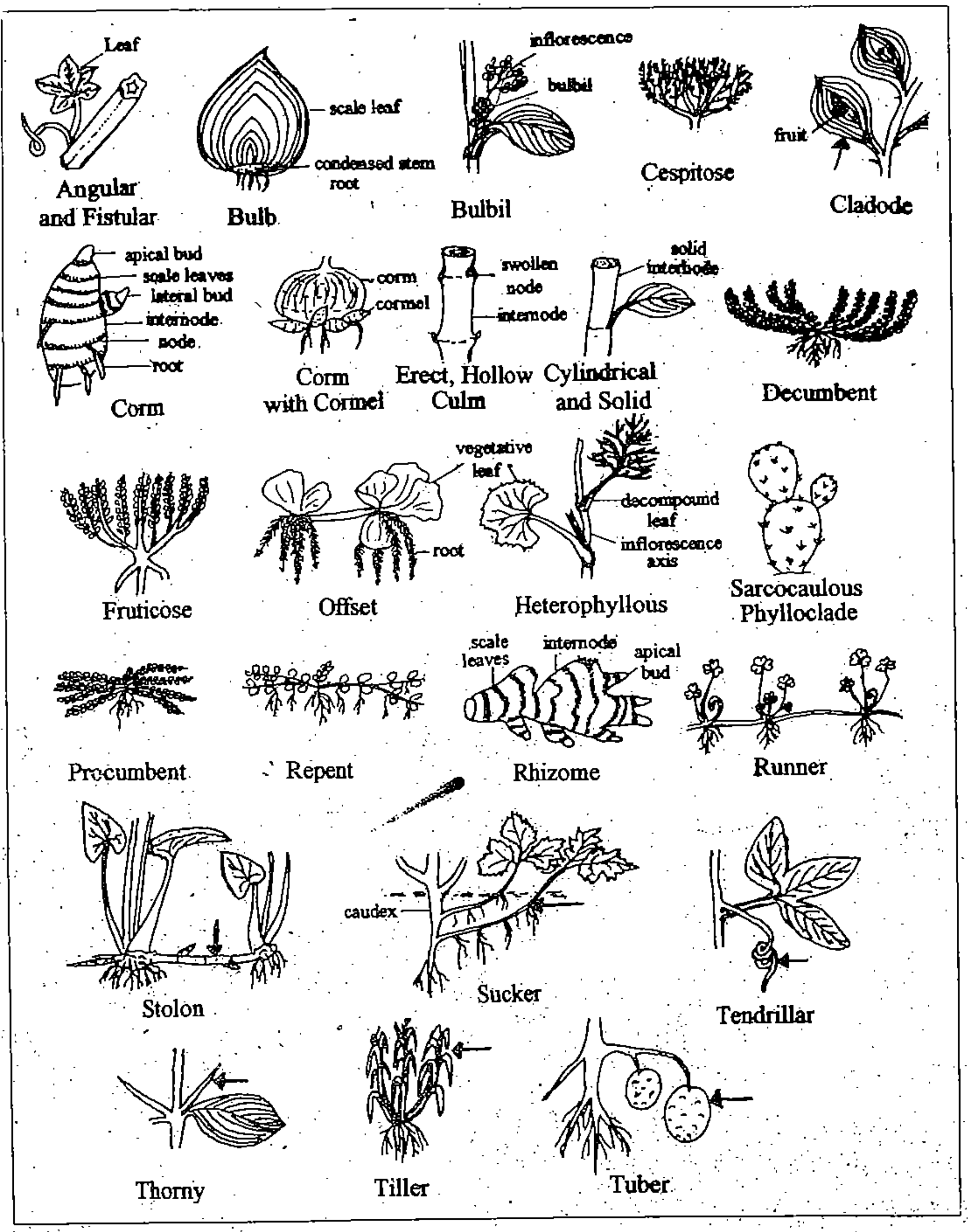
Repent / Trailing : creeping or lying flat and rooting at the nodes
Rhizome : a horizontal underground stem with scale leaves, generally has fleshy and a storage stem
Rootstock : a term applied to miscellaneous types of underground stems or parts
Runner : a slender, prostrate branch with nodes and long internodes, which produces roots and shoots at tip, and forms a new plant

Sarcocaulous : fleshy
Scandent : climbing without aid of tendrils
Sclerocaulous / Woody : hard, dry; not herbaceous
Solid : with pith; not hollow
Spur : a very short branch on which leaves or flowers and fruits are borne
Stolon : a prostrate, horizontally growing lateral branch with nodes and short internodes, and which produces roots and shoots at the nodes
Sucker / Surculose : an underground branch growing upwards to form an aerial shoot, roots arise from nodes below ground
Suffrutescent : semi-shrubby, lower parts of stem woody and upper herbaceous

Tendrillar : tendril-like modification of branch, adapted for climbing
Thorny : a sharp, pointed modification of branch, usually with vascular supply
Tiller : a branch produced from the base of the stem, especially in grasses
Tuber : a thick, swollen, underground, storage stem, usually not upright

Unbranched / Eramous : without branches or lateral shoots

Plate – 9: Different types of stems.



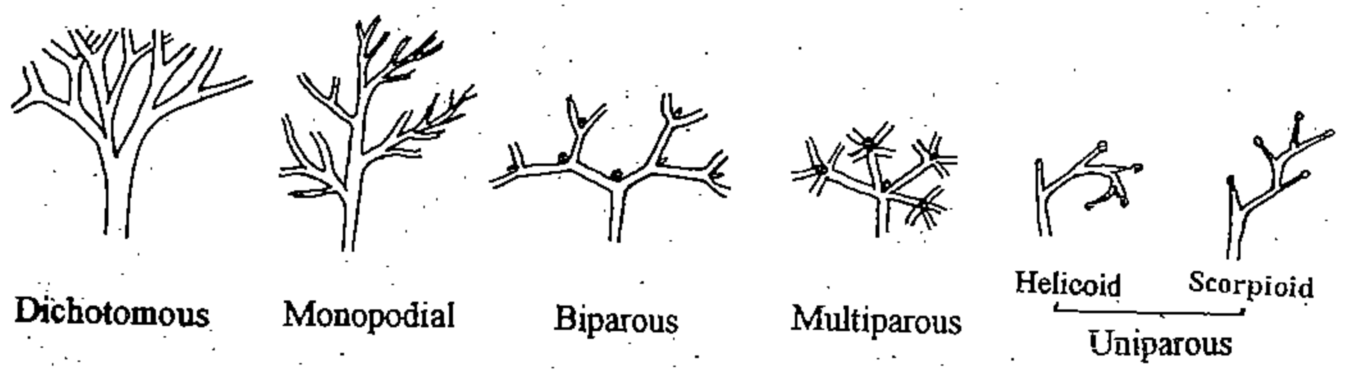
C. Branching Patterns (Plate – 10)

Dichotomous : two branches formed at the tip by the division of apical meristem; commonly found among lower plants, as in *Riccia*

Lateral : branches are produced laterally from the sides of the main stem

- Monopodial / Racemose / Indefinite : main stem continues to grow indefinitely, branches develop in acropetal succession, the lower branches are older and larger than the upper ones
- Sympodial / Cymose / Definite : growth of the main stem is limited or definite, lateral branches, at each stage of branching, develop at the tip below the inactive terminal bud
  - Biparous / Dichasial: with only two lateral branches at each stage, below terminal bud
  - Multiparous / Polychasial : with more than two laterals at each stage of branching
  - Uniparous / Monochasium : with only one branch at each stage of branching
    - Helicoid : a type of uniparous sympodium branching where successive lateral branches arise only on the same side of stem
    - Scorpioid : a type of uniparous sympodium branching where successive lateral branches arise on either side of the stem

Plate – 10: Various kinds of branching patterns.



Additional terms and figures

2.6.5 The Leaf (Plate – 11)

A. Leaf Parts (Plate – 11)

Apex : tip or extreme distal part of lamina

Base : lower or proximal part of lamina

Lamina / Blade : flat, expanded portion of leaf.
Leaflet : a distinct and separate segment of a compound leaf
Ligule : a strap-shaped flap of tissue outgrowth or projection from the surface of leaf

Midrib : the central conducting and supporting structure of blade of a simple leaf; a continuation of petiole
Midvein : the central conducting and supporting structure of the blade of a leaflet

Nerve : one of the principal veins of a parallel-veined leaf

Petiole : leaf stalk
Petiolule : leaflet stalk
Pinna (pl. pinnae) : primary division of a compound leaf bearing leaflets
Pinnule : secondary division of a compound leaf bearing leaflets

Rachilla / Rhachilla : diminutive, secondary axis of compound leaf
Rachis (pl. rachides / rachises) : the main axis of a pinnately compound leaf, (also of inflorescence)

Sheath : portion of leaf surrounding the stem
Stipel : one of a pair of appendages at the base of a petiolule
Stipule : one of a pair of appendages at the base of a petiole

Vein : a secondary conducting structure in the leaf blade, arising from midrib or petiole
Veinlet : a tertiary conducting structure in the leaf blade, arising from a vein

B. Leaf Arrangements (Plate – 11)

Alternate / Acyclic / Spiral : one leaf per node, leaves arise spirally around the axis in a clock-wise or anti clock-wise direction according to Fibonacci phyllotaxis*

* Fibonacci phyllotaxis : a fundamental type of leaf arrangement expressed as a fraction in which each succeeding fraction is the sum of the two previous numerators and the sum of the two previous denominators, i.e., 1/2, 1/3, 2/5, 3/8,5/13, 8/21, etc. The numerator represents the number of turns or spirals around a stem before one leaf is directly above another and the denominator represents the number of leaves between the first leaf and the next leaf that is directly above the first. The 2/5 phyllotaxy would mean between the one leaf directly above it, there are two twists and five leaves before one leaf is directly above the other.

- Distichous : 2-ranked, ½ arrangement with two leaves in one spiral so that the third leaf develops over the first one
- Octostichous : eight rowed or ranked; 3/8 arrangement with eight leaves in three spirals so that ninth leaf arises over the first leaf, as in *Carica papaya*
- Pentastichous : in five rows; 2/5 arrangement with five leaves in two spirals so that the sixth leaf develops over the first one
- Polystichous : in many rows
- Tristichous : in three rows, 1/3 arrangement with three leaves in one spiral so that fourth leaf arises over the first one

Conglomerate / Agglomerate / Crowded / Aggregated : densely clustered, usually irregularly overlapping each other

Equitant : 2-ranked with overlapping bases, usually sharply folded along midrib

Opposite : two leaves borne on opposite sides of a stem
- Decussate : opposite leaves at right angles to preceding pair, tetrastichous or four rowed with fifth leaf developing over the first one after two cycles of leaves
- Superposed : opposite leaves directly above the preceding pair in the same plane, distichous with two leaves in one cycle so that the third leaf develops over the first one

Rosette : an arrangement of leaves radiating from a crown or center and usually at or close to the ground

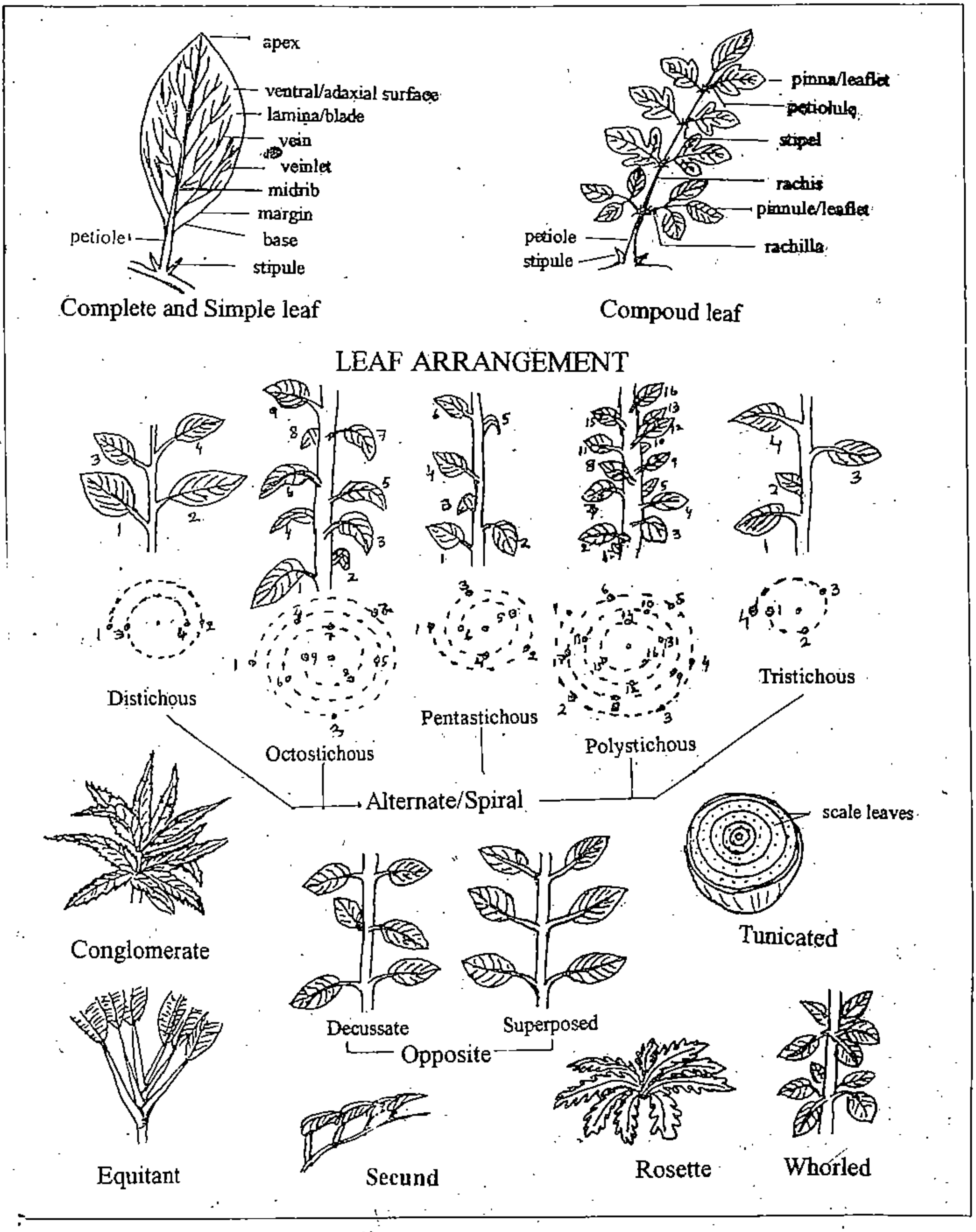
Secund / Unilateral : on one side of the stem

Tunicated : arranged in circles when viewed in cross-section, as in onion

Whorled / Radiate / Verticillate : three or more leaves per node

Additional terms

Plate – 11: Leaf parts, simple and compound, arrangements.



C. Leaf Types (Plate – 12)

Bi-foliate / Geminate/ Jugate/ Unijugate : with two leaflets from a common point, palmate or pinnately compound
Bigeminate/ Bijugate / Di- or bi-foliate : with two orders of leaflets, each bifoliate; doubly paired, palmate or pinnately compound
Biternate : with two orders of leaflets, each ternately compound
Bract : modified leaf at the base of flower or inflorescence
Bracteole / Prophyllum / Prophyll : small leaf, usually on a pedicel or below the perianth of flower

Cauline : more or less evenly distributed on stem
Complete : leaf with lamina, petiole, and stipule
Compound : with leaf divided into two or more leaflets (see Plate – 11)

- Palmately compound : with leaflets arising from one point at end of petiole
  - Bipalmately compound : with two orders of leaflets, each palmately compound
  - Digitate / Multifoliate : palmately compound leaf with more than four leaflets
  - Quadrifoliate : a palmately compound leaf with four leaflets, as in *Marselia*
  - Tripalmate : with three orders of leaflets, each palmately compound
- Pinnately compound : with leaflets arranged oppositely or alternately along a common axis, the rachis
  - Bipinnate : with two orders of leaflets, each pinnately compound
  - Imparipinnate : with odd number of leaflets, odd leaflet terminal
  - Paripinnate : with even number of leaflets, without a terminal leaflet
  - Tripinnate : with three orders of leaflets, each pinnately compound
  - Unipinnate : with one order of leaflets, pinnately compound; leaflets borne directly on the midrib

Cotyledon : embryonic leaf

Deciduous : falling at the end of growing season
Decompound : a general term for leaflets in two or more orders – bi-, tri- etc; pinnately, palmately, or ternately compound; simple leaf with many times parted or dissected lamina
Dorsiventral : with structurally different dorsal and ventral surfaces

Elaminate : without lamina or blade
Exstipellate : without stipels
Exstipulate : without stipules

Hook : hook-like modification of leaf or leaflet

Incomplete : leaf without one or more parts – lamina, petiole, stipules
Isobilateral : with structurally indistinct dorsal and ventral surfaces

Palmate-pinnate : with first order leaflets palmately arranged, second order pinnately arranged
Petiolate : leaf with a petiole
Petiolulate : leaflet with a petiolule

Phyllode / Phyllodium : leaf with much reduced lamina, but with flattened lamina-like petiole or midrib

Radical / basal / rosulate; near ground, arising from top of rootstock
Ramal / Ramous : more or less evenly distributed on branch
Reproductive : with foliar buds present on the leaf, aid in vegetative propagation

Scale : small, non-green leaf on bud or modified stem
Sessile : leaf without a petiole or epetiolate, (leaflet without a petiolule or epetiolule)
Simple : leaf not divided into leaflets
Spinose : spine-like modification of whole leaf, or leaflet
Sporophyll : a spore bearing leaf
Storage leaf : succulent, fleshy leaf

Tendrillar : a slender, coiled tendril-like modification of a leaf, or leaflet
Ternate : with leaflets in three's
Trifoliate : with three leaflets, pinnately compound with terminal petiolule longer than lateral, or palmately compound with petiolules equal in length
Unifoliate : with a single leaflet, petiolule distinct from the petiole of the whole leaf, as in *Cercis*

Additional terms

F. Style Types (Plate – 36)

Apical / Terminal : at the apex of ovary

Bifid : divided into two

Eccentric : off-center

Flabellate : fan-shaped

Geniculate : bent abruptly
Gynobasic : attached at the base of ovary in a central depression

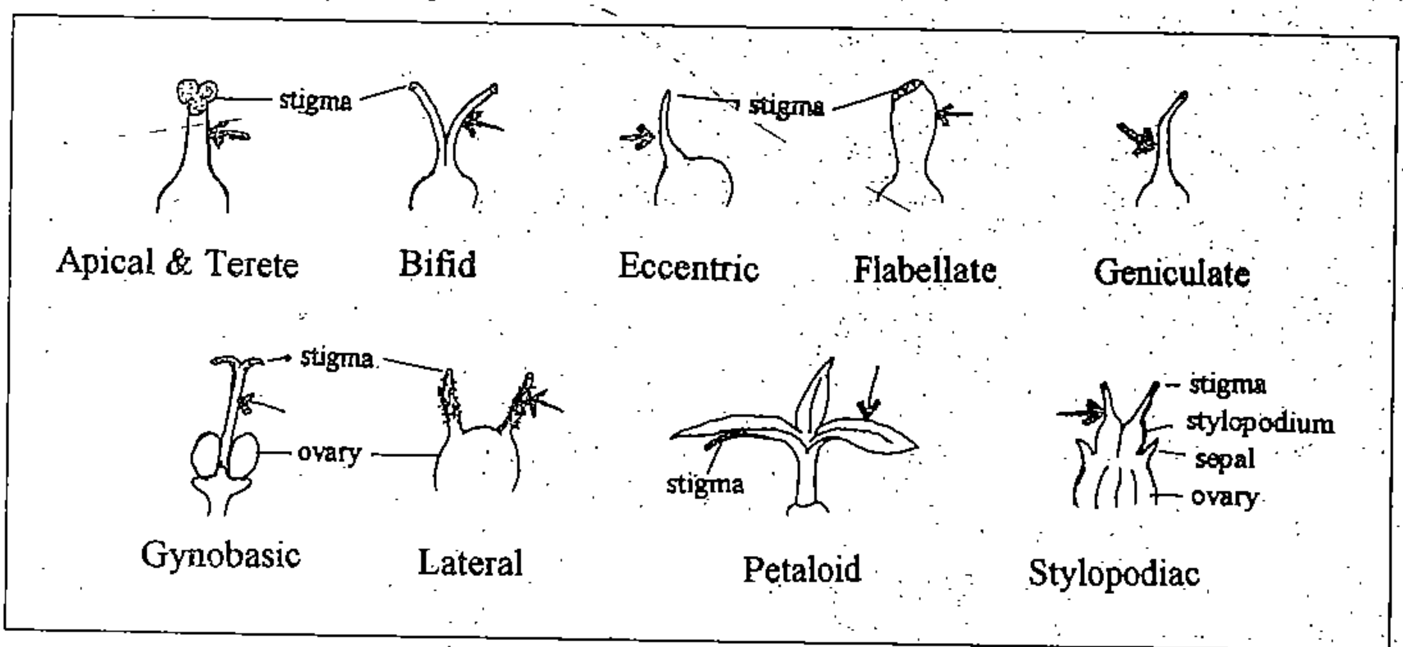
Lateral : at the side of ovary

Petaloid : petal-like

Stylopodiac : with a stylopodium or swollen base

Terete : cylindrical and elongate

Plate – 36: Different types of styles.



Additional terms and figures

D. Stipule and Stipel Types (Plate – 13)

Adnate : attached to the petiole or petiolule

Foliaceous : flattened, green and leaf-like, as in *Lathyrus*
Free-lateral : small, green and free, borne on two sides of leaf base, as in *Hibiscus*

Interpetiolar : present between the petioles of opposite leaves, as in Rubiaceae

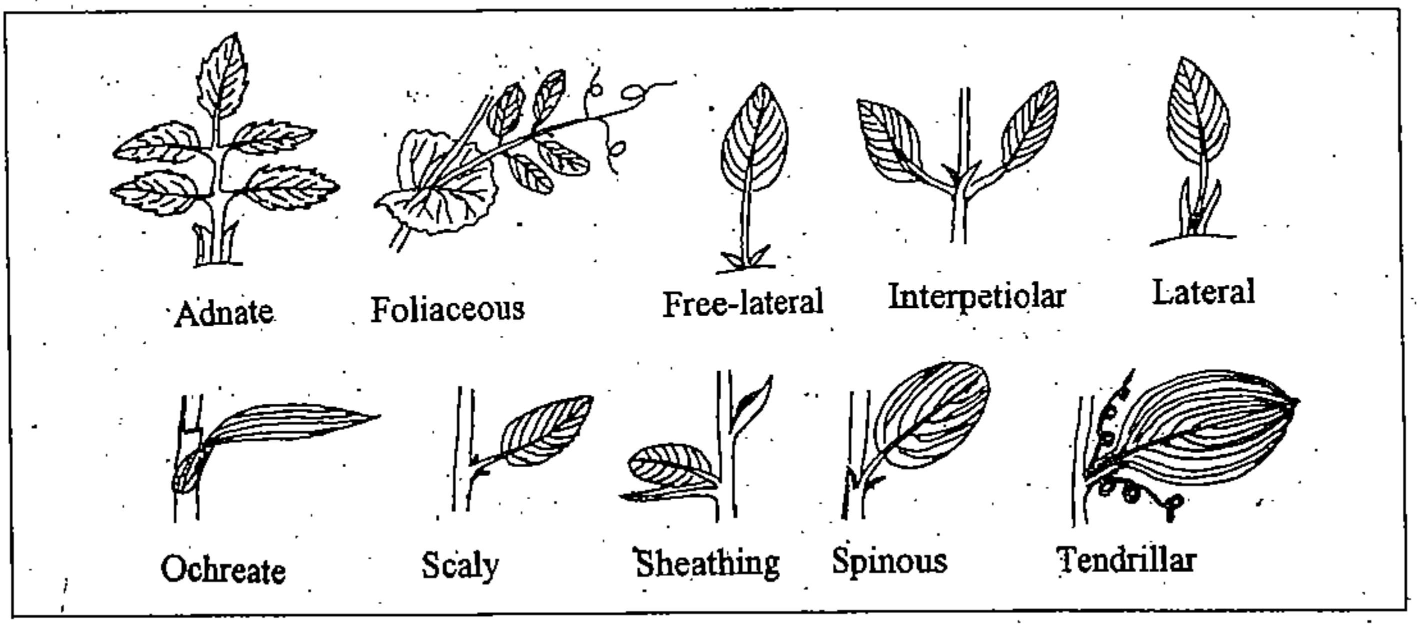
Lateral : adnate to petiole, with free part located along the petiole

Ochreate : hollow, tube-like, encircling the stem from the node up to a certain height of internode, as in *Polygonum*

Scaly : small, dry, and scale-like
Sheathing / Protective : enclosing a leaf
Spinous : small, sharp, and pointed; spine-like

Tendrillar : tendril-like

Plate – 13: Various types of stipule and stipel.



Additional terms

E. Petiole and Petiolule Types (Plate – 14)

Inflated : swollen or thickened, as in *Eichhornia*

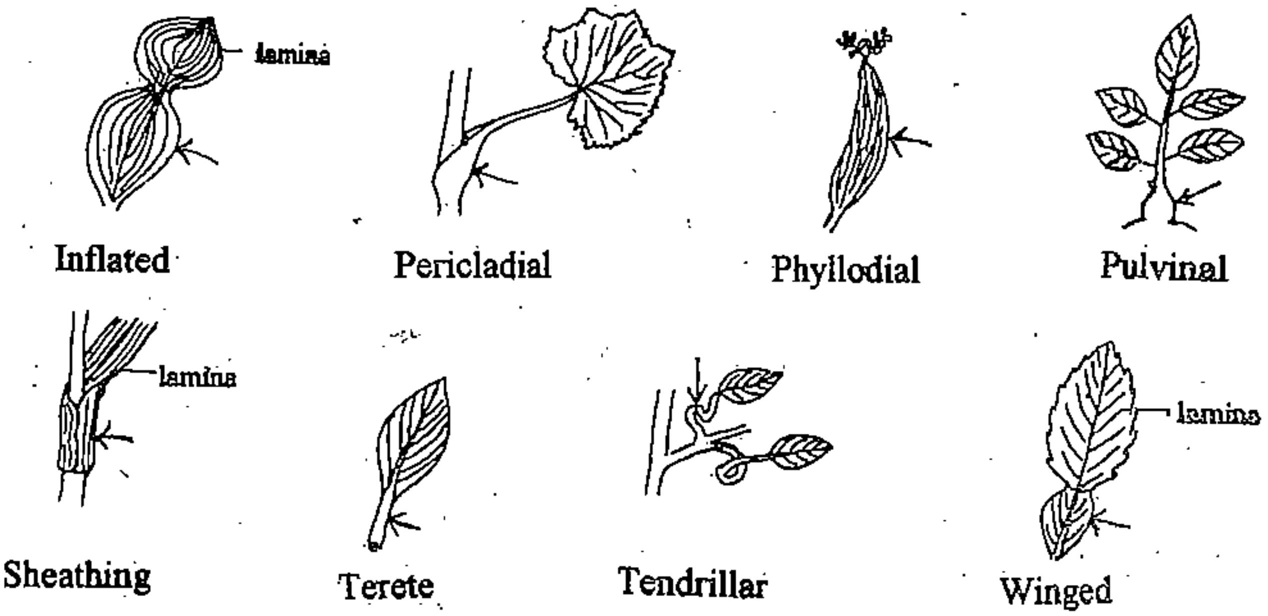
Pericladial : with a sheathing base, as in Apiaceae
Phyllodial : flattened and lamina-like; leaf-like
Pulvinal / Pulvinus : with swollen base, as in Fabaceae

Sheathing : flattened and encloses stem

Tendrillar : tendril-like, as in *Clematis*
Terete : cylindrical

Winged : with margins flattened and lamina-like

Plate – 14: Different types of Petiole and petiolule.



Additional terms and figures

B. Fruit Types (Plate – 38)

Accessory / Pseudocarp / False : fruit derived from simple or compound ovary surrounded by some closely adpressed non-ovarian tissues such as calyx, hypanthium, and bracts.
- Hip / Cynarrhodion : an aggregation of achenes surrounded by an urceolate receptacle or hypathium, as in Rosaceae
- Pome : fruit with cartilaginous pericarp surrounded by fleshy receptacle, as in *Malus*
- Pseudocarp : an aggregation of achenes embedded in a fleshy receptacle, as in strawberry
- Sorosis : multiple fruit derived from an aggregation of fruits of individual flowers along with the fleshy perianth and fleshy or woody peduncle, as in pineapple, jack-fruit and mulberry
- Syconus / Syconium : multiple fruits surrounded by a hollow, fleshy, pear-shaped receptacle, as in *Ficus*

Aggregate : a collection of simple fruits developed from separate carpels of a single flower
- Etaerio of achenes / Achenecetum : an aggregation of achenes
- Etaerio of berries / Baccacetum : an aggregation of berries
- Etaerio of drupes / Drupecetum : an aggregation of drupelets
- Etaerio of follicles / Follicetum : an aggregation of follicles
- Etaerio of samaras / Samaracetum : an aggregation of samaras

Multiple / Composite : derived from coalesced ovaries of several flowers on an inflorescence axis
- Sorosis : fused fruits on a spike or spadix, as in pineapple, mulberry, jack-fruit
- Syconus / Syconium : an aggregation of achenes in a hypanthodium, as in *Ficus*

Additional terms

2.1 GENERAL TERMS

A- : a prefix meaning without, as in asepalous (without sepals)
Abaxial / Dorsal : side of an organ away from the axis or center of axis, lower surface
Abortive : defective, imperfectly developed
Acropetal : arising or developing upward in a longitudinal plane from a lower to a more apical position; the opposite of basipetal
Acyclic : arranged spirally, not whorled
Adaxial / Ventral : side towards the axis, or adjacent to axis, upper surface
Adherent : close proximity of dissimilar organs without fusion of tissues or histological continuity
Adnate : fusion, with histological continuity, of dissimilar organs
Aerial or epigeal : above ground or water, in air
Aestivation / Vernation : arrangement of leaves or perianth parts with respect to each other in a bud
Albumen : nutritive material accompanying the embryo (e.g., endosperm in seed)
Anthesis : flowering; opening of flower for pollination
Anthotaxis : arrangement of sporophylls
Apex (pl. apices) : the tip or distal end
Aphyllous : leafless
Apical / Terminal : at the top, tip, or distal end of a structure
Appendage : an attached, subsidiary or additional part
Arborescent : tree-like in appearance and in size
Articulate : jointed; with nodes or joints
Attenuate : tapering gradually to a slender tip
Awn / Arista : a bristle-like appendage
Axil : upper angle area formed between the organ and the axis that bears it
Axillary : pertaining to or situated in the axil

Basal : at the bottom or base of a structure
Basicaulus : near the base of stem
Basipetal : developing downward in a longitudinal plane from an apical or distal point towards the base
Bi- : a prefix meaning two or twice, as in bilobed or two-lobed
Bifid : two-clefted or divided apically into two parts
Bifurcate : divided into two forks or branches
Biseriate : in two rows, series or whorls
Bladdery : thin-walled and inflated
Bloom : whitish easily rubbed off powdery covering on a surface
Bristle : short, stiff trichome or hair

Caducous: falling off early or prematurely
Calciform/calyculate : calyx-like
Canaliculate : with a longitudinal channel or groove
Cauline : belonging to main conspicuous stem
Cell : locule or cavity in an organ (this does not refer to the cell – the unit of life)
Centrifugal : developing or progressing from center to periphery
Centripetal : developing or progressing from periphery to center
Circinate : coiled from apex downwards
Coalesced : with like or unlike parts or organs incompletely separated; partially fused in more or less irregular fashion

G. Leaf Apices (Plate – 16)

Acuminate : with a small, tapered protrusion of angle less than 45°
Acute : with a sharp protrusion of angle between 45-90°
Aristate : with a much elongated, narrow protrusion, usually a straight and stiff awn or bristle

Caudate : with a long, tail-like protrusion
Cirrhose / Cirrhous : with a slender, coiled and flexuous protrusion; tendrillar
Cuspidate : with an abruptly elongated, sharp, stiff and coriaceous protrusion

Emarginate : shallow notch in the middle of a broad apex

Mucronate : obtuse with short, sharp, abrupt spur or spiny protrusion

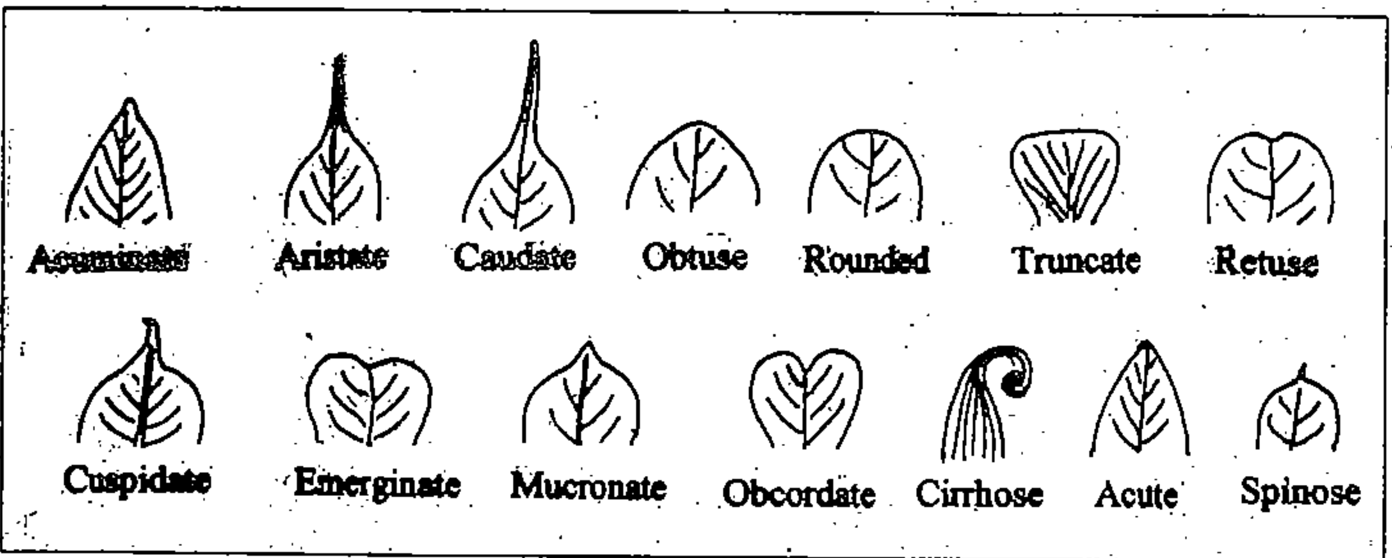
Obcordate : notched with rounded lobes on both sides
Obtuse : blunt or rounded with a terminal angle of more than 90°

Retuse : obtuse or truncated apex with a shallow notch in the middle
Rounded : apex forms a smooth arc

Spinose / Pungent : spine-tipped; coriaceous and stiff acuminate apex

Truncate : straight across, at right angles to midrib or midvein

Plate – 16: Different types of leaf apices.



Additional terms and figures

H. Leaf Bases (Plate – 17)

Amplexicaul : basal lobes completely clasp the stem
Auriculate / Auricled : with ear-shaped lobes projecting on both sides

Connate / Connate-perfoliate : bases of opposite leaves fused around the stem
Cordate : deeply invaginated; with rounded lobes
Cuneate : wedge-shaped; triangular, with narrow end at point of attachment

Decurrent : extending along the stem downward from leaf base

Hastate : with two basal lobes oriented outward or divergently in relation to petiole or midrib

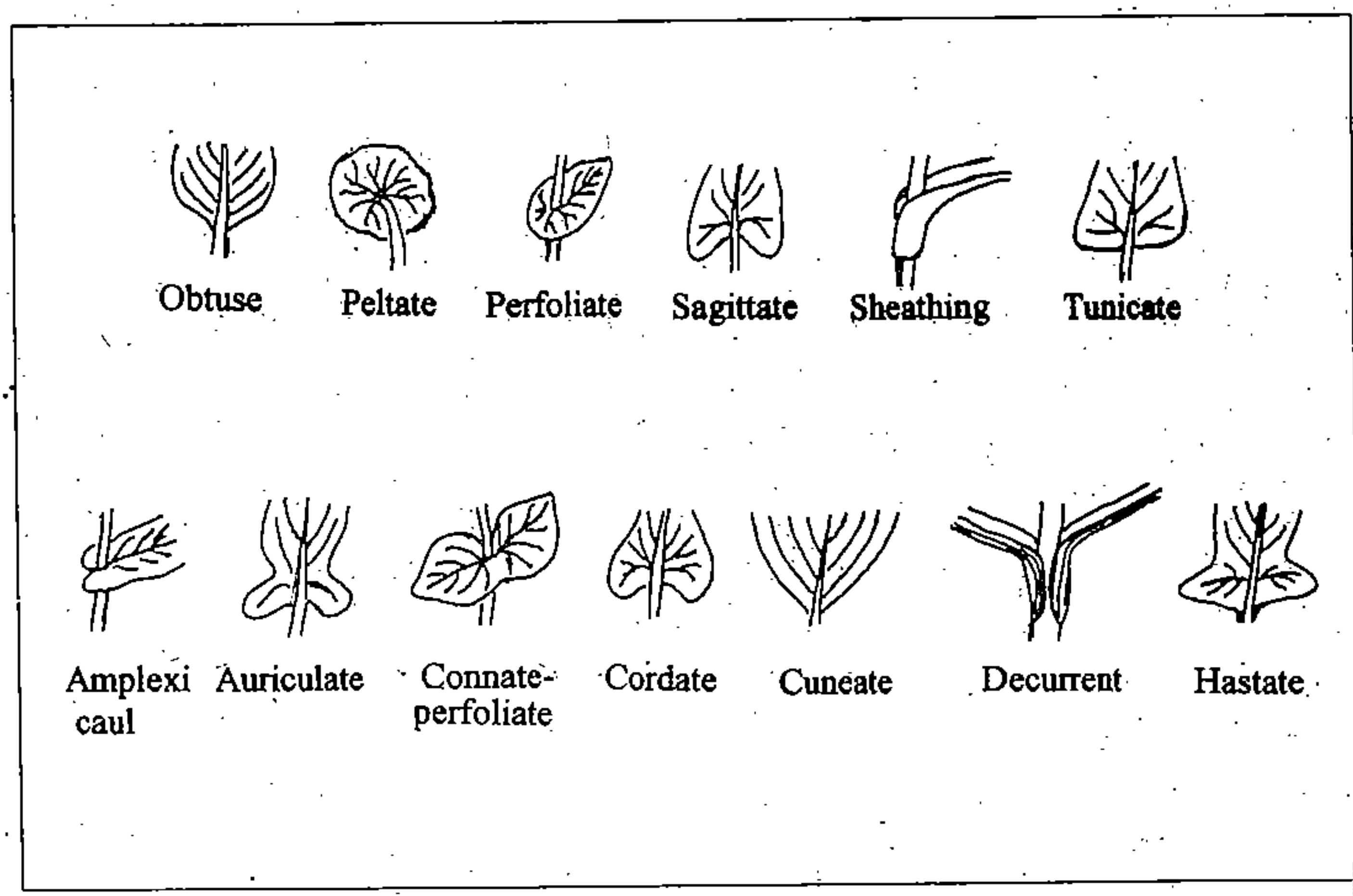
Obtuse : blunt and rounded

Peltate : base near center of lamina; petiole attached on the underside of lamina
Perfoliate : basal lobes fused and completely surround the stem

Sagittate : two basal lobes pointing down or concavely toward the stalk
Sheathing : tube-like, enclosing the stem above insertion of lamina or petiole

Tunicate : straight across, at right angles to midrib or midvein

Plate – 17: Various kinds of leaf bases.



Jointed : with nodes; with points of real or apparent articulation
Jugum : a pair, as of leaflets

Keeled : ridged like the bottom of a boat

Lacerate : torn; irregularly cleft or cut
Laciniate : slashed into narrow pointed and parallel ribbon-like or strap-like projections
Lactiferous : producing or bearing latex
Lacuna : a cavity, hole, or gap
Lamellate : provided with many fin-like blades or cross-partitions
Lateral : on or at the side
Latex : milky sap
Lax : loose, not congested
Leptosporangiate : type of sporangium development where the sporangium forms from one initial cell
Lineate : lined, bearing thin parallel lines
Lobe : any part or segment of an organ
Locule / Loculus (pl. Locules / Loculi) : a compartment or cavity

Marcescent : withering but the remains persisting
Marginal : pertaining to the border or edge
Medial : upon or along the longitudinal axis
Megaspore : the spore which on germination gives rise to female gametophyte from which develops female gamete or the egg cell
Megasporophyll : a sporophyll that bears megasporangia, often produced in the axil of a bract; a carpel in an angiosperm
Meristem : undifferentiated tissue whose cells are capable of developing into various organs or tissues
-merous : a suffix indicating the number of parts in a whorl of stems, leaves or floral organs, as a tri-merous flower having perianth parts in sets of three
Microsporangium : sporangium containing only microspores
Microspore : the spore which on germination gives rise to male gametophyte from which differentiate the male gamete or sperm cell
Mono- : a prefix meaning one or once, as in monocyclic (one whorled)
Mucilage : sticky and slimy substance produced by glandular cells in plant tissues
Multi- : a prefix meaning several or many, as in multicellular (many-celled)

Nectary : a secretory gland producing sugary liquid that attracts pollinators
- Floral : present in the flower
- Extra-floral : present in organs of plant other than the flower, as in leaf, bract

Nodose : knobby; knotty

Ob- : a prefix usually signifying inversion, as in obovate (inverted ovate)
Oligo- : a prefix signifying few, as in oligospermous (few seeded)
Operculum : a lid or cover produced by circumscissile dehiscence
Ortho- : a prefix indicating straight
Ovuliferous : bearing ovules

J. Leaf Venations (Plate – 19)

Dichotomous : with veins branching in pairs equally

Multicostate : with more than one primary vein arising from a common point at base

Parallel : with veins extending from base to apex, unbranched and essentially parallel

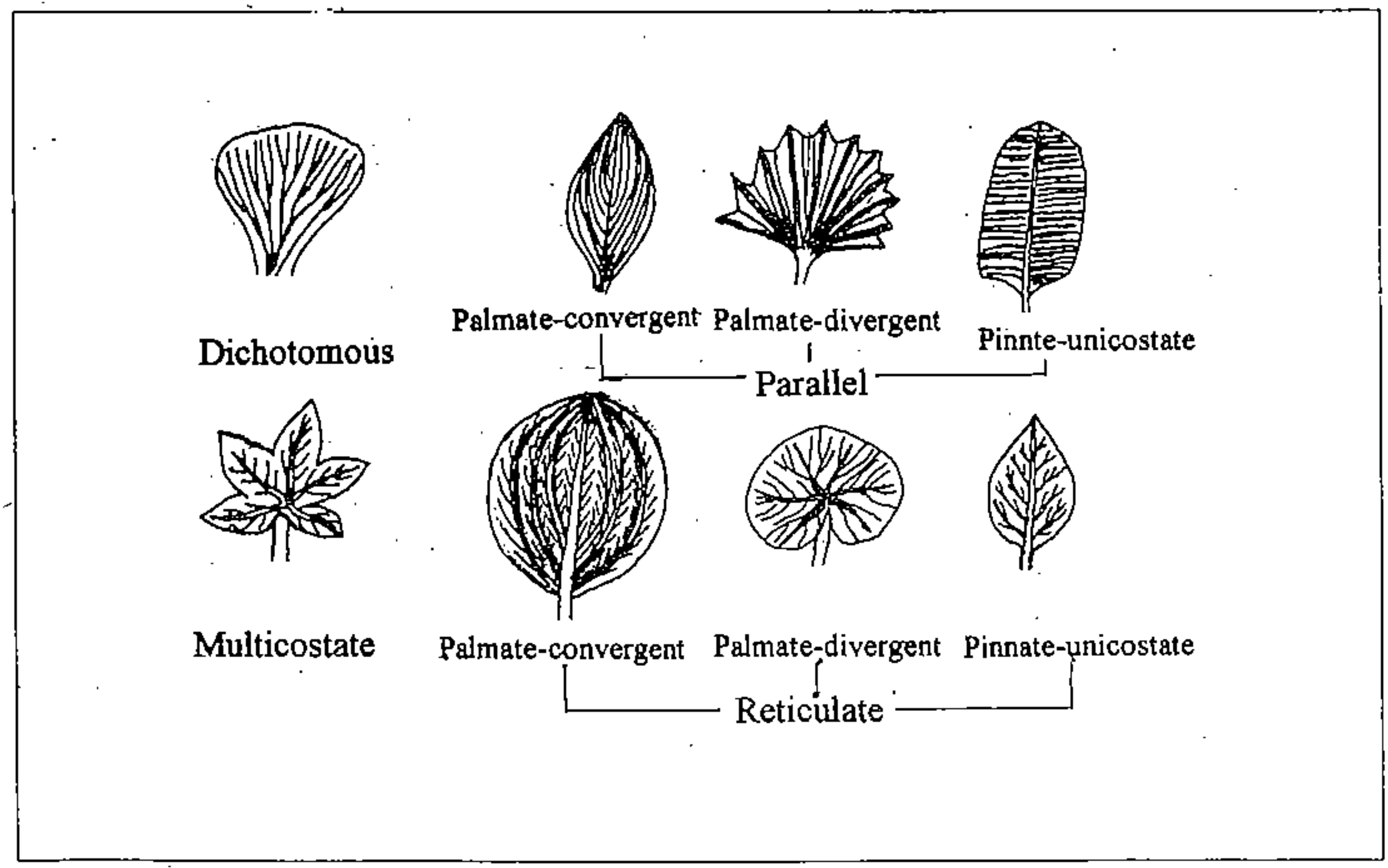
- Palmate-parallel-convergent : parallel veins diverge from the base but converge at apex, as in grasses
- Palmate-parallel-divergent : parallel veins diverge from the base and remain divergent, as in *Borassus*
- Pinnate-parallel / Penni-parallel / Penni-nerved : unicostate with veins extending from midrib to margins, essentially parallel, as in banana

Reticulate : with veins branching and anastomosing to form a network

- Palmate-reticulate-convergent : multicostate with main veins converging at tip, secondary veins forming a network, as in *Zizyphus*
- Palmate-reticulate-divergent : multicostate with main veins diverging toward margins, secondary veins forming a network, as in cotton, grapes
- Pinnate-reticulate : unicostate with secondary veins arising from the midrib and forming a network

Unicostate : with only one primary vein or midrib

Plate – 19: Types of leaf venation.



2.6.6 The Inflorescence

A. General Terms Related to Flowering, Inflorescence and Flower

Aestival : flowering in summer
Aianthous / Semperflorous : flowering throughout the year
Annotinal : flowering once in a year
Autumnal : flowering in autumn

Cauliflory / Cladanthy : inflorescence arising directly from the surface of old stems

Dichogamy : maturation of stamens or anthers and carpels or stigma at different times
- Protandry : stamens or anthers maturing before carpels or stigma
- Protogyny : carpels or stigma maturing before stamens or anthers

Diurnal : flowers opening during the day

Heterogamous : inflorescence with flowers of different sexes
Heteromorphic : inflorescence with flowers of different morphological forms and functions, as in capitula of some Compositae
Hibernal / Hiemal : flowering in winter
Homogamous : with maturation of stamens or anther and carpels or stigma at the same time; in some Compositae, inflorescence with flowers of same morphological form and function
Homomorphic : inflorescence with flowers of same morphological form

Pseudanthium : cluster of several flowers appearing as a single flower, as capitulum of Compositae

Resupination : the complete inversion of flower by the torsion of its support such that the anterior part of flower becomes apparently posterior, and vice-versa

Seasonal : flowering during a particular season or during each season
Secund : with flowers arranged on one side of axis

Vernal : flowering in spring

Additional terms and figures

B: Inflorescence Parts (Plate – 20)

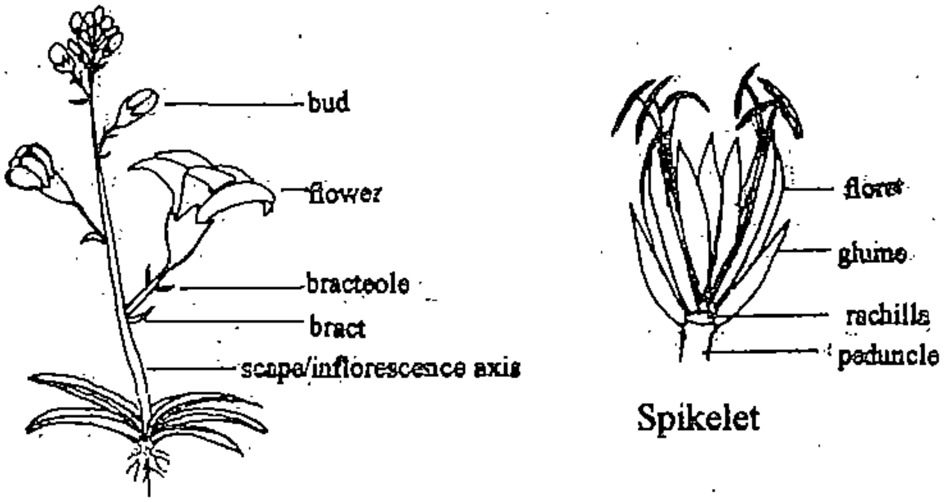
Floret : a small flower, usually one of a dense cluster
Flower : modified reproductive shoot of angiosperms

Inflorescence axis / Peduncle: main stalk for entire inflorescence

Rachilla : central axis of a grass or sedge spikelet
Ray : secondary axis in a compound inflorescence, as branch of a compound umbel

Scape : leafless inflorescence axis

Plate – 20: Parts of inflorescence.



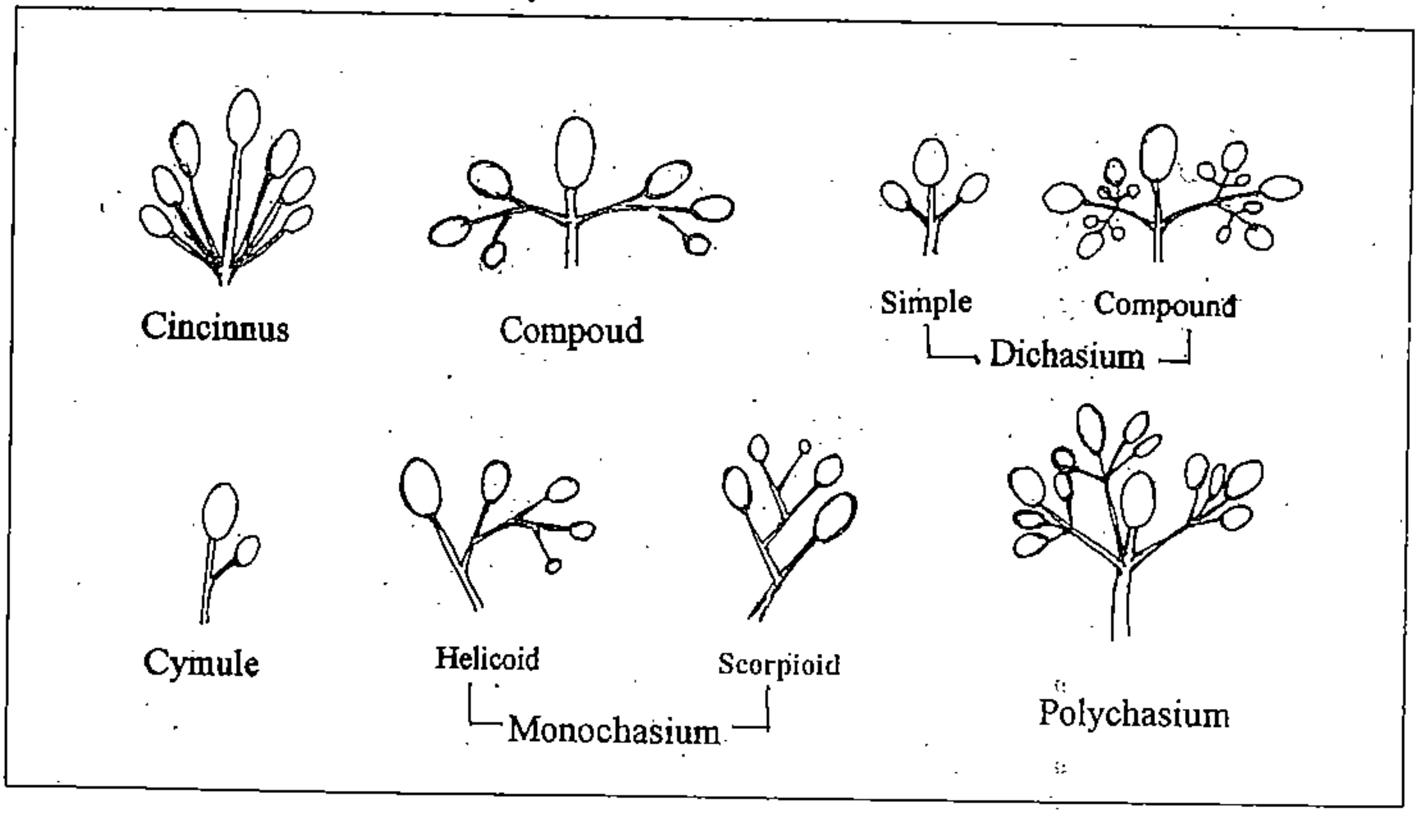
Additional terms and figures

C. Inflorescence Types (Plate – 21)

Cymose / Determinate : sympodial branching; inflorescence axis ends in a flower, with younger, lateral axis or axes developing below the flower; flowers develop in basipetal succession

- Cincinnus : a dichasial cyme in which each branch is a tight, modified monochasial cyme with flowers having short pedicels
- Compound cyme : a branched cyme
- Cymule : a diminutive of cyme, usually few flowered
- Dichasium / Biparous : a cymose inflorescence with two lateral flowers developing below the central flower at each stage of branching
- Monochasium / Uniparous : a cymose inflorescence with only one lateral flower developing at each stage of branching
    - Helicoid cyme : a monochasium with all flowers developing only on one side of axis, forming a helix
    - Scorpioid cyme : a monochasium with successive lateral flowers developing alternately on opposite sides below the central flower
- Polychasium / Pleiochasium / Multiparous : a cymose inflorescence with more than two lateral flowers developing at each stage of branching
- Simple cyme : a cyme with only one stage of branching

Plate – 21: Types of Inflorescence – Cymose.



Additional terms and figures

C. Inflorescence Types (*Cont.*) (Plate – 22)

Racemose / Indeterminate : monopodial branching; main inflorescence axis grows indefinitely and gives off flowers laterally in acropetal succession, i.e., lower and outer flowers are older than the upper and inner flowers

- Corymb : a flat-topped raceme where extra elongation of the lower flower stalks raise the flowers of whole inflorescence to a common level at the top
  - Compound : with branched inflorescence axis
  - Simple : with single, unbranched inflorescence axis
- Panicle : a branched raceme
- Raceme : an unbranched recemose inflorescence with pedicelled flowers
- Spadix : a spike with elongated and sometimes fleshy inflorescence axis, subtended by a spathe

Spike : a recemose inflorescence of sessile flowers

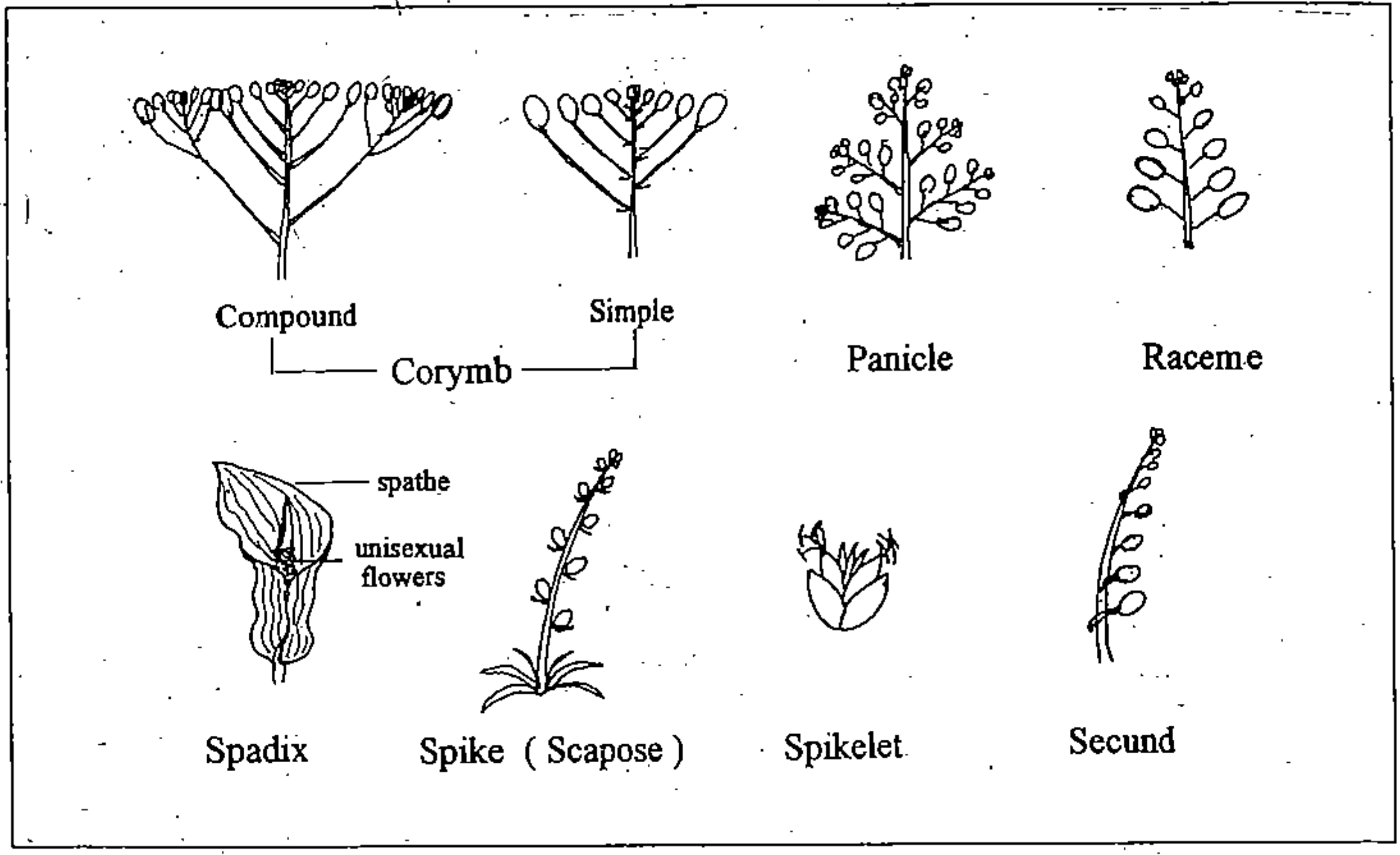
Spikelet / Locusta : a small, few flowered, spike

Scapose : with a solitary flower or inflorescence on a scape

Secund : inflorescence with flowers appearing to be borne from only one side

Solitary : one-flowered; not a cluster of flowers

Plate – 22: Types of Inflorescence – Racemose.



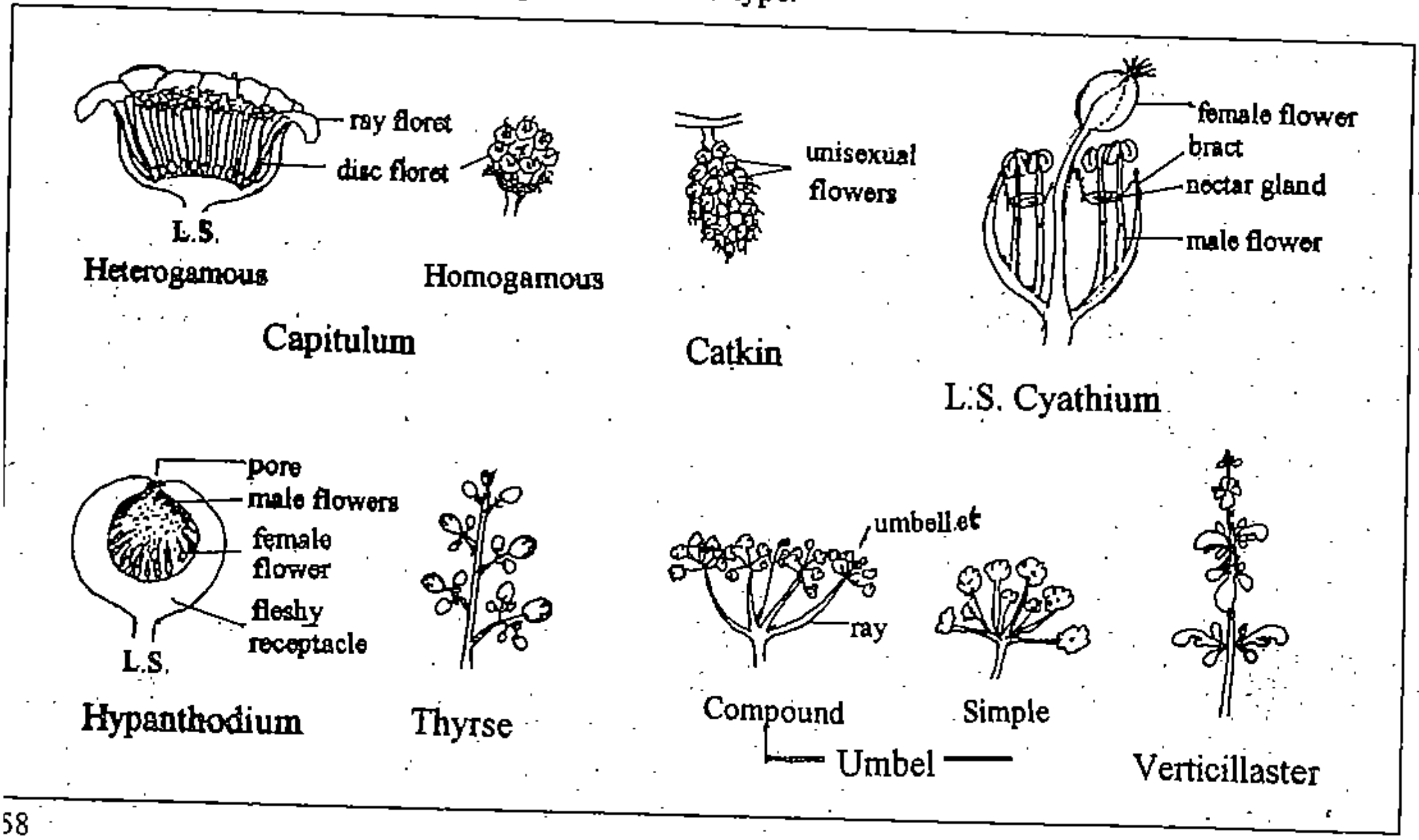
Additional terms and figures

C. Inflorescence Types (*Cont.*) (Plate – 23)

Special or Mixed Type

- Capitulum / Head : a crowded group of sessile or subsessile flowers in racemose or cymose arrangement on a compound receptacle or torus
  - Heterogamous : with flowers of different sexes
  - Homogamous : with flowers of same morphological form and function
- Catkin / Ament : a spike or spike-like inflorescence of cymules with unisexual flowers
- Cyathium : a special type of cymose inflorescence with several highly reduced unisexual flowers clustered within a cup-shaped involucre, often with petaloid glands. Male flowers reduced to single stamens are generally present in cymose clusters opposite each bract, and a single female flower reduced to a pistil present in the center of the cup
- Hypanthodium : a special type of inflorescence with flowers (generally unisexual) borne on inner side of a hollow, fleshy, pear-shaped receptacle with a narrow apical opening guarded by scales
- Thyrse (pl. Thyrsus) : a mixed inflorescence with an indeterminate central axis and many lateral cymes
- Umbel : a recemose or cymose inflorescence with flowers arising from a common point forming a flat or rounded cluster
  - Compound : a branched umbel; an umbel with primary rays arising at a common point with secondary umbel arising from the tip of the primary rays
  - Simple : unbranched with one cluster of flowers
  - Umbellet : the secondary umbel in a compound umbel
- Verticillaster : a mixed inflorescence with paired and sessile dichasia at each node of an indeterminate, elongated main axis

Plate – 23: Types of Inflorescence – Special or mixed type.



D. Inflorescence Positions. (Plate – 24)

Axillary : in the axil of leaf

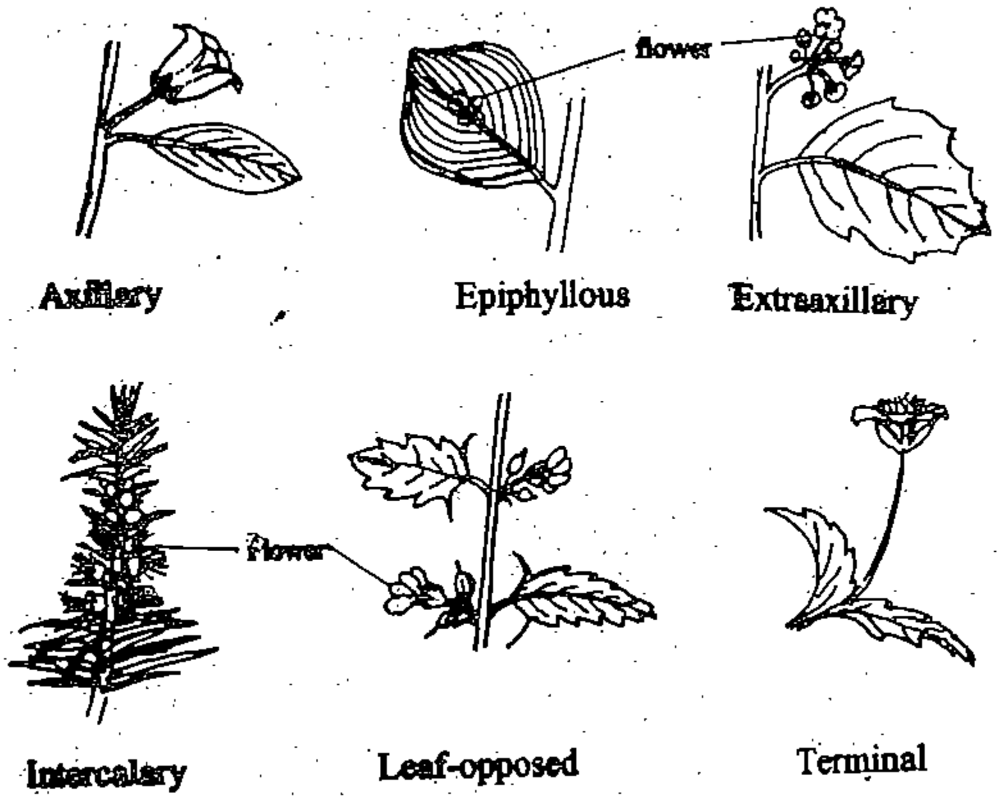
Epiphyllous : on a phylloclad or bract
Extra-axillary : emerges from the internode above the axil of leaf, as in *Solanum*

Intercalary : between leafy or vegetative regions of an axis

Leaf-opposed : on stem opposite the base of leaf, as in *Corchorous*

Terminal : at or near tip of branch

Plate – 24: Various positions of inflorescence.



Additional terms and figures

2.6.7 The Flower (Plate – 25)

A. Flower Parts (Plate – 25)

Accessory organs / semaphylls : the sepals and petals or the tepals
Androecium : a collective term for all the stamens in a flower
Androgynophore / Gynandrophore : the elongated internode above the perianth, bearing the stamens and pistil
Androphore : the elongated internode above the perianth, bearing the stamens
Anterior : part of flower away from the mother axis; towards the subtending bract; abaxial
Anthophore : elongated internode between calyx and corolla

Bract : modified, usually reduced, leaf in the axil of which one or more flowers arise
Bracteole / Bractlet / Prophyll / Prophyllum : a secondary or smaller bract on the pedicel or below perianth

Calyx (pl. calyces) : the outer whorl of floral envelopes or perianth, composed of sepals, a collective term for sepals
Carpel : female sporophyll within flower; floral organ that bears ovules in angiosperms; a unit of gynoecium; a simple pistil or part of a compound pistil
Column / Gynostemium / Gynandrium : rod-like structure formed by fusion of stamens, stigma and style, as in Orchidaceae
Corolla : the inner whorl of floral envelopes (above calyx), composed of petals; a collective term for petals

Disc / Disk : a discoid structure developed from receptacle or stamens below ovary

Essential organs : the androecium and gynoecium

Floral envelope : envelop of accessory organs present around the sporophyll usually these are the calyx or corolla

Gynoecium : a collective term for carpels or female sporophylls in the flower; comprised of a single carpel of a simple pistil, a group of separate carpels, or fused carpels forming a compound pistil
Gynophore : the elongated internode between the androecium and gynoecium
Gynostegium : disc-like structure formed by fusion of stamens, stigma and style, as in Asclepiadaceae

Hypanthium : fused or coalesced basal portion of floral parts (sepals, petals, and stamens); extension of floral axis around ovary bearing the perianth and androecium at its margin; may be cup-shaped, saucer-shaped, tubular or rod-shaped
Mother axis : axis on which flower is borne
Pedicel : stalk of a flower
Perianth / Perigone : collective term for the floral envelopes, corolla and calyx; generally used when the envelops are not distinct; an aggregation of tepals

Pericladium : a sub-floral stalk of compound nature, formed by fusion of gynophore and the bases of other floral parts, found in many members of Liliaceae

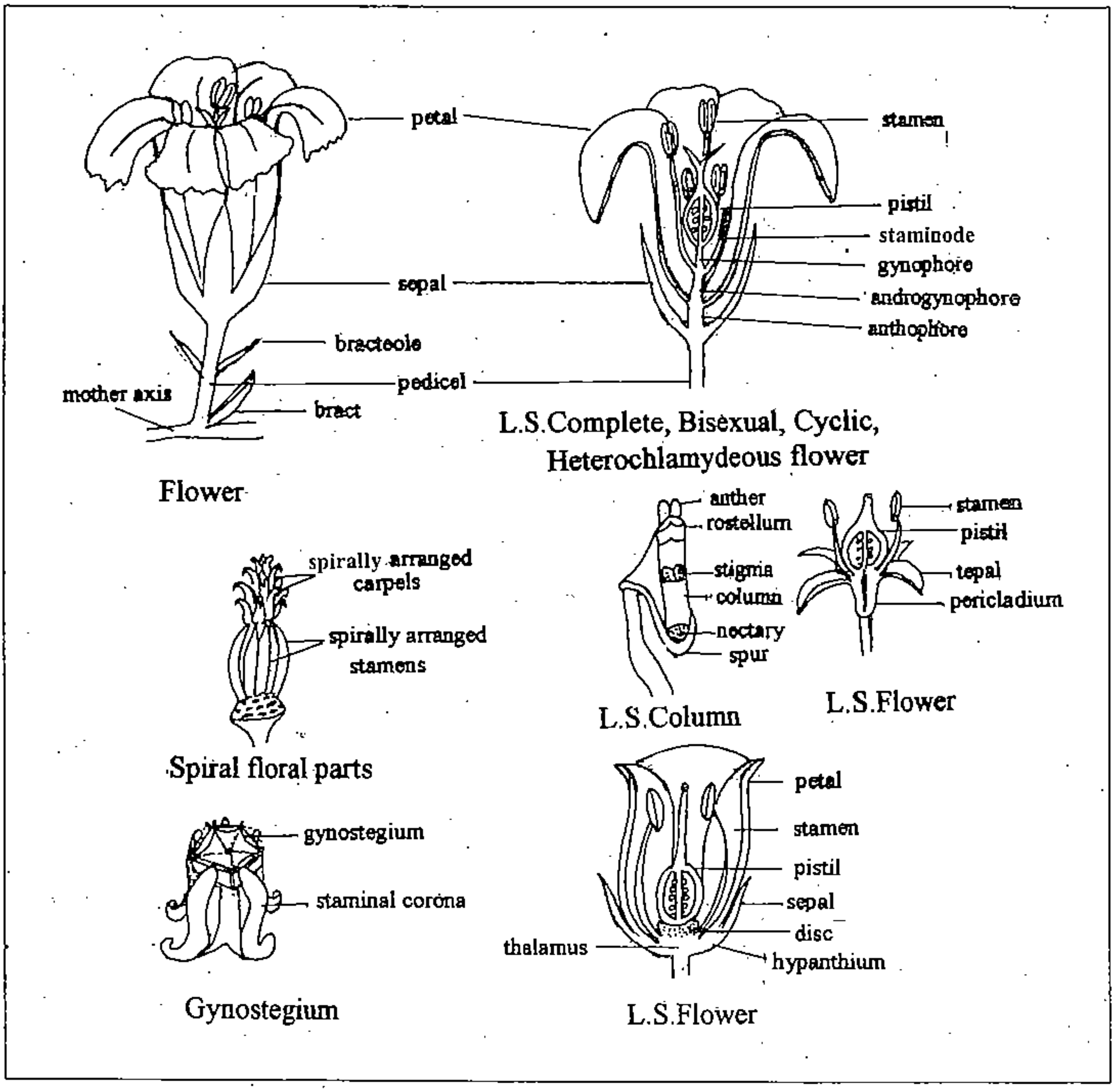
Posterior : the region of the flower next to the mother axis; away from the subtending bract; adaxial

Stamen : the male sporophyll within the flower, bearing pollen; a unit of androecium

Staminode : a rudimentary or vestigial stamen

Thalamus / Receptacle / Torus : the end of the stem or flower axis on which some or all of the flower parts are borne

Plate – 25: Parts of flowers.



B. Flower Types (Plate – 26)

Acarpous : no carpels or carpellate whorl; no pistil
Achlamydeous : without perianth
Acyclic / Haplomorphic : with floral parts arising spirally on the thalamus at a simple level in a semispheric or hemispheric form
Asymmetric / Amorphic / Paleomorphic / Irregular : having perianth without symmetry; usually with an indefinite number of stamens and carpels, and usually subtended by bracts or discolored upper leaves as in *Salix discolor*; sometimes referred to flower without symmetry as in *Canna*

Bisexual / Perfect / Hermaphrodite : with both stamens and carpels or pistils functional
Bracteate : with bract
Bracteolate : with bracteoles

Chasmogamous : flowers that open or expose their reproductive organs for pollination and fertilization
Chlamydeous : with perianth
Cleistogamous : flowers that do not open for pollination; remain closed throughout
Complete : with all the floral organs, i.e., with sepals, petals, stamens and carpels
Cyclic : with floral parts arising in whorls or circles on the thalamus

Dichlamydeous : with perianth composed of two envelopes
- Heterochlamydeous : with the two envelopes distinguishable into calyx and corolla
- Homochlamydeous : with the two envelopes of similar parts, not distinguishable into calyx and corolla, each part called a tepal

Ebracteate : without bract
Ebracteolate : without bracteole
Epigynous : with perianth and androecial parts inserted above ovary, ovary inferior

Hemicyclic / Spirocyclic : with some floral parts arising spirally and others in circles
Heteromerous / Anisomerous : with different floral envelopes consisting of different number of members
Hypogynous : with perianth and androecial parts attached below the ovary, ovary superior

Incomplete : with one or both the accessory organs absent but possessing two essential organs

Monochlamydeous / Haplochlamydeous : with only one perianth envelope

Neuter / Agamous / Sterile : without stamens and carpels; sex organs abortive

Pedicellate / Pedicillate : with pedicel
Pentamerous : with each perianth envelope composed of five members

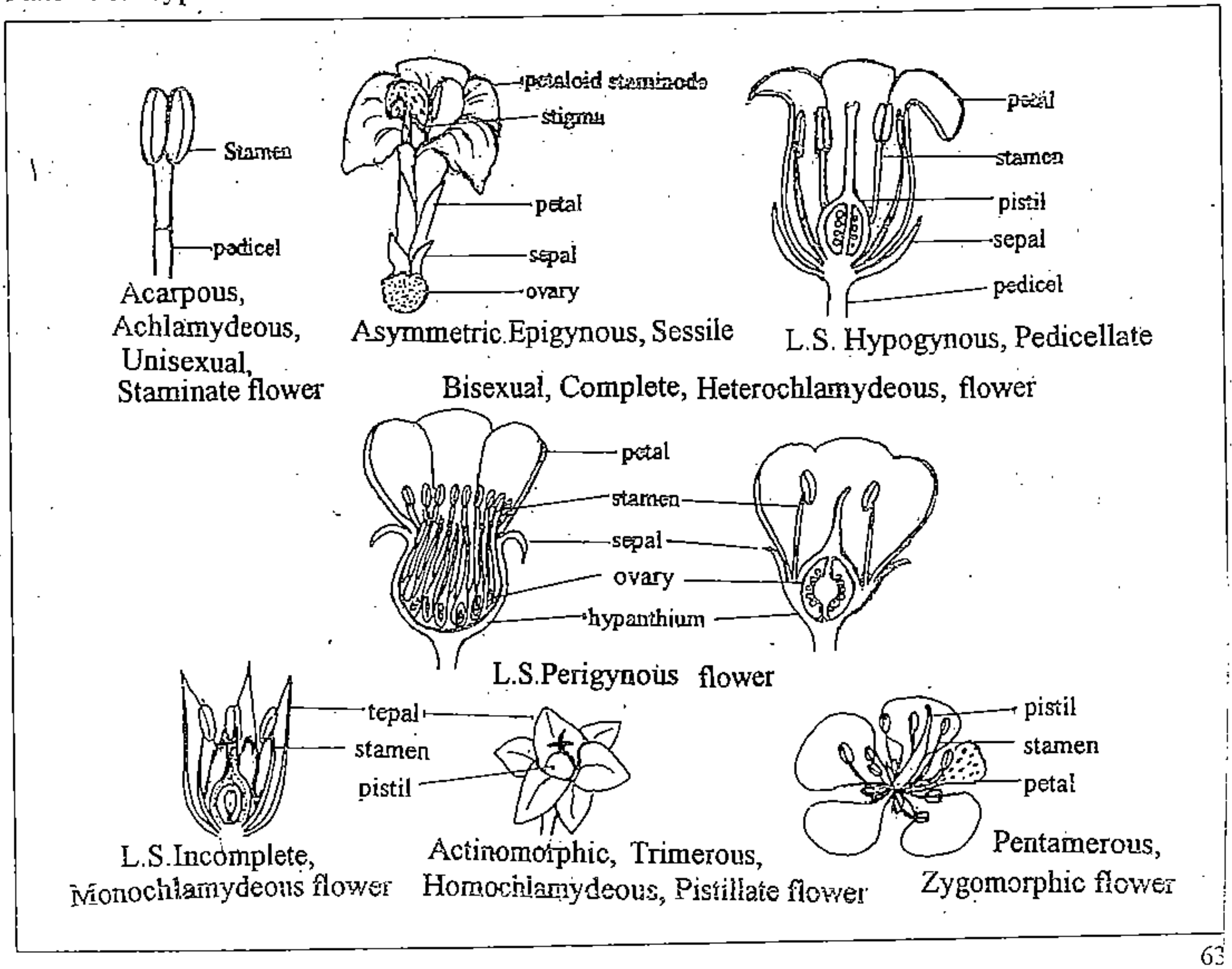
Perigynous : with perianth and androecial parts inserted on hypanthium around the ovary, hypanthium and ovary may not be united (ovary superior) or may be partially united (ovary semi-inferior)
Polymerous : with each perianth envelope composed of many members
Pseudomonomerous : with each perianth envelope seemingly composed of one member which is a fusion product of two or more parts

Stereomorphic : flowers 3-dimensional with basically radial symmetry; parts many or reduced, and usually regular as in *Narcissus*
Symmetric : with symmetrically arranged perianth parts
- Actinomorphic / Regular : perianth with radial symmetry, i.e., can be cut into equal halves in any plane
- Zygomorphic : perianth with bilateral symmetry, i.e., can be cut into equal halves in only one, vertical, oblique or transverse plane

Tetramerous : with each perianth whorl composed of four members
Trimerous : with each perianth whorl composed of three members

Unisexual / Imperfect : flowers with only stamens or carpels
- Pistillate / Carpellate : with only pistils or carpels
- Staminate : with only stamens

Plate – 26: Types of flowers.



C. Bract and Bracteole Types (Plate – 27)

Chaff / Pale : scale or bract at base of tubular flower in members of Compositae
Cymba : a woody, durable, boat-like, persistent spathe

Epicalyx / Calycle / Calyculus : a whorl of bracteoles below calyx but resembling true calyx

Foliaceous : leaf-like

Glume : bract, usually occurring in pairs, at the base of the spikelet of grass

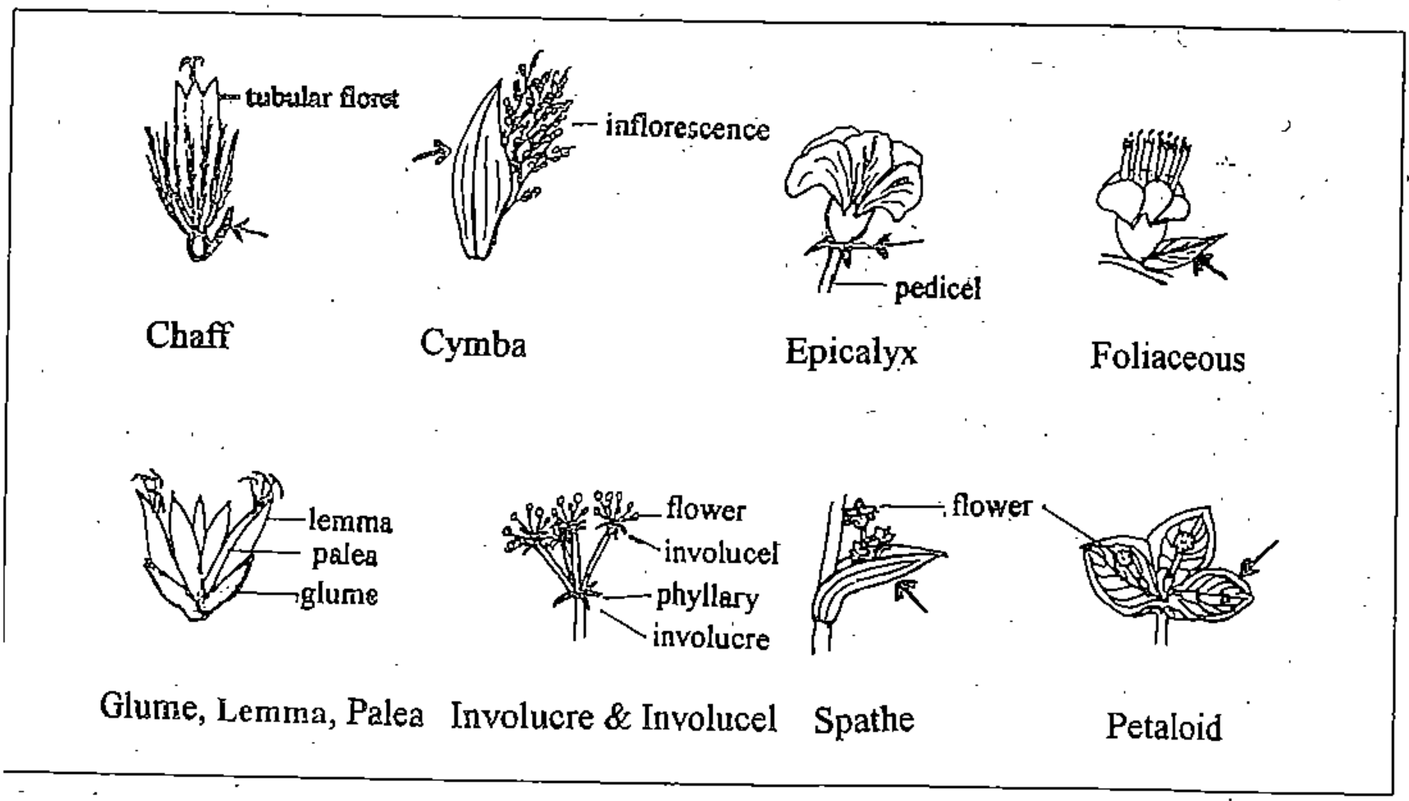
Involucel : small or secondary involucre
Involucre : a group or cluster of bracts subtending an inflorescence

Lemma : outer scale or the fertile bract subtending grass floret

Palea : inner scale or bracteole subtending grass floret
Petaloid : coloured and petal-like
Phyllary : individual bract of an involucre

Scaly : scale-like
Spathe : a large sheathing bract enclosing an inflorescence

Plate – 27: Types of bracts and bracteoles.



Additional terms and figures

D. Perianth Parts (Plate – 28)

Claw : the long narrow petiole-like base of a sepal, petal or tepal
Corona : a crown; an outgrowth of petal between stamens and corolla; can also be of staminal origin

Hood : a cover-like perianth part, usually with a turned down margin

Keel / Carina : a projecting central longitudinal line or ridge, as in the bottom of a boat, the two united petals of a Papilionaceous flower

Labellum / Lip : one of the two parts of a divided corolla or calyx
Limb : expanded portion of corolla or calyx above the tube, throat or claw
Lobe : any, usually rounded, segment or part of the perianth
Lodicule : hyaline, scale-like, abortive perianth part at the base of ovary in family Poaceae, functions to push apart lemma and palea

Palate : raised area or rounded prominence in the throat of sympetalous, especially personate, corolla
Petal : a corolla member or segment; a unit of corolla

Sepal : a calyx member or segment; a unit of calyx; usually green and foliaceous
Spur : a tubular or pointed projection from the perianth
Standard / Banner / Vexillum : the upper usually wide petal in a Papilionaceous corolla

Tepal : a perianth member or segment; generally used for perianth parts undifferentiated into distinct sepals and petals
Throat / Mouth : open, expanded part of the fused perianth tube
Tube : the cylindrical part of the perianth

Wing / Alate : lateral petal in a Papilionaceous corolla; appendage or projection from a perianth part

Additional terms

E. Perianth Types (Plate – 28)

Biseriate : consisting of both calyx and corolla

Caducous : fall-off early
Calcarate / Spurred : with spur
Carinate : keeled
Coronate : with tubular or flaring outgrowth; petaloid appendage

Deciduous : falls at maturity

Gamopetalous / Sympetalous / Synpetalous / Monopetalous : with fused or united petals of various forms
- Bilabiate : two-lipped
- Campanulate : bell-shaped; with flaring tube and limb
- Cucullate : Hooded
- Gibbous : Inflated on one side near the base, as in snapdragon
- Infundibular : Funnel-shaped
- Ligulate / Ray : Strap-shaped
- Operculate : fused petals forming a cap-like structure or operculum, adnate to calyptra, which falls off at anthesis, as in *Eucalyptus*
- Personate : two-lipped with the upper one arched, and with a projection; the palate, from the lower lip protruding into and almost closing the corolla throat
- Rotate : wheel-shaped, with a short tube and a wide limb at right angles to tube
- Saccate : pouch-like
- Salverform / Hypocrateriform : Trumpet-shaped, with long slender tube and limb nearly at right angles to tube
- Tubular : cylindrical; tube-like
- Urceolate : corolla tube urn-shaped

Gamophyllous : with fused or united tepals (exhibits gamopetalous or gamosepalous forms)
Gamosepalous / Symsepalous / Synsepalous / Monosepalous : with fused or united sepals of various forms
- Bilabiate : two-lipped
- Calyptrate : sepals fused forming a cap-like structure, the calyptra, which falls off at anthesis, as in some member of Papaveraceae
- Campanulate : bell-shaped
- Clefted : sepals fused to the middle
- Entire : sepals fused completely
- Partite : sepals fused only at the base and free above
- Toothed : sepals almost completely fused , only the tips are free
- Tubular : cylindrical; tube-like

Persistent : remain attached till fruit formation
Petaloid : petal-like sepals or tepals
Polypetalous / Apopetalous / Choripetalous : with separate petals
- Caryophyllaceous : with five free petals having long claws, and limbs of petals placed at right angles to the claws
- Cruciate / Cruciform : four separate petals in cross-form

- Papilionaceous : with large posterior petal (standard), two lateral petals (wings) and usually two connate lower petals (keel); as in Papilionaceae
- Rosaceous : free petals with very short claws, and limbs spread outward

Polyphyllous / Apophyllous / Choriphyllous : with separate tepals
Polysepalous / Aposepalous / Chorisepalous : with separate sepals
- Pappus : bristly, hairy or scaly calyx, common in the Asteraceae
- Spinous : spine-like sepals, as in *Trapa bispinosa*

Sepaloid : sepal-like petals or tepals

Unguiculate : perianth members with limb and claws, claws well-developed
Uniseriate : consisting of one floral envelope, calyx or corolla

Plate – 28: Parts, and types of perianth.

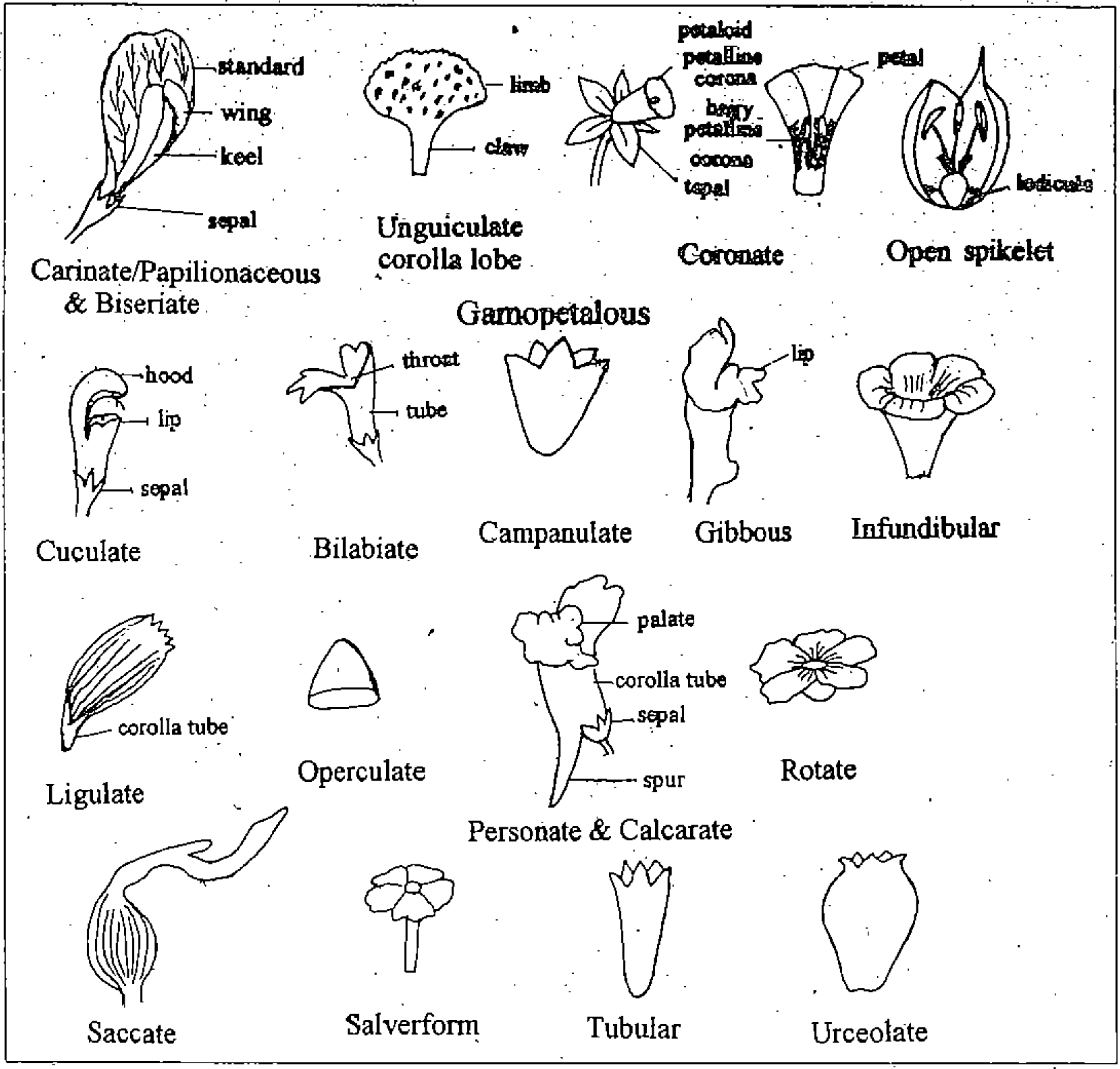
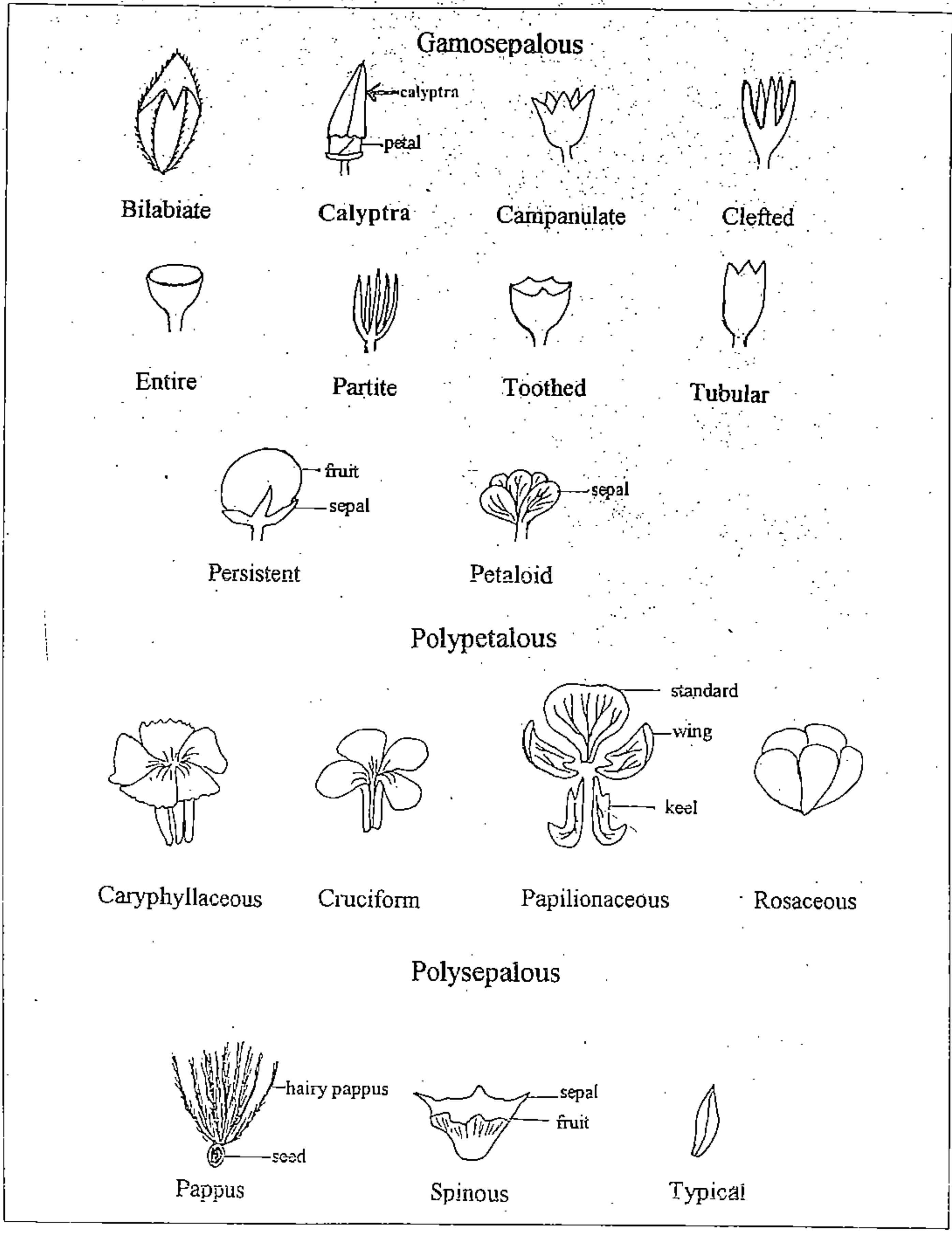


Plate – 28: Parts, and types of perianth (*Cont.*)



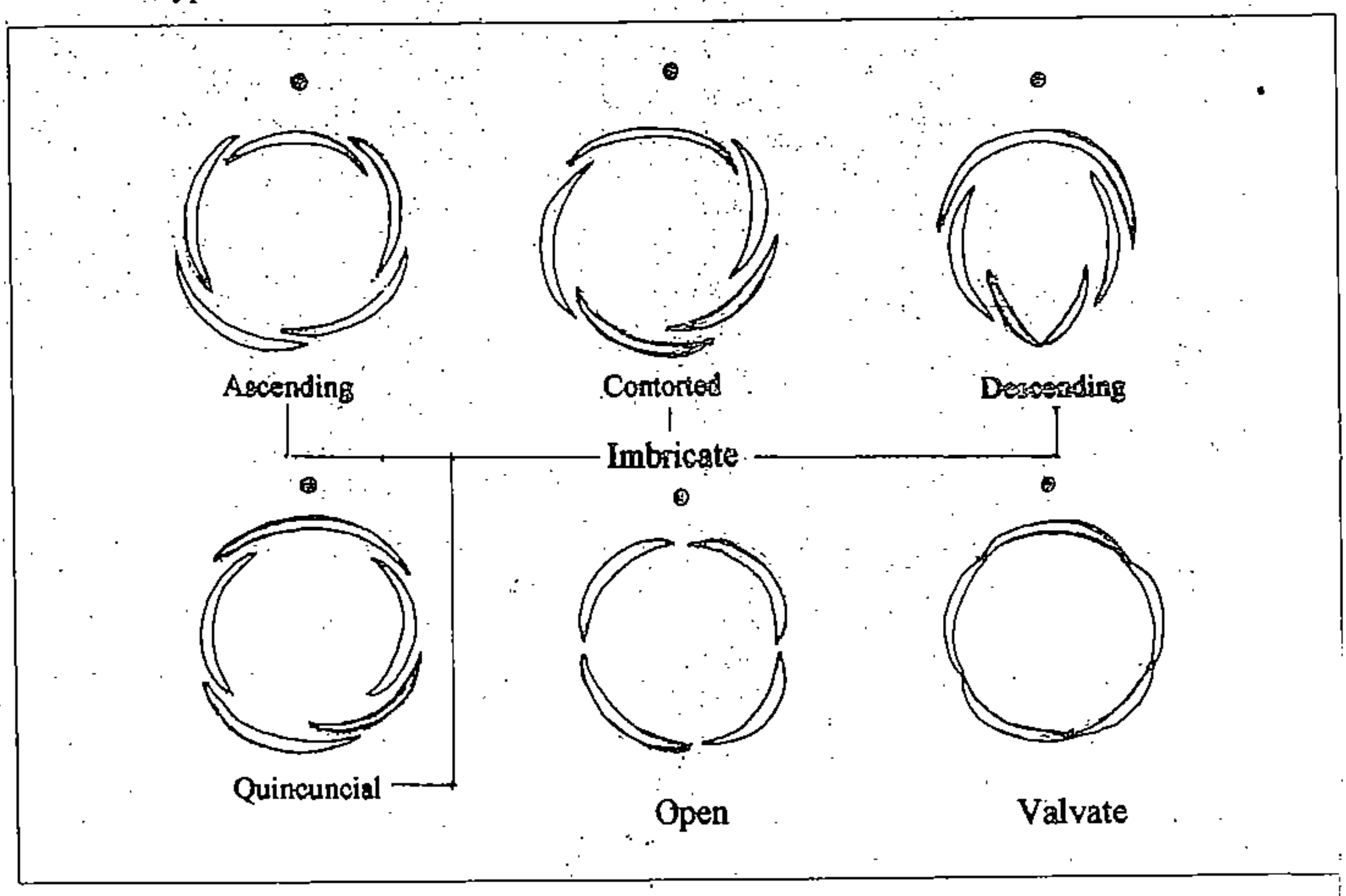
F. Aestivation (Plate – 29)

Imbricate : members with overlapping margins within one whorl
- Ascending : with five members, of which the posterior one is the innermost, three with one margin inside or overlapped and the other outside, and one member outermost without any overlapped margins, as in the Caesalpiniaceae
- Contorted / Twisted / Rotate : with one margin of a member overlapping that of adjacent member
- Descending / Vexillate : with five members, of which the posterior one is the outermost, and anterior two keeled, as in the Papilionaceae
- Quincuncial : with five members, two of which are exterior, two interior, and a fifth with one margin outside and other inside

Open : without overlapping margins within one whorl

Valvate : with margins of adjacent structures touching at edges only

Plate – 29: Types of aestivation.



Additional terms and figures

2.6.8 The Androecium

A. Androecial Parts (Plate – 30)

Corona : a crown; an outgrowth of stamen between the filaments and corolla; can be of petalline origin

Stamen : male sporophyll within the flower; organ that bears pollen in angiosperms; a unit of androecium
Staminode / Staminodium : sterile stamen, may be in a reduced form or modified as nectary or petaloid structure
Staminal disc : a fleshy, elevated cushion formed from coalesced staminodes or nectaries

B. Androecial Types (Plate – 30)

Antipetalous : stamens opposite petals
Antiphyllous : stamens opposite tepals
Antisepalous : stamens opposite sepals
Apostemonous / Free : stamens separate, not united

Diadelphous : stamens connate by their filaments to form two bundles
Didymous : having four stamens in two equal pairs
Didynamous : with four stamens in two pairs of different lengths
Diplostemonous : with stamens in two alternating whorls, outer alternating with the petals

Epipetalous / Petalostemonous : with stamens attached to or inserted upon the petals; filaments partly or wholly fused to corolla, anthers free
Epiphyllous : with stamens attached to or inserted upon tepals ; filaments adnate to tepals, anthers free
Episepalous : with stamens attached to, or inserted upon sepals
Exserted / Phanerantherous : with stamens protruding out of the flower

Gynandrial / Gynosteminal / Gynostegial : with stamens and carpels (style and stigma) fused, as in Orchidaceae and Asclepiadaceae

Haplostemonous : with stamens in one whorl, alternating with petals

Included / Cryptantherous : with stamens present inside the flower, not protruding out

Monadelphous : with stamens in one group connate by their filaments

Obdiplostemonous : with stamens in two alternating whorls, outer opposite petals

Polyadelphous : with several groups of stamens connate by their filaments
Polyandrous : with many stamens
Polystemonous : stamens in more than two whorls

Synandrous : with stamens connate by their filaments as well as anthers
Syngenesious / Synantherous : with stamens coherent by their anthers, filaments free

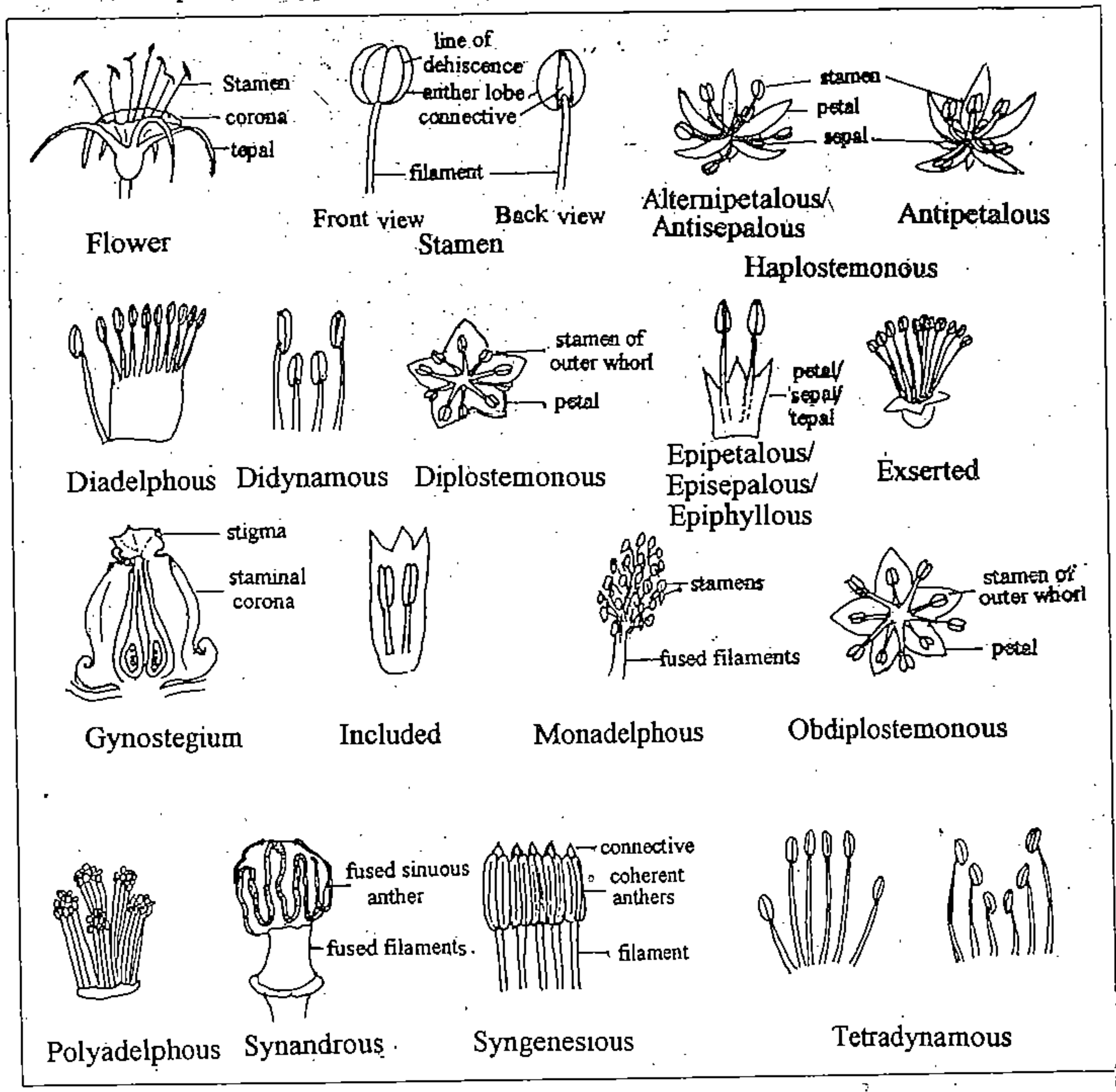
Tetradynamous : with six stamens, four inner longer than the outer two
Tridynamous : with six stamens in two equal groups of three

C. Stamen Parts (Plate – 30)

Anther : part of stamen bearing microsporangium (pl. microsporangia) and pollen

Filament : stalk of stamen

Plate – 30: The parts, and types of androecium.



Additional terms and figures

D. Stamen Types (Plate – 31)

Appendicular / Appendiculate : typical stamen with variously-shaped or modified, protruding connective, as in *Viola*.

Petalantherous : with a terminal anther and distinctly petaloid filament, as in *Saxifraga*

Petaloid : petal-like stamen without distinct anther and filament but with marginal microsporangia as in *Magnolia nitida*

Typical / Filantherous : stamen with distinct anther and filament with or without thecal appendages

E. Anther Parts (Plate – 30)

Caudicle / Retinaculum : thread-like or strap-shaped stalk that forms the lower sterile portion of a pollen mass (pollinium) in the Orchidaceae and Asclepiadaceae

Cell / Lobe : the protruding region of the anther containing the microsporangia, a typical anther has two lobes, with two sporangia in each lobe

Connective : central tissue connecting the microsporangia, to which is attached the filament

Corpusculum : a two-parted gland forming part of translator apparatus in (the Asclepiadaceae)

Locule / Loculus (pl. locules / loculi) : central region of a microsporangium containing reproductive or germ cells

Microsporangium : male sporangium consisting of wall layers (epidermis, endothecium, tapetum, with or without middle layers) and sporogenous cells which differentiate into pollen grains

Microspore : male spore with a single haploid nucleus

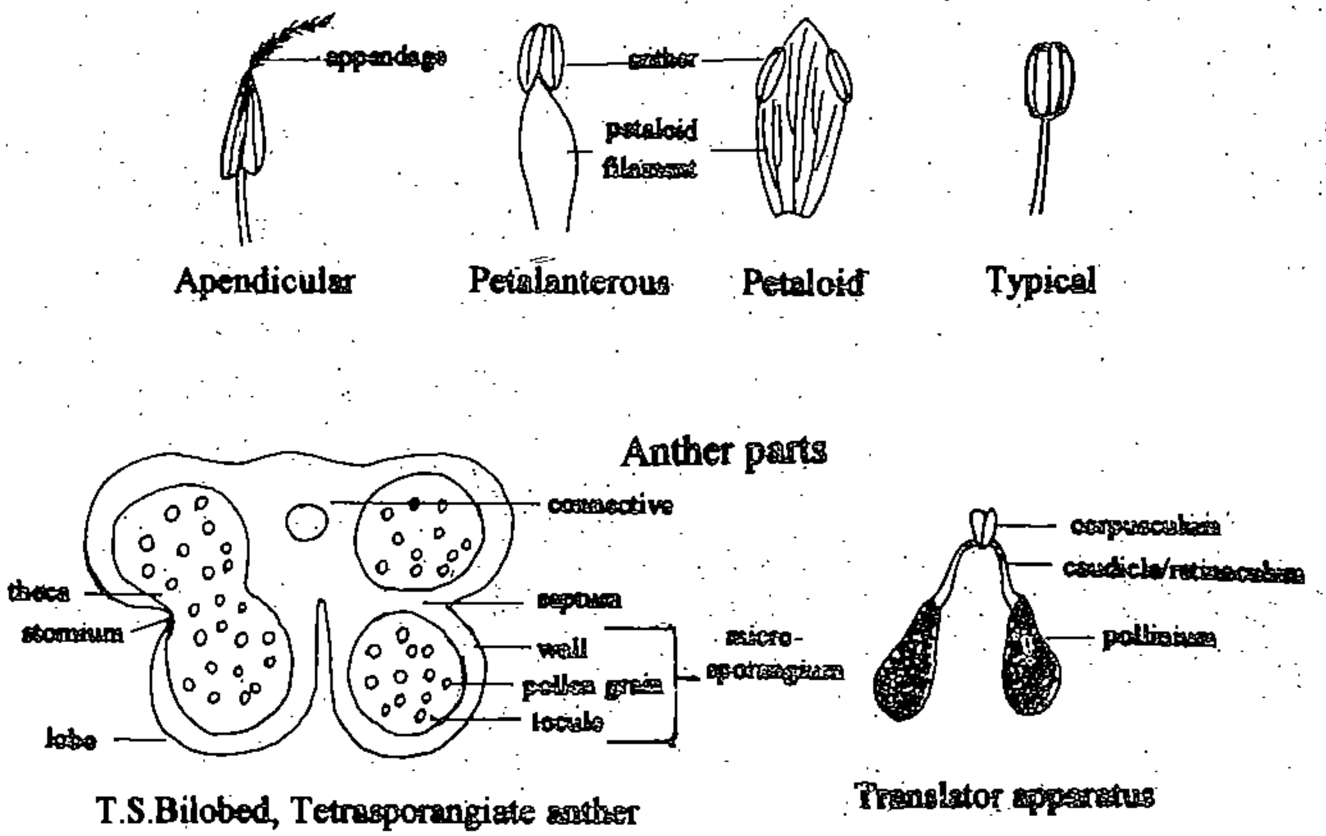
Pollen grain : male gametophyte

Septum : tissue separating adjacent sporangia or locules in a lobe

Theca (pl. thecae) / Pollen sac : sac-like cavity containing all the pollen grains of one anther lobe, formed after breakdown of septum between locules of adjacent microsporangia of a mature anther

Additional terms

Plate – 31: The types of stamens, and parts of anthers.



Additional figures

F. Anther Types (Plate – 32)

Adnate : with elongated anther lobes attached length-wise to filament, either extrorse, introrse or latrorse

Basifixed : anther attached at its base, to apex of filament
Bilobed : with two lobes
Bithecous / Dithecous : with two thecae or pollen sacs

Distractile : with transversely elongated connective separating the two anther lobes
Divergent : anther lobes divaricate or separated from one another at an acute angle to the connective or filament; connective may be bifurcated
Dorsifixed : anther attached dorsally to apex of filament

Extrorse : anther lobes facing and dehiscing outward, away from the center of flower

Introrse : anther lobes facing and dehiscing inward or towards the center of flower

Latrorse : anther lobes facing and dehiscing laterally, neither inward nor outward

Monothecous : with one theca or pollen sac
Multithecous : with many thecae or pollen sacs formed due to septation of thecae, as in *Acacia nilotica*

Oblique : anther lobes lower on one side of connective than the other

Parallel : anther lobes longitudinal to each other and along the sides of connective

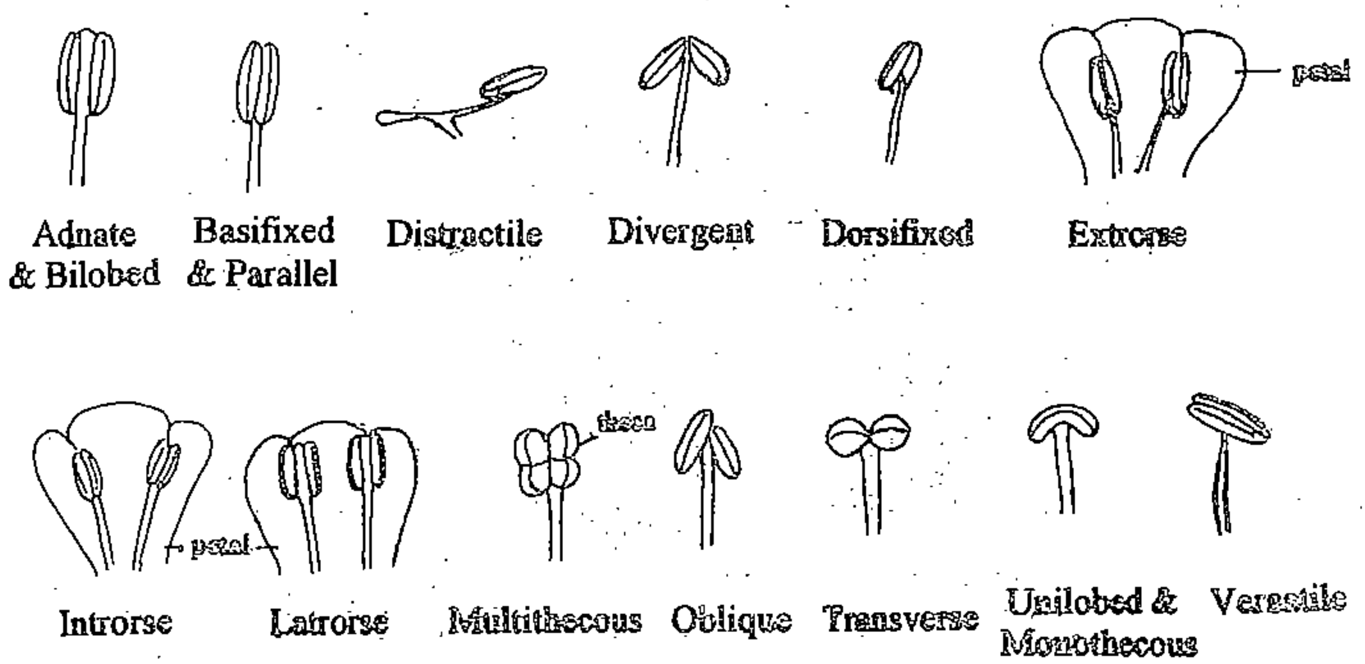
Transverse / Explanate : anther lobes with maximum divergence of about 90° from the connective or filament

Unilobed : with single lobe

Versatile : dorsifixed but attachment to filament is limited to a single point on the connective so that the anther swings freely on the filament

Additional terms

Plate – 32: The different types of anther.



Additional terms and figures

G. Anther Dehiscence (Plate – 33)

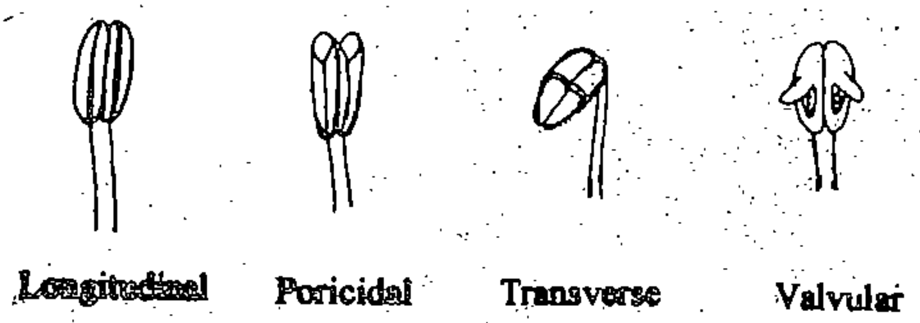
Longitudinal : dehiscing along the long-axis of anther lobe

Poricidal / Poral : dehiscing through a pore at the apex of anther lobe

Transverse : dehiscing at right angles to the long-axis of anther lobe

Valvular : dehiscing through a pore covered by a flap or valve

Plate – 33: Different types of anther dehiscence.



Additional terms and figures

2.6.9 The Gynoecium

A. Gynoecial Parts (Plate – 34)

Carpel : female sporophyll within flower; floral organ that bears ovules in angiosperms; a unit of gynoecium
Carpophore : prolonged floral axis between carpels of a compound ovary

Ovary : ovule-bearing part of pistil

Pistil : A unit of gynoecium, comprised of ovary, style (when present) and stigma
- Compound : consisting of more than one carpel
- Simple : consisting of one carpel

Pistillode : a rudimentary or vestigial pistil which does not bear ovules, present in some staminate flowers

Stigma : pollen-receptive surface of carpel, present generally at the tip of style
Stipe : pistillate or carpellary stalk formed by the sterile basal part of gynoecium or ovary
Style : attenuated, non-ovule bearing portion of pistil between stigma and ovary

B. Gynoecial Types (Plate – 34)

Apocarpous : with free carpels

Bicarpellary : with two carpels

Monocarpellary / Unicarpellary : with single carpel
Multicarpellary / Polycarpellary : with many carpels

Syncarpous / Coenocarpous : with ovaries of adjacent carpels completely fused, styles and stigmas may or may not be fused

C. Ovary Parts (Plate – 34)

Locule / Loculus (pl. locules / loculi) : cavity of ovary containing ovules

Ovary wall : wall forming the ovary
Ovule : megasporangium with integument(s) containing the megagamete or egg cell; embryonic seed

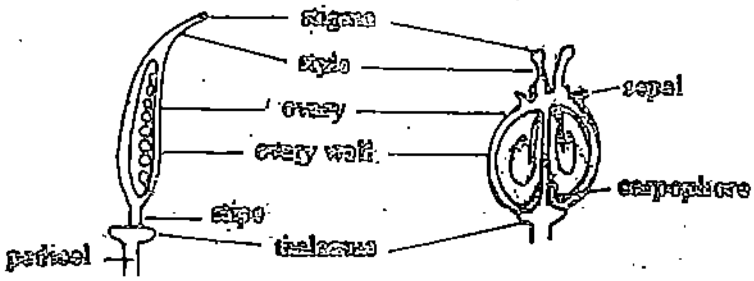
Placenta (pl. placentae) : tissue in ovary from which ovules develop

Replum : false septum formed by extension of placental tissue, as in Brassicaceae

Septum (pl. septa) : partition or cross-wall in the ovarian cavity

Plate – 34: Gynoecium – parts, types; and parts of ovary.

Gynoecium

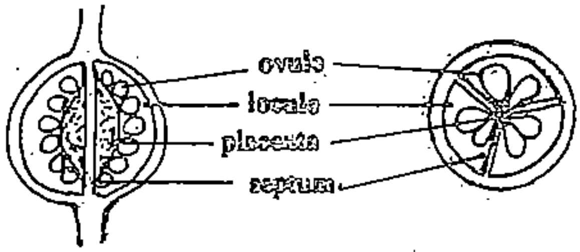


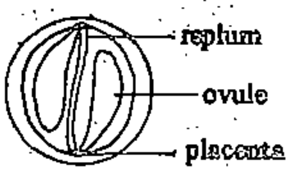
L.S.Carpel/Simple pistil (Monocarpellary)

L.S.Compound pistil (Bicarpellary & Syncarpous)

L.S.Compound pistil (Multicarpellary & Apocarpus)

Ovary





L.S. Compound ovary

T.S.Trilocular ovary

T.S.Unilocular ovary

Additional figures

D. Ovary Types (Plate – 35)

Bilocular : with two locules

Compound : ovary of a syncarpous gynoecium; fused ovaries of many carpels

Inferior : ovary positioned completely below other floral organs which are inserted on it

Multilocular : with many locules

Semi-inferior / Half-inferior : other floral organs inserted on a hypanthium which is adnate to lower half of ovary; basal part of ovary is below the point of attachment of other floral organs

Simple : ovary of a single carpel

Superior : ovary above the point of attachment of other floral organs and hypanthium, if present

Trilocular : with three locules

Unilocular : with one locule

E. Placentation Types (Plate – 35)

Axile : with ovules borne along the central axis in a compound ovary with septa

Basal : with ovules arising from placenta at the base of a compound ovary

Central : with ovules borne along the central axis in a compound ovary without septa

Free-central : as in central placentation except that the central axis is not attached to ovary wall at its apical or distal end

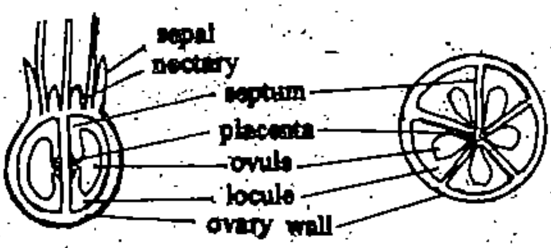
Lamellate / Laminate / Superficial : a modification of parietal placentation wherein the ovules are borne on the inner surface of plate-like lamellae or septae formed by invagination of placentae

Marginal / Ventral : with ovules borne along the ventral suture or margin of simple ovary

Parietal : with ovules borne on the wall of a unilocular compound ovary

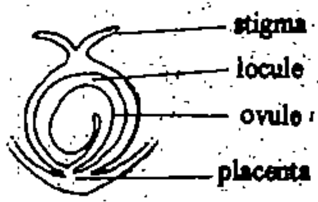
Additional terms

Plate – 35: The types of ovary, and placentation.

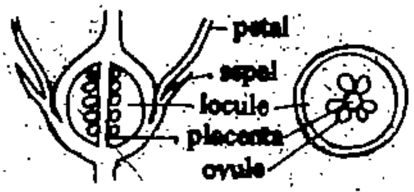


L.S. Inferior, Bilocular ovary

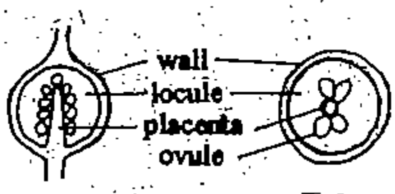
T.S. Trilocular ovary with Axile placentation



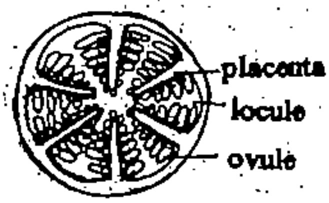
L.S. Superior, Unilocular ovary with Basal placentation



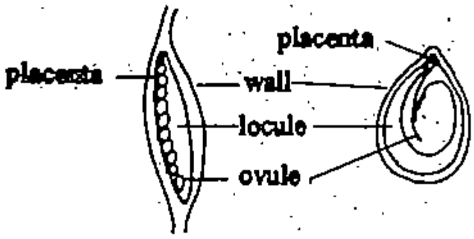
L.S. T.S.
Semi-inferior, Unilocular ovary with Central placentation



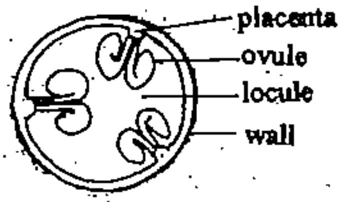
L.S. T.S.
Unilocular ovary with Free-central placentation



T.S. Unilocular ovary with Lamellate placentation



L.S. T.S.
Unilocular ovary with Marginal placentation



T.S. Unilocular ovary with Parietal placentation

Additional figures

F. Style Types (Plate – 36)

Apical / Terminal : at the apex of ovary

Bifid : divided into two

Eccentric : off-center

Flabellate : fan-shaped

Geniculate : bent abruptly
Gynobasic : attached at the base of ovary in a central depression

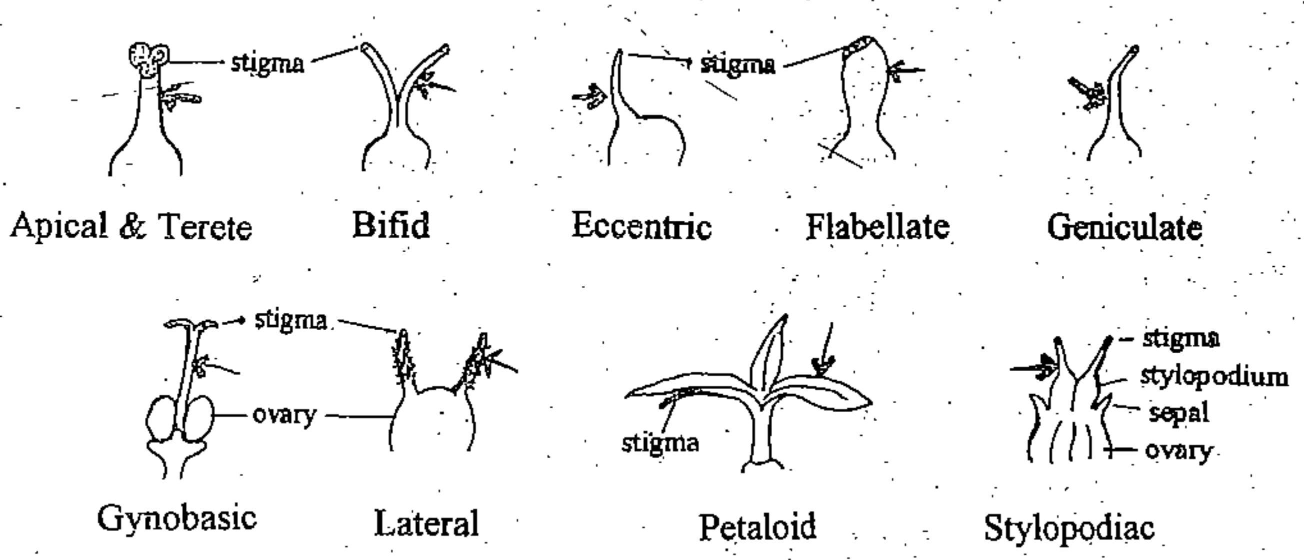
Lateral : at the side of ovary

Petaloid : petal-like

Stylopodiac : with a stylopodium or swollen base

Terete : cylindrical and elongate

Plate – 36: Different types of styles.



Additional terms and figures

G. Stigma Types (Plate – 37)

Bifid : forked or divided into two

Capitate : head-like

Clavunculate : dumb-bell shaped, with a receptive apical and a thickened, glandular basal part, as in Apocynaceae

Decurrent : elongate, extending downward

Diffuse : spread over a wide surface

Discoid : disc-like

Infundibuliform : funnel-shaped, as in *Crocus sativus*

Lineate / Linear : in lines, stigmatic surface linear

Lobed : divided into lobes

Plumose : feather-like

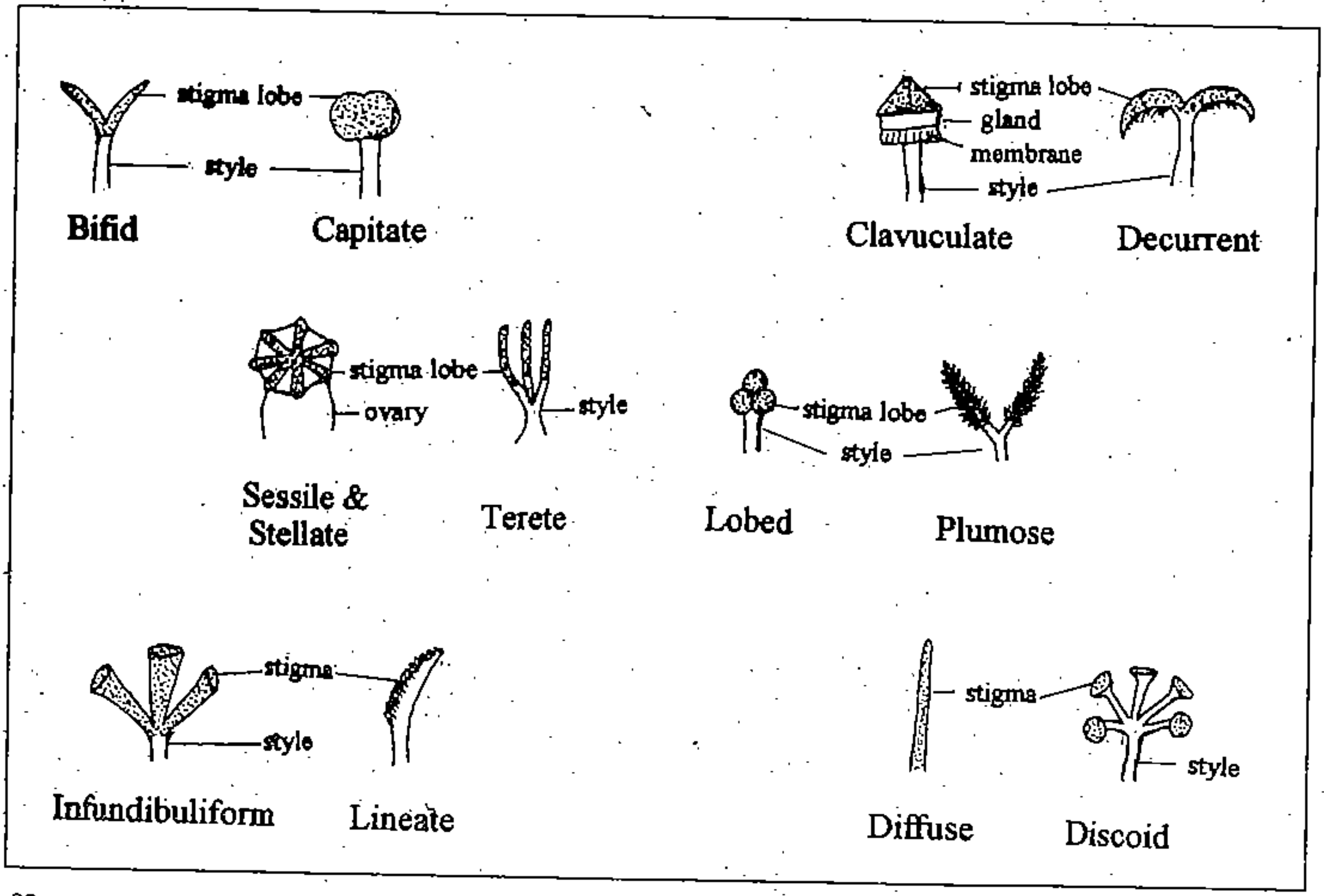
Sensitive : sensitive to touch, as in *Mimulus, Martynia*

Sessile : without style

Stellate / Radiate : star-shaped

Terete : cylindrical and elongate

Plate – 37: Different types of stigma.



2.6.10 The Fruit (Plates 38 – 40)

A. Fruit Parts (Plates 38 – 40)

Article : one of the segments of a jointed fruit such as a lomentum

Carpophore : extended floral axis between adjacent carpels, as in Apiaceae
Coccus (pl. Cocci) : one-seeded part of a lobed and leathery or dry fruit, opens along ventral suture to expel seeds

Husk : outer covering derived from perianth or involucre

Locule / Loculus (pl. locules / loculi) : cavity or chamber within fruit

Mericarp : an indehiscent one-seeded part of fruit that splits off and seemingly matures as a separate fruit

Nutlet / Nuculi : a small one-seeded part of fruit that splits off and resembles a nut with hard pericarp

Pericarp : matured ovary wall; fruit wall; generally composed of three differentiated layers
- Endocarp : innermost layer
- Epicarp / Ectocarp / Exocarp : outermost layer
- Mesocarp : middle layer

Perisperm : nutritive tissue derived from nucellus or integuments
Pyrene : pit or stone of fleshy fruits containing stony or bony endocarp with seed(s)

Replum : false septum (of placental origin) between the two locules of cruciferous fruits
Rostellum / Beak : persistent stylar base on fruit

Seed : a matured ovule
Septum / Dissepiment : partition separating adjacent locules of a multilocular fruit
Suture : demarcation on the ovary wall indicating the marginal fusion of carpel(s); a line along which fruit opens

Valve : a segment of a capsule

Additional terms

B. Fruit Types (Plate – 38)

Accessory / Pseudocarp / False : fruit derived from simple or compound ovary surrounded by some closely adpressed non-ovarian tissues such as calyx, hypanthium, and bracts.

- Hip / Cynarrhodion : an aggregation of achenes surrounded by an urceolate receptacle or hypathium, as in Rosaceae
- Pome : fruit with cartilaginous pericarp surrounded by fleshy receptacle, as in *Malus*
- Pseudocarp : an aggregation of achenes embedded in a fleshy receptacle, as in strawberry
- Sorosis : multiple fruit derived from an aggregation of fruits of individual flowers along with the fleshy perianth and fleshy or woody peduncle, as in pineapple, jack-fruit and mulberry
- Syconus / Syconium : multiple fruits surrounded by a hollow, fleshy, pear-shaped receptacle, as in *Ficus*

Aggregate : a collection of simple fruits developed from separate carpels of a single flower

- Etaerio of achenes / Achenecetum : an aggregation of achenes
- Etaerio of berries / Baccacetum : an aggregation of berries
- Etaerio of drupes / Drupecetum : an aggregation of drupelets
- Etaerio of follicles / Follicetum : an aggregation of follicles
- Etaerio of samaras / Samaracetum : an aggregation of samaras

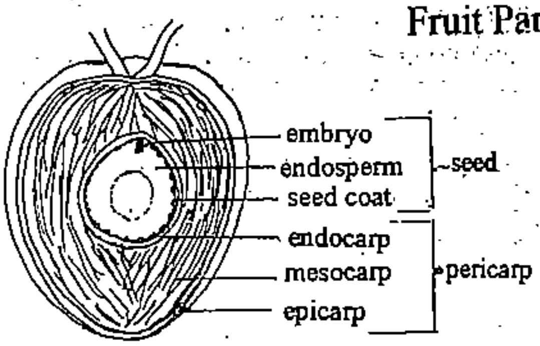
Multiple / Composite : derived from coalesced ovaries of several flowers on an inflorescence axis

- Sorosis : fused fruits on a spike or spadix, as in pineapple, mulberry, jack-fruit
- Syconus / Syconium : an aggregation of achenes in a hypanthodium, as in *Ficus*

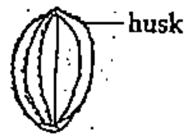
Additional terms

Plate – 38: The different types of fruit.

Fruit Parts



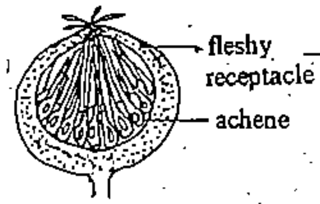
L.S.Coconut fruit



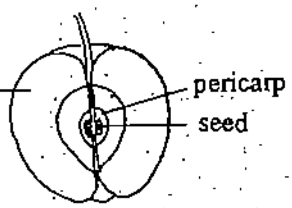
Cereal grain

Fruit Types

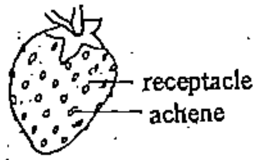
Accessory



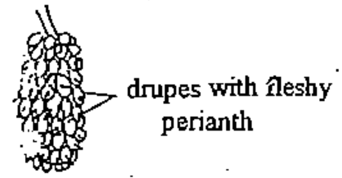
L.S.Hip



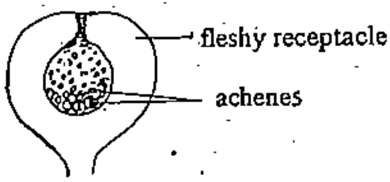
L.S.Pome



Psuedocarp

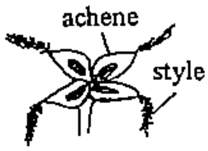


Sorosis

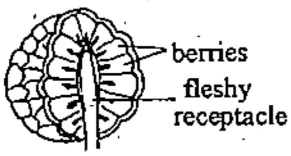


L.S.Syconus

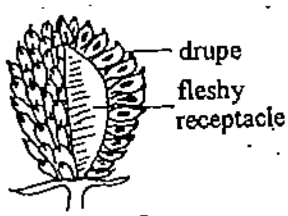
Aggregate



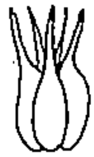
Etario of Achenes



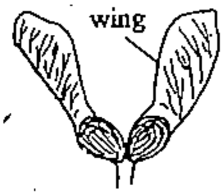
Etario of Berries



Etario of Drupes



Etario of Follicles



Etario of Samaras

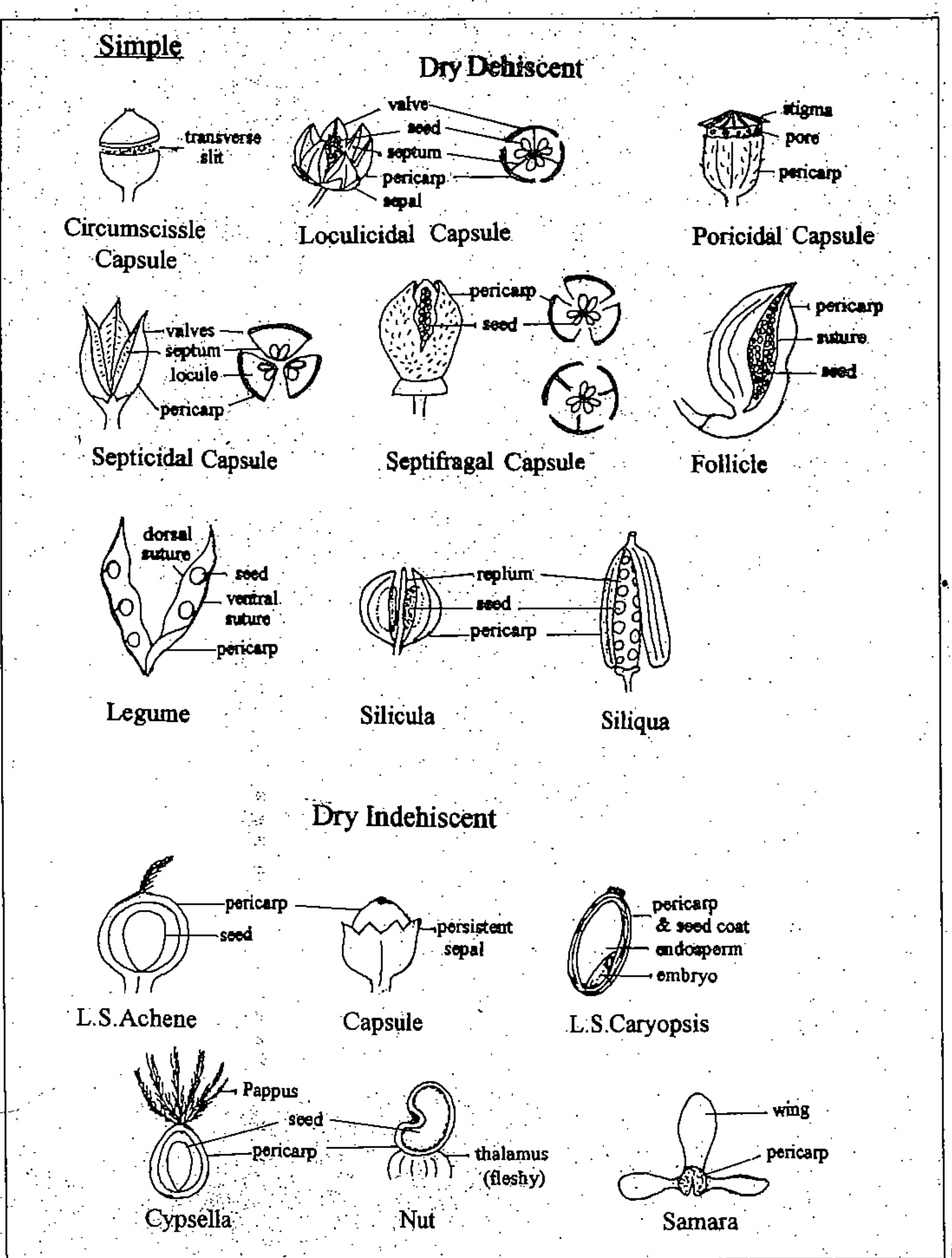
Additional figures

B. Fruit Types (*Cont.*) (Plate – 39)

Simple : derived from ovary of a solitary pistil in a single flower
- Dry dehiscent : non-succulent fruits that open along definite sutures and seams, have indistinct layers of pericarp
  - Capsule : derived from a compound ovary of two or more carpels dehiscing in various ways
    - Circumscissile / Pyxis / Pyxidium : dehisces transversely, along the horizontal axis of the fruit
    - Loculicidal : dehisces longitudinally opposite the locule exposing the cavity
    - Poricidal : dehisces through pores, which may be covered by a lid (operculate) as in *Papaver*
    - Septicidal : dehisces longitudinally along the septa
    - Septifragal : dehisces irregularly loculicidally or septicidally with valves falling away, leaving the seeds attached to the central axis
  - Follicle : derived from a simple ovary that splits along one suture
  - Legume / Pod : derived from a simple ovary that splits along two sutures
  - Silicula / Silicle : short and broad fruit derived from a compound ovary, with two valves and a persistent partition after dehiscence
  - Siliqua : long and narrow fruit derived from a compound ovary, with two valves and a persistent partition after dehiscence

- Dry indehiscent : non-succulent fruits that do not open at maturity and have indistinct pericarp layers
  - Achene / Akene : a one-seeded, one-loculed fruit with seed coat free from the thin pericarp, derived from a simple, superior ovary
  - Capsule : derived from a two- or more-loculed ovary, as in *Peplis*
  - Caryopsis : a one-seeded fruit with seed coat adnate to pericarp, derived from a one-loculed superior ovary
  - Cypsela : an achene derived from a compound one-loculed inferior ovary
  - Nut : a one-loculed, one-seeded fruit with a hard pericarp, generally derived from a compound, two or more loculed, superior or inferior ovary by abortion of all but one ovule
  - Samara : an achene with wings, that are derived from pericarp

Additional terms


Simple
Dry Dehiscent
transverse slit
Circumscissle Capsule
valve
seed
septum
pericarp
sepal
Loculicidal Capsule
stigma
pore
pericarp
Poricidal Capsule
valves
septum
locule
pericarp
Septicidal Capsule
pericarp
seed
Septifragal Capsule
pericarp
suture
seed
Follicle
dorsal suture
seed
ventral suture
pericarp
Legume
replum
seed
pericarp
Silicula
Siliqua
Dry Indehiscent
pericarp
seed
L.S.Achene
persistent sepal
Capsule
pericarp & seed coat
endosperm
embryo
L.S.Caryopsis
Pappus
seed
pericarp
Cypsella
thalamus (fleshy)
Nut
wing
pericarp
Samara

2-1-B

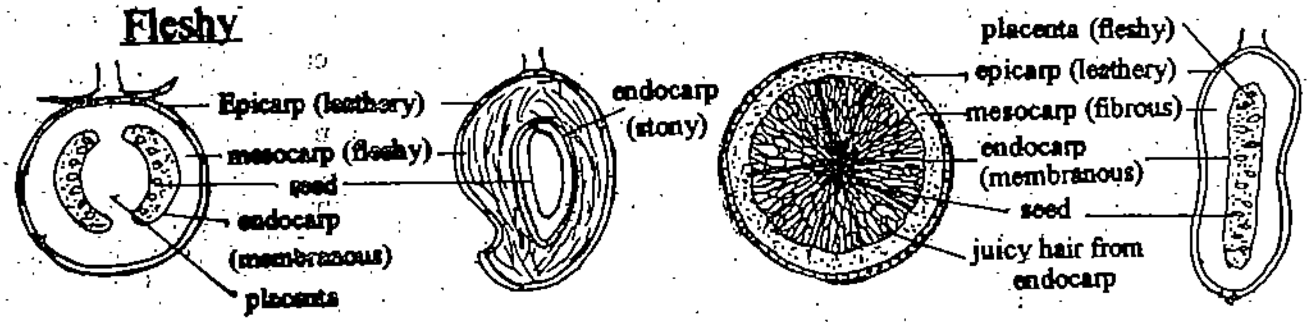
B. Fruit Types (*Cont.*) (Plate – 40)

- Fleshy : having succulent or fibrous pericarp with well-differentiated epicarp, mesocarp and endocarp
  - Berry / Bacca : with thin, coloured epicarp, fleshy mesocarp and membranous endocarp, derived from a superior or inferior ovary, as in *Lycopersicon esculentum*, *Psidium*
  - Drupe : with fleshy mesocarp and stony endocarp, derived from a superior ovary, single-seeded, as in *Mangifera,* or many seeded, as in *Ilex*
  - Hesperidium : a berry with leathery epicarp, fibrous mesocarp, and membranous endocarp bearing fleshy glandular hairs, as in *Citrus*
  - Pepo : a berry with leathery epicarp, derived from an inferior ovary, as in *Cucurbita*

- Schizocarpic : derived from two- or more-loculed compound ovary in which the locules separate at maturity appearing as fruits derived from simple pistils
  - Carcerulus : dry fruit derived from a compound, generally superior, ovary which at maturity separates into one- to many-seeded locules or mericarps, as in *Althaea*.
  - Cremocarp : derived from a two-loculed, inferior ovary, the locules separating at maturity into two single-seeded, dry, indehiscent mericarps, as in the Apiaceae
  - Lomentum : a legume which is constricted or partitioned between the seeds and splits into a number of one-seeded compartments or articles at maturity, as in *Acacia*
  - Regma : derived from a compound, multilocular ovary which separates at maturity into dry, one-chambered, one- or two-seeded cocci which open along ventral suture to expel, as in *Ricinus*
  - Schizocarpic achenes : separating achenes, as in *Sida*
  - Schizocarpic berries : separating berries, as in *Phytolacca*
  - Schizocarpic follicles : separating follicles, as in Apocynaceae
  - Schizocarpic nutlets / Cenobium : separating nutlets enclosed in a calyx tube, as in Lamiaceae
  - Schizocarpic samaras : separating samaras, as in *Acer*

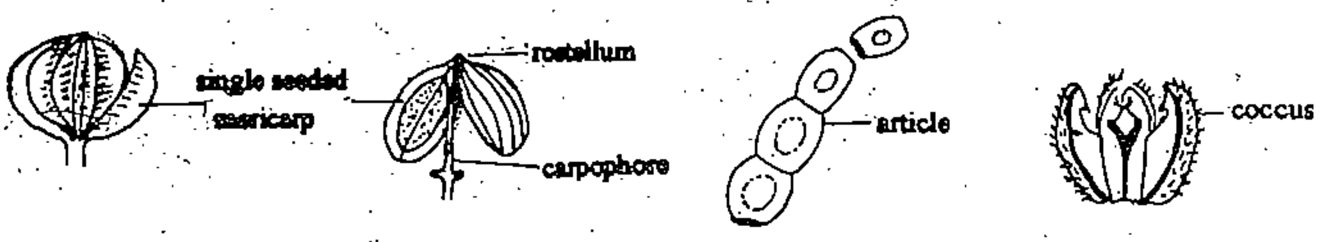
Additional terms

Fleshy



L.S.Berry L.S.Drupe T.S.Hesperidium L.S.Pepo

Schizocarpic



Carcerulus Cremocarp Lomentum Regma

Additional terms and figures

2.6.11 The Seed (Plate – 41)

A. Seed Parts (Plate – 41)

Aril : an outgrowth of funiculus or ovular stalk outside the seed coat, generally covers the seed more or less completely

Arillode : an aril-like outgrowth of integument at the micropylar region

Caruncle : a fleshy tissue at the micropylar end of the seed, derived from the tip of outer integument

Embryo : a mass of cells derived from the zygote; the young sporophyte

Endosperm : nutritive tissue derived from fertilized central cell

Hilum : scar left behind on the seed coat after detachment of funiculus

Jaculator / Echma / Retinaculum : a persistent indurated, hook-like funiculus on which seed rests, as in Acanthaceae; helps in dispersal of seed

Micropyle : pore through seed coat

Raphe : ridge on seed coat formed by fusion of funiculus with seed when funiculus is bent

Seed coat : outer protective covering of seed derived from integument(s)
- Tegmen : inner seed coat derived from inner integument and, rarely, outer layers of nucellus
- Testa : outer hard and leathery seed coat derived from one or both integuments

B. Seed Types (Plate – 41)

Arillate : seed covered with aril

Carunculate : seed with a caruncle

Comose / Plumed : with a tuft of hair at one end

Endospermous / Albuminous : with food reserves in endosperm

Fleshy : covered by a fleshy outer coat

Hairy / Woolly : covered with hair or trichomes

Non-endospermous / Exalbuminous : without endosperm

Perispermous : with food reserves in perisperm

Winged : with wing(s) or flat membranous expansion(s) of seed coat

C. Embryo Parts (Plate – 41)

Coleoptile : protective sheath around epicotyl in grasses
Coleorhiza : protective sheath around radicle in grasses
Cotyledon : embryonic leaf

Embryonic axis : axis of embryo containing shoot apex at one end and root apex at the other
Epicotyl : part of embryonic axis or stem above the point of insertion of cotyledon(s), gives rise to shoot system

Hypocotyl : part of embryonic axis between the point of insertion of cotyledon(s) and the radicle
Plumule : embryonic leaves and shoot apex derived from epicotyl; first bud of embryo

Radicle : embryonic root with the root apex that gives rise to root system
Root apex : extreme tip of radicle containing the root meristem and the underlying undifferentiated cells derived from them

Shoot apex : extreme tip of embryonic axis containing shoot meristem and the underlying undifferentiated cells derived from them

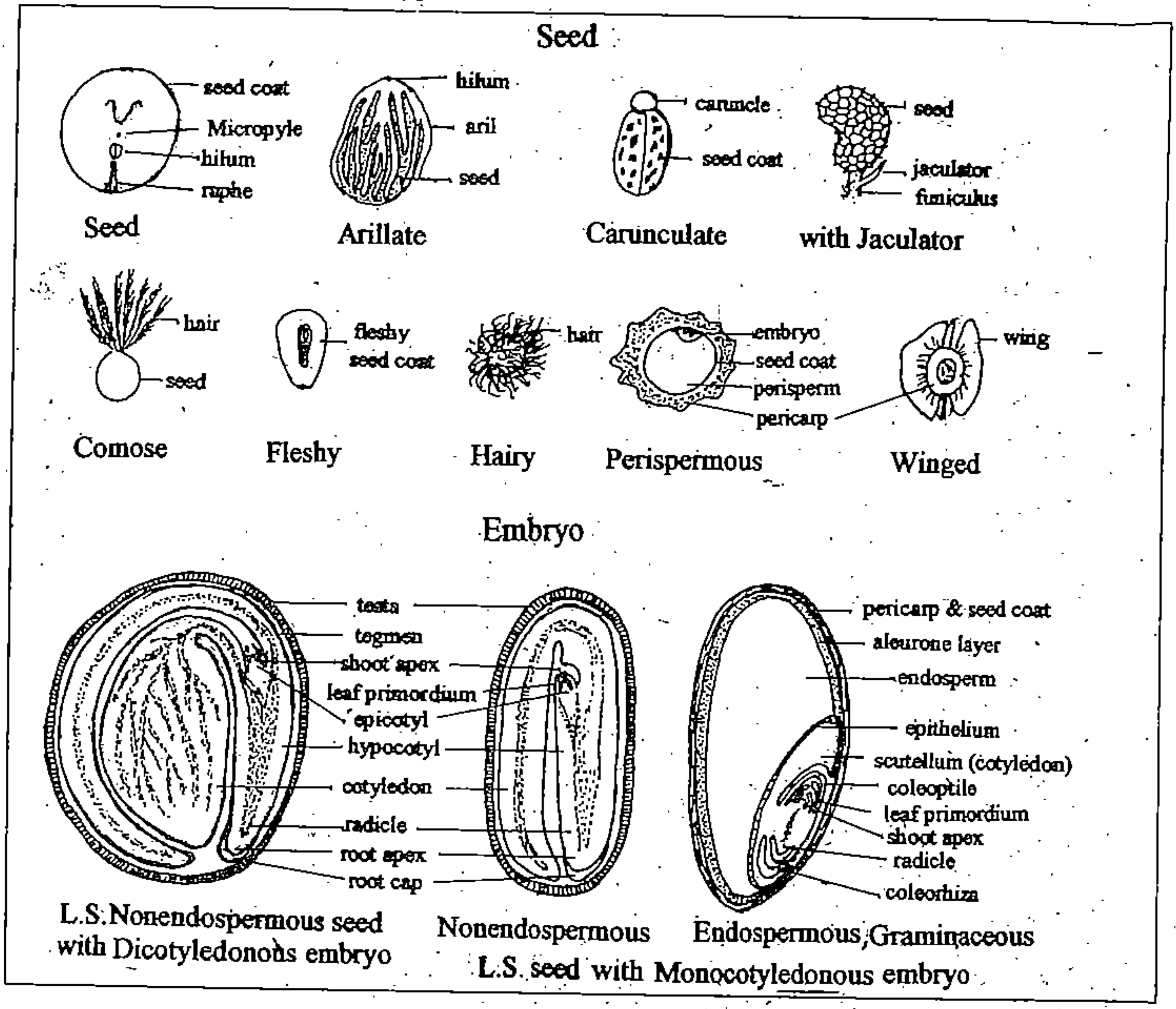
D. Embryo types (Plate – 41)

Dicotyledonous: with two cotyledons

Monocotyledonous: with one cotyledon

Additional terms

Plate – 41: Seed - the parts, and types; and Embryo - parts, and types.



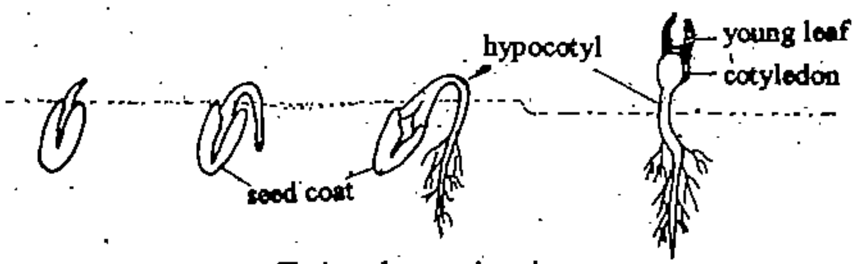
Additional figures

2.7 GERMINATION TYPES (Plate – 42)

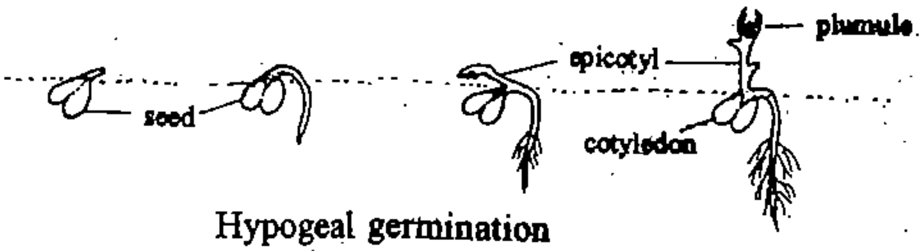
Epigeal : germination where cotyledons are pushed upward by elongation of hypocotyl

Hypogeal : germination where cotyledons remain in soil and the plumule is pushed up by elongation of epicotyl

Plate – 42: Types of germination.



Epigeal germination



Hypogeal germination

Additional terms and figures

NOTES

NOTES

NOTES

Uttar Pradesh
Rajarshi Tandon Open University

UGBY -03
PLANT DIVERSITY LAB

Block

1

Cyanobacteria, Algae, Fungi and Lower Plants

PLANT DIVERSITY LABORATORY

The course Plant Diversity Lab [LSE-14(L)] is based on Plant Diversity-I (LSE-12) and Plant Diversity-II (LSE-13) theory courses. It is a 4 credit course and consists of the following:

Block 1 Cyanobacteria, algae, fungi and lower plants (2 credits, based on LSE-12 Course)

Coordinator: Dr. (Ms.) Swadesh Taneja

Block 2 Higher Plants (2 credits, based on LSE-13 Course)

Coordinator: Dr. (Ms.) Jaswant Sokhi and
Dr. (Ms.) Amrita Nigam

Further details of the two blocks are given in the "Block Introduction" of the respective blocks. You must read them carefully before going through the exercises.

Assessment

You will be assessed on this laboratory like the previous two Laboratory Courses LSE-04(L) and LSE-08(L).

You should bear in mind that **attendance in the Laboratory courses is compulsory.** Every exercise is evaluated and is included for final evaluation, the weightage being 70%. Hence you should perform all the exercises in order to be able to secure maximum marks. The remaining 30% marks are assigned for the final exam, which will be held on the last day of the course.

BLOCK 1 CYANOBACTERIA, ALGAE, FUNGI AND LOWER PLANTS

Dear students,

This block is designed to give you 'hands on' experience of the various classes of organisms you studied in the course Plant Diversity – I (LSE-12). You will explore the morphology, anatomy, cellular structure and reproductive features of cyanobacteria, algae, fungi, bryophytes and pteridophytes. Many of these organisms are microscopic in nature and you will probably see them for the first time. This study is planned in 17 exercises and will be conducted in 12 sessions of 4 hours each.

To ensure that your curiosity and interest are maintained we have tried the investigatory approach and designed this manual differently from the routine manuals. This manual does not include observations on specimens/slides under study in the form of drawing and description. In fact, the challenge of a scientific investigation is lost if the results are available beforehand. We would like that you develop the ability and skills to prepare specimens for examination, study the organisms, record observations, analyse the results in view of what you are taught in the theory course.

It is seen that students at times are not serious about laboratory work. Some do not understand what they do and some copy from the manual/report of fellow students/reports of previous years and thus rely on the observations made by others. This may relieve them from the workload and reward them for a short term but in the long term they cannot benefit from such practice. These students miss the opportunity of exploring the biological world and their spirit of scientific inquiry remains buried. We want to discourage this practice and will try that you develop a true spirit of scientific inquiry. During 'hands on' experience it is necessary to be mentally alert also otherwise the purpose of these exercises will be defeated.

Our effort is that you get trained and develop the ability to work independently and be confident about your own observations. Initially, it is quite likely that you may not see in a preparation the structures described in the theory text. You must not make conclusions after a first glance of the material/preparation. It is necessary to explore a few preparations of the material and study them a few times. In scientific investigation repetitions are necessary to confirm the results. The results are not valid if they are different when repeated. Therefore, if you are not sure about your investigation you should repeat it one or more time, till the outcome is satisfactory. Besides, you must cultivate intelligent curiosity and sharpen your critical faculty of exploration. Problems will of course, occasionally arise and when they do, seek the help of your counsellor. Once you have finished with the exercise it is often valuable to discuss the findings and conclusions with your fellow colleagues.

You must realise conducting laboratory work is a very expensive affair. It also requires a lot of effort on the part of the counsellor and technical staff of the laboratory. Therefore, it must be taken seriously from a learning standpoint. So you must avail this opportunity to learn the scientific method and apply it in real life situations.

Practical work is an interesting and enjoyable exercise. To avoid many of the difficulties you must come prepared with background knowledge on the topic. You must read the text pertaining to the topics as mentioned in Sec. "Prior Readings" in each exercise. You will not be allowed to bring Blocks of the theory course or any other botany book to the lab. To do the exercises you will gain most of the information from the manual.

Objectives

After doing the exercises included in this block you should be able to:

- follow a suitable procedure for the study of morphological, anatomical and reproductive features of cyanobacteria, algae, fungi, bryophytes and pteridophytes,
- prepare whole mounts, peel mounts, smears to study them,
- dissect and cut sections of the organisms or their parts,
- classify the organisms into respective sub-groups on the basis of your observations on their distinguishing features,
- display the characteristic features of these organisms by selecting suitable techniques,
- use specific stains required for resolving the anatomical features of the organisms,
- identify the studied organisms in their natural habitats,
- collect the specimens from their habitats and suitably preserve them using appropriate methods and
- exemplify the range of structural variations and the evolutionary trend in the groups examined.

We wish you all the best for the course.

Swadesh Taneja
(Coordinator)

A note for the counsellors

There is a separate counsellors' manual for conducting exercises of this block. A copy of it can be obtained from the Coordinator of your Study Centre. If the Coordinator has not received a copy, he/she may write/e-mail to:

Coordinator LSE-14(L)
School of Sciences
Maidan Garhi
E-mail: swadeshjt1@hotmail.com

SESSION PLAN FOR PLANT DIVERSITY LAB (BLOCK 1)

	Introduction	½ hour
Session I	Exercise 1 Investigation of a plant of your choice Exercise 2 Study of sub-cellular organization of prokaryotic and eukaryotic cells	2½ hours 1 hour
Session II	Exercise 3 Comparative study of prokaryotic and eukaryotic organisms Exercise 4 Comparative study of characteristic features of cyanobacteria, algae, fungi, bryophytes and pteridophytes	2 hours 2 hours
Session III	Exercise 5 Comparative study of morphology of some representative genera of unicellular, filamentous and colonial algae Exercise 6 Comparative study of morphology of some representative genera of advanced algae	2 hours 2 hours
Session IV	Exercise 7 Comparative study of reproductive features of some representative genera of algae	4 hours
Session V	Exercise 8 Comparative study of habit, external features and asexual reproduction in some representative genera of fungi Exercise 9 Study of sexual reproductive structures in fungi	2 hours 2 hours
Session VI	Exercise 10 Study of common fungal diseases of crop plants Exercise 11 Study of the morphological, anatomical and reproductive features in lichens	2 hours 2 hours
Session VII	Exercise 12 Comparative study of morphological features of some representative genera of bryophytes	4 hours
Session VIII	Exercise 13 Comparative study of anatomical features of some representative genera of bryophytes	4 hours
Session IX	Exercise 14 Comparative study of asexual and sexual reproductive structures of some representative genera of bryophytes	4 hours
Session X	Exercise 15 Comparative study of morphological features of some representative genera of pteridophytes	4 hours
Session XI	Exercise 16 Comparative study of anatomical features of some representative genera of pteridophytes	4 hours
Session XII	Exercise 17 Comparative study of reproductive structures of some representative genera of pteridophytes	4 hours
Session XIII	Revision of work	
Session XIV	Initiation of Block 2A lab work	

You will be provided with the items listed below in Biology Laboratory Kit.

Biology Laboratory Kit

Dissection microscopes/hand lens
Compound microscopes
Plane slides
Cover slips
Petridishes
Droppers
Staining solutions
Filter paper
Tissue paper

You must bring the items listed below in Biology Laboratory Student Kit.

Biology Laboratory Student Kit

A pair of sharp scissors
A pair of fine tipped forceps
A pair of dissecting needles
Scalpel
Razor blade
Hand lens
Camel hairbrush
Lens cleaning tissue
2 HB pencil
Eraser
Ruler
Practical record book

EXERCISE 1 INVESTIGATION OF A PLANT OF YOUR CHOICE

1.1 INTRODUCTION

In scientific work it is important to make true, systematic, adequate, unbiased and independent observations. This is what we have in mind while formulating this exercise. It is an open-ended investigation of a plant that you will select for study. This should acquaint you with the procedure of investigation and help you to study the organisms included in the exercises that follow. We would like to encourage you to apply methods of investigation other than routinely employed or we have mentioned here.

Prior Readings

For doing satisfactory work, you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- Laboratory Course – I (LSE-04 (L)), Experiment 1: Microscopy, Sec.1.7 Operation of a compound microscope, p 8; Sec.1.8 Precautions, p. 8; Sec. 1.9 Dissection microscope, p. 9.
- Laboratory Course – I (LSE-04 (L)) Experiment 7: Squash technique for the study of mitosis and meiosis, Sec 1.3 Procedure for the squash preparation of onion root tips for the study of mitosis, p. 44.
- You may revise morphology and anatomy of plants from "Botany for Degree Students" by A.C. Dutta, Oxford University Press, Calcutta, or any other botany textbook.

Objectives

After doing this exercise you should be able to:

- appreciate the merits of independent investigation and develop an attitude towards it,
- suggest the steps that could be used for the study of a given plant material for its gross-features and anatomy,
- suggest and test new methods that could be used to study a given biological material,
- record your personal observations of a material in the form of well-labelled sketches,
- suggest a method of recording observations and
- write a report of your investigation.

1.2 MATERIAL REQUIRED

1. The biology laboratory kit (see items given on page 8)
2. The biology laboratory student kit (see items given on page 8)
3. A plant of your choice

1.3 PROCEDURE

You may select any plant from the college campus or any other area for investigation.

1. Make a thorough study of its gross features such as stem, branches, ro (if possible), leaves, flowers, seeds and fruit (if any) etc. in its natural environment.
2. For laboratory (lab) studies cut a small young branch and bring it immediately to the lab. Begin examination of its parts from the base tc apex. For a detailed study you will need to separate its parts. Before yi separate the parts draw a sketch of the branch and label it. Now study minutely each part with help of a hand lens or a dissection microscope Draw whatever additional details are visible of each part. If need be, y may prepare whole mounts of some parts for examination under compound microscope.
3. For anatomical studies select a part (leaf, bud or floral parts) that interc you and prepare a few slides by using any of the methods listed below. You may consult your counsellor for selecting the stain. Examine the stained slides and compare them with unstained ones by placing each f under low and then high power objective lens of a compound microscc

   The following two methods are routinely used for the study of anatomy plants.

   Section cutting
   Peal mount
4. It is important that we innovate some new methods of investigation. Therefore you must test the following methods or any other that you ca think of to see if they can be used to study plants.

   Squash preparation
   Smear mount

The magnifying power of a hand lens and dissection microscope is almost equal.

1.4 RECORD OF OBSERVATIONS

To facilitate your investigation on the plant, its various parts and to record observations, we have listed several technical terms in Appendix 1. You ma select the terms, which will describe your observations correctly.

1. **Study of the plant in its natural environment**

   You are expected to write at least 10 points about its external features.

2. **Study of a young branch of the plant**

   You should record your observations on the gross features of the branch and also of its parts, as they appear under hand lens or dissection microscope and compound microscope in the form of labelled sketches. Also write explanatory captions, optical form and magnification employe Give a brief description of your observations. **Do not write what you could not observe or the additional information given in theory** textbooks.

3. Anatomy of a part of the plant

You would record your observations on the tissues, cells and on sub-cellular organelles whatever is visible.

Submit your report in the format given in Laboratory Report 1.

Marking Scheme

Characteristic features of the plant	1 mark
Observations on a young branch of the plant	1 mark
Preparation of two samples	½×2 = 1 mark
Anatomy	1 mark
Laboratory skills	1 mark
Total	**5 marks**

Appendix 1

General parts - Vegetative shoot, Reproductive shoot, Leaf, Buds, Fruit, Flower, Node, Internode, Pod, Thorn, Hook, Root, Tendril, Scale

Stem - Erect / Climber / Prostrate / Stolon / Rhizome

Root - Fibrous roots / Foliar roots / Adventitious roots / Prop roots / Epiphytic roots / Assimilatory roots / Climbing roots

Leaf - Type of leaf – Simple / Compound, Pinnate / Palmate, Size of leaf – Small / Big, Shape of leaf – Linear / Elliptical / Oval / Ovate / Oblong / Rotund/ Reniform / Oblique, Leaf-apex, Leaf-margin, Leaf-blade, Leaf -base, Sheath, Stipules, Pulvinus, Petiole / Sessile, Vein, Mid-rib, Veinlet, Venation – Reticulate/Parallel, Lateral appendages, Scales.

Flower - Carpels, Stamens, Androecium, Gynoecium or Pistil, Sepals, Petals. Perianth, Bracts, Thalamus, Pedicel, Filament, Anther, Stigma, Unisexual, Bisexual, Staminate, Monoecious, Dioecious, Polygamous

Buds - Axillary buds, Lateral buds, Foliar buds, Accessory buds

Seed - Seed coats, Testa, Tegmen, Hilum, Micropyle, Raphe, Embryo, Cotyledons, Radicle, Plumule, Monocotyledon / Dicotytedon

LABORATORY REPORT – 1

Name: ....   Enrol. No.: ....

Session: I   Date: ....

Time allotted: 2½ hrs.   Time spent: ....

EXERCISE 1 INVESTIGATION OF A PLANT OF YOUR CHOICE

1. Materials and Procedure

Technique(s) used for slide preparation (W.M., section cutting, smear etc.)

Note: You should write this section if you have used a method other than the one given in the manual. Otherwise omit it.

2. Observations

Study of the plant in its natural environment
(Characteristic Features)

Study of a young branch of the plant
(Gross Features)

Habit sketch of the branch

Anatomy of a part of the plant
Under low power
Under high power
(mention magnification)

3. Comments/Problem/Suggestions

Notes

EXERCISE 2 STUDY OF SUB-CELLULAR ORGANISATION OF PROKARYOTIC AND EUKARYOTIC CELLS

2.1 INTRODUCTION

The invention of microscope in the 17^{th} century opened up a world of unseen structures. The biologists found out that living organisms are composed of small units and there is a fundamental unity of life that underlies the apparent diversity of living things. Since then tremendous improvements in the construction and resolution of microscope as well as in the methods of preparing specimens, sectioning and staining have been made. A major technological breakthrough occurred in 1950 when transmission electron microscope (TEM) was developed. The resolution of this microscope was 1000 times greater than light microscope and 500,000 times greater than human eye. The resolving power of EM is about 0.5 nm or less as opposed to 0.2 μm of light microscope.

Under the electron microscope it was possible to study sub-cellular structures of various groups of organisms such as bacteria, protozoa, algae, fungi, plants and animals. The study revealed two types of sub-cellular organisations and formed the basis of regrouping of organisms into prokaryotes and eukaryotes.

In this exercise you will learn to study sub-cellular organisation as revealed in the electron micrographs of the two cell types and make a comparison.

Prior Readings

For doing satisfactory work, you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- Laboratory Course – I, LSE-04 (L), Experiment 1: Microscopy, Sec. 1.5 Resolving power of microscope, p. 7.
- The course "Plant Diversity – I" (LSE-12), Block 1A Diversity of Plants and Related Organisms, Unit 1: Plants and related organisms and their classification, Sec. 1.5, Organisation of cells — prokaryotes and eukaryotes; Fig.1.1, Table 1.1, p. 10-11.

Objectives

After doing this exercise you should be able to:

- point out the finer details of a cell in a given electron micrograph,
- distinguish between the electron micrographs of prokaryotic and eukaryotic cells on the basis of their sub-cellular organisation,
- make a comparison and list the differences between the two cell types and
- draw neat diagrams to show sub-cellular structures of the two cell types.

2.2 MATERIALS REQUIRED

1. The biology laboratory student kit
2. Electron micrographs of a prokaryotic cell of a blue-green alga and a eukaryotic cell of a plant

2.3 PROCEDURE AND RECORD OF OBSERVATIONS

1. First study the micrographs one at a time. Begin your observations from the periphery of the structure and gradually move toward the centre. Try to observe very minute details also. Draw the two cells and label them.

   You are expected to make and record the observations on the micrographs as follows:

   Outer most layer(s)
   Detailed structure of the cytoplasm
   Sub-cellular organelles and their details

2. Now keep the two electron micrographs side by side and compare them. Give comparative account of the structure of the two cells as tabulated in Laboratory Report-2.

   You will find Appendix 2 useful for selecting the terms appropriate for labelling the electron micrographs.

Marking Scheme

Labelled, drawing and description of the two electron micrographs	1×2 =	2 marks
Comparison of the two cell types		2 marks
Neatness in work.		1 mark
	Total	**5 marks**

Appendix 2

Sub-cellular Structures – Ribosome, Cell wall, Nucleus, Chloroplast, Mitochondria, Plastid, Smooth endoplasmic reticulum, Plasma membrane, DNA fibrils, Nucleoplasm, Nuclear membrane, Nuclear pores, Dictyosomes, Cristae, Photosynthetic lamellae, Thylakoids, Stroma matrix, Grana lamellae, Stroma lamellae, Cytoplasm, Endoplasmic reticulum studded with ribosomes, Free ribosomes, Chromatin, Chromosomes, Mitochondrial envelop, Chloroplast envelop, Pyrenoid, Vacuole, Tonoplast.

LABORATORY REPORT - 2

Name: .... Enrol. No.: ....

Session: I Date: ....

Time allotted: 1 hour Time spent: ....

EXERCISE 2 STUDY OF SUB-CELLULAR ORGANISATION OF PROKARYOTIC AND EUKARYOTIC CELLS

1. Observations

   Ultrastructure of a prokaryotic cell

   Description

   Ultrastructure of a eukaryotic cell

   Description

2. Comparison of sub-cellular structures of prokaryotic and eukaryotic cells as revealed in the electron micrographs

Features	Prokaryotic Cell	Eukaryotic Cell

EXERCISE 3 COMPARATIVE STUDY OF PROKARYOTIC AND EUKARYOTIC ORGANISMS

3.1 INTRODUCTION

In the previous exercise you studied the ultrastructure of prokaryotic and eukaryotic cells with the help of electron micrographs and compared their sub-cellular organisation. You know that cells of prokaryotes are much smaller than eukaryotes and possess a primitive type of cellular organisation. They lack nucleus and other cell organelles such as chloroplasts and mitochondria. Bacteria and related organisms are prokaryotes and rest of the organisms is eukaryotes.

Among algae, blue- green algae are prokaryotes and are true bacteria. They are called cyanobacteria because they posses certain accessory pigments such as phycocyanin and phycoerythrin. The presence of these pigments and chlorophyll *a* together impart characteristic blue colour to these organisms. In Plant Diversity – I course you learnt that algae are not true plants but they are included in this study because traditionally botanists study them.

In this exercise you will examine the live specimens of a bacteria and a eukaryotic algae, and a slide of a nitrogen fixing cyanobacteria found in the nodules of leguminous plants. You cannot distinguish between their cell types under a compound microscope because the details observed are substantially limited. However, it is a valuable tool and will enable you to compare cellular organisation of various organisms and help you to distinguish among them.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course "Plant Diversity – I" (LSE-12), Block 1B Algae, Unit 3: Comparative morphology and cell structure in algae, Sec 3.2 Algal morphology, p. 6-14. If you are short of time, look at the figures 3.1, 3.2, 3.3 and their captions. Unit 6: Algal habitats and distribution, Sec. 6.4.3 Algal-symbiotic associations, p. 72-73.

Objectives

In this exercise you should be able to:

- prepare well stained whole mounts of *Lactobacilli* and an algae,
- examine the structure of bacteria in root nodules of legumes and curd and
- compare the structures of a bacteria with an alga and identify the characteristic features that can help to distinguish among them.

3.2 MATERIALS REQUIRED

1. The biology laboratory kit.
2. The biology laboratory students kit
3. Fresh curd
4. Permanent slide of root nodules of any leguminous plant showing cells filled with bacteria
5. Fresh/preserved/permanent slide of an alga
6. Crystal violet stain
7. Glycerine
8. Iodine solution

Precautions

1. Always use a brush for holding the mounting material. Do not use forceps.
2. Ensure that your temporary mounts do not dry up. Keep them immerged in the mounting liquid.
3. View the temporary mounts immediately as they tend to dry up or become distorted in a short period of time.

3.3 PROCEDURE

1. To prepare a fresh mount of curd it is best to use the water, which separates in fresh curd. This will give you a good slide as it has limited number of bacteria. Place a drop of curd water on a clean slide and a drop of crystal violet stain. Wait for two minutes and then place a cover slip on the top.
2. If you are provided with fresh/preserved material of alga, prepare a whole mount and stain it with iodine solution. Refer to Exercise 5 for preparation of whole mount of algae.

3.4 RECORD OF OBSERVATIONS

Observe the three slides - curd, root nodules and the alga under the low and high power objective lens of compound microscope. Make sure that you focus sharply on the specimen. You should spend enough time on each slide and make a record of the number of cells, their size, shape, colour, cell wall and ground substance etc. in the three materials. Also see if nucleus, chloroplast, pyrenoid, flagella etc are visible. Record your observations according to the format given in Laboratory Report 3. Appendix 3 is provided to guide you for making observations systematically and correctly.

Also compare the features of the three preparations. It is quite unlikely that you will be able to see all organelles listed in the Appendix 3. Therefore do not write in your report what is not visible.

Marking Scheme

W.M. of two samples	1×2 = 2 marks
Labelled diagrams and description of the three specimens	1×3 = 3 marks
Comparison of 3 specimens	3 marks
Laboratory skills	1 mark
Viva voce	1 mark
Total	**10 marks**

Appendix 3

Form – microscopic/macroscopic, unicellular/multicellular

Multicellular

Organisation of cells - single/aggregates/clumps, colonial/filamentous branched/unbranched

Differentiation - main body, holdfast (present/absent)

Comparative size of cells - uniform/not uniform

Shape of cells - round/ oval/ spherical/cylindrical/ rectangular /square/ indefinite

Colour/pigments - green/brown/white/black, chlorophyllous/achlorophyllous, pigmented

Sub-cellular structures

Cell sheath - (visible/invisible), mucilaginous/rough, thick/thin

Cell wall - (visible/invisible), thin/thick, even/uneven, light/dark, layered/not layered

Plasma membrane - (conspicuous/inconspicuous), uniform/uneven, extensions

Cytoplasm - smooth/granular

Nucleus - chromatin/chromosomes (conspicuous/inconspicuous)

Nucleoli - (visible/invisible)

Chloroplast/plastids (visible/invisible) - photosynthetic lamellae (visible/invisible)

Shape of chloroplast - cup-shaped/star-shaped/ girdle-shaped/stellate/spiral

Organs of motion - cilia/flagella, number, length

Pyrenoid - (visible/invisible)

Eye spot - (visible/invisible)

Vacuole - (visible/invisible)

LABORATORY REPORT - 3

Name: ....

Enrol. No.: ....

Session: II

Date: ....

Time allotted: 2 hrs.

Time spent: ....

EXERCISE 3 COMPARATIVE STUDY OF PROKARYOTIC AND EUKARYOTIC ORGANISMS

1. Materials and Procedure

Technique(s) used for slide preparation (W.M., section cutting, smear etc.)

Note: You should write this section if you have used a method other than the one given in the manual. Otherwise omit it.

2. Observations

Diagram of bacteria (give magnification used)
Description

Diagram of the section of nodules containing bacteria (give magnification used)
Description

Diagram of alga (give magnification used)
Description

3. **Comparison between prokaryotic and eukaryotic specimens as observed under compound microscope**

Features	Bacteria	Cyanobacteria	Alga
Gross features			
Unicellular/multicellular			
Organisation of cells			
Type of cell(s)			
Any special features			
Individual cells			
Shape			
Comparative size of individual cells			
Pigmentation/colour			
Organs of motion			
Sub-cellular structures			
Cell sheath			
Cell wall			
Plasma membrane			
Nucleus/Chromatin			
Nucleoli			
Mitochondria			
Pyrenoid			
Eye spot			
Vacuole			
Stained structure(s)			
Identification (prokaryotic/eukaryotic cell)			

4. Comments/Problems/Suggestion

EXERCISE 4 COMPARATIVE STUDY OF CHARACTERISTIC FEATURES OF CYANOBACTERIA, ALGAE, FUNGI, BRYOPHYTES AND PTERIDOPHYTES

4.1 INTRODUCTION

In Plant Diversity Course – 1 and 2 you learnt that diversity of plants and related organisms on the earth is tremendous ranging from bacteria, algae, fungi, mosses, ferns, conifers and flowering plants. These organisms show differences in size, shape, colour, cellular organisation, differentiation, habitats, distribution, mode of nutrition as well as in their sub-cellular structures.

In this exercise you will be provided with representative specimens of cyanobacteria, green algae, fungi, bryophytes and pteridophytes for study. You will make a comparative study of their gross morphology, extent of differentiation, complexity in organisation, cellular and sub-cellular structures. On the basis of comparative features you will try to list their characteristics and classify them according to the principles of five kingdom classification.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course "Plant Diversity – I" (LSE-12), Block 1A Diversity of Plants and Related Organisms, Unit 2: Introduction to cyanobacteria, fungi, algae and lower plants, p. 28-41.

Objectives

In this exercise you should be able to:

- make systematic and comparative investigation of the gross morphology, extent of differentiation, cellular and sub-cellular organisation of representative samples of cyanobacteria, algae, fungi, bryophytes and pteridophytes,
- give an account of your observations in the form of sketches and written description,
- list and compare the characteristic morphological, cellular and sub-cellular features of the specimens provided,
- point out the features in the specimens that show gradual increase in complexity in organization and
- compare and contrast the characteristics that are the basis of categorising the samples into different kingdoms.

4.2 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology students laboratory kit
3. Permanent slide of
   a cyanobacterium
   a green alga (showing vegetative stage)
4. Living material of
   a cyanobacterium
   a green algae
   a fungus growing on bread
   living/preserved thallus of a bryophyte
   living/preserved material of a pteridophyte
5. Cotton blue stain
6. Lactophenol
7. Safranine stain
8. Glycerine

4.3 PROCEDURE

1. Examine all the specimens by unaided eye and under hand lens. On the basis of your observations classify them into microscopic and macroscopic forms. First study microscopic forms.
2. Prepare a slide of fresh algal material by mounting it in fresh water (follow the procedure given in Exercise 5).
3. Examine contaminated bread with hand lens and record observations. Pick up a few hyphae with the help of a forceps and place them on a slide; stain with cotton blue; add lactophenol and gently tease out the hyphae; mount neatly without air bubbles.
4. In macroscopic specimens note if the specimens show any structural organisation in the form of thallus, root/rhizoids, stem/rhizome, leaves/sporophylls, sorus, scales and/or any appendages. Examine the dorsal and ventral surfaces under the dissection microscope.
5. Mount various distinguishable structures and study them under low and high power magnification of a compound microscope.

4.4 RECORD OF OBSERVATIONS

You may like to use Appendix 4 to make a systematic study. Record your observations as given below:

1. **Gross morphology** (as observed with unaided eye) - make sketches and describe them.
2. **Differentiation** (as observed by hand lens or dissection microscope)
3. **Cellular organisation** (as observed under the low power objective of compound microscope before and after staining)
4. **Sub-cellular details** (as observed under the high power objective of compound microscope)
5. **Classification** (on the basis of your observations, classify the specimens according to five kingdom classification and justify your decision).

Marking Scheme

Preparation of whole mounts (mark 2 best out of 3 to 5)	1×2 = 2 marks
Labelled sketches and their description (mark 4 best out of 5)	1×4 = 4 marks
Justification of assigning the 5 samples to the respective kingdoms	½×5 = 2½ marks
Viva voce	1½ marks
	Total 10 marks

Appendix 4

Gross Morphology

Appearance/touch - soft / hard / slimy / cottony / mouldy

Colour - chlorophyllous/ achlorophyllous/ pigmented

Form - microscopic / macroscopic, unicellular / multicellular

Microscopic multicellular - filamentous (uniseriate / branched / unbranched / colonial)

Macroscopic multicellular – size, shape (thalloid – single layered sheet / multilayered sheet), mycelium (septate / non-septate)

Differentiation - (undifferentiated / highly differentiated)

Underground structures - rhizoids / roots, stolon / rhizome

Aerial parts - shoot

Vegetative structures - leaves / sporophylls, rachis, trichome, scales

Reproductive structures - sporangia / archegoniophore / antheridiophore

Cellular Organisation

Special type of cells - heterocyst / akinetes / photosynthetic / storage cells

Sub-cellular structures - outer sheath mucilaginous / cell wall, cell wall projections, cytoplasm (thin / thick / even / uneven, ectoplasm / endoplasm), movement of ectoplasm, nucleus, nucleolus, plasma membrane, photosynthetic lamellae, chloroplast, shape of chloroplast – (cup / girdle / star), vacuole (number - one / many)

LABORATORY REPORT – 4

Name: .... Enrol. No.: ....

Session: II Date: ....

Time allotted: 2 hrs. Time spent: ....

EXERCISE 4 COMPARATIVE STUDY OF CHARACTERISTIC FEATURES OF CYANOBACTERIA, ALGAE, FUNGI, BRYOPHYTES AND PTERIDOPHYTES

1. Materials and Procedure

Note: You should write this section if you have used a method other than the one given in the manual. Otherwise omit it.

Technique(s) used for slide preparation (W.M., section cutting, smear etc.)

2. Observations

Gross morphology

Habit sketch and cellular and sub-cellular organisation of specimens 1 to 5

3. Classification

4. Comments/Problems/Suggestions

Notes

EXERCISE 5 COMPARATIVE STUDY OF MORPHOLOGY OF SOME REPRESENTATIVE GENERA OF UNICELLULAR, FILAMENTOUS AND COLONIAL ALGAE

5.1 INTRODUCTION

You have learnt in Unit 3 of Plant Diversity -1 course that algae show range of forms from simple microscopic to more complex macroscopic organisation. The simple forms show single cells either with or without flagella, loose grouping of individual cells within a mucilaginous envelop forming a colony or single row of cells attached to each other forming a filament. In advanced forms the filaments are intricately branched and form flat, leaf-like sheets either by tight packing of individual filaments or by division of cells in two or more planes. There are also heterotrichous algae where thallus is differentiated into a projecting erect system and prostrate creeping system, which is for anchorage to the substratum. In kelps the algal bodies become very large and get differentiated into structures called stipe and blade (frond) that superficially appear like stem and leaves respectively but are unlike them in the internal structure.

In the previous exercise you examined the distinguishing features of cyanobacteria, algae, fungi, bryophytes and pteridophytes. In this exercise you will be provided with unicellular, colonial and filamentous algae to study their comparative morphology and cellular organisation. In the following exercise you will study forms relatively advance in differentiation.

As a student of Botany, it is important that you take interest in the study of algae of your area and acquire knowledge about their occurrence, abundance, and distribution, and explore their role in human welfare. There may be some algae of value and commercial interest also. Therefore we are including methods of collection of algae from their different habitats.

In this exercise you will collect two samples of algae from their habitats and you will be given specimens of representative unicellular, colonial and filamentous algae for laboratory study.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course "Plant Diversity – I" (LSE-12), Block 1B Algae, Unit 3: Comparative morphology and cell structure in algae, Sec.3.2.1 Unicellular forms, p. 6; Sec. 3.2.2 Colonial algae, p. 7; Sec.3.2.3, Filamentous forms, p. 9.

In case you are short of time, just go through the figures 3.1, 3.2 and 3.3 and their captions carefully so that you get some idea about this exercise.

Objectives

In this exercise you should be able to:

- collect samples of algae for laboratory study,
- prepare a temporary mount of an alga under study,
- examine a specimen of an alga with hand lens/dissection microscope and compound microscope and make observations on its morphological characteristics and cellular features,
- develop skills to distinguish among unicellular, colonial and filamentous algae,
- identify the genera of unicellular, colonial and filamentous algae studied in the theory course,
- diagrammatically represent an alga as viewed under the compound microscope and label its structure appropriately and
- write a report of your observations and discuss them in light of the information given in the theory course.

5.2 MATERIALS REQUIRED

For collection

1. Vials/flasks/glass jars/polythene bags or any type of wide mouthed bottles with lid
2. Planktonic net (optional)
3. Knife
4. Scalpel
5. Spatula
6. Permanent pen marker
7. Labels

For study

1. The biology laboratory kit
2. The biology laboratory student kit.
3. Samples of algae (collected)
4. Specimens 1-7 of fresh/preserved samples/permanent slides of algae (provided)
5. Staining solutions
6. Glycerine

5.3 PROCEDURE

Collection of algae

Location

You should collect two samples of algae from any location of your choice. Algae can be easily spotted in ponds, streams, and temporary water puddles, lakes and ocean shores because of their bright colour and profuse growth. They are also seen on soil surface, old pots and damp walls particularly during the rainy season. In case you live near the coast you can find them in abundance on shore rocks.

Collection

When you go for collection carry the items listed in the section "Materials Required" for collection. You should follow the method of collection according to the habitats of algae. These are given below:

Collection from sub-aerial surface

Use a dull edged knife to scrap greenish coating from the surface of a wall, rock, tree trunk or other objects wherever the algae appear to grow and place the mat in a vial or in any other container containing enough water.

Collection from soil

Use a scalpel/knife to carefully remove the crust of algae present on the surface of the soil and store it in a vial containing water.

Collection from fresh water bodies

Using your fingers you can pull out the submerged grass or aquatic plants from their attachment and scrap algae with a scalpel or knife and store in a vial. A planktonic net is generally used to collect large samples.

Collection from sea-water

Marine algae are also pulled out from their submerged attachment. A marine alga needs to be procured carefully. The alga should be transferred from saline water to normal water before it is fixed in formalin. It can also be left in an open dish containing marine water so that it is not deteriorated till fixed.

Labelling

The vial in which you have collected the sample must be labelled. Record the following information.

Sample specification

Common name (if any) ....

Habitat (terrestrial / sub-aerial / soil / sub-soil / aquatic / marine) ....

Location ....

Date of collection ....

Collector's name ....

Most likely you will not go to the laboratory immediately after the collection, therefore store the samples at home in a cool place in dim light or in a refrigerator. When you take the samples to the lab, transfer the content of the vial in a shallow dish so that they are well aerated.

Preservation

Before you preserve the samples clean them by carefully pouring each in a shallow dish and changing the water a few times. The soil particles attached to the algae will settle down at the bottom of the dish. You can pick up algal material using a forceps and place it in a petridish or a vial containing 10-15 ml of 4% formalin.

Preparation of slides

The algal material is generally in the form of dense clumps of opaque mass. It should be spread out evenly in thin layers with the help of a needle and forceps. If your sample is in the form of balls then using a pair of needles pull the green ball apart releasing out the strands. Then using a fine forceps transfer a few strands about the size of a dot along with a drop of water on a clean slide. *Spread out material to get a very thin layer of single cells so that light can pass through easily making the cells visible through the microscope.*

5.4 RECORD OF OBSERVATIONS

You must remember that a scientist begins an investigation by making correct observations. Therefore you should not hesitate to record your observations if they do not correspond to what is given in the theory. However you must try to find out the reasons for different results and give an explanation for the same.

First using a hand lens/dissection microscope you can make some general observations about the appearance, colour and texture of the fresh/preserved materials under study. Then observe the prepared and permanent slides one by one under the low power of the compound microscope to see shape, size, density, aggregation and organisation of cells.. Try to distinguish clumps of unicellular cells of an alga from a true multicellullar form. Distinguish between colonial and filamentous forms and record your observations. Examine carefully if all the cells of an alga are alike or they can be distinguished into more than one types.

Next fix the sample under the high power for detailed study and again observe shape, size, colour and density of each cell and their contents such as cytoplasm, nucleus, chloroplast(s) and flagella and try to see if there is anything unusual about them.

Use Appendix 5 as well as the previous appendices to choose the appropriate terms and describe your observations correctly. Also mention the optical forms used for taking the observations. Record your observation as directed in Laboratory Report 5.

Marking Scheme

Collection of algae (mark any 2 samples)	$\frac{1}{2} \times 2 =$	1 mark
Preservation and labelling of samples	$\frac{1}{2} \times 2 =$	1 mark
Labelled diagrams and description of collected and given samples (mark 6 best out of 8)	$1 \times 6 =$	6 marks
Viva voce		2 marks
	Total	10 marks

Appendix 5

Appearance - soft/hard, slimy/cottony/ any other

Colour - green/red/brown/yellow, chlorophyllous/achlorophyllous/ any other

Form - unicellular/multicellular, microscopic/macroscopic, differentiated/not diferentiated

Multicellular

Organisation of cells - aggregates/clumps, colonial/ coenobium/ filamentous - branched/ unbranched, uniseriate, thin hair like/thalloid, single layed/ multilayered sheets

Differentiation/distinguishing structures - main body, holdfast, gonidial cells if any

Shape of cells - round/oval/spherical/cylindrical/rectangular/square/indefinite

Comparative size of cells - uniform/not uniform

Unicellular/cells

Sub-cellular Structures

Cell sheath - visible/invisible, mucilaginous/rough, thick/thin

Cell wall - visible/invisible, thin/thick, even/uneven, light/dark, layered/not layered

Plasma membrane - conspicuous/inconspicuous, uniform/uneven, any extensions

Cytoplasm - smooth/granular, pigmented, distinguishable regions

Nucleus - conspicuous/inconspicuous, uninucleate/multinucleate/coenocytic, position – central/ perietal, chromatin/ chromosomes, minute/large, shape, appearance

Nucleoli - visible/invisible

Chloroplast/plastids - size, appearance, number, position, photosynthetic lamellae (visible/invisible),

Shape of chloroplast/plastid - cup-shaped/star-shaped/girdle-shaped/stellate/ spiral/disc-shaped/band-shaped/plate-like

Organs of motion - cilia/flagella, number, length - equal/unequal

Pyrenoid - visible/invisible

Eye spot - visible/invisible

Vacuole - visible/invisible, position, number, size, shape

Special cells - heterocyst/akinete/cap cells/any other

LABORATORY REPORT - 5

Name: ....   Enrol. No.: ....

Session: III   Date: ....

Time allotted: 2 hrs.   Time spent: ....

EXERCISE 5 COMPARATIVE STUDY OF MORPHOLOGY OF SOME REPRESENTATIVE GENERA OF UNICELLULAR, FILAMENTOUS AND COLONIAL ALGAE

1. Materials and Procedure

   Technique(s) used for slide preparation

   Note: You should write this section if you have used a method other than the one given in the manual. Otherwise omit it.

2. Observations

   Cellular organisation

   Labelled diagrams and description of specimens 1 to 8
   (Give magnification)

3. Comments/Problems/Suggestions

EXERCISE 6 COMPARATIVE STUDY OF MORPHOLOGY OF SOME REPRESENTATIVE GENERA OF ADVANCED ALGAE

6.1 INTRODUCTION

In the previous exercise you prepared temporary mounts of unicellular, colonial and filamentous algae and studied them. In this exercise you will continue this study and examine some representative genera of heterotrichous, thalloid and polysiphonoid forms of algae.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course – "Plant Diversity – I" (LSE-12), Block IB Algae, Unit 3: Comparative morphology and cell structure in algae, Sec.3.2.4 Heterotrichous forms, p. 11; Sec. 3.2.5 Thalloid forms, p. 13; Sec.3.2.6 Polysiphonoid forms, p..14.

  In case you are short of time, just go through the Figs. 3.4, 3.5, and 3.6 of the unit and their captions carefully.

Objectives

In this exercise you should be able to:

- examine and record the characteristic features of thalloid, heterotrichous and polysiphonoid forms of algae and distinguish among them and
- identify the algal genera on the basis of the features observed.

6.3 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology laboratory student kit
3. Fresh/preserved specimens or permanent slides of heterotrichous, thalloid and polysiphonoid forms of algae
4. Methylene blue
5. Glycerine

6.4 PROCEDURE

Prepare temporary mounts of the fresh/preserved specimens of algae as described in the previous exercise (Sec. 5.3.4), for microscopic examination.

To avoid confusion you must number your slides. Examine the slides one at a time under low and high power objective lens of compound microscope.

6.5 RECORD OF OBSERVATIONS

You must make observations as instructed in the previous exercise in Sec. 5.3.4. Try to recall the observations you made on *Chlamydomonas* a unicellular alga, *Volvox* a colonial alga and *Ulothrix* a filamentous alga, while you examine the advanced forms of algae and pay attention to further differentiation in the cells. On the basis of shape, size, number, position and organization, note the various types of cells that are distinguishable. See how similar cells are associated together and what is their position with respect to other types of cells. In case you find branched filaments, observe the pattern and the origin of branching and describe them. In some samples you will find cells arranged in layers. See if the layers formed are distinguishable as outer, inner, middle/central. Draw and label them appropriately. Choose from the terms given in Appendix 5 and 6 to describe the organization of cells, and identify algal forms. You may like to refer to Appendices 3 and 4 also for describing the cellular and sub-cellular details.

Record observations as given in Laboratory Report 6.

Remember, the resolving power of your microscope is limited and therefore once again we strongly suggest that you should record your true observations only. It is unscientific and unethical to put down imaginary or someone else's observations in your practical record book.

Marking Scheme

Labelled diagrams of 6 specimens of algae (mark 3 best out of 6)	1×3 = 3 marks
Description of the algae examined (mark 3 best out of 6)	1×3 = 3 marks
Comparative account of the specimens	2 marks
Viva voce	2 marks
Total	**10 marks**

Appendix 6

Colour – green/deep-green/yellow/brown/blue/red/any other

Appearance – tubular/cylindrical/filamentous/bushy/flat/sheet-like/any other

Vegetative differentiation – prostrate/erect system or both/any other

Form – heterotrichous/polysiphonoid/thalloid/filamentous

Filamentous – branched/unbranched, origin of branching, regularly branched/ irregularly branched, sparsely branched/much branched/profusely branched, row of cylindrical/tubular cells, uniform/not uniform cells /apex cell-thickness/ shape-rounded/tapered/hair-like bristles

Thalloid – differentiated/not differentiated, nodes/internodes, holdfast/ rhizoids, stipe, blade-like (fronds)

Polysiphonoid – disk-like/cushion-like, septate/non-septate, midrib, receptacle, air bladder, layer of cells/outgrowth of cells

LABORATORY REPORT – 6

Name: .... Enrol. No.: ....

Session: III Date: ....

Time allotted: 2 hrs. Time spent: ....

EXERCISE 6 COMPARATIVE STUDY OF MORPHOLOGY OF SOME REPRESENTATIVE GENERA OF ADVANCED ALGAE

1. **Materials and Procedure**

   Mention the technique(s) and the stains used for slide preparation.

   Note: You should write this section if you have used a method other than the one given in the manual. Otherwise omit it.

2. **Observations**

   Labelled diagrams of specimens 1 to 6
   (give magnification used)

   Description

3. **Comparative account**

4. **Comments/Problems/Suggestions**

EXERCISE 7 COMPARATIVE STUDY OF REPRODUCTIVE FEATURES OF SOME REPRESENTATIVE GENERA OF ALGAE

7.1 INTRODUCTION

Algae show all the three types of reproduction – vegetative, asexual and sexual. Vegetative reproduction is the most common method and it occurs by fragmentation of parent algae. In asexual reproduction specialized cells are formed. In *Nostoc* the specialized cells called akinetes are formed by transformation of vegetative cells into thick-walled dormant cells containing accumulated food. Akinetes can withstand dryness and high temperatures for a long time. In algae such as *Chlamydomonas, Ulothrix, Oedogonium, Ectocarpus, Draparnaldiopsis* and *Ulva*, flagellated motile spores called zoospores initiate new filaments. They are formed when the entire cell content divides by mitosis a few times and produces several zoospores. The number of flagella in zoospores of different genera varies. In many algae zoospores are formed in special structures called zoosporangia which are unilocular or plurilocular and produce single or several zoospores respectively. In some species when the conditions are unfavorable zoospores shed the flagella and round up. Such non-motile zoospores are called aplanospores.

The formation of zoospores, their structure and the number of flagella are characteristic of a species. Therefore, zoospores may be studied for the identification purposes also.

In sexual reproduction, division of cells of an algal thallus forms gametes. The two gametes male and female (- and + strains) may develop on the same thallus (homothallic) or different thallus (heterothallic). You learnt in the theory course that in algae the two gametes may be motile and similar in size or male gamete may be somewhat smaller than the female gamete or the female gamete may be non-motile and much larger than the male gamete. Accordingly the three types of gametic fusion-isogamy, anisogamy and oogamy are observed in algae.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course "Plant Diversity – I" (LSE-12), Block 1B: Algae, Unit 4: Reproduction in algae, Sec. 4.2.2 Asexual reproduction, p. 28-29; Sec. 4.2.3 Sexual reproduction, p. 30-31; Sec. 4.3 Reproduction and life cycle, p. 32-40.

If you are short of time study the figures in Unit 4 and also go through their captions.

Objectives

In this exercise you should be able to:

- examine and record the asexual and sexual reproductive features of some representative genera of algae and
- identify the specimens of algae on the basis of reproductive structures.

7.2 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology laboratory student kit
3. Permanent slides of specimen of algae showing reproductive features

7.3 RECORD OF OBSERVATIONS

Examine the slides of algae focused under compound microscopes by your counsellor. For comparative study examine 3-4 slides at a time. You must spend enough time on each. Try to distinguish between vegetative and reproductive cells/structures. Make your observations as suggested in the previous two exercises on algae. Compare the types of sporangia, structure of spores, antheridia and oogonia, sperms and oospore, whichever is visible in the slide.

By now, we hope that with the experience gained from the previous exercises, you can make systematic and correct observations. You may find some terms given in Appendix 7 applicable to your observations. Record your observations on each slide and also write a comparative account of the reproductive structures of different algae examined.

Marking Scheme

Labelled diagrams of 6 specimens of algae (mark 5 best out of 6)	1×5 = 5 marks
Description of the above	1×6 = 6 marks
Discussion	2 mark
Viva voce	2 marks
Total	**15 marks**

Appendix 7

Appearance – microscopic/ macroscopic

Gametophyte/sporophyte – shape, size, colour

Reproductive cells – thick-walled cells (akinetes), dividing cells/cells with flagellated spores

Reproductive structure – spore-bearing cells, sporangia, spores, antheridia, oogonia, gametes

Sporangia – position, number, size, shape, type (unilocular/plurilocular, stalked/sessile)

Spores – number (single/a few/numerous), shape, size, outer sheath, flagellated/unflagellated, ornamentation

Oogonia – position (restricted/all over), number (few/numerous), size, shape, wall, margins, contents (starchy/oil drops), oospore

Antheridia – number, position, size, shape, wall, sperms

Fusion of gametes – Isogamy/anisogamy/oogamy

LABORATORY REPORT – 7

Name: .... Enrol. No.: ....

Session: IV Date: ....

Time allotted: 4 hrs. Time spent: ....

EXERCISE 7 COMPARATIVE STUDY OF REPRODUCTIVE FEATURES OF SOME REPRESENTATIVE GENERA OF ALGAE

1. **Observations**

   Labelled diagrams of specimens 1 to 6
   (Give magnification used)

   Description

2. **Discussion**

3. **Comments/Problems/Suggestions**

EXERCISE 8 COMPARATIVE STUDY OF HABIT, EXTERNAL FEATURES AND ASEXUAL REPRODUCTION IN SOME REPRESENTATIVE GENERA OF FUNGI

8.1 INTRODUCTION

In Unit 8, "Fungal habitats and morphology" of Plant Diversity – I course, you learnt that fungi are heterotrophic and live as saprophytes, parasites or symbionts. They vary in size, color, morphology, habitats as well as in the reproductive structures. Fungi show microscopic, unicellular, filamentous and pseudoparenchymatous forms that may be cellular or acellular, uninucleate or multinucleate. The macroscopic forms such as mushrooms, *Ascobolus*, puffballs and morels are compact aggregates of fungal filaments. The vegetative body of a great majority of fungi is composed of branched, tube-like, septate or non-septate coenocytic filaments.

Thus we find fungi vary greatly in morphological features, habitats, method of nutrition, fructification and in the types of spores they produce during asexual and sexual reproduction. However, each group shows certain special features which help us to distinguish it from another.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course on "Plant Diversity – I" (LSE-12), Block 2: Fungi, Unit 8: Fungal habitats and morphology, Sec. 8.2 Fungal habitats, p. 8; Sec. 8.3 Nutrition and growth in fungi, p. 5-6; Sec. 8.4 Fungal morphology, p. 6-12; Unit 9: Comparative account of reproduction in fungi, Sec. 9.2.2. Read asexual reproduction in *Rhizopus*, *Neurospora* and *Puccinia*.

Objectives

In this exercise you should be able to:

- follow an appropriate procedure for examination of morphological and cellular features of an unknown fungal colony with unaided eye and using optical devices,
- examine the habit, general morphology, cellular organization and fructification of a fungal colony,
- give a comparative account of the above features in given fungal specimens,
- study asexual reproductive bodies in the given materials or slide,
- record your observations in the form of sketches and give detailed explanatory notes on the specimens examined and

identify and list the external and asexual reproductive features that may be used to distinguish among fungal groups.

8.2 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology laboratory student kit
3. Cultures of fungi
4. Permanent slides of fungi
5. Glycerine
6. Lactophenol
7. Cotton blue

8.3 PROCEDURE

1. You will be provided with four cultures of fungi labelled 1 to 4. Since there will probably be a single culture of each fungus, you may work in groups and study a fungal culture at a time.
2. First observe the habit, colour, growth of the colony and gross morphology of the fungus. Use a hand lens for making accurate observations. Record your observations.
3. Place a very small portion of the specimen from the petridish along with its substrate and fruiting bodies (if any) on a slide and observe under dissection microscope. In case the sample is in liquid form mount it on a slide and observe. To record your observations draw sketches of the specimens examined and describe them.
4. To study cellular organisation and asexual reproductive bodies in detail you need to prepare temporary mounts as follows:
   i) Place a small drop of cotton blue on a clean slide; pick up a few hyphae from the substratum and place them in the stain.
   ii) Gently tease out the hyphae; add a small drop of lactophenol to the preparation.
   iii) Use bits of filter paper to remove excess stain by gently slanting the slide.
   iv) Place a cover slip neatly and avoid air bubbles.
5. Prepare a scrape mount of spores of *Puccinia* as demonstrated by your counsellor.
6. Study the preparation under low as well as high power objective of a compound microscope. Compare them with the permanent slides of the specimens.

8.4 RECORD OF OBSERVATIONS

You will record observations on the specimens in the format given in Laboratory Report 8. Use Appendix 8 to choose appropriate terms to record your findings.

1. Gross morphology

Record the substrate, appearance, texture, microscopic or macroscopic nature, colour, general morphology, fructification and other distinguishable features of the specimens, as observed with unaided eye or under a dissection microscope.

Draw, label and give written explanatory notes.

2. Structural details

Examine the temporary mounts and permanent slides under a compound microscope. Observe mycelium, its branching pattern, differentiation and cellular structure. Draw sketches and describe them.

You may consult Appendix 8 to make systematic investigations of the specimens.

3. Asexual reproductive bodies

You should observe fructification, which may be in the form of sporangiophores, conidiophores or other kind of spores. Record size, colour, shape etc. and make neat labelled diagrams. Submit a report of the exercise in the format given in Laboratory Report 8.

Marking Scheme

Preparation of the whole mounts and scrape mount (mark any 2)	2 marks
Diagrams and description of gross morphology and internal structure of 6 fungi (mark 3 best out of 6)	1×3 = 3 marks
Report on asexual reproductive bodies	2 marks
Comparative account of 6 fungi	2 marks
Viva voce	1 mark
Total	10 marks

Appendix 8

Colour – blackish/brownish/greenish/white/bluish/or any other

Appearance – slimy/cottony/mouldy/powdery/soft/hard

Pigments – chlorophyllous/achlorophyllous

Size – microscopic - (visible to unaided eye/seen under hand lens/compound microscope)/macroscopic, unicellular/multicellular

Distinguishable parts – within the substrate - rhizoids/roots, creeping on the substrate, ramification, filamentous – branched/unbranched, colonial

Hyphae – septate/non-septate, branched/unbranched, number of nuclei - few/many

Rhizoids – present/absent, single in groups

Fructification – fruiting bodies, spare/profuse, stalked/sessile, asexual bodies-sporangiophores/conidiophores/ sexual bodies - apothecium/perithecium/ cleistothecium

Sporangiophores – origin/ distribution (specific/random), branched/ unbranched, single/in groups

Sporangia – shape, colour, size, stalked/sessile, structure - collumella (visible not visible), at similar developmental stage / at various stages of development

Conidiophores – sterigmata, branched/unbranched, type of branching, erect/horizontal

Lime nodules – present/absent, shape, size, colour

Spores – colour/colourless, shape, position, origin, hyaline/opaque, spore wall - smooth/spiny/reticulate, flagella – present/absent, number, length, uredospores, teleospores

Conidia – size, number, beaded chains - types of chains, exogenous/ endogenous, origin

Cells – single/in groups, approximate number, relative size, shape, type of association

Cell organelles – nucleus, number, uninucleate/ binucleate /multinucleate, size, chloroplast, vacuole, other structures

Buds – visible/not visible

Staining pattern – the organelles stained, colour

Note: The appendix given should not be considered complete because there may be lot mor to observe in your specimens.

LABORATORY REPORT – 8

Name: .... Enrol. No.: ....

Session: V Date: ....

Time allotted: 2 hrs. Time spent: ....

EXERCISE 8 COMPARATIVE STUDY OF HABIT, EXTERNAL FEATURES AND ASEXUAL REPRODUCTION IN SOME REPRESENTATIVE GENERA OF FUNGI

1. Materials and Procedure

Technique(s) used for slide preparation

Note: You should write this section if you have used a method other than the one given in the manual. Otherwise omit it.

2. Observations

Gross morphology and internal structure

Diagrams and descriptions of specimens 1 to 6

Asexual reproductive structures

3. Comparative account of fungal material

Features	Specimen I	Specimen II	Specimen III	Specimen IV	Specimen V	Specimen VI
Colour Appearance Pigments Size Differentiation Hyphae Sub-cellular features Fructification Sporangiophores Conidiophores Sporangia Spores Conidia						

You are expected to further elaborate the above points

4. Comments/Problems/Suggestions

Notes

EXERCISE 9 STUDY OF SEXUAL REPRODUCTIVE STRUCTURES IN FUNGI

9.1 INTRODUCTION

In the previous exercise you examined habit, mode of nutrition, distinguishing morphological features, fructification, types of spores and their formation in fungi. In this exercise you will study stages of sexual reproduction and the resultant fruiting bodies in some representative genera of fungi.

In fungi during sexual reproduction the hyphae produce different types of sex organs such an antheridia and oogonia in Oomycetes, (example *Phytophthora*), antheridia and ascogonia in Ascomycetes (example *Penicillium* and *Neurospora*). No sex organs are formed in Basidiomycetes (example *Puccinia*). In Zygomycetes (example *Rhizopus*) the fusion of gametangia of + and – strains results in the formation of a zygophore which on germination forms zygosporangium bearing zygospores.

The zygote or its derivatives, the spores, are very characteristic of a fungal group. They are called zygospores in Zygomycetes, ascospores in Ascomycetes and basidiospores in Basidiomycetes. The structures bearing ascospores and basidiospores are called ascus and basidium and the fruiting bodies ascocarp and basidiocarp respectively. The ascocarp is cup or saucer-shaped in *Ascobolus* (apothecium), flask-shaped in *Neurospora* (perithecium) and indehiscent (cleistothecium) in *Phyllactina* and is therefore valuable for identifying them.

In this exercise you will study sexual reproductive structures of some fungal species.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course on "Plant Diversity-I" (LSE-12), Block 2: Fungi, Unit 9: Comparative account of reproduction in fungi, Sec. 9.2.3 Sexual reproduction p. 22-26; Sec. 9.3.2 *Rhizopus*, p. 29-32: Sec. 9.3.3 *Neurospora* p. 33-34; and Sec. 9.3.4 *Puccinia* p. 35-38 . Also see Figs. 9.7, 9.11, 9.13 and 9.14.

Objectives

After doing this exercise you should be able to:

- identify the stages of sexual reproduction in some fungi,
- examine the sexual fruiting body of different fungi and distinguish among them,
- prepare a scrape mount of spores of *Puccinia*,

- cut sections of ascocarp of *Ascobolus* and
- classify a fungus in an appropriate group on the basis of structure of its fruiting bodies.

9.2 MATERIALS REQUIRED

1. The biology laboratory kit.
2. The biology laboratory student kit.
3. Permanent slides of various groups of fungi showing reproductive stages
4. Fresh/preserved material of *Ascobolus*
5. Glycerine
6. Lactophenol
7. Cotton blue

9.3 PROCEDURE

1. Study of permanent slides (1 to 5)

Examine the focused slides one at a time under the low and high power objectives of compound microscope. Try to identify the reproductive structures and the probable genus.

2. Section cutting of a fruiting body of *Ascobolus*

From *Ascobolus* culture, pluck a cup-shaped body with the help of forceps and place it on a slide. Cut a thin vertical section, stain it with cotton blue (lactophenol) and examine.

9.4 RECORD OF OBSERVATIONS

Record your observations as follows:

i) Draw and describe the features visible in the slides, including the different stages of reproduction.
ii) Give detailed account of differentiated structures.
iii) Mention cellular details that are visible.

Make neat and labelled diagrams of the slides and describe them. You should look for the details in the slides given in Appendix 9. Compare your observations with information given in the theory. Try to identify the genus on the basis of fruiting bodies.

Marking Scheme

Section cutting of apothecium	2 marks
Diagram and description of apothecium	1 mark
Scrape mount of *Puccinia*	2 marks
Diagrams and description of permanent slides 1 to 5 (Mark 4 best out of 5)	2×4 = 8 marks
Viva voce	2 marks
Total	**15 marks**

Appendix 9

Reproductive structures – Gametangial copulation/fruiting bodies, progametangia, gametangia, suspensor, zygophore, zygosporangia, ascocarp – shape (cup-shaped/ saucer-shaped/flask-shaped/indehiscent), colour

Asci – location (all over/at the base), shape (erect/globular), number of ascus (a few/many), periphyses, appendages

Ascospores – arrangement in the ascus, number in each ascus (2/4/8)

LABORATORY REPORT – 9

Name: .... Enrol. No.: ....

Session: V Date: ....

Time allotted: 2 hrs. Time spent: ....

EXERCISE 9 STUDY OF SEXUAL REPRODUCTIVE STRUCTURES IN FUNGI

1. Materials and Procedure

Technique(s) used for slide preparation

Note: You should write this section if you have used a method other than the one given in the manual. Otherwise omit it.

2. Observations

Diagrams and description of slides 1 to 5
(Mention magnification used)

Diagram and description of section of apothecium

3. Comments/Problems/Suggestions

Notes

EXERCISE 10 STUDY OF COMMON FUNGAL DISEASES OF CROP PLANTS

10.1 INTRODUCTION

In the theory course you learnt about fungal diseases such as late blight of potato, powdery mildew of rose, red rot of sugarcane, loose smut of wheat and wheat rusts. You learnt that each of these diseases is caused by a specific fungal pathogen. In this exercise you will study the specimens of crop plants infected by fungi, examine the symptoms and try to identify the disease.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course "Plant Diversity-I" (LSE-12), Block 2 Fungi, Unit 10: Fungal diseases, Sec. 10.2.1, p. 44; Sec.10.3.1 p. 46; Sec.10.4.1 p. 48; Sec.10.5.1 p. 50; Sec. 10.6.2 p. 52, read the sections on symptoms.

Objectives

After doing this exercise you should be able to:

- distinguish a healthy plant from an infected plant,
- identify whether a crop disease is due to a fungal or any other pathogen,
- examine the infected area of a plant to see how the pathogen has manifested itself,
- list the identification symptoms of a disease,
- attempt to identify the class of fungal pathogen and
- make a proper record of your observations.

10.2 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology laboratory student kit
3. Infected specimens of 4-5 crop plants (fresh/herbarium specimens/slides)
4. Slides of infected parts of the plants

10.3 PROCEDURE

First examine in each specimen the part of the plant and the surface(s) infected with a pathogen. Note the location, extent of spread, change in colour and the way the pathogen has manifested itself. If you are provided with a fresh specimen, scrap out the infected part under a dissection microscope or hand lens to study the nature of the pathogen. Also observe the slides of infected host.

10.4 RECORD OF OBSERVATIONS

Make neat, labelled sketches of host plants infected with the pathogens and write appropriate captions. Give a comparative account of your observations in tabulated format as given in Laboratory Report 10. Glance through Appendix 10 before your write down your observations. Like previous appendices you can use it for making a systematic investigation. Choose the terms from the alternatives given in describing your observations correctly.

Marking Scheme

Sketches of the host plants infected with pathogens (mark 4 best out of 5)	1×4 =	4 marks
Comparative account of 5 specimens		5 marks
Viva voce		1 marks
	Total	**10 marks**

Appendix 10

Infected aerial plant part - leaf/shoot/spikelet/bud/flower/branches/ stem/underground parts – root/rhizoid/tuber

Infected surface(s) - partially/completely infected, dorsal/ventral surface or both.

Colour change in host - red/black/ashy/brown/white/rusty/orange/ yellow/any other

Colour of the pathogen - yellow/brown/black/white/any other

Extent of spread of infection - slight/moderate/heavy

Change in the appearance of host plant/or its part - dry/burnt/shrunken/gall formation/spots/raised surface/changes in the margin.

Nature of the pathogen - powdery mass/water soaked regions/spores - uredia/telia/pustules/ sporangia, shape - oval/round/lemon

LABORATORY REPORT - 10

Name: .... Enrol. No.: ....

Session: VI Date: ....

Time allotted: 2 hrs. Time spent: ....

EXERCISE 10 STUDY OF COMMON FUNGAL DISEASES OF CROP PLANTS

1. **Observations**

   Sketches of specimens 1 to 5

2. **Comparative account of symptoms of fungal diseases**

Symptoms	Specimen I	Specimen II	Specimen III	Specimen IV	Specimen V
1. Part infected with pathogen 2. Surface(s) infected 3. Change in the colour of the host 4. Colour of the pathogen as manifested on the host 5. Change in the appearance of the host 6. Spread of the pathogen as observed on the surface of the host • area • size • shape 7. Nature of the pathogen 8. Any other symptoms 9. Identification of pathogen					

EXERCISE 11 STUDY OF THE MORPHOLOGICAL, ANATOMICAL AND REPRODUCTIVE FEATURES IN LICHENS

11.1 INTRODUCTION

Lichens are derived as a result of symbiotic association of a fungus and an alga. The two partners together produce a thallus distinct in morphology and anatomy. Three major kinds of lichen thalli are crustose, fruiticose and foliose that can be distinguished on the basis of their morphological appearance on the substrates. They occur on various habitats such as bark of trees, soil and rocks. In India you would find them in Ooty, Shillong, Darjeeling and on the highest mountains in Himalayas.

Lichens reproduce both by vegetative and sexual reproduction. In this exercise you will study morphological, anatomical and reproductive features of lichens.

Prior Reading

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course "Plant Diversity – I" (LSE-12), Block 2: Fungi, Unit 12: Lichens, Sec. 12.2.2 Structure and anatomy of lichens, p. 72 and Sec. 12.3 Reproduction in lichens, p. 75-76, Figs. 12.3 and 12.4.

Objectives

After doing this exercise you should be able to:

- identify the three types of lichen thalli on their substrates,
- examine the anatomical features of a lichen thallus and investigate the type of symbiotic association of fungal and algal partners,
- observe the modifications in the anatomical features of the fungus and the alga in such symbiotic association,
- record your observations on the specimens and slides in the form of labelled diagrams and give their description,
- recognise reproductive structures in lichens and describe them and
- prepare a report of your investigation.

11.2 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology laboratory student kit
3. Lichen specimens on the substrates
4. Permanent slides of lichens showing vegetative and reproductive structures

11.3 PROCEDURE

1. First examine carefully one at a time the three specimens provided to you on their substrate. Examine both the surfaces and margins, and the distinct morphological features. Then make a comparative study of the three specimens.
2. Next examine permanent slides focused under the microscope by your counsellor. Try to distinguish the different fungal and algal regions. Study minute details to see the type of arrangement of the cells within a region and their association with the cells of the adjacent region(s). You must spend enough time on each slide so that you can compare their anatomical features. Also identify the special structures, if any, formed for reproductive function.

11.4 RECORD OF OBSERVATIONS

You should make observations on the specimens provided and make a record of it in the format given in Laboratory Report 11 for submission.

Marking Scheme

Morphology - Labelled sketches and description of specimens 1 to 3	-	1marks
Anatomy – labelled diagram and description	-	1marks
Asexual reproductive structures – labelled diagram and description	-	1marks
Sexual reproductive structures – labelled diagram and description	-	1marks
Viva voce	-	1 marks
	Total	5 marks

LABORATORY REPORT - 11

Name: ....

Enrol. No.: ....

Session: VI

Date: ....

Time allotted: 2 hrs.

Time spent: ....

EXERCISE 11 STUDY OF THE MORPHOLOGICAL, ANATOMICAL AND REPRODUCTIVE FEATURES IN LICHENS

1. Observations

Habit sketches of specimens 1 to 3

Study of slides 1 to 3

	Specimen 1	Specimen 2	Specimen 3
Morphological features			
Colour			
Texture			
Morphological appearance on the substrate			
Structure of a single thallus			
Structure formed by the grouping or union of thalli			
Any special structure(s)			
Type of lichen			

	Slide 1	Slide 2	Slide 3
Anatomical features			
Distinguishable regions			
Cellular organisation in the upper region			
Cellular organisation in the lower region			
Cellular organisation in the middle/central region			
Zone(s) similar to fungal structures (if any)			
Zone(s) similar to algal structures (if any)			
Type of section			
Asexual reproductive structures			
Type of reproductive bodies			
Shape			
Size			
Frequency			
Type of cells			

Fungal like asexual reproductive structures (if any)
Algal like asexual reproductive structures (if any)
Identification of structures

Sexual reproductive structures

Shape
Size
Type
Frequency
Nature of the constituent cells
Fungi like sexual reproductive structures (if any)
Algae like sexual reproductive structures (if any)

Spore like structures, if any (visible/not visible)
Spores enclosed within some structure
Other distinguishable structures
Similarity to fungal reproductive bodies
Identification of type of structure

EXERCISE 12 COMPARATIVE STUDY OF MORPHOLOGICAL FEATURES OF SOME REPRESENTATIVE GENERA OF BRYOPHYTES

12.1 INTRODUCTION

In Exercise 4 you examined the structure of a typical bryophyte and compared its features with those of a typical alga, fungus and pteridophyte. You know that bryophytes are the simplest primitive non-vascular land plants, which thrive in habitats that are intermediate between aquatic and terrestrial, particularly in those which are more or less perpetually wet. It is believed that they were the first land plants and might have originated from fresh water photosynthetic ancestor probably from algae. In Unit 13 of LSE-12 course you learnt that bryophytes acquired certain adaptations to survive on land. In this exercise you have an opportunity to observe and verify them.

Like all other land plants bryophytes show two well-defined phases in their life cycle, sexual and asexual. There is distinct alternation of generations between gametophytic and sporophytic phases. One of the remarkable features of bryophytes is that their gametophyte is conspicuous, independent and photosynthetic while the sporophyte is wholly or partially dependent on it. In other groups of land plants it is the sporophyte that is visible to the naked eye and forms a dominant phase of the life cycle and the gametophyte is microscopic and remains well protected within the sporophyte.

With this background you can begin this exercise and do a comparative study of the morphological features of representative genera of the three classes of bryophytes – Hepaticopsida, Anthocerotopsida and Bryopsida, and try to identify them.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course --"Plant Diversity – I" (LSE-12), Block 3: Bryophytes, Unit 13: Morphology and anatomy of bryophytes, Sec. 13.4, p. 12-22. Study only morphology of the genera described and go through Figs. 13.1, 13.3, 13.4, 13.6, 13.7, 13.8 and 13.10 carefully.

Objectives

After doing this exercise you should be able to:

- follow a right procedure for examination of a specimen of bryophyte for investigating its morphological characteristics,
- make a sketch of the morphology of a specimen observed and label its features,

- write a report on the morphological features of a specimen examined,
- compare and contrast the morphological features of bryophytes with those of algae,
- distinguish among some representative genera of bryophytes on the basis of morphological features observed and
- investigate the features which help them to survive on land.

12.2 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology student laboratory kit
3. Fresh/preserved specimens of bryophytes
4. Safranine stain (1%)
5. Glycerine

12.3 PROCEDURE

Study each sample using a hand lens/dissection microscope. Prepare whole mounts of the parts and examine them under low power lens of compound microscope.

1. External features

i) Dorsal and ventral surfaces – observe both surfaces for colour, form, size/dimension, branching pattern, surface features, appendages, leaves etc.

ii) Reproductive structures (if any) – observe, location, size, type, and their arrangement.

2. Study of parts

Using a forceps and needle detach rhizoids, scales, leaves, reproductive bodies and any appendages/outgrowth from dorsal and ventral surfaces. Prepare a whole mount of each in glycerine. Use safranine to stain the rhizoids and leaves. The scales need not be stained. Observe the slides under the low power of compound microscope.

12.4 OBSERVATIONS

Record your observations in the form of drawings and label them. Also draw and label the cellular details of rhizoids, scales and leaves as seen in whole mounts under dissection and compound microscopes. Use Appendix 12 to make systematic investigation of the specimens and select appropriate terms for describing them.

Make a comparative account of the specimens examined in tabulated format as given in Laboratory Report 12. Circle common features of the specimens with same ink colour so that the commonalities and distinctions among them become apparent. You may need 3-4 colours to circle the commonalities of the 5 specimens.

Marking Scheme

Labelled sketches of 6 specimens and their parts	½×6	= 3	marks
Comparative account of the 6 specimens		= 3	marks
Classification and identification	½×6	= 3	marks
Mounting and staining		4	marks
Viva voce		2	marks
	Total	**15**	**marks**

Appendix 12

Gametophyte/ Sporophyte or both

Colour – green/ deep-green/ brown/ transparent/ colourless/any other.

Size – visible to unaided eye/not visible to unaided eye, dimensions

Appearance/form – prostrate/erect or both, upright leafy shoot/ flat thylloid, thin/thick, fleshy, lobbed, ribbon-like, dorsi-ventral, embedded

Differentiation – dorsi-ventral, thallus, rhizoids/roots, main shoot, branched/unbranched, dichotomously branched, leaves, scales, foot, seta, capsule.

Dorsal view – thalloid/erect axis, surface – smooth/rough, even/uneven, skinny/fleshy, midrib (present/absent), markings (pentagonal/hexagonal/any other), ridge/furrow, spores, scales, rhizoids

Ventral view – surface – even/uneven, smooth/rough, ridge/furrow, scales

Rhizoids – colour, shape, number (a few/many), unicellular/multicellular, branched/unbranched, smooth/tuberculate.

Scales – colour, shape, arrangement of cells

Leaves – shape, size, thickness of lamella, midrib, arrangement of leaves (coma),type of cells (dense/perforated/hyaline),with or without chloroplasts, arrangement of cells

Sex organs – present/ absent, archegonia/antheridia or both

Sporophyte – foot, seta, capsule (their position, origin, shape, size)

The appendix should not be considered complete. There may be several other details that you may observe which may not be mentioned here.

LABORATORY REPORT – 12

Name: .... Enrol. No.: ....

Session: VII Date: ....

Time allotted: 4 hrs. Time spent: ....

EXERCISE 12 COMPARATIVE STUDY OF MORPHOLOGICAL FEATURES OF SOME REPRESENTATIVE GENERA OF BRYOPHYTES

1. Materials and Procedure

Technique(s) used for slide preparation (W.M.)

Note: You should write this section if you have used a method other than the one given in the manual. Otherwise omit it.

2. Observations

Labelled diagrams of specimens 1 to 6

3. Comparative account of morphology of specimens 1 to 6

Specimens

No.	Features	1	2	3	4	5	6
	Gametophyte/Sporophyte						
1.	Colour						
2.	General appearance						
3.	Size						
4.	Dorsal view						
5.	Ventral view						
6.	Extent of differentiation						
7.	WM of rhizoid						
8.	WM of scales						
9.	WM of leaves						
10.	Sporophyte						

You may further elaborate the above points for giving a comprehensive description.

4. Classification and identification
5. Discussion
6. Comment/Problems/Suggestions

Notes

EXERCISE 13 COMPARATIVE STUDY OF ANATOMICAL FEATURES OF SOME REPRESENTATIVE GENERA OF BRYOPHYTES

13.1 INTRODUCTION

In the previous exercise you observed morphological features of gametophyte and sporophyte of liverworts and mosses. You found that they are very small plants and show a little differentiation in comparison to higher plants. In this exercise you will examine and compare their internal structure, and determine the relationship among the genera of different groups as well as with that of algae. Therefore, it is important to keep in mind the structure of the simplest thallus of algae while you make observations.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course – "Plant Diversity – I" (LSE-12), Block 3 Bryophytes, Unit 13: Morphology and anatomy of bryophytes, Secs. 13.4.1 to 13.4.3, p. 13 –22. Read sections on internal structure and study Figs 13.3, 13.5 to 13.11 carefully.

Objectives

After doing this exercise you should be able to:

- prepare materials for examination of internal structure of a specimen of bryophyte,
- examine the anatomical features of an unknown bryophyte, draw a diagram and write explanatory notes,
- point out the distinguishing features of bryophytes on the basis of internal structure observed,
- classify a specimen of bryophyte in one of the three groups on the basis of internal structure and
- identify the genera studied in Plant Diversity – I course.

13.2 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology student laboratory kit
3. Fresh/preserved/ permanent slides of liverworts and mosses
4. Glycerine
5. Safranine stain
6. Iodine solution
7. Pith (pieces of potato tuber/*Calotropis* stem /unripe/papaya)

13.3 PROCEDURE

Permanent slides

The permanent slides to be studied are focused under the compound microscopes by your counsellor. Examine each slide carefully, make a diagram and record your observations. Then make a comparative study of internal structure of the thalli and erect axis. Record your findings.

Preparation of W.M. and smear of thallus

Can you judge which of the thalli of the four specimens of bryophytes has *Nostoc* colonies and pyrenoids? Take that thallus and prepare a whole mount as well as a smear as demonstrated by your counsellor.

Section cutting

Take a piece of potato tuber, *Calotropis* stem or unripe papaya fruit as pith. Make a longitudinal slit with the help of a scalpel. Place the material in the desired plane. As demonstrated by your counsellor, try to cut thin sections of the material using a razor blade. To avoid drying of the material, add a few drops of water at small intervals of time while cutting sections. Transfer the sections to a watch glass or a petridish with the help of a camel hairbrush. Select, thin and perfect sections and stain them with safranine. Remove excess stain by washing sections in another watch glass. Pick up the sections with the brush, mount in glycerine on a slide, and examine under low and high power objective lens of compound microscope.

13.4 RECORD OF OBSERVATIONS

Observe the slides under low power objective of compound microscope. What do you find? Are these the V. S. of thalli? Critically observe cells of a thallus in different layers from the periphery towards center or from the upper to lower region. In some specimens you may probably find distinguishable regions as outer, inner and central or green photosynthetic and non- green storage regions. See if the pores are present. What could be the function of pores? Pay attention to the cavities containing *Nostoc* colonies or mucilage. What could be the advantage of *Nostoc* colonies to the plant? Look for the presence of rhizoids and scales. Use Appendix 13 to aid in observation on details on the photosynthetic and storage regions.

Record your observations by making outline diagrams of varioust thalli.

Under a high power objective lens you can observe cellular and probably some sub-cellular features of different regions. Note the shape, size, colour, cell wall, cytoplasm, cellular arrangement etc.

These are the earliest and most primitive plants. Do you find vascular bundles in the T.S. of thallus/erect axis? Make a drawing to show the anatomical features and include finer details of the cells.

Tabulate comparative account of the distinct features of the specimens provided and try to identify them. Record your observations as given in Laboratory Report 13.

Marking Scheme

Section cutting		= 1 mark
Preparation of smear		= 1 marks
Line drawing, internal structure and description of specimens (fresh/permanent slide) of bryophytes (mark 8 best only)	1×8	= 8 marks
Identification (any 6)	½×6	= 3 marks
Viva voce		2 marks
	Total	**15 marks**

Appendix 13

Type of section – thallus/ axis

Types of cells – parenchymatous / any other

Internal differentiation – differentiated into distinct zones/not differentiated, number of zones/layers, photosynthetic chlorophyllous/non photosynthetic, upper and lower regions, epidermis, cortex, central cylinder, rhizoids, hydroids, leptoids

Photosynthetic region – epidermis, column of cells – number of cells in a column, type of cells, top cell, air channels, archegonia, antheridia, air chambers, air pores, partitions, photosynthetic filaments – number of cells

Non-photosynthetic storage region – mucilage cavities, mucilage, cells with pyrenoids, male and female organs, number of layers of cells in cortex, type of walls of cells in cortex, central core, shape, retort cells, *Nostoc* colonies

LABORATORY REPORT – 13

Name: .... Enrol. No.: ....

Session: VIII Date: ....

Time allotted: 4 hrs. Time spent: ....

EXERCISE 13 COMPARATIVE STUDY OF ANATOMICAL FEATURES OF SOME REPRESENTATIVE GENERA OF BRYOPHYTES

1. Materials and Procedure

Describe the method of preparation of smear of thallus containing *Nostoc* colonies.

2. Observations

Line drawing of specimens

Anatomy of specimens

Description

3. Comparative account of anatomy of specimens

We are sure that with experience gained in the previous exercises you will be able to tabulate the features and record your observations.

4. Comments/Problems/Suggestion

Notes

EXERCISE 14 COMPARATIVE STUDY OF ASEXUAL AND SEXUAL REPRODUCTIVE STRUCTURES OF SOME REPRESENTATIVE GENERA OF BRYOPHYTES

14.1 INTRODUCTION

From the previous two exercises you got a fairly good idea about the morphology and anatomy of a few genera of bryophytes. One of the most remarkable features of these tiny plants is that their chief photosynthetic body is gametophyte. The gametophyte develops gametangia, the structures that bear gametes for sexual reproduction. The gametes – egg and sperms are protected in gametangia in the jacket of sterile cells. You may recall that in algae gametes producing cells rarely have protection beyond the wall of the parent cell. Algae also show isogamy, a primitive form of sexual reproduction, where two alike gametes unite to form a zygote. Since bryophytes are advanced in comparison to algae they show only oogamy involving an egg and a sperm.

The position of male gametangia – antheridia and female- archegonia varies from genera to genera. They may be embedded in a thallus, borne on stalked receptacles or borne on special branches. The plants may be monoecious or dioecious in nature.

In common with all land plants bryophytes shelter and retain their embryo within a protective body. The embryo develops into sporophyte. The spore mother cells develop inside the capsule and form tetrad spores by meiosis. You will observe a progressive sterilisation of potential sporogenous tissue and increase in protective tissue from liverworts to mosses.

In mosses the sterile tissue consists of a foot, a long seta and a capsule. The capsule comprises – apophysis, its many layered wall, columella, wall of the spore sac, peristome, annulus and operculum.

In this exercise you will examine reproductive features of some bryophytes.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course "Plant Diversity – 1" (LSE-12), Block 3 Bryophytes, Unit 14: Reproduction and evolutionary trends in bryophytes, Sec. 14.3: Study of reproduction in representative genera, p. 29-55; read sub-sections on sexual reproduction only and look at the figs. 13.3, 13.4, 14.1 to 14.19.

Objectives

After doing this exercise you should be able to:

- prepare the slides for examination of reproductive structures,
- examine, identify and describe the reproductive structures such as gemmae cups, antheridia, archegonia and spore bearing structures in the materials provided,
- enumerate the reproductive features of the given specimens,
- compare the reproductive structures of the specimens provided,
- identify a genera on the basis of reproductive features and
- discuss the evolutionary trends in reproduction in light of the specimens of algae and fungi studied in the previous exercises.

14.2 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology student laboratory kit
3. Glycerine
4. Safranine
5. Fresh/preserved plant materials of

   Anthoceros with sporophyte
   Funaria with sporophyte
6. Permanent slides showing reproductive features of representative genera of bryophytes

14.3 PROCEDURE

First you should observe the permanent slides focused by your counsellor under the microscope. It should be possible to identify a bryophyte from the structure of its thallus and gametangia. You will need to recall one or two of its characteristics of reproduction in bryophytes studied in LSE-12 course.

1. Dissection of female head of *Funaria*

Place the specimen in a drop of glycerine on a slide and observe under dissection microscope. With the help of needles remove the leaves. Also remove periphyses and dissect out the head to separate operculum, peristome, annulus and spores.

2. Dissection of capsule of *Anthoceros*

Preparation of the above is little tricky. So you must work carefully.
Place the sporophyte on a slide with a drop of glycerine. Split it into two parts by running a needle through it. Alternatively lower the cover slip and slightly press or tap to expose.

3. Preparation of whole mount

Mount the following parts separately in glycerine and cover it with a cover slip. Observe under low and high power of compound microscope.

Funaria

W.M. Peristome
W.M. Annulus
W.M. Operculum
W.M. Spore

Anthoceros

W.M. spores
W.M. pseudoelators

14.4 RECORD OF OBSERVATIONS

You should make your observations on prepared and permanent slides as instructed below and draw a diagram of each.

1. Asexual reproductive bodies

Identify the gemmae cups, observe their position, shape, margins and detailed structure.

2. Sexual reproductive structures

Note the origin, position, shape, size, colour and number of antheridia and archegonia. Also see if they are protected by some structures. Can you observe the cellular organization of the reproductive bodies? If so make observations and record.

Sporophyte

Distinguish foot, seta and capsule and try to observe details of each.

Capsule

Note the shape of the capsule, its different cell layers, epidermis, hypodermis, meristematic zone, chlorenchymatous tissue, involucre, columella, air spaces, trabeculae, conducting strands, spore sac, pseudoelators, stomata, spore mother cells, spores, their number and ornamentation.

W.M. Peristome

Try to distinguish layers of the peristome, number of teeth in each ring and their size.

W.M. Annulus

Observe shape and size of cells and number of rows of cells

W.M. Operculum

Note its features and record.

Spores

Record their colour, shape, size and ornamentation.

Record your observations on the whole mounts and permanent slides as suggested in the previous exercises. Make use of the terms given in Appendix 14 and submit your report in the format given in Laboratory Report 14.

Marking Scheme

Preparation of WM (mark best 3 out of 5-6)	3 marks
Observations on prepared slides (mark 3 best out of 5- 6)	3 marks
Observation on permanent slides (mark any 10 slides)	10 marks
Viva voce	4 marks
Total	**20 marks**

Appendix 14

Gametophyte – archegoniophore, antheridiophore, perichaetum, archegonia, gemma cups, monoecious, dioecious, , antheridia, sterile jacket

Gemmae cup – position, origin, size, number, structure (stalk, main body, furrow/notch)

Antheridia and archegonia – origin, arrangement, position, shape, size, colour, margin, distinguishable regions, neck, neck canal cells, venter, venter canal cells, egg, cover cells, stalk, androgonial cells

Sporophyte – position, size, colour, parts (foot, seta, capsule and their details)

Capsule – peristome, spores, epidermis, hypodermis, chlorenchyma tissue, airspaces, trabaculae, columella, conducting strands, spore sac, spore mother cells, psudoelators, involucre, calyptra, operculum, annulus, (shape, size, number of rows of cells) spore-sac, jacket. peristomo inner and outer, teeth, number, size, number of rings

Spores – size, shape, number, tetrad, ornamentation

Note: The above appendix should not be considered complete. Your counsellor may help you to see more details in the given materials and they must also be recorded.

LABORATORY REPORT - 14

Name: .... Enrol. No.: ....

Session: IX Date: ....

Time allotted: 4 hrs. Time spent: ....

EXERCISE 14 COMPARATIVE STUDY OF ASEXUAL AND SEXUAL REPRODUCTIVE STRUCTURES OF SOME REPRESENTATIVE GENERA OF BRYOPHYTES

1. Materials and Procedure

   Note: You should write this section if you have used a method other than the one given in the manual. Otherwise omit it.

2. **Observations**

   Well-labelled diagrams of W. M. of specimen 1 to..........
   Description of specimens

   Well-labelled diagrams of permanent slides of specimen 1 to ....
   Description of slides

3. Discussion

4. Comments/Problems/Suggestions

EXERCISE 15 . COMPARATIVE STUDY OF MORPHOLOGICAL FEATURES OF SOME REPRESENTATIVE GENERA OF PTERIDOPHYTES

15.1 INTRODUCTION

Pteridophytes include an ancient group of plants that have survived till present times. They include lycopods, horsetails and ferns. The lycopods are probably the oldest of vascular plants.

The major advancement of pteriodophytes over bryophytes was the evolution of specialized vascular tissue which enabled them to achieve larger size than their predecessor. There was also evolution of microphylls and megaphylls as the main organs of photosynthesis.

The life cycle of pteriodphytes involves a clearly defined alternation of generations. The plants we observe represent diploid or sporophytic generation. The sporophyte shows a horizontal undergound stem, called rhizome and above the ground an erect stem. The plants bear roots, branches and leaves/fronds. The conspicuous plant body forms spores in sporangia which may be borne solitary, terminal, in cone-like strobili at the tip of stem or in the sporophylls. In ferns the sporangia are clustered together in the form of distinct sori.

The gametophytes are tiny-green microscopic structures bearing antheridia and archegonia.

As you know pteridophytes are next to bryophytes in evolutionary hierarchy of land plants. The plants included in this group show a range of morphological forms in spite of basic similarity in their life cycle. In this exercise you will examine the morphological features of a few representative genera of pteridophytes.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course "Plant Diversity – 1" (LSE-12), Block 4: Pteridophytes, Unit 16: Pteridophytes: Comparative morphology and anatomy, Sec. 16.5, p. 20-39. Read the morphology of *Psilotum, Lycopodium, Equisetum, Selaginella, Pteris* and *Marsilea* and go through Figs. 16.7 to 16.14.

Objectives

In this exercise you should be able to:

- follow an appropriate procedure for examination of a specimen of pteridophyte for finding its characteristic morphological features,
- observe, make diagrams and list the gross and fine morphological features of the specimens under study,
- distinguish among the genera of pteridophytes on the basis of their morphological characteristics and try to identify them and
- exemplify gradual increase in complexity in their structure in view of organization of thallus of algae and bryophytes.

15.2 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology student laboratory kit
3. Glycerine
4. Safranine stain
5. Fresh/herbarium specimens of pteridophytes

15.3 PROCEDURE

Examine specimens one at a time with unaided eye beginning from the base to the apex. Also observe carefully the surfaces using a hand lens. You may find reproductive structures as well. First list the structures observed and then examine the finer details of each. You may follow the procedure given in Exercise 1 if you are working with fresh/ preserved specimens.

For systematic examination you should use Appendix 15. The terms relevant to this exercise are listed in it. You may also look at the table given in Laboratory Report 15 for making necessary observations.

15.4 OBSERVATIONS

You are expected to record observations on each specimen as follows:

1. **Morphological features** :
   Make a habit sketch and write its description.

2. **Structure of the parts**
   Draw the structure of each part as observed with hand lens

3. **Comparative account of the genera studied**
   Compare the features listed in Laboratory Report 15

Precautions

1. Detach the appendages carefully without causing damage to the plant.
2. A material should be kept in the centre of a slide, while preparing a whole mount.

3. Do not over stain the material.
4. Remove excess of glycerine with the help of a blotting paper.

Marking Scheme

Labelled habit sketches of the 6 specimens and their parts (mark 4 best out of 6)		= 4 marks
Description of the specimens	½ × 6	= 3 marks
Comparative account of the 6 specimens		= 3 marks
Identification of the specimens	½ × 6	= 3 marks
Viva voce		= 2 marks
	Total.	**15 marks**

Appendix 15

General appearance – slender, tufted, bushy, delicate/stout, herb/shrub

Size/Dimensions- big/small, actual measurement

Colour – green/brown/black/any other

Main parts – erect system, prostrate system – rhizome – surface, size and other details, rhizoids – short/long, origin, rhizophore – short/long/creeping, roots – origin, nature – fibrous, slender, cluster, adventitious

Erect system – main axis/stem – ridges, furrows, branched/unbranched, nodes, internodes, leaves, fruiting bodies

Branching – sparse/profuse, monopodial/ dichotomous

Leaves – inconspicuous/conspicuous, size, arrangement, nature - scaly/thorny, types (if more then of one kind) - microphyll/megaphyll, simple/compound, leaflets, pinnate/palmate, lamella and its surface, venation, cell strucure

Appendages – ligule/any other, glasspodium,sheath

Spore-bearing bodies –synangium/stobili/sori/sporocarp their arrangement, position - axial/terminal/lateral, on leaves - sporophylls, shape, colour, size, solitary/in groups, protective structures (present/absent), sporangia, spores, uniform in size (homosporous) not uniform in size (heterosporous), shape, number

Note: The above appendix should not be considered complete. Your counsellor may help you to observe more details in the given materials and they must also be recorded.

LABORATORY REPORT - 15

Name: .... Enrol. No.: ....

Session: X Date: ....

Time allotted: 4 hrs. Time spent: ....

EXERCISE 15 COMPARATIVE STUDY OF MORPHOLOGICAL FEATURES OF SOME REPRESENTATIVE GENERA OF PTERIDOPHYTES

1. Observations

Labelled sketches of specimens 1 to 6 and their parts

Description of specimens 1 to 6

2. Comparative account of the morphology of specimens 1 to 6

Specimens

Features	1	2	3	4	5	6

1. Habit
2. Size of plant
3. Degree of differentiation
4. Stem surface and other surfaces
5. Type of branching
6. Leaves
   (i) Nature (microphyllous/megaphyllous)
   (ii) Origin
   (iii) Type (simple/compound)
   (iv) Size
   (v) Shape
   (vi) Arrangement
   (vii) Venation
7. Root
8. Spore producing structures
   (i) Position
   (ii) Shape
   (iii) Arrangement (solitary/in groups)
   (iv) Protective structures (if any)
   (v) Spore size
   (vi) Spore shape
   (vii) Spore number

Notes

EXERCISE 16 COMPARATIVE STUDY OF ANATOMICAL FEATURES OF SOME REPRESENTATIVE GENERA OF PTERIDOPHYTES

16.1 INTRODUCTION

In the previous exercise you examined the morphological features of some pteridophytes. In this exercise you will continue with their study and examine anatomical features of stem, rhizome, roots, leaves and rachis in detail. While you do this exercise, it is important to keep in mind that pteridophytes are early vascular plants that show origin and evolution of stele. You will recall that stele is the central core cylinder axis in sporophytic plants. The primitive simplest stele is found in all living pteridophytes in the sporeling stage and is retained in some pteridophytes till maturity. The siphonostele is found later in the evolutionary sequence from which a variety of steles evolved when the vascular cylinder diverted into a leaf or branch. Therefore you must pay attention to the stele of the specimens under examination and also learn to identify their type.

Like stele, first simple leaf appeared in early pteridophytes. Later the two kinds of leaves – microphylls and megaphylls and very large leaves of ferns evolved.

We believe that this is a very important and exciting exercise because you get a chance to see internal structure of early vascular plants that led to the evolution of higher plants.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course "Plant Diversity – I" (LSE-12), Block 4: Pteridophytes, Unit 16: Pteridophytes: Comparative morphology and anatomy, p. 17-39. Read the sections on internal structure and carefully see the figures showing their anatomy.

Objectives

In this exercise you should be able to:

- prepare W.M./ sections of parts of pteridophytes for examination of the finer/anatomical features,
- examine anatomical details of leaf, petiole, rachis, rhizome, stem and roots of a given pteridophyte, make diagrams and describe them,
- distinguish between the sections of root and stem of pteridophytes,
- make a comparative account of the anatomical features of pteridophytes under study,
- point out the features that are unique to a genera,

- identify a given pteridophyte on the basis of its anatomical features,
- distinguish different types of stele and
- distinguish between non-vascular and vascular plants on the basis of their anatomical features.

16.2 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology student laboratory kit
3. Glycerine
4. Safranine
5. Fast green
6. Pith (pieces of potatoes/*Calotropis* stem)
7. Fresh/preserved specimens of some representative genera of pteridophytes
8. Permanent slides showing the anatomical features of pteridophytes

16.3 PROCEDURE

The materials provided in this exercise are quite familiar to you since you have examined their morphology in the previous exercise. To study their finer details/anatomy you will prepare whole mounts/cut sections of the parts as given below.

Whole mounts

Prepare W.M of the following parts:

Rhizophore
Leaf
Peel mount (to see stomata)
Young sporophyte

Place the material on a slide under dissection microscope. With the help of forceps detach carefully the parts you would like to examine. Prepare the whole mounts in glycerine and stain them with safranine and fast green stains like you did in some earlier exercises. If a part is more than one cell in thickness, it would be difficult to see its features in the W.M. Therefore cut thin sections of the thick materials. You may also think of an innovative method to study their anatomy. Try it out.

Section cutting

Cut T.S. of the following parts

Stem
Rhizome
Leaf
Petiole
Rachis
Root

Take a piece of potato or *Calotropis* stem to serve as pith. Make a slit and keep the part of the plant you want to section. Make sure that it is placed in correct orientation so that you get sections in the desired plane. Try to cut thin sections of the material using a razor blade. Transfer these sections to a watch glass or petridish and stain them with safranine and fast green stains. Remove excess stain by washing the sections in another watch glass. Transfer the section on a slide with a brush and mount in glycerine.

16.4 RECORD OF OBSERVATIONS

Observe the whole mounts and permanent slides of the specimens under low power objective of the compound microscope. Begin from outside and gradually move towards the centre. Try to distinguish various layers/tissues. Make outline diagrams of the preparations and label them.

Now study each slide under high power of microscope and critically observe the organization and structure of the cells from the periphery towards the centre. Note the arrangement of the cells, their shape, size, cell wall and other visible features in different layers.

The specimens/slides along with the features are given below. The features given are not in any sequential order. Identify your specimen by comparing its features with the following:

Psilotum

T.S. of Rhizome
Phloem, inner cortex, xylem, cuticle, endodermis, epidermis, middle cortex, outer cortex, fungal hyphae
T.S. of stem
Endodermis, stoma, cortex, cuticle, outer cortex, inner cortex, middle cortex, xylem, phloem, epidermis

Lycopodium

T.S. of stem
Inner cortex, endodermis, xylem, phloem, middle cortex, outer cortex, epidermis
T.S. of root
Inner cortex, xylem, outer cortex, phloem, epidermis

Equisetum

T.S. .of stem (nodal region)
Endodermis, vallecular canal, chlorenchyma, sclerenchyma, stoma, epidermis, protoxylem, metaxylem, phloem, pith, carinal canal

Selaginella

W.M.of rhizophore
Epidermis, cortex, xylem, phloem, endodermis

T.S. of stem
Trabeculae, cortex, pericycle, epidermis, xylem, phloem, stele

W. M. of leaf
Mesophyll cells, air spaces, stoma, vascular bundle, epidermis (upper and lower)

Marsilea

T. S. of rhizome
Cortex, aerenchyma, phloem (outer and inner), endodermis (outer and inner, pith, xylem, septa

T.S. of petiole
Septa, aerenchyma, xylem, phloem, endodermis

T.S. of root
Endodermis, phloem, protoxylem, septa, metaxylem, epidermis, cortex

Pteris

T.S. of rhizome
Hypodermis, root trace, meristele, cortex, phloem, epidermis, xylem, endodermis, pericycle

T.S. of root
Pericycle, endodermis, outer cortex, inner cortex, metaxylem, protoxylem, root layer, epidermis

T. S. of petiole
Cortex, xylem, phloem, pericycle,endodermis, epidermis

T.S. of rachis
Cortex, xylem, phloem, pericycle, endodermis, epidermis

Precautions

1. Cut thin sections of uniform thickness.
2. Do not overstain the sections.
3. Always cover sections with a cover slip before observing them under the compound microscope.
4. Remove excess glycerine around cover slip with the help of a filter paper.
5. Place the cover slip in such a way that no air bubble is trapped in glycerine.

Marking Scheme

Preparation of W.M. of specimens (mark 1 best only)		= 1 mark
Section cutting (mark 3 best only)	1×3	= 3 marks
Line drawing of anatomical features of specimens (mark 3 best only)	1×3	= 3 marks
Observations on permanent slides (mark 3 best only)	1×3	= 3 marks
Identification of specimens (mark 6 only)	½×6	= 3 marks
Viva voce		2 marks
	Total	**15 marks**

Appendix 16

Type of stele – Haplostele, actinostele, plectostele, siphonostele, dictyostele, protostele

Note: The terms relevant for this exercise are given in text therefore they are not repeated here.

LABORATORY REPORT - 16

Name: ....   Enrol. No.: ....

Session: XI   Date: ....

Time allotted: 4 hrs.   Time spent: ....

EXERCISE 16 COMPARATIVE STUDY OF ANATOMICAL FEATURES OF SOME REPRESENTATIVE GENERA OF PTERIDOPHYTES

1. Materials and Procedure

Technique(s) used for slide preparation (W.M., section cutting, smear etc.)

Note: You should write this section if you have used a method other than the one given in the manual. Otherwise omit it.

2. Observations

Labelled diagrams of prepared and permanent slides

3. Comparative account of the anatomy of specimens 1 to 5

	Specimens				
Features	1	2	3	4	5
Root					
Rhizome					
Stem/axis					
Leaf					

4. Comments/Problems/Suggestions

Notes

EXERCISE 17 COMPARATIVE STUDY OF REPRODUCTIVE STRUCTURES OF SOME REPRESENTATIVE GENERA OF PTERIDOPHYTES

17.1 INTRODUCTION

You learnt that pteridophytes like bryophytes also have two distinct generation in the life cycle: gametophytic and sporophytic that alternate each other in regular succession. The gametophytes are microscopic in size and short-lived. The male and female gametes are produced in antheridia and archegonia respectively. Like other embryophyte, the zygote gives rise to a multicellular embryo that undergoes its early development within an archegonium or an embryo sac. Since this phase is microscopic, it is difficult to procure materials for laboratory study. You will be given a whole mount of gametophyte (prothallus) to study the reproductive features.

Pteridophytes show a distinct advancement over bryophytes. The dominant sporophyte is organized into root, stem and leaves. It can synthesize its own food. You may recall that in pteridophytes the sporangia are either born on a terminal shoot called fertile axis or on leaves called sporophylls. They may be organized in a cone like structure called strobilus. The study of reproductive structures of a specimen may help in the identification of its genus. You may recall that spore-bearing structures are varied in pteridophyes. One of the remarkable features they show is the transition from homospory to heterospory. You should remember this fact while examining them.

In this exercise you will examine prothallus with antheridia and archegonia and different spore-bearing structures of plants. On the basis of their distinct structure and arrangement you will try to identify the genera.

Prior Readings

For doing satisfactory work you must read the following before coming to the lab. You will not be allowed to carry the theory course blocks or any other botany book with you to the lab.

- The course "Plant Diversity – I" (LSE-12), Block 4: Pteridophytes, Unit 17: Pteridophytes: Comparative Study of Reproduction in Pteriodophytes, p. 49-78. Read sections on *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum*, *Pteris*, *Marsilea* and look at the Fig. 17.1, 17.4, 17.7, 17.12, 17.14, 17.15 and 17.18.

Objectives

After doing this exercise you should be able to:

- examine, identify and describe the reproductive structures of pteridophytes,
- examine the reproductive structure of a pteridophyte in a given slide, make a diagram of the structure observed and describe it,

- compare the gametangia and spore-bearing structures of different genera of pteridophytes,
- identify the specimens on the basis of reproductive structures observed and
- exemplify the evolutionary trends in pteridophytes in light of the specimens examined.

17.2 MATERIALS REQUIRED

1. The biology laboratory kit
2. The biology student laboratory kit
3. Permanent slides of some representative genera of pteridophytes showing reproductive features

17.3 PROCEDURE AND OBSERVATIONS

We hope that by now you can make observations on the features of a specimen in a slide. The permanent slides given in this exercise are listed below along with the features you may observe in the sections of specimens provided to you. Make observations on each slide and match the observed features with the list and identify the reproductive organ. Report your results by making diagram of the slides and describing them.

Synangium

Spores
Tapetum
Spore mother cells
Septum
Lobes

Strobilus

Sporophyll
Sporangium
Microsporangium
Megasporangium
Ligule
Microsporophyll
Megasporophyll
Spores
Microspore
Megaspores
Spore mother cells
Stalk
Disc
Leaf
Annulus
Sporangiophore
Sporangia

Sori

Sporangia
Receptacle
Stalk
Spores
Annulus
Stomium

Prothallus

Archegonia
Antheridia
Prothallus
Rhizoids

W.M. spores

Exine
Intine
Spore
Elaters

Sporocarp

Gelatinous ring
Placental vascular supply
Indusium
Megasporangium
Microsporangium
Receptacle

Identify the genera on the basis of the structures observed. You should use the terms listed above in making your observations. A separate appendix is not provided, as it is not necessary.

Marking Scheme

Well-labelled diagrams and description of observations on slides (mark 10 best only)	1×10	= 10 marks
Identification of reproductive bodies and the genera (mark 10 best only)	½×10	= 5 marks
Neatness in work		2 marks
Viva voce		3 marks
	Total	**20 marks**

LABORATORY REPORT - 17

Name: .... Enrol. No.: ....

Session: XII Date: ....

Time allotted: 4 hrs. Time spent: ....

EXERCISE 17 COMPARATIVE STUDY OF REPRODUCTIVE STRUCTURES OF SOME REPRESENTATIVE GENERA OF PTERIDOPHYTES

1. Observations

   Labelled diagrams of permanent slides examined

2. Comments/Suggestions

Block

2A1

Higher Plants

Exercises: Page No.

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BLOCK 2A HIGHER PLANTS

This block pertains to the laboratory exercises on higher plants about which you have studied in the Plant Diversity – II Course, Course code: LSE–13.

Block # 2A & 2B : Design, and purpose

This block (#2A) is accompanied by Block # 2B, entitled 'Key and Glossary'. Block # 2A, the one in your hand, is designed to serve two purposes : *One* as your self-instructional learning material; and *two*, as your work-book-cum-record-book. Block # 2B would be your chief resource book for this course, and you would be using it extensively for the taxonomy related exercises. In addition, it would also serve as your reference book after the completion of this course.

Credit weightage of lab work on higher plants

The lab course on higher plants has a total weightage of 2 credits, requiring about 60 hours of your working time. In terms of days, it involves 6 days of learning by working through the guided exercises, followed on the last day by a formal assessment – by means of unguided exercises, coupled with the evaluation of your Project-Report. More details regarding the 'formal assessment component' are given below.

Lab. Curriculum of these 2 credits

- **The components**
  As reflected in the content page, guided exercises (# g) and project work (# p), constitute the learning component of the curriculum on higher plants. The evaluation (# e) of : a) your performance in the unguided exercises; and b) your Project-Report, constitute the formal assessment component.

- **Successful Completion of Course**
  For earning these 2 credits, it is essential to successfully complete all the above-mentioned three components : #g, #p, and #e.

How to go about

- The exercises, 27 in number, are given in this block. As stated earlier, this block has been designed as a work-book, meaning thereby that you have to record all your observations in this book itself. You can use additional sheet(s) wherever needed, but don't forget to attach it/them at the right place in the work-book.

- Each exercise begins with the date and session # recording, followed by the time allocated for the exercise. In some of the exercises, at the first glance, you may think that the time allocated is too short for the given numbers and kinds of tasks. It's true, time is a constraint, but the right strategies should see you successfully through any or all kinds of constraints. We have suggested some effective ways of working, and time management, either in the Study Guide or in the text, in the exercises where we thought it was required. And we believe that by using these strategies, you should be able to complete all your exercises in an easy and enjoyable manner.

- Project-work has been slotted as Exercise # 28. Detailed guidelines are given on page # 5, but one *suggestion about the timing of the project work, is that you could take it up well ahead of the lab course.* The first reason being that you **would need your Project-Report at the time of your formal assessment or examination,** slated for the last day of this lab course. The other reason is, that it may not be convenient for you to handle both the lab work and project work at the same time.

- Another point about your Project-Report! You would have to make all your project-work related recordings separately, as no provision has been made for this purpose in the work-book (Block # 2A). The vast range of probable topics, the approaches that could be taken, and the consequent findings and outcomes are the obvious reasons for doing so.

Objectives

After completing this part of the lab course, you should be able to:

- give a broad overview of the diversity pertaining to higher plants;
- select, and use the right tools and techniques for studying the morphological, anatomical, taxonomical, and economic botany-related aspects of higher plants;
- describe and illustrate the specializations related to the above-mentioned aspects (morphological, anatomical, ...) in the representative plants that you studied;
- handle, study and interpret any unfamiliar higher plant material provided to you; and
- make an in-depth study on a selected topic on higher plants through project work, and present the outcome in the form of a Project-Report.

Attention:

Dear Student Block 2 is being printed in three blocks:

$2A_1$ – will contain Gymnosperm and Anatomy from Page (1 – 240);
$2A_2$ – Economic Botany from Page (241 – 428);
$2A_3$ – Taxonomy and Economic Botany from Page (429 – 594).

EXERCISE 28 PROJECT WORK

'What? ....the last exercise of the course, here ....
in place of the first exercise ....? Perhaps a printing and binding mistake!!' – these may be the thoughts crossing your mind.

Dear learner, this is a well thought-of, 'intentional mistake' committed with the sole purpose of catching your attention and getting your thought-process rolling, so that you plan and begin working on this exercise, ahead of this lab course.

Time of submission of Project Report (PR): In the Examination Session of this course on higher plants. It would be on the last day of the lab course.

Structure Page No.

28.1 WHAT IS PROJECT WORK?

Laboratory exercises and project work are the two main and compulsory components of the lab course on higher plants. While the laboratory exercises are structured activities, the project work is an independent area of enquiry and investigation in your area of interest. Project work is a type of action-oriented research that includes elements of planning and designing. By including project work in this lab course, our objective is not just to give you a feel of research work, but also develop your ability to analyse and evaluate your observations. As you begin and get involved with the project work, you will find that it hones up your earlier known skills and develops some new skills; it encourages you to think and develop an insight in the area of study; discover solutions to problems; and develop your interpersonal and communication skills. Taking your own decisions and successfully completing a project gives you self-confidence and, more importantly, a sense of achievement!

For us, it is a very encouraging and a satisfying feeling that you will be going beyond what you learnt through the related theory course, i.e., LSE-13.

Through this project work, you will be locating information in your area of interest, organizing and analyzing it, and then writing down your observations and results of your experimental/exploratory work that you obtained after applying different approaches such as surveys, interviews, case study and so on.

28.2 WHAT YOU HAVE TO DO?

You are required to choose a problem or theme related to the topics covered in the corresponding theory course on Higher Plants – Course Code: LSE-13. Some suggestions for the problems/themes are given in Section 28.7 for your guidance. However, none of these suggestions are sacrosanct. You can definitely think about and work on a new problem/theme which is not mentioned in our suggestions – we would appreciate that!

28.3 HOW 'BIG' HAS THE PROJECT TO BE

We expect that you choose some activity that can be completed in about 30 hours time. If you can spare on an average two hours a day, you can spread thi work over a period of about 15 days.

This 30 hours is the total time in which you have to carry out all the steps starting from identifying the theme and the topic, fine-tuning the topic till the completion of writing of the PR (Project Report). Remember! There are lot many steps in between these two ends!

The Project Report of about 5000 words (~ 20 pages) is required to be presented on the last day of this lab course, i.e., at the time of your assessment of the unguided exercises.

28.4 THE WEIGHTAGE FOR PROJECT WORK

The weightage for Project Work is 15 marks.

The evaluation of your project work comprises evaluation of the PR and related viva-voce to be conducted during your practical examination session.

The break-up of these 15 marks, from the point of view of evaluation, is as follows:

	Marks out of 15
1. **Planning** *Clear objectives and a clearly directed plan of work*	2 marks
2. **Procedure** *The means and ways to achieve the objectives of the project*	2 marks
3. **Data Collection, Observation and Recording** *Systematic and correct methodology*	2 marks
4. **Results** *The findings of the report*	1 mark

5. **Discussion and Conclusions** — 4 marks
   Interpretation, logical analysis of data, exploration of literature

6. **Presentation** — 1 mark
   The style and clarity in presentation, Bibliography and other aspects

7. **Viva-Voce** — 3 marks
   Clear and thorough understanding about the topic, coherent presentation of the details asked for, communication skills.

28.5 WHEN TO DO THE PROJECT WORK

As suggested in the previous section, you require about 15 days' time when you devote nearly two hours daily on your project work. And if you have already looked at the schedule of the lab course, you may not find it easy time-wise and energy-wise to work on your project during your lab course. And since, you have to bring in your PR for evaluation on the last day of the lab course, you need to complete your work ahead of the lab course. **The best way would be to start your project work as you register for the lab course at your study center.** To make it clearer, supposing you find out about the date when the lab course begins, and you give your consent to attend the same, at that time you can have preliminary discussions with your Counsellor, who would be your guide, about your proposed project work. And thereafter, you could start your work on it. You can seek all kinds of guidance and clarifications from your Counsellor. You are also welcome to interact with the faculty members whose names are given below, through e-mail or telephone or letter, or by visiting our Head Quarters at Maidan Garhi, if you are based in Delhi and it is convenient to you. The details for contact by the above modes are given below:

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Office telephone no.:	26857067 (STD Code 011)
Days and hours of contact through telephone, or personal visit (with prior information):	From Monday to Friday between 10.00 a.m. and 3.00 p.m.

28.6 STEPS IN EFFECTIVE PROJECT WORK

Before listing and elaborating on the various steps of project work, we draw your attention to the word 'effective' in the above title. Its relevant dictionary meaning says – 'producing the intended effect', and 'making a striking impression'. This terminal project of your Bachelors Degree Programme is expected to be of this order! This is achievable with an honest, sincere and disciplined approach.

The following four steps are involved in any science-based project work:

i) Preparation of a detailed plan of the project work
ii) Conducting the project work
iii) Analyzing observations and drawing conclusions
iv) Writing the Project Report (PR)

i) Preparation of a detailed plan of Project Work

This is the same as preparing a project proposal. It is a description of what you hope to achieve and how you intend to go about it. To elaborate it further, it involves jotting down briefly the objectives of the proposed work, and the methodology to be used.

This stage is very crucial, therefore don't rush over this stage. Taking time to think through the project beforehand can save you from much of the anxiety and overwork later.

For drawing out a project plan, first go through the suggested themes # 1-24 given in Section 28.7. Choose the one which interests you and you think you can handle. You can also select a new theme, other than the ones mentioned here.

Decide on the area, i.e., place/community/village/forest area/factory/institution and so on, where you want to work. If your work is based on any institution, or industry your Counsellor may be able to guide you as to whom to contact there.

Visit your area of work in advance to get an idea of the ground situation.

Take a decision on the approaches and strategies you would use to collect the information or the data.

After all these, put down your project proposal in about 500-600 words, and show it to your Counsellor for advice and feasibility of work. You may fine tune your proposal on the basis of the suggestions received.

We would like to draw your special attention to the following points: You should not be over-ambitious while selecting a project topic. Choose a project that you feel confident about and think you can handle. Your project need not be earth shattering or mind boggling. Approach your project with an open mind. The reason being that most profound observations in science were made by scientists when they approached science (nature) with humility and with an open and free mind. There are plenty of examples to support what we have said, for instance, you might have heard the stories of great scientists – Archimedes, Edison, and Newton. Another point you should keep in mind is that no one has all the answers to all the questions and everyone has some problem at some stage or the other. Do not hesitate to discuss your ideas and doubts with your Counsellor at any stage of your project work.

ii) **Conducting the Project Work**

Once your detailed project plan is prepared and approved by your Counsellor, you can begin work on the theme in a step-by-step manner. Focus on only one aspect at a time, and never allow yourself to be side-tracked, as time is too short for any fascinating secondary aspects that you may come across.

For a project involving field-work, visit the area that you have chosen for collecting the data. Collect the relevant information say where the factory is located, where the plants you are interested in are grown, who are the people involved in collection, what are the names of the plants your grandmother mentioned, procure the statistical data if needed, and so on. The various steps for conducting the project work would depend on the topic.

Using a diary/laboratory notebook for record keeping – You must keep a diary or a laboratory notebook, in which you should record the experiment(s) you performed and the observations made on any particular day, and the results as you obtain them. You should also enter any obstacles/snags/problems that you faced, your thoughts on how to overcome them and the things you wish to remember to do at a later date. List the points you wish to check on, in the library, or anything you would like to ask your teacher.

Interim evaluation and modifying the project – As you proceed with your project work, you should monitor your progress regularly. Don't leave the analysis of your results to the very end. Instead, carry out preliminary analyses too. This will help you to modify your experimental/exploration work, if you feel you have bitten off more than you can chew, or if some unforeseen difficulties have cropped up, or you find something really interesting and unexpected, and you decide to follow that up, instead of your original aim. All these are valid reasons for modifying your project. You may say, we are now advising you against sticking to the original topic and design. Remember there is a fine line between showing perseverance and inflexibility. As a student of science, you need to constantly evaluate your progress, and think about whether to continue as intended, or change track/make certain additions or deletions in your work.

Ethical considerations – While pursuing your work on scientific lines, never compromise on the code of conduct of that particular place, along with the relevant ethical considerations. Never cause any suffering or inconvenience to any living being during the course of your work. While interacting with people personally or through questionnaires, don't ask unduly personal questions. Also do not cause damage to the environment, for example, by uprooting plants in large quantities. Take care that the rare plants are not completely eliminated, or the ecosystem is not disturbed or harmed in any way. In case you need some plant material from a private garden or farm, or a wild area declared as a protected-area, seek the necessary permissions for procuring the plant materials. Coming back to the data collection part, please do not 'copy' the 'story' from any book. It would not only be unfair, but you would miss out on the intended development and expansion of your mind. Yes you can refer to the literature available, and freely get others' views on the subject but one major aim of your doing the project work is that you add your perspective too to the chosen topic of study. One more important point, don't forget to acknowledge the source of data/information that you have used for your project work.

Safety considerations – Your safety is our prime concern on anything you do regarding your project work. Take all precautions and steps to ensure your safety – in the field, at home or in the lab. Ensure that you let your parents/family know where you are, whenever you go out in connection with your project work. Do not taste or smell any unknown or a chemically preserved plant material. It could be poisonous or injurious to your health.

iii) Analyzing observations and drawing conclusions

After collecting substantial data/information, return to your desk and table. Start compiling all the information that you have collected in various forms such as in tables, in chronological/alphabetical order, linking and fitting- in the related pictures/graphs/illustrations, and organizing the contents to construct some meaning out of it, and see if they fulfill your objectives of the project work. If there are any gaps in your data/information, complete them. After bridging the gaps, you should work on to conclude from your findings. Side by side, plan the layout of your PR. Make sure you leave plenty of time to write down your PR.

iv) Writing the Project Report (PR)

When you reach that wonderful stage of having completed your field work or data collection, surely there would be a sense of satisfaction. Well, the next stage, when you put everything down on paper can be both challenging and time-consuming.

Before beginning to write the report, you must first think about how you would like to organize the report. Suggested headings for different sections of the report are dealt with after the following paragraph. It would be of great benefit to first collect the information/materials on the following at one place.

- The list of tools and techniques used
- Original and English/Hindi translation versions of materials when working in any regional language like the local names of plants and varieties, local terms for various products, technical processes and so on
- Data organized in the form of tables
- Analysis and conclusions on the basis of the observations
- Herbarium sheets of the plants that you have collected
- Samples of economically useful products you have collected. Keep them in small plastic bottles/card boxes or in other ways, and label them
- Detail/brochures from factories/industries/institutions you had visited
- Photographs of the area in which the concerned plants/trees are grown and the places where they are processed

The basic elements of a scientific PR usually include the following in one form or the other:

- List of contents
- Introduction
- Materials and Methods
- Procedure
- Observations
- Results and Discussion
- Conclusions
- Bibliography

However, there can be some variations in the above, from one theme to another. You can club two or more headings, and likewise make any changes as per your need. Now, we shall explain in brief as to what we mean by the above mentioned headings in the context of a PR.

- List of contents – This is the route map of your PR, and has to be placed first of all. You could write this out in the same way as we write the structure of any unit/exercise. Indicate page numbers corresponding to each section/subsection in the final PR. Though it is the first page, it is the last one to be prepared in the PR.
- Introduction – It entails the description of the topic/theme and about the place of exploration/study. It needs to reflect on as to what the project aims to achieve, and why this topic fascinated you to take up as a project. The objective should be clearly listed after the Introduction. The introduction can also include the reasons of any modifications made in the project work, and their precise explanation.
- Materials and Methods – The various materials, tools used/chemicals prepared, and describe the way these were used.
- Procedure – It consists of how you went about the various steps and stages of the project work, the techniques employed for study/exploration/data collection; and the timing of the project work.
- Observations – This involves description of what actually happened when the project was conducted, note what all you felt and perceived in the form of description and data.
- Results and Discussion - It is the elaboration of the facts that you learnt in relation to your theme. If you felt that the results you obtained were influenced by some special factors, those must be discussed in detail under this very heading. Similarly, there would be some features or aspects you might want to explain or highlight, this is the place in the PR to do this.
- Conclusions – It is the sum total of your project work, what you have learnt or what the outcome of your work is, in a summarized form.
- Bibliography – Prepare and attach a list of the literature/references/sources of information consulted. These details should be complete in the following aspects. Authors name(s), name of the editor(s) if any, year of publication, title, page numbers, publishers, country where published.

28.7 SOME SUGGESTED THEMES

You have two very broad canvases for selecting your project theme. One is Angiosperms, and the other is Gymnosperms. First, choose any one of them. Next, decide the aspect of study you are interested in – the economic aspect, the morphological and anatomical aspect, or the taxonomic aspect. Each of these three aspects has many sub-aspects, or may be sub-sub-aspects. For instance, if we take the first one, i.e., economic aspect, its one sub-aspect can be medicinal plants, and its sub-sub-aspect can be – i) the listing of the endemic plants; ii) the process of drug manufacture from a resource plant; and iii) the current issues of importance, and so on.

After these general guidelines, some themes in outline form and randomly arranged are given below:

i) Endemic medicinal plants

- 'Endemic' and 'medicinal' are the key words in this theme, it is essential to first understand their meaning
- Highlight the phytogeography and climatic conditions
- Find out about such plants from local people, your family members, local farmers. About 25 plants would be a fairly good number
- Identify the morphological portion/structure of the economically useful plant part
- Information regarding the medicinal use, precise method/way of consumption of the 'medicine', is it to be taken alone or together with something else
- Identification features of the plants
- Observations of plants in the field – ecology, social nature, the characters of plants as they appear in field conditions
- Collect a representative specimen for Herbarium for each; make a detailed illustration of each plant
- Identify the taxonomic status of these plants
- Samples of the medicine made out of these plants
- Current scenario vis-à-vis the usage of these plants
- What potentials do you see in this area?

ii) A Herbarium collection of locally available cereals and millets

- The meaning of 'cereals' and 'millets' to be clearly understood
- Identify your area, geography and climatic conditions and the edaphic conditions where these plants grow
- The following could be the sources of your information: the local grocery shop, town/village elders, friends, and tribal people
- Local name(s) of plants
- Areas where these plants are grown
- Method of their cultivation
- Yield
- Method of plant use
- Collect samples of grains along with their mother plants
- Make herbarium sheets containing the requisite information

iii) Story of the manufacture of a drug from a resource plant to the final product

While tackling this theme do not 'copy' the story from the book. The project will be considered valid only on giving proofs of your original study and work.

- The botanical name of the plant
- Common names
- Plant part used for drug making
- Plant cultivated/gathered from nature
- Soil and climatic conditions
- Development stage of plant when it is collected for drug preparation
- Method and time of collection
- Various steps in the manufacture of drug
- Efficiency of the process, i.e., how much of the plant material is consumed to yield how much drug
- Is this an environmental-friendly process
- Whether any pre-tests are done before marketing
- This project can be done at the local Vaid's place or by visiting a drug factory

iv) Method of oil extraction from a specific oil-yielding plant

- Same advice as for #iii. Don't copy from book or submit a 'processing/ technology' from a vanaspati oil factory. Take pains to collect information about the traditional and local extraction procedures
- Botanical name
- Common name(s)
- Plant part used for oil extraction
- Time of the year when the plant material is available
- Is it a year-round activity or seasonal
- Method of extraction
- Conditions required for expressing the oil
- Factors affecting the oil quality
- Whether the extracted oil is purified or is used as such
- Input of resource material: output of oil
- Rating of the process – environment friendly or not
- Use of oil cake or the left-overs after oil expelling

v) Aromatic species of an area and their utilization

- What are aromatic species
- See the guidelines given for Topic # i
- Chemical nature of the aromatic substance(s)
- Their uses
- Also see LSE-13, Unit – 19

vi) Process of essential oil extraction in a specific plant species

- Follow the same advice, i.e., don't copy from any book. Try to collect information regarding the method used locally.
- See the guidelines given for Topic # iv.
- Refer to LSE-13, Unit – 19.

vii) Identification of common adulterants of spices

- Collect information from housewives/grocers as to how they ascertain the purity of their purchase
- Different ways and means of identification of spices
- Identification of pure spices and their adulterants on botanical basis

viii) Local practices in the extraction of fibers from plants of an area

- Mark the terms 'local practices', elaborate in context of your work
- Discuss the histological, cytological, chemical nature of fibers
- Factors affecting/governing the quality
- Local innovations
- Cost-effectiveness of the process

ix) Compendium of the products of plant fibre(s)

- You may choose to either work on one fibre, say Jute, or some more fibres
- Plant source of the fibre
- The part from where it is extracted
- Whether specific treatment is required for specific use
- Products
- Nature of fibre – its particular usage

x) Ways of utilizing by-products emanating from oil/sugar producing units/industries

- You may select this theme if you belong to areas like Meerut, Saharanpur, Vijayawada, Muzzaffarpur, Aurangabad, Hoshiarpur, and so on.
- Process in brief
- By-products ,e.g., Sugar industry – molasses, beverages, medicines, Astons and other chemicals; Oil industry – oil cake, fertilizers and other uses
- Name of stages at which by-products are marketed
- Local/national/international utility of products
- Economic returns of by-product marketing vis-à-vis the main product

xi) Icons of 20 local wild plant species

- You may take up this project if you have an aptitude for drawing
- First take a plant, observe its habit in nature – tree, shrub, etc. Make as real a sketch as you can, on a herbarium-sized sheet.
- Enlarge its morphological peculiarities such as flowers, thorns, modifications of plant parts, and so on.
- Make your drawing conveying more information about its various parts by use of colours. This would enhance the clarity of your illustrations

xii) Detailed study of a timber plant like *Pinus, Deodar, Shisham, Mango, Teak* and others along with their local, economic uses

- You may select one plant for your project for a detailed study
- Don't copy from book
- Highlight the diagnostic features of the plant using illustrations
- Mention specific local uses of each

xiii) Identification of common grasses of a locality used for various purposes

- Here you have to collect information regarding grasses that commonly grow in a locality/region, and are used for various purposes. These may include their use as fodder; making mats, brooms, thatch and so on.
- The purpose of this project is to link the identification of grasses to their use in day to day life. Write the botanical name, common names, taxonomic status, identification method or making a dichotomous key, the time of the year it is available and is used, and the way it is used for each of the species

xiv) A local process of paper-making

- You may study the paper making process if there is a local paper-making cottage industry
- You can begin by collecting information about the various plant resources used in paper-making; the process details, i.e., inputs and time involved at each step, the by-products emanated – their use or method of discarding.
- Analyse its costing, i.e., whether it is a profitable way of paper making
- Also evaluate if it is an ecofriendly way of paper manufacture
- Any suggestions for improvement of the process

xv) Collection, and key-based identification of 25 naturally growing plants of a family/genus in your region

- This taxonomy-based project requires sound knowledge of the diagnostic features of angiosperm families, along with an ability as well as interest to study plants in the real or field situation
- If you have not done any such exercise previously but are willing to gain the first hand experience in identification of species of a particular family/genus, you may take up this project
- Not only would you learn or practise the way of identification of species, you would also get an idea of the extent of variation among species of the same family or even in the same genus. For example, both potato (*Solanum tuberosum*) and brinjal (*Solanum melongena*) belong to the same genus, potato – a stem modification, and brinjal – a fruit. Potato needs temperate climate, and brinjal is almost an all weather crop. Similarly, you can also look for diversity in plant characters
- Select the members of a family/genus, collect as many specimens of species as you can. Observe for variations – both floral and morphological, and on this basis try to place species in an order of similarity. Question which variations are greater – floral or vegetative, and try to correlate the variations with the environment in which these species exist. Find out if you could get any 'ecotypes' within the species
- After studying the diversity, jot down the diagnostic features of each species, and prepare a key for their identification

xvi) Prepare a detailed account/essay on one economically important plant product of your area, e.g., arecanut, jute, coconut, coffee, citrus, mango, tobacco, tea, and so on

- Again like Project #|xii, select a plant product. Now, remember first you will have to make up your mind about the 'product'
- The following flow chart indicates one way of going about this project:

  Product → plant source/plant part used → morphological nature of the product → cultivation of the plant → improvement of plant to promote quantity and quality of the product → processing of the product → conventional and modern methods of utilization of the product

xvii) The lesser known fruit/vegetable plants of an area.

- Note the key words – 'lesser-known', 'fruits and vegetables', 'an area', four or five such examples that are well-studied should form a decent project work
- Try to know and understand why these fruits and vegetables of a particular area are lesser-known
- Is it because of their endemic nature
- Or, due to local preferences that remain restricted to a small community of people with a particular way of life and consumption pattern
- Or, lack of awareness outside the area
- List these fruits and vegetables. Collect their botanical details – botanical name; plant part used. This is relevant particularly for vegetables, for fruit is a fruit; season when it is available; is it sold in market or is it cultivated by people; the food value in tenns of nutrient elements provided by these
- It would be interesting to know whether there has been a change in the 'availability' or the consumption pattern of these fruits and vegetables with time
- Or, is there a scope of changing their 'lesser-known' status to a 'well-known' status? What strategies should be adopted for this?

viii) Seasonal variations in an economically important species

- This can be a monographical account encompassing the botanical intricacies of the species, alongwith the related sociological aspect.
- For study of botanical intricacies, you would need to make detailed investigations on the morphology, anatomy, taxonomy, and ecology of the plant – to get well-acquainted with the species. You may carry on this work for a particular season or for a longer duration
- But remember, you require good lab support for this work, and the long time required to complete your study
- Looking at the species from the second angle, i.e., the sociological one, you may study that how local food habits are related with this species in different seasons. You could also observe the local practices of preservation of economically important plant products for use in off-season; and so on.

xix) Make an album exhibiting diversity in leaves/flowers, inflorescences/ seeds of members of a family/genus/'ecotypes'

- This is largely a herbarium-based exercise
- For getting an idea of diversity, you require to have a 'wide' range of specimens to look into. We are not suggesting any number as some families/genera/ecotypes may not exceed two digit numbers. We suggest you take up this project, if a good number of specimens at any of the three levels indicated above are easily available in your region
- You can observe the following aspects:

  Leaf: size, shape, venation, colour, pattern of margins, and so on.

  Flower: colour, size, number of floral parts, and position of gynoecium

  Inflorescence: types of inflorescence, and its size

  Seed: shape, size, time, nature of germination, and the duration of dormancy

xx) Species of horticultural value – how to know them?

- You may take up any of the following:
  - Rock plants
  - Bulbous plants
  - Orchid species
  - Cacti and succulents
  - *Dahlia* species
  - Varieties of Bougainvillea
  - Palms and cycads
  - Aquatic plants
  - *Rosa* species

  A study of ten specimens of any one of the above categories should be okay
- Prepare a detailed manual of their identification. Also, give details pertaining to their morphology, particularly the part(s) that give it the horticultural value (e.g., in rose – the flower morphology – colour, structure, etc.)
- You are required to complement your description either with their actual photographs taken by you or by making their outline sketches, or submitting them as herbarium sheets

xxi) Size and age correlation of cones of any gymnosperm

- You may take up this activity if you belong to a temperate zone like Kumaon, Garhwal, Shivalik or Himalayan hills.
- Again, this work too requires study over an extended period, at least over a full growing season. So keep this in your mind while taking up this topic.
- Collect cones – both male and female of different sizes/different stages of development
- Examine how size can be correlated with the age of the cone

xxii) Equipment used in growing any crops – cotton, potato, soybeans, sugarcane, wheat, sunflower and others

- Collect information about the various equipments used from sowing to harvesting of a particular crop and making it market-ready
- Get their photographs/make outline diagrams
- Find out the variants in a particular equipment, that is, the local innovations made
- Try to link the design of the equipment, and the plant part it has to handle. That is, how is care taken of, or is 'built' in the design to prevent damage to the plant part it is handling, e.g., the panicles while harvesting , the dehusking of grains and so on

xxiii) Profile of how an agronomic crop is grown in your area

- Select any one example of the crop
- Indicate the details like:
  - source of seed stock
  - seedbed preparation
  - seeding rate
  - fertilizers required and applied
  - pest control
  - harvesting
  - marketing

xxiv) The oil seed sources of some commercially used vegetable oils

- Visit grocery store(s), and after seeking the owner's permission, read the labels on the bottles/cans of vegetable oils of different brands and make notes on the oilseed source
- Also, note other information that the labels of these brands display
- Put this information, the product name, and the botanical name for the oilseeds used, in a chart-form
- Collate information about the local consumer preference, and the reasons why some are popular brands and others are not – price-line can be one factor, ingredients can be other, various incentives and gifts with the oil is an irresistible factor

We hope by now you could make up your mind about your project area. As you go about your project work, do remember to weave it in a scientific matrix, with due ethical and safety considerations.

Best of luck for your project work. Let it to be a pleasure-cum-work-cum-knowledge gathering exercise.

EXERCISE 1 TOOLS AND TECHNIQUES FOR THIS COURSE

Date ....

Session #..................

Time allocated - 1Hour

Structure

Read this exercise before beginning your work.

Don't forget to wear your lab coat while working in lab.

1.1 INTRODUCTION

Being a student of Biology, you must be familiar with the set-up and working in a biology lab. Here is another opportunity for you to improve and develop some new skills, particularly those relating to the study of higher plants. In this first exercise of the week-long laboratory course, you would learn about laboratory etiquettes, requirements for the various kinds of lab work, and some frequently used techniques for studying angiosperms and gymnosperms. The techniques explained here are largely used for studying the morphological, anatomical and histochemical aspects of higher plants. Some special techniques, other than the ones included in this exercise, would be explained separately in the exercises.

Objectives

After completing this exercise, you should be able to:

- conduct yourself in a disciplined way, following all the safety guidelines of lab, to accomplish the outlined objectives of the course;
- select and use the correct technique(s) for studying particular aspect(s) of the plant material(s); and
- prepare the exercise-wise lists of various instruments and chemicals required.

Study Guide

Read this exercise thoroughly before you come to the lab. The techniques explained in Sections 1.5 and 1.6 would be demonstrated to you by your Counsellor. Observe them carefully as you will have to use them independently in the later exercises.

1.2 LABORATORY ETIQUETTES

To get the most out of any lab work, one needs to inculcate or develop certain qualities such as curiosity to learn, sincerity, honesty, and an unbiased, analytical frame of mind. This laboratory course besides helping you to increase your knowledge on the subject matter, would also give you an opportunity to further develop the qualities mentioned above. To utilize any opportunity fully, it is essential to respect and follow certain rules or observe the etiquettes for the given situation. The six points given below may be helpful to you in this regard:.

i. It is important that you should read each of the laboratory exercise in advance along with the related theory portions given in the course LSE-13.

ii. Make a sincere effort to complete the assigned work within the stipulated time. Prior planning and proper use of time would help in accomplishing your targets.

iii. Judicious and optimum utilization of the facilities provided is the key to success.

iv. Follow the instructions written in the work-book as well as those given by your Counsellor and get your work checked immediately after completing the given exercise.

v. Never underestimate your observational skills. If your observations are at variance with the expected ones, do not hesitate to explore its reasons. Also, freely discuss with your Counsellor whenever in doubt.

vi. Handle laboratory provisions with utmost care and leave your place clean and in order at the end of the class each day.

By following these points, both success and satisfaction will be yours!

Your Notes

1.3 INSTRUMENTS AND OTHER REQUIREMENTS

Before your laboratory course gets underway, we suggest that you prepare a small *kit* containing the following items. *Do not forget to carry this kit everyday with you for the one-week lab course.*

- A pair of forceps
- Two fine, long-handle dissecting needles
- A sharp razor or a fresh unused blade
- A pair of fine-hair brushes
- A pair of scissors
- Two sharpened pencils, one each of HB and H grade,
- Six coloured pencils (for highlighting the important points and details)
- A pencil eraser
- A sharpener
- A small (6" or 15 cm) scale
- A clean, soft, handkerchief-sized piece of cloth
- A lab coat – to be worn throughout the lab session

Along with the above kit, carry a small note-book (80-100 pages), and this Work-Book (that you are holding) everyday to the lab.

Instruments and items such as the dissecting and compound microscopes, staining racks and bottles, microslides (=slides) and microcoverslips (= coverslips) and other requirements for your practical work would be made available to you in the lab itself.

Your Notes

1.4 CHEMICAL REQUIREMENTS

The broad list of chemicals given below indicates the concentrations/dilutions that are largely used along with the methods of their preparation:

Corrosive
Acetic acid

Highly flammable
Ethanol

Corrosive
Hydrochloric acid

Irritant
Iodine solution

1.	Ammonium hydroxide (5%)	Dissolve 5 g in 100 ml of distilled water (DW)
2.	Ammonium molybdate (5%)	Dissolve 5 g in 100 ml of DW
3.	Barfoed's reagent	Dissolve 13.3 g of copper acetate in 200 ml of 1% acetic acid solution
4.	Benedict's qualitative reagent	i) Dissolve 86.5 g of hydrated sodium citrate, and 50 g of hydrated sodium carbonate ($Na_2CO_3.10H_2O$), in 350 ml of DW. You may need to warm it gently. Filtering may also be necessary. ii) Dissolve 8.65 g of copper sulphate in 50 ml of DW. iii) Slowly add this solution (*made in Step ii*) to the citrate and carbonate mixture (*made in Step i*). Stir constantly, and make up to 500 ml with DW.
5.	Chloroform	Use as such
6.	Cobalt chloride (5%)	Dissolve 5 g in 100 ml of DW
7.	Copper sulphate (1%)	Dissolve 1 g in 100 ml of DW
8.	Copper sulphate (5%)	Dissolve 5 g in 100 ml of DW
9.	Ethanol 50%	(V/V) in DW
10.	Ethanol 95%	(V/V) in DW
11.	Ether	Use as such
12.	Fehling's reagent	Mix equal volumes of Fehling A, and Fehling B solutions.
13.	Fehling's A solution	Dissolve 35 g of copper sulphate in 500 ml of DW
14.	Fehling's B solution	Dissolve 50 g of sodium hydroxide, and 173 g of sodium-potassium-tartarate (Rochelle salt) in 500 ml of DW.
15.	Hydrochloric acid (dilute)	Use as such
16.	Iodine solution	Dissolve 0.5 g of iodine in 100 ml of 1% potassium iodide solution. You may need to leave it overnight or perhaps longer, for iodine crystals to dissolve.
17.	Lead acetate solution (5%)	Dissolve 5 g in 100 ml of DW.

18.	Mercuric chloride solution (5%)	Dissolve 5 g in 100 ml of DW.
19.	Millon's reagent	Put 5 g of mercury in a beaker, and add 95 ml of conc. sulphuric acid and then dilute to 200 ml by addition of DW after the complete dissolution of mercury.
20.	∝-Naphthol solution (1%)	Dissolve 1 g in 100 ml of 70% ethanol.
21.	Ninhydrin solution (5%)	Dissolve 5 g in 100 ml of DW.
22.	Nitric acid (concentrated)	Commercially available acid may be used as such or carefully diluted one part in two with DW.
23.	Nitric acid (dilute)	1% (V/V) in DW
24.	pH papers – broad range	Available ready made
25.	pH papers – different narrow ranges	Available ready made
26.	Potassium chlorate (crystals)	Use as such
27.	Seliwanoff's reagent	Dissolve 100 mg of resorcinol in 100 ml of 50% (V/V) HCl.
28.	Schultze's solution (Chloro-zinc-iodine)	i) Prepare solution A – Dissolve 20 g zinc chloride in 10 ml of DW. ii) Prepare solution B – Dissolve 1 g of potassium iodide, and 0.5 g of iodine in 20 ml of DW. iii) Add a few drops of solution A, to the whole of solution B until a precipitate of iodine crystals appear and remain even after shaking thoroughly.
29.	Sodium bicarbonate (mild solution)	Dissolve 0.5 g in 100 ml of DW.
30.	Sodium hydroxide (5%)	Dissolve 5 g in 100 ml of DW.
31.	Sodium sulphite (3%)	Dissolve 3 g in 100 ml of DW.
32.	Sudan III stain (saturated solution)	Dissolve 0.5 g in 100 ml 70% ethanol. You may need to place it in a warm water bath to help the dye dissolve. Allow it to stand overnight. Filter, if necessary.
33.	Sulphuric acid (concentrated)	Commercially available concentrated H_2SO_4 may be used as such, or carefully diluted one part in two with distilled water.
34.	Tannic acid (20%)	Dissolve 20 g in 100 ml of DW.

Poisonous
use a fume cupboard t
make this solution

Inflammable
Ninhydrin

Toxic
Ninhydrin

Irrita
Ninhy

Corrosive
Nitric acid

Corrosive
HCl

Very poisonous
Schultze's solution

Caution
Always add acid very slowly to water and not other way round. Coo continuously

1.5 SOME FREQUENTLY USED TECHNIQUES

The main focus of studies on higher plants in this course is on their morphological, anatomical and histochemical details. Therefore, you will have to be well-versed with four basic techniques that would be used several times in the following exercises – (1.5.1) free-hand sectioning; (1.5.2) peel mount preparation, (1.5.3) squash mount preparation; and (1.5.4) maceration.

1.5.1 Free-hand sectioning

Aost of the plant materials ›eing opaque and thick ›revent light passing ırough them. But a thin ection of the same allows nough light to pass through : making it possible to see :s anatomical details. By ıe use of suitable stains and taining techniques, the isibility of the anatomical etails can be further nhanced.

When we want to examine the internal structure of a plant (for instance, the types of tissues, cell arrangement, and structure), we usually cut thin sections of the plant part of interest and stain them. The stained sections are then examined under the light microscope. The anatomical details vary with the part of the plant. To get the three-dimensional anatomical picture of an organ say, a stem, its sections are cut in *transverse*, *radial* and *tangential* planes. These sections after staining are viewed under a light microscope, and a composite picture is constructed. Figures 1.1 and 1.2 will make this point clear.

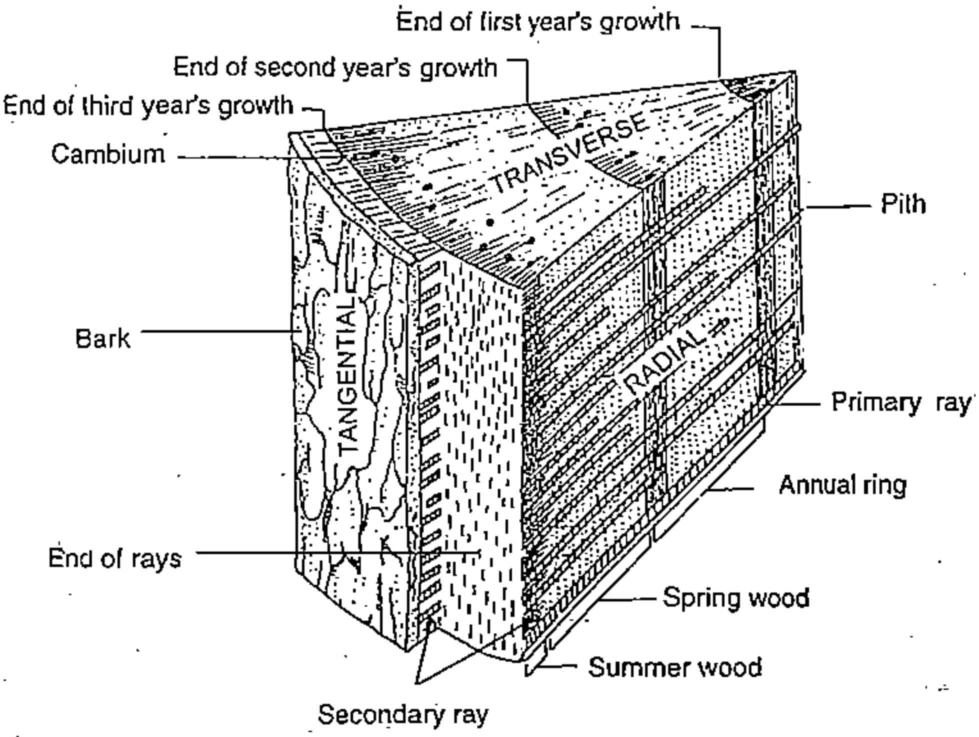
Transverse Section

When the section is cut at right angles to the long axis of the organ, the section is called **transverse section** (Fig. 1.3 a). It is abbreviated as **t.s.**

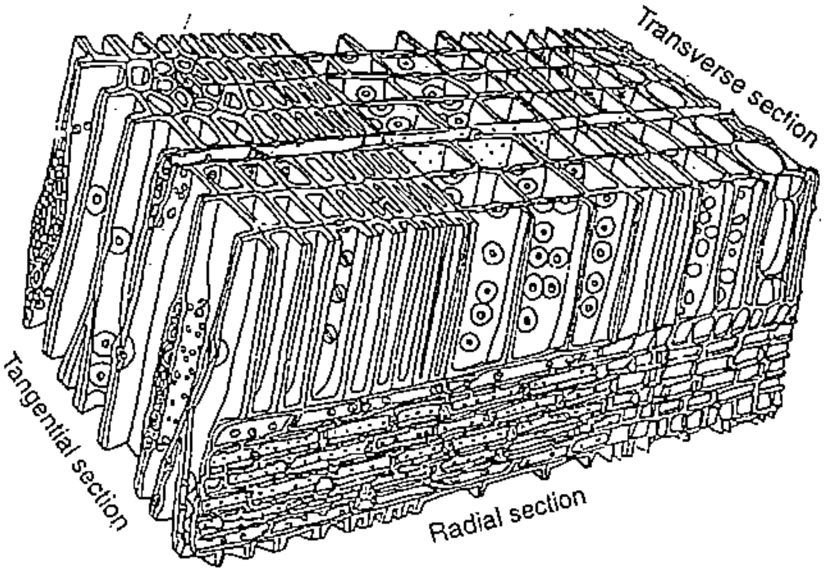
For cylindrical organs like stems and roots, the section cut in this way is referred to as transverse section or t.s. On the other hand, for dorsiventral organs such as leaf, its transverse section is referred to as **vertical transverse section**, abbreviated as **v.t.s.** or simply as **v.s.** (Fig. 1.3 b).

The term **cross-section** abbreviated as **c.s.**, is also used by some people for the transverse section of a dorsiventral organ. To put it in other words, vertical transverse section (v.t.s.) and cross-section (c.s.) are one and the same.

Your Notes



(a)



(b)

g. 1.1: a) A sector of three-year-old stem of pine (*Pinus*) cut in transverse (see the top portion), radial longitudinal (towards the right hand side), and tangential longitudinal (facing the front) sections represented diagrammatically.

b) An enlarged, three-dimensional view of a block of stem. Note the different kinds of details visible in the three planes.

[Source: a) Hartman, H.T. et. al., 1988. *Plant Science*. *2nd ed. Prentice Hall, New Jersey*. b) Romberger, J.A. et.al. ,1993. *Plant-Structure Function and Development*. Springer-Verlag, Berlin.]

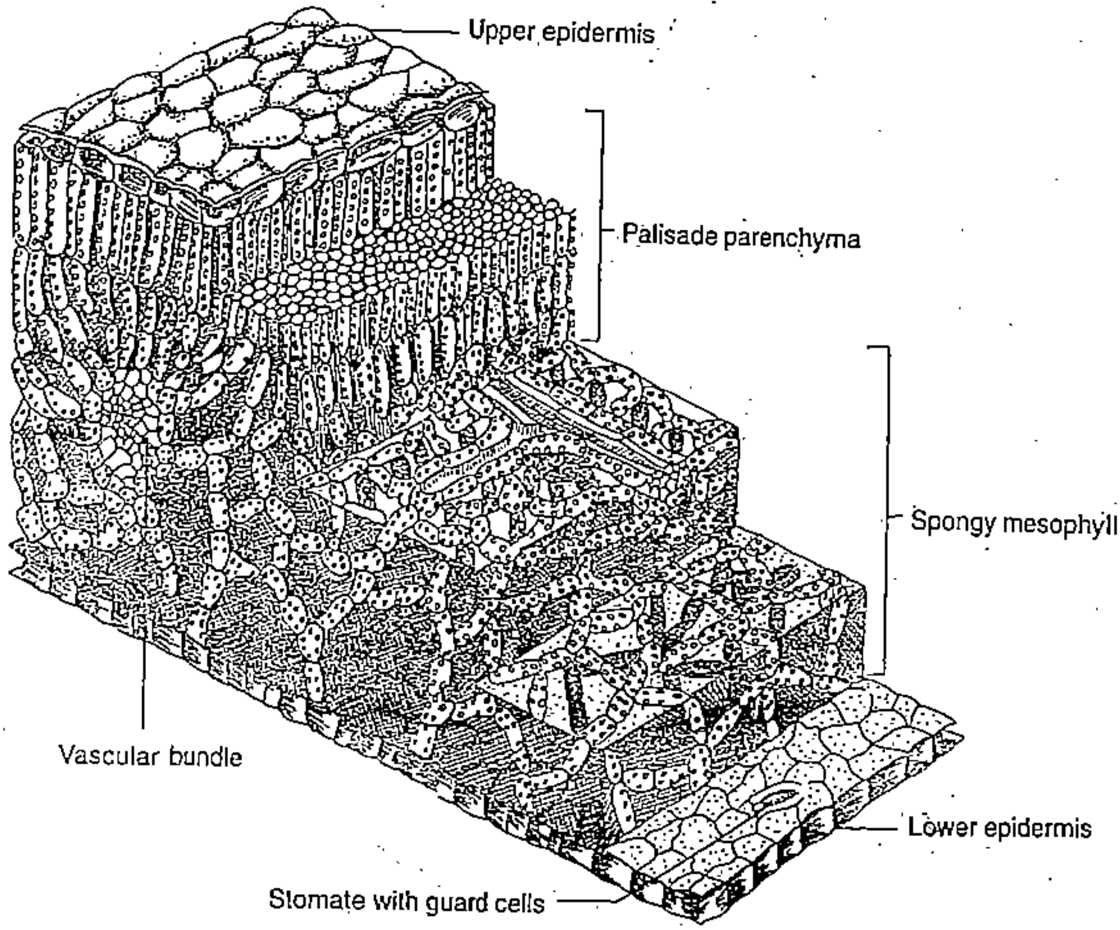


Fig. 1.2: Three-dimensional cutaway view of an apple leaf. Note the relationship between the different cells and the cellular details of tissues as seen in different sections cut at different levels and planes.
[Source: Eames, A.J. & L.H. McDaniels. 1947. *An Introduction of Plant Anatomy*. 2nd ed. McGraw-Hill, New York.]

Longitudinal Section

When a section is cut parallel to the long axis of the organ, it is called longitudinal section (see Figs 1.4 a & b). It is abbreviated as **l.s.** Referring to a cylindrical plant material such as stem or root, if the plane of the l.s. is parallel to its radius, then such a section is known as **radial longitudinal section** (Fig. 1.4 a), and it is abbreviated as **r.l.s.** And if the plane of the l.s. is parallel to the circumference of the organ, i.e., at right angles to the radius, then such a section is called **tangential longitudinal section** (Fig. 1.4 b), abbreviated as **t.l.s.** The t.l.s. and r.l.s. are particularly important in the study of wood anatomy.

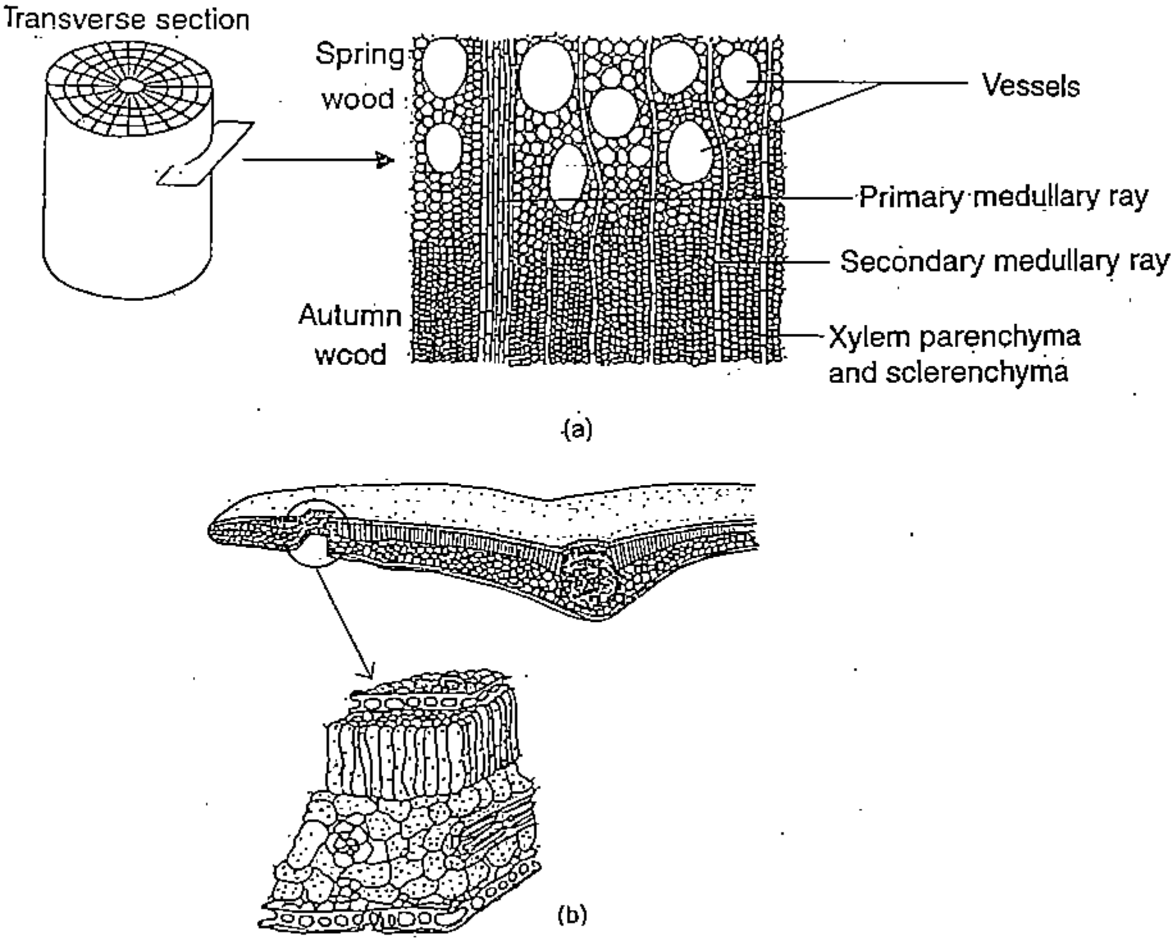


Fig. 1.3: Diagrammatic depiction of the plane of cutting transverse section in: a piece of woody stem a); and in a leaf b). Mark the kind of details visible in each sections.

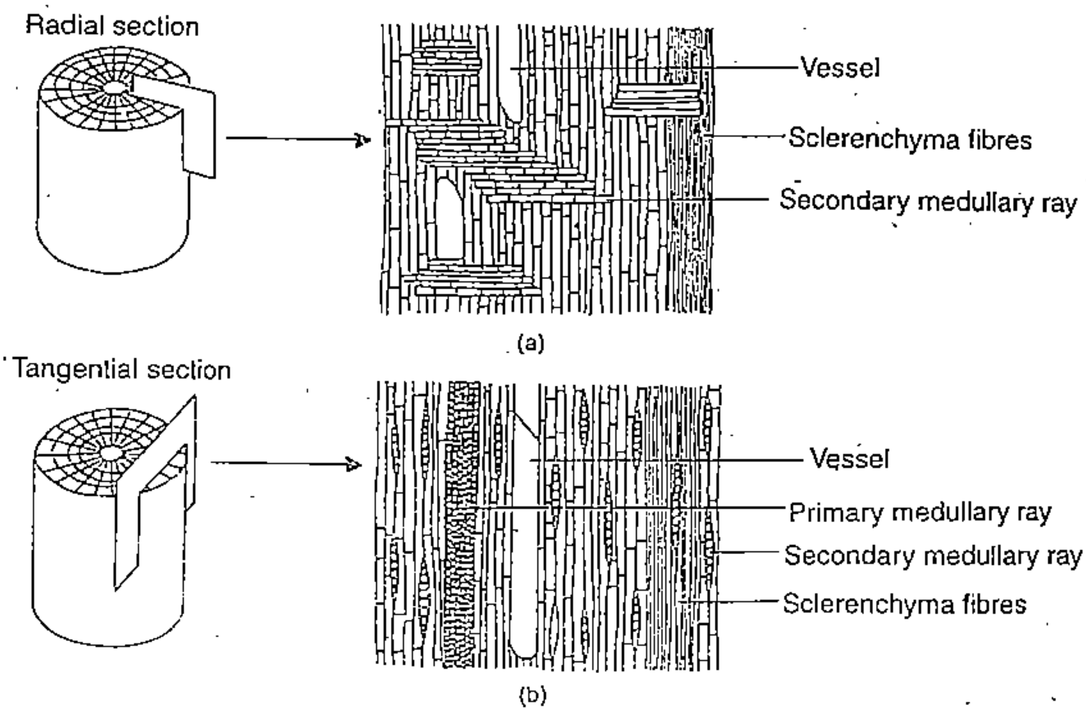


Fig. 1.4: a) & b) Radial and tangential longitudinal sections, respectively, through the woody stem. Note that each section reveals different kinds of details. Compare these with those shown in Fig. 1.3 a.

ndle the razor/ blade with care and do not injure yourself.

How to cut a section?

A free hand section of 20 µm can be prepared if the material is sufficiently hard to withstand the pressure of a sharp cutting instrument. Very thin sections, of 4 to 10 µm can be easily cut by experience and skill. Figure 1.5 depicts the method of section cutting, and the legend explains the process step-wise.

Use of pith in section cutting

Sectioning can be perfected, especially for soft materials like young stems, leaves and roots, by placing the material in a vertically split piece of pith. Internodal segments of *Calotropis* stem, tapioca stem; tuber of potato; roots of carrot, and radish; wood of *Aeschynomene*; cork-blocks; and many such materials can be used as pith material. A method of free-hand sectioning with the use of pith is explained below.

- Trim a firm piece of pith into a rectangular block of about 5 cm.
- Split it vertically to its ¾ length if the material is a flat structure. For cylindrical materials such as roots, make a hole with a needle.
- Place the given material vertically in the slit/ hole. Hold firmly in the left hand between the thumb and fore-finger (as shown in Fig. 1.5 a). If a l.s. is desired, then the material must be placed horizontally in between the lobes of the pith.
- Take a razor (shave-sharp and preferably plano-concave) or a fresh unused razor-blade. Place a drop of water on the concave surface. Hold the razor exactly horizontal the handle directed away from you, at the level with the pith (Fig. 1.5 b)
- Draw the razor towards the body in a gentle, long, sliding movement. Repeat until thin good, median, and complete sections are obtained (Fig. 1.5 c).
- Care should be taken to see that the cut surface of the material and the pith are not oblique lest the sections become oblique.
- Transfer the sections from the razor with a brush to a watch glass filled with water.
- Select thin, complete sections for observations.
- Selected sections may be stained suitably, as per requirement.

Handle the razor/ blade with care and do not injure yourself.

Caution
Be careful while drawing the razor for cutting the section.

Your Notes

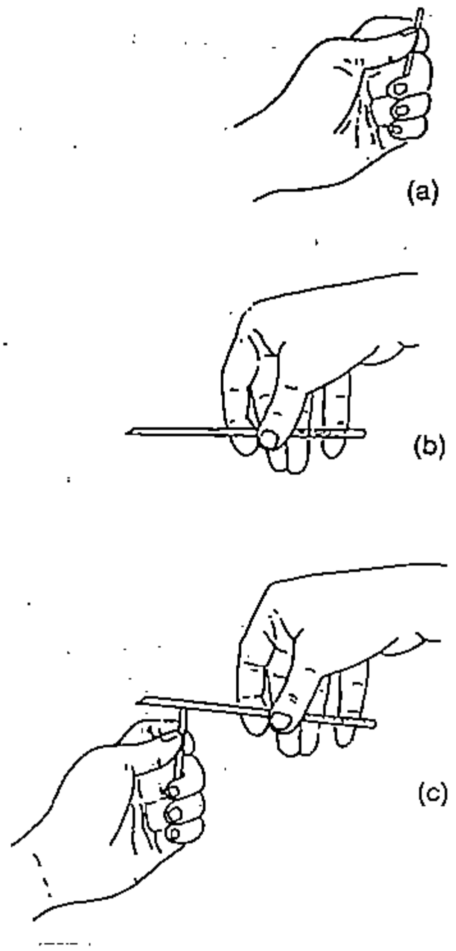


Fig. 1.5: Diagrammatic depiction of the method of cutting sections.

a) This shows the correct way to hold the material.
b) Similarly, the way to hold a razor is shown in this figure.
c) The position of holding the material ready for the stroke of the razor is illustrated in this figure.

1.5.2 Peel mount preparation

Epidermal tissue of a plant organ can be examined by observing its peel mount. When you view such cells under the microscope, you view them as if looking down at them. This is known as the aerial view. In this view the surface characteristics such as the types and arrangement of epidermal cells, stomata and trichomes, and other structures can be studied.

Peeling off the epidermis can be done as follows:

- Take a leaf, or the organ to be studied. The remaining method that is explained here with respect to leaf can be similarly applied to any other organ of the plant.
- Put a drop of water on a microslide.
- If the peel from the adaxial (top or upper) surface of the leaf is required, then fold the leaf over so that its adaxial surface is broken (Fig. 1.6 a). Using forceps, grasp the edge of the epidermis that is exposed along the break (Fig. 1.6 b).

- Gently pull the epidermis away from the break as shown in Fig. 1.6 b. A thin sheet of tissue should peel off. Repeat the process if you are not successful.
- Similarly, a peel from the ventral surface can be obtained by peeling off the epidermis on the ventral (lower, under) side of the leaf.
- Float the epidermal peel on a drop of water kept on the slide. The peel should be clean without any underlying tissue. If your peel includes some portion of mesophyll tissue, cut this portion off with a razor blade.
- Gently place a coverslip and view the tissues under the compound microscope.

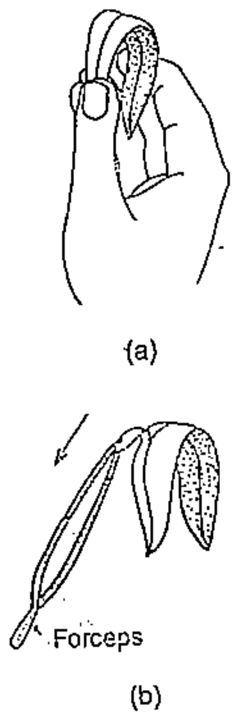


Fig. 1.6: Making an epidermal peel mount from a leaf.
a) Bending the leaf such that to cause a break.
b) Peeling off the epidermis.

1.5.3 Squash mount preparation

If one wants to study an internally placed cell in totality without sectioning, then squash mount is the most preferred method. It is both an easy and inexpensive method. On the other hand, maceration and clearing techniques, which are pretty drastic as most of the internal structures of cells are lost, are preferred less. However, these two techniques are mostly used to study reproductive cells, chromosomes, and so on.

The technique of squashing is used for materials that are neither sufficiently soft to make a smear nor sufficiently hard to be sectioned without embedding in wax. The materials like root tips, ovaries/ovules, petals, tendrils, stigmas and so on, reveal minute details that are best visible in a squash preparation. Prior to squashing, the cells have to be separated well. This is done by removing the pectic material of the middle-lamellae. It is either done by acid-, or by enzyme-hydrolysis. We shall be using the former agent and the method as follows:

Acid-hydrolysis

- Place the material in a drop of 10% hydrochloric acid or 45% acetic acid on a microslide.
- Place a coverslip on it.
- Tap it gently, till the tissue is spread out evenly.
- Remove the coverslip, wash gently with water, stain as per your requirement.

Corrosive
Hydrochloric acid
Acetic acid

Caution
The squashed material may be washed off the slide, if washing is not done gently.

1.5.4 Maceration

The separation of cells of plant materials through hydrolysis of their cementing middle lamellar materials is known as maceration. It is generally used to study hard tissues such as phloem, xylem and sclerenchyma. Macerated cells/tissues can be observed in a three-dimensional view. The reagents and techniques used in the process largely depend upon the nature of the middle-lamella. Mere boiling the tissue in plain water separates the cells of several herbaceous plants. In woody tissues, however, the middle-lamella is more ligneous and can be hydrolyzed by treatment with alkali, acid or enzymes.

The common methods employed for maceration are:

A. Jeffrey's method

- Cut fresh or dried material into small pieces, thinner than tooth-picks.
- Boil the material in water in a test-tube until it settles down.
- Replace water with a solution of 10% nitric acid and 10% chromic acid mixed in equal parts.
- Heat the test-tube containing material dipped in acid till the material becomes soft and pulpy.
- Transfer the above mentioned contents in the test-tube to a watch glass.
- Drain out the fluid and wash the macerated materials gently several times with water till all the acid is removed.
- Stain the material with safranin. Destain in water, if stained in excess. Mount in glycerine.
- Tap the microcoverslip gently so as to spread the material evenly on the microslide. Observe the preparation under the microscope.

Corrosive nitric acid
chromic acid

Caution
Hold the test-tube with a test tube holder. Keep mouth of the test-tube away from you.

B. Harlow's method

- Slice and boil the material with chlorine water for two hours.
- Wash it in running tap water.
- Boil the washed material for 15 minutes in 3% sodium sulphate.
- Wash again in water.
- Macerate (as above), stain, destain (if needed), mount and observe under a compound microscope.

Corrosive
Nitric acid

C. **Schultze's method**

- Slice and boil the material in water in a test-tube.
- Remove water and replace it with conc. nitric acid
- Add a few crystals of potassium chlorate.
- Heat it gently, and slowly till the material is bleached white.
- Drain out all the liquid from the test-tube.
- Wash the material with tap water, repeatedly.
- Macerate, stain, remove excess stain if required, mount, and observe under a compound microscope.

Your Notes

1.6 MICROCHEMICAL TESTS

This section describes methods to identify the main classes of chemical compounds in ground-up tissues, intact cells, food stuffs and extracted juices. Methods to detect the more common substances such as carbohydrates, proteins and fats are being described in the following pages. *Since you will be handling many chemicals and some procedures require heating also, so pay foremost attention to your safety.* The icons given in the margin space here and before will alert you to be careful while handling dangerous chemicals, and suggest ways to work with safety. While working in the lab, always wear a lab coat and the use of safety spectacles would be ideal. It is safer to use water baths for heating liquids.

Use of safety spectacles is a good practice

1.6.1 Carbohydrates

Experiment	Observations	Inferences
1) All Carbohydrates **Molisch's test:** Add a few drops of α-naphthol solution to 1-2 ml of sample solution. Shake it. Finally, add conc. sulphuric acid slowly along the margin of the test tube.	A violet ring or purple violet colouration is formed at the junction of the two liquids.	A positive test indicates the presence of **all types of carbohydrates.**
2) Reducing sugars **i) Benedict's test:** Add 2-3 ml of Benedict's qualitative reagent to equal volume of the test material. Boil it for 5 minutes. **ii) Fehling's test:** Add 1 ml of Fehling solution **A**, and 1 ml of Fehling solution **B** to a dry test tube. Mix them thoroughly. Add, 2 ml of test solution to	The solution first turns green, then yellow and finally red depending upon the amount of reducing sugars in the sample. The solution first turns green, then yellow and finally red depending upon	Nonreducing sugar present. (Cont.)

Corrosive Sulphuric acid

Caution
Danger of liquid spilling over you while boiling. Hold the test tube with a holder, and keep the mouth of the test tube away from

	it. Boil the mixture in a water-bath for 5-10 minutes.	the amount of reducing sugars in the sample.	**Reducing sugars present.**
	iii) Barfoed's test:		
Be careful while boiling the mixture.	Add 1 ml of test solution to 3 ml of Barfoed's reagent in a test tube. Boil for 1-2 minutes. Let it cool down.	Red precipitate is formed at the bottom of the test tube.	**Positive** test means **reducing sugars** are present in the test sample.
	iv) Moore's test:		
Corrosive NaOH	To about 2 ml of sample solution add 2 ml of 5% NaOH solution. Boil for 2-5 minutes in a water bath.	The solution turns yellow and then reddish brown due to the formation of a condensation product of the sugars.	**Positive test** indicates presence of **reducing sugars,** particularly glucose.
	v) Seliwanoff's test:		
	To about 3 ml of Seliwanoff's reagent add 1 ml of the test solution. Boil in a water bath for 5 minutes.	A red colouration is observed.	Presence of **ketohexose (fructose)** in test solution is indicated.
	vi) Cobalt chloride test:		
Be careful while boiling the mixture.	Add 1-2 ml of cobalt chloride (5%) solution to about 3 ml of sample solution. Heat the mixture till it boils. Allow it to cool before adding a few drops of NaOH (5%) solution.	If the solution turns greenish-blue	This indicates presence of **glucose.**
		Or	
		If the solution turns purplish-violet	This indicates presence of **fructose.**
		Or	
			(Cont.)

	The upper part of the solution turns greenish-blue and the lower part turns purplish-violet.	This points out that both **glucose** and **fructose** are **present** (in the hydrolysed sucrose solution)
vii) **Ammonium molybdate test:** To about 2 ml of sample solution, add 2-3 ml of ammonium molybdate solution (5%). Heat it to boiling point in a water bath.	If the solution turns bluish-green.	Presence of **ketohexose (fructose)** in sample solution is confirmed.
3) Non-reducing sugars (Sucrose) i) Except the monosaccharides and a few disaccharides, all other carbohydrates are of non-reducing type. They all test negative for any of the reducing-sugar test prior to their hydrolysis. a) Fehling's Benedict's reagent test for a solution of non-reducing disaccharide. b) Test solution (3-5 ml) is hydrolysed by the addition of a few drops of dil. HCl and then it is boiled. Neutralize with mild solution of $NaHCO_3$ Confirm the loss of acidity with pH paper. The neutralized	No reaction.	Indicates absence of **reducing sugar.** (Cont.)

and hydrolysed test solution is subjected to (any/all of the following as per requirement):	—	
• Fehling's test	Red precipitate	Indicates **reducing sugars are present** in hydrolysed sample.
• Benedict's test	Red precipitate	Confirms **the presence of reducing sugars** in hydrolysed sample.
• Cobalt chloride test	Upper part green, lower part purplish	Indicates both **glucose** and **fructose are present.**
• Seliwanoff's test	Red colouration	**Positive** for **ketohexose** in hydrolysed sample.
• Ammonium molybdate test	Solution turns bluish-green	**Test positive** for **ketohexose** in the hydrolysed sample.
4) Non-reducing polysaccharides. **i) Iodine test:** To about 2-3 ml of sample solution add a few drops of dil. iodine solution.	If the solution turns blue immediately. Or If the solution turns reddish brown.	**Positive** test indicates the presence of **polysaccharides (starch)** in the sample solution. This indicates that **Dextrin is present** Or **Glycogen** type of polysaccharide is present in the sample solution.

(Cont.)

If you are testing a food stuff in water, a blue colour sometimes appears on the foodstuff itself rather than the solution, as starch is relatively insoluble in water.

ii) Tannic acid test: Add 5-6 ml of 20 % tannic acid to 3-4 ml of sample solution.	A precipitate is immediately formed.	This indicates presence of **starch/glycogen (polysaccharide)** in the sample solution.
5) Cellulose Add Schultze's solution to sample mixture.	Blue-violet patches appear.	The **presence of cellulose** is indicated wherever the purple colouration is observed.

Your Notes

1.6.2 Proteins


Inflammable Ninhydrin


Toxic Ninhydrin


Irritant Ninhydrin


Corrosive NaOH


Corrosive H_2SO_4


Corrosive Millon's reagent


Toxic Millon's reagent

Experiment	Observations	Inference
1) Test for amino acids		
Add a few drops of 5% ninhydrin solution to a small amount of test sample. Heat in water bath for 10 minutes.	If the solution turns purple or bluish.	This indicates that the sample contains **amino acids**.
2) Tests for proteins		
i) Biuret test:		
Add 1 ml of 5% NaOH solution to 3 ml of test solution.		
Next, add a few drops of 1% $CuSO_4$ solution.	If a violet or blue colouration is produced.	This means that the test sample has **compounds with** (CONH) peptide **bonds**.
ii) Xanthoprotein test:		
Add 1 ml of conc. H_2SO_4 to 3 ml of test solution/sample.	If a white precipitate is formed which turns yellow on boiling, and turns orange when NH_4OH solution is added to it.	It shows that test sample has **proteins** as well as the **amino acids tryptophan and/or tyrosine.**
iii) Millon's test:		
Add 3 ml of test solution to 4.5 ml of Millon's reagent. Heat it.	If a white precipitate is produced which turns brick red on warming. The precipitate may dissolve and make the solution red.	**This confirms the presence of protein.** This test mainly detects insoluble proteins.
iv) Precipitation test:		
To the test solution any of the following can be added: a) 5% $CuSO_4$ solution b) 5% $HgCl_2$ solution c) 5% $Pb(CH_3COO)_2$ solution.	If a white colloidal precipitate is formed.	The presence of **proteins** is confirmed.

1.6.3 Fats/Oils

Experiment	Observations	Inferences
i) Sudan III test:		
1. Add a drop of Sudan III to a section of the plant material. After 15-20 minutes, wash the section in 50% ethanol and mount in glycerine, and observe under the microscope.	If red stained oil droplets can be seen within the cells of the section as well as floating around the section.	The **presence of oils** and fats in the test material is confirmed.
2. Take ground-up tissue in a test-tube and add water to it. Boil it. Oils/fats if present will escape from the tissue and rise to the surface. Now add a few drops of Sudan III. Keep the test-tube in the test tube stand and allow the oil layer to settle.	If the surface (upper) layer of the mixture turns red.	The **presence of oils/fats** is confirmed in the plant tissue.
ii) Solubility test: To the ground-up tissue add water, 95% ethanol, ether, and chloroform in different test tubes. Shake them thoroughly. Allow them to stand for a few minutes.	Oil is insoluble in water; but soluble in 95% ethanol, ether, and chloroform.	**Presence of oils** in the tissue is confirmed.

Highly flammable Ethanol

Your Notes

EXERCISE 2 DIFFERENTIATED TISSUES

Date ....
Session #........................
Time allocated - 1½ **Hours**

Structure

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in lab.

2.1 INTRODUCTION

In this exercise, you will study six categories of differentiated tissues. Each of this category is dealt with in a separate section, from sections # 2.2 to 2.7. The objectives for each category are listed in each section and the instructions for study, materials to be used and procedures are also explained for each separately. You have to record your observations/findings, write answers to the Self-assessment Questions (SAQs) in the Worksheets.

Objectives

After doing this exercise, you should be able to identify the constituent cells of the following tissues, highlighting their characteristic features:

- parenchyma;
- collenchyma;
- sclerenchyma;
- xylem;
- phloem; and
- the epidermal system.

Study Guide

- This exercise is based on the Unit 7 – Tissues, of the LSE-13 course. It will be very helpful to revise this unit before taking up the present laboratory exercise.
- It will be a good idea to make a time utilization plan for this exercise. This will help you to complete your lab work in the stipulated time and accomplish the objectives outlined for this exercise.

2.2 PARENCHYMA

Parenchyma is composed of cells that are most abundant and the least differentiated amongst the various cell types that are found in vascular plants. They may be primary or secondary in origin. Their cell walls are generally primary and are rather thin and plastic.

Cell Shape and Arrangement

The newly formed cells are more or less spherical. Subsequently, they may assume various shapes and sizes. Their cells are vacuolate, living and may contain small and simple pits. The cells of parenchyma occasionally contain air-spaces within them and exhibit tremendous functional diversity. You will observe the variations in cell shape and their arrangement in Fig. 2.1 in Worksheet # 2.1.

Cell Inclusions

During differentiation and maturation, certain structural changes take place in a parenchyma cell. These changes very often are correlated to the functional adaptations of the plant. You will observe some of them in Fig. 2.2 in Worksheet # 2.2.

a) **Plastids:** Plastids are the cell organelles characteristic of plant cells. They arise from pro-plastids which are present in the meristem cells. Prominent kinds of plastids are: chloroplast (Fig. 2.2 a); chromoplast (Fig. 2.2 b, c); and amyloplasts (Fig 2.2 d). Fig. 2.2 e shows oils/fats which are produced by elaioplasts. The elaioplasts are not easily observable under the compound microscope.

b) **Ergastic substances:** Reserve and waste materials produced by the cells are called ergastic substances. A few of such substances are: starch, proteins, fats/oils and crystals.

   i) **Starch:** It is a carbohydrate comprising long-chain molecules. It appears within the cells in the form of grains which commonly stain bluish-black with a solution of I_2-KI. The starch grains generally show layering around a point, called **hilum**. The position of hilum within a starch grain is significant. It can be central (e.g., *Triticum*) or eccentric (e.g. *Musa sinensis, Solanum tuberosum*). The structure of starch grain is taxon-specific. The starch grains when occur in aggregates are called **compound starch grains** (e.g., *Oryza sativa, Ipomoea batatas, Avena sativa, Fagopyrum esculentum*).

   ii) **Proteins:** The outermost layer of endosperm, the aleurone layer in caryopsis of cereals is rich in amorphous proteins. Proteins could also be found as cuboidal crystalloid (as are found in peripheral cells of tuber of potato; in the parenchyma of fruit of capsicum). The crystalloid and amorphous proteins are found together in aleurone grains in the endosperm of *Ricinus communis*.

   iii) **Fats/oils:** They are very common reserve food materials in the plants. These are mostly present in seeds and fruits in the form of glycerides of fatty acids. They stain reddish when treated with Sudan III/IV.

Waxes, esters of long-chain fatty acids and long-chain monohydric alcohols are widespread in plants. They provide protective coating on the epidermis of stems, leaves, fruits and seeds. Lipids, other than fats, oils, waxes, e.g., terpenes/essential oils are usually produced by specialized secretory tissues.

iv) **Crystals:** The crystals are depositions of excess inorganic materials within the cells. Most of them are salts of calcium or deposits of silicon dioxide. These crystals are classified on the basis of their shapes and forms as follows:

Prismatic: rectangular, pyramidal (Fig. 2.2 g)
Druses: spheroidal aggregates of prismatic crystals (Fig. 2.2 h)
Raphides: thin, elongated crystals with tapering ends (Fig. 2.2 i and j) usually in aggregates.
Styloids/Pseudoraphides: long prismatic crystals, which taper as blade, and occur solitary.

The crystals are found in the vacuoles of cells and are surrounded by an envelope. Crystals of calcium carbonate are found rarely in higher plants. They are associated as ingrowth of cell walls. These crystals are known as **cystolith**. The cell, wherein the cystolith deposition takes place is known as **lithocyte** (Fig. 2.2 k). The trichomes in *Cannabis,* and *Boehemeria* have cystolith depositions.

Note: Follow the instructions provided in Worksheets. In case you find the shape, size, location, contents in variance with the drawings in the Worksheet, consult your Counsellor and follow your own observations, if approved by your Counsellor.

Objectives

On completing this exercise concerning parenchyma, you should be able to:

- identify the various shapes the cells acquire at maturity;
- identify the absence or presence of intercellular spaces; aerenchyma; schizogenous and lysigenous cavities;
- identify various kinds of cell contents, viz., plastids and ergastic substances; and
- appreciate the diversity of its distribution, structure and function.

Mode of Study

You will study the tissue by observing the temporary/permanent slides provided to you. Observe the tissue, comprehend its structure and arrangement of cells; complete the diagrams given in the worksheets, label the focused structures, and answer the given questions.

Optional: Time permitting, you could try to prepare a few unstained/stained temporary mounts of the materials provided.

Materials required

Listed below are various plant materials that are required to study the structures/parameters represented in the Figs 2.1 and 2.2. You can choose other plant materials, if necessary.

Figure #		Source Material
2.1 a	:	Cortical cells of primary dicot root (*t.s.*).
2.1 b, d	:	Mesophyll of a dorsiventral leaf (*v.s.*).
2.1 c	:	Palisade parenchyma of *Lilium candidum* leaf (*v.s.*)/photograph.
2.1 e	:	Mid-rib region of *Canna* leaf (*v.s.*).
2.1 f	:	Endosperm of a cereal grain (*l.s.*).
2.1 g, i	:	Storage parts of fleshy axial organs/fruit (*t.s.*); Pith cells of primary dicot stem (*t.s.*); and Ground tissue of *Nymphaea* (*v.s.*) / stem of *Juncus* (*t.s.*)/ leaf of *Canna* (*v.s.*)/ leaf of *Musa* (*v.s.*).
2.1 j	:	Resin ducts in stem/ leaf of *Pinus* (t.s.)/ secretory ducts in stems of Compositae, Apiaceae (Umbelliferae) plants (*t.s.*).
2.1 k	:	Cortical zone of root of Poaceae (Gramineae), Cyperaceae (*t.s.*)/ rind of *Citrus* fruit (*t.s.*)/ ground tissue in primary stem of *Mangifera indica* (*t.s.*).
2.2 a	:	*Hydrilla* leaf (*w.m.*).
2.2 b, c	:	Pulp of *Lycopersicon* fruit (*w.m.*)/ epidermal peel of petal of *Calendula* (*w.m.*).
2.2 d	:	Tuber of *Solanum tuberosum* (*t.s.*).
2.2 e	:	Endosperm of *Cocos nucifera* (*t.s./l.s.*).
2.2 f	:	Aleurone cells in endosperm of *Ricinus communis* (*t.s./l.s.*), and cereals.
2.2 g	:	Cortex of petiole of *Begonia* (*t.s.*)/ mesophyll of leaf of *Citrus* (*v.s.*).
2.2 h,	:	Cortex of petiole of *Begonia* (*t.s.*)/ mesophyll of leaf of *Datura stramonium, Ruta graveolens* (*v.s.*).
2.2 i, j	:	Ground tissue of leaf of *Arum, Zebrina* (*v.s.*)/ stem of *Zebrina, Tradescantia* (*t.s.*)/ rhizome of *Colocasia esculenta* (*t.s.*)/ epidermal peel of petals of *Impatiens balsamina* (*w.m.*)/ ground tissue of root of *Ipomoea batatas* (*t.s.*).
2.2 k	:	Multiple epidermis (adaxial) of leaf of *Ficus elastica* (*v.s.*)/ trichome of *Boehemeria* (*w.m.*)/ hooked trichome of *Cannabis* (*w.m.*).

Procedure

Study carefully the given preparations under the compound microscope. Focus the region as mentioned in the section – materials required (remember, the given slide may have many other kinds of tissues which are not part of this exercise).

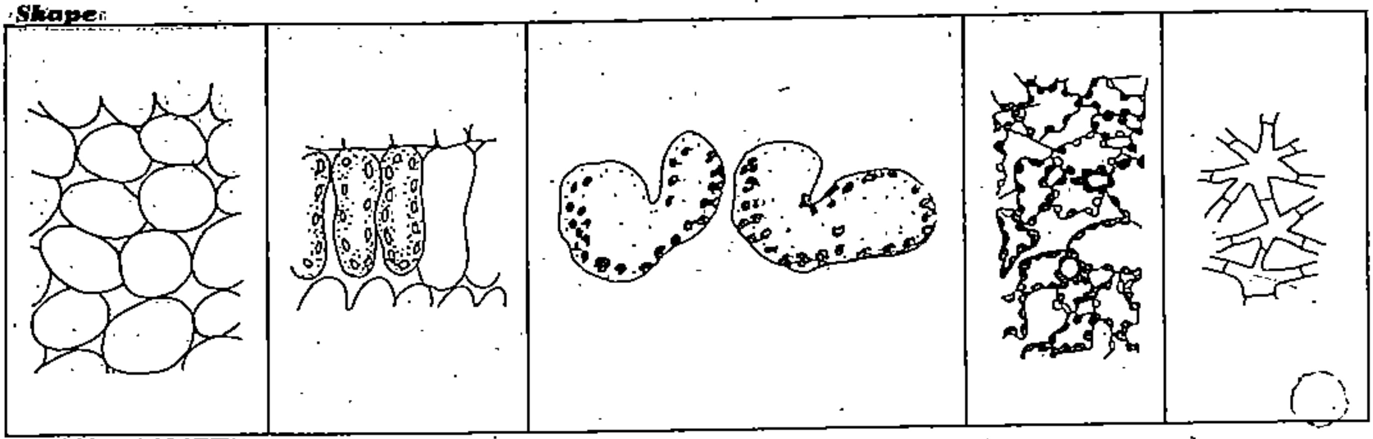
- After you have made the observations, check them with the drawings on the worksheets. Follow the instructions provided on the worksheet.
- Write down the comments/answers as instructed.
- Consult your Counsellor in case of doubt.

Observations and Interpretations

Pay attention to the shape of cells, arrangement of cells, and note if any air spaces are present or not. Also observe and study the cell inclusions. Record your observations in the Worksheets # 2.1 – 2.4.

Worksheet #2.1: Study of parenchyma.

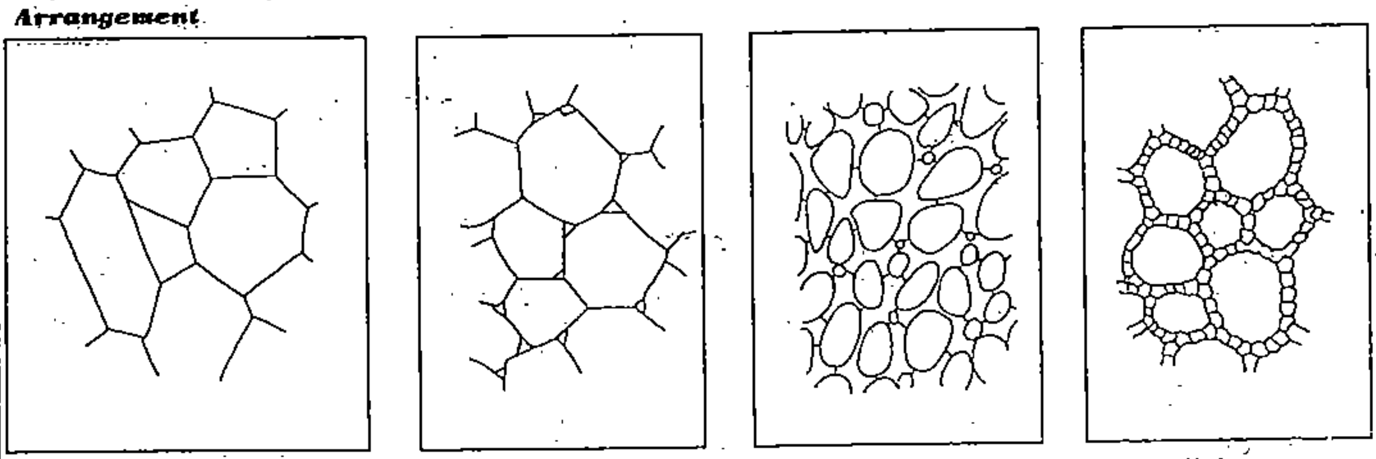
Shape



a) ………………… b) ………………… c) Lobed d) …………… e) ……………

Q.1: Identify the cell shapes in Figures a, b, d and e.

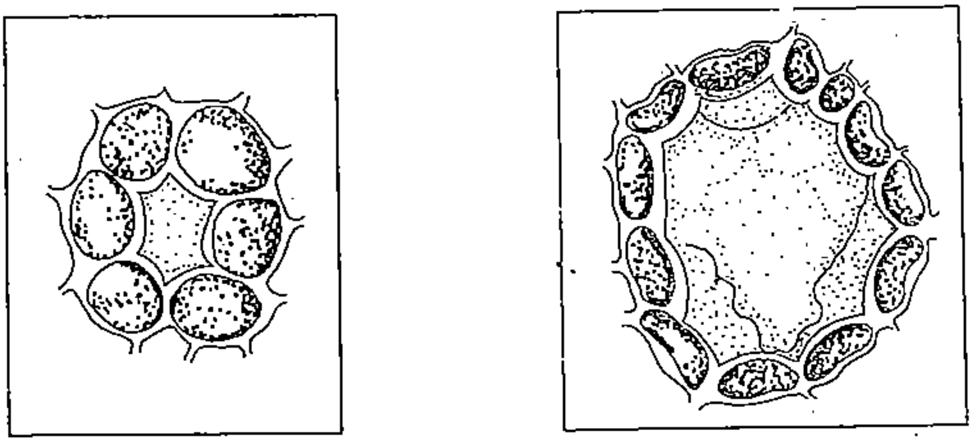
Arrangement



f) Cells without intercellular spaces. g) Cells with small intercellular spaces h & i resp.) Cells with large intercellular spaces

Q.2: Draw arrows to identify cell spaces in Figures g-i.

Cavities



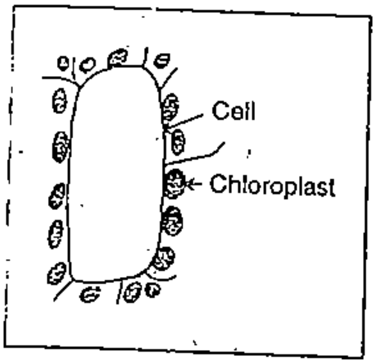
j) ……………………… k) ………………………………

Q.3: Name the kind of cavities in figures j & k.

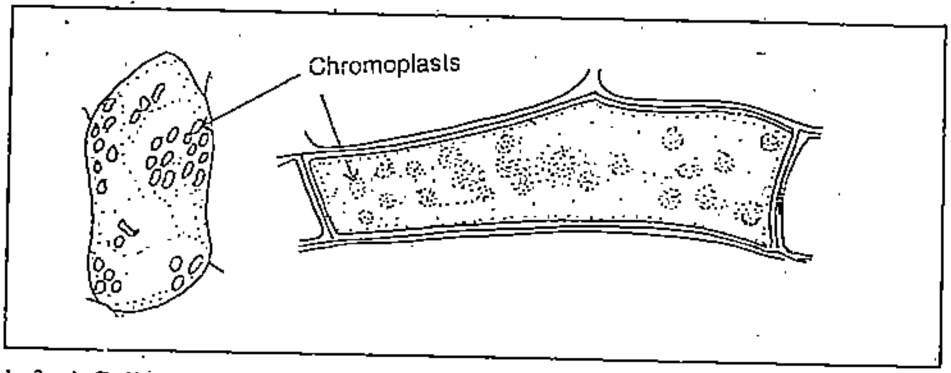
Fig. 2.1: a-k) Different shapes and arrangement of parenchyma cells.

Worksheet # 2.2: Study of parenchyma (cont.)

Plastids



a) Cells (shown here partly) with chloroplasts.

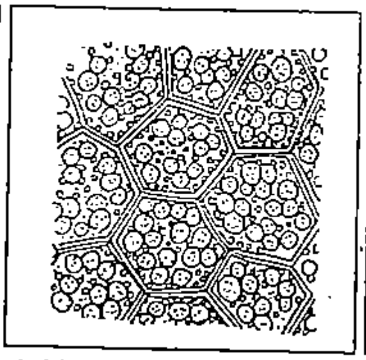


b & c) Cells containing chromoplasts.

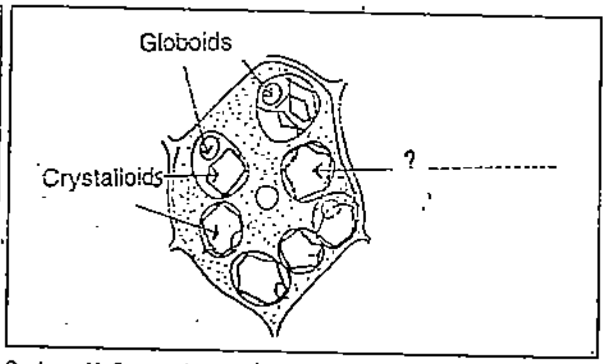
Q.1: After observing the slide, draw a few chloroplasts in the blank cell.

Q.2: Identify chromoplasts in the given preparation/permanent slide.

d) Cells with amyloplasts.



e) Oils/fats containing cells.

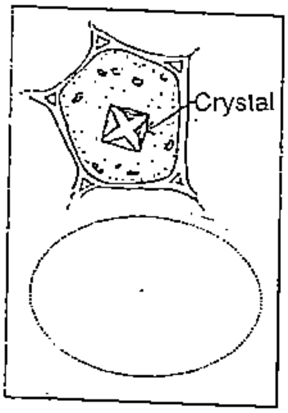


f) A cell from aleurone layer with globoids and crystalloids.

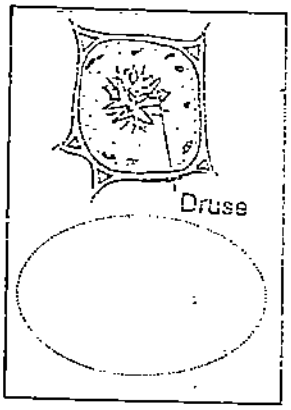
Q.3: Draw a few starch grains in the blank cell.

Q.4: Indicate the oil/fat globules in the cells.

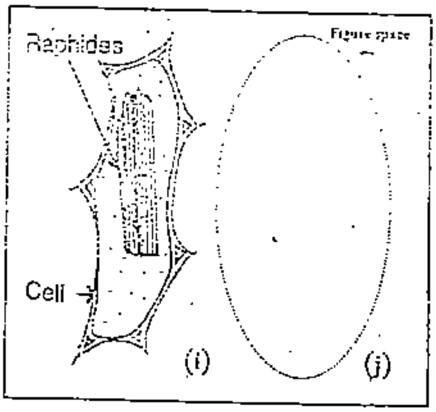
Q.5: Identify the '?-marked' cell inclusion.



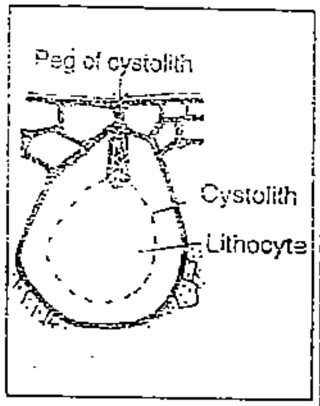
g) Cell with solitary prismatic crystals.



h) Cell with aggregate prismatic crystals.



i & j resp.) Fig. i shows raphides.



k) A cell with a part of the cystolith.

Q.6: Draw one crystal.

Q.7: Draw a druse from the slide.

Q.8: Draw one/two raphides in fig. space j.

Q.9: Draw the remaining portion of the cystolith.

Fig. 2.2: a-k) Various kinds of cell inclusions in parenchyma cells.

I. Shapes:

Q.1 Write down the five different kinds of shapes that you have observed in Figures 2.1 a to e. (in the Worksheet # 2.1).

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....

....

Q.2 How is the polygonal shape of a parenchyma cell brought about?

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....

Q.3 In what manner are the cells depicted in Fig. 2.1 c (in Worksheet # 2.1) unique?

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....

Q.4 Where does spongy parenchyma occur? What is its functional significance?

....

....

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....

(Cont.)

Worksheet # 2.3: Study of parenchyma (cont.).

II. Arrangement:

Q.5 What is a lysigenous cavity?

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Q.6 When are the schizogenous spaces in a parenchyma formed?

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Q.7 Mention the functional significance(s) of aerenchyma.

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Worksheet # 2.4: Self-assessment Questions.

SAQ 1

Mention 5 characteristics of a parenchyma cell.

a) ....

b) ....

c) ....

d) ....

e) ....

SAQ 2

What happens to chloroplasts of green chilli when they turn red?

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SAQ 3

Define: a) Ergastic substances

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b) Druse

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....

2.3 COLLENCHYMA

Collenchyma is another form of simple tissue because it is composed of only one kind of cells. This tissue is primary in origin and mainly functions as supporting tissue in the growing organs of dicotyledonous plants, viz., hypocotyls, young stems, petioles, pedicels, and peduncles. The cells of collenchyma are live, flexible and possess considerable tensile strength. The main characteristics of the tissue are:

- The cells are live when active and distinctly vacuolated. The cells are more long than broad, may be chlorophyllous and may contain tannins.
- The cells possess simple pits and may have small intercellular spaces between them.
- The tissue elongates along the axis of the organ in which they are differentiated. They are generally peripherally situated in an organ, mostly below the epidermis. They often form a cylinder near the periphery of the organ or occur in the form of discrete strands.
- The cell-walls are primary and cellulosic. In addition, hemicellulose and/or pectin are also deposited. The wall materials are either evenly distributed within the cell or are more concentrated in certain regions of the cell.
- Based on the kind of wall-thicknenings, three distinct types of collenchyma have been recognized:
  a) **Angular collenchyma:** These are the commonest type. The extra wall depositions are predominantly at the corner or angles of the cells.
  b) **Lacunar collenchyma:** The additional wall thickenings are deposited mainly around the intercellular spaces between the cells.
  c) **Lamellar collenchyma:** The additional wall thickenings are deposited more heavily on the tangential walls than on the radial cell walls.

Objectives

On completion of this exercise related to collenchyma, you should be able to:

- identify the **three** main kinds of collenchyma tissue;
- recognize their distribution within an organ, and be able to identify whether they are present as a cylinder or as discrete strands;
- identify the middle-lamella, the thick cell wall deposition and lacuna (intercellular space) whenever present; and
- identify its protoplasmic contents and tell whether the given collenchyma is chlorophyllous or not.

Your Notes

Materials required

Listed below are some plant materials that are required for the study of collenchyma tissue. The examples mentioned here are only representative ones, you can choose other plant materials that are easily available.

1. **Angular collenchyma:** T. S. petiole or young stem of Apiaceae (= Umbelliferae); *Vitis, Morus, Cannabis, Begonia, Coleus, Beta, Datura, Cucurbita* (Fig. 2.3 a and d, in Worksheet # 2.5).
2. **Lacunar collenchyma:** T. S. petioles/young stems of Asteraceae, *Salvia, Malva, Althaea, Asclepias* (Fig. 2.3 b and e).
3. **Lamellar collenchyma:** T. S. stem of *Sambucus nigrum, Rhamnus* (Fig. 2.3 c and f).

Procedure

- You are provided with permanent slides/temporary-stained preparations.
- Focus the slide under the low power of compound microscope. Now, locate and identify the band/strands of collenchyma. Find out whether it is in form of a cylinder or present as discrete strands.
- Next, focus a portion of the tissue under the high power of compound microscope. Study and compare the structures as shown in the diagrams (a-f) in Worksheet # 2.5.
- In some tissues, you will have to make some effort to locate and observe lacunae in the lacunar type collenchyma.
- Similarly, you may have to search for an ideal focus showing lamellar thickenings. Take the help of your Counsellor wherever needed.

Observations and Interpretations

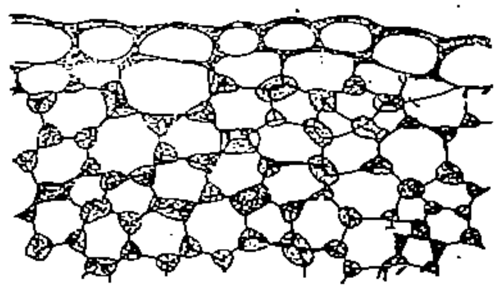
While observing the preparations, give special attention to the following aspects:

- The identification of middle lamella, cell wall and protoplast.
- Outline/shape of a cell as delimited by middle lamella.
- The extra thickenings on the cell walls. Correlate them with the diagrams in the Worksheet # 2.5.

Note: Follow and complete the exercise as per instructions provided on the Worksheet # 2.5.

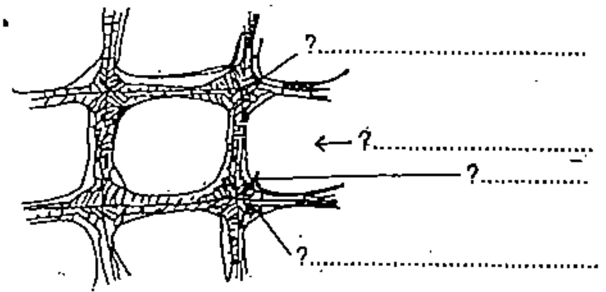
Your Notes

Worksheet # 2.5: Study of collenchyma.



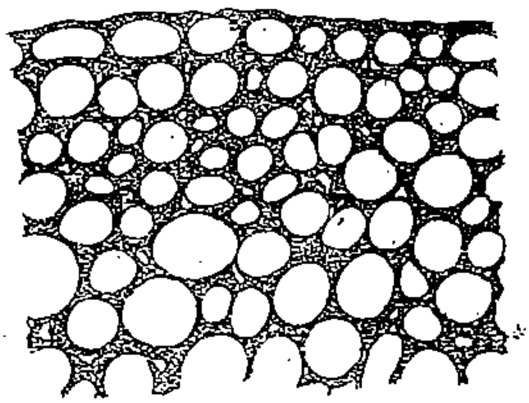
a) .... collenchyma.

Q.1: Identify the type of collenchyma.



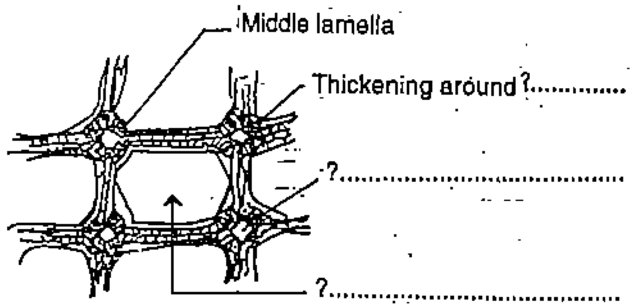
b) A portion of figure a magnified.

Q.2: Label the marked portions in the above figure.



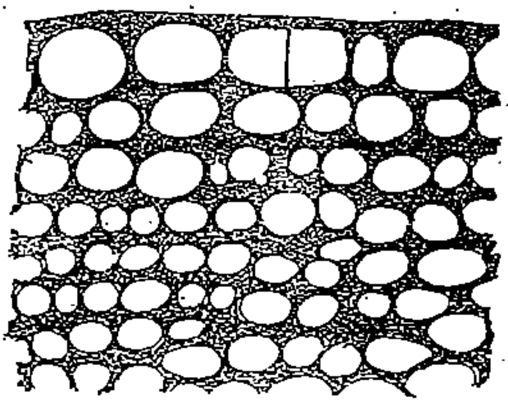
c) .... collenchyma.

Q.3: Identify the type of collenchyma.



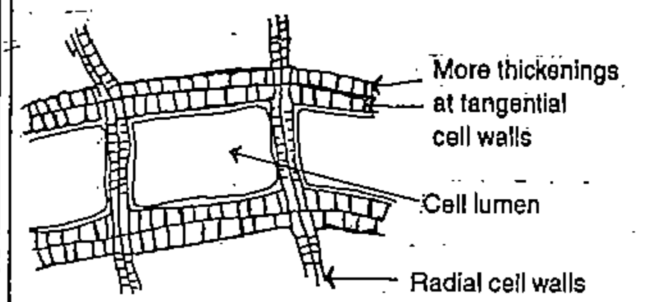
d) A portion of figure c magnified.

Q.4: Label the marked portions in the above figure.



e) .... collenchyma.

Q.5: Identify the type of collenchyma.



f) A portion of figure e magnified.

Fig. 2.3: *Collenchyma – types and structure.*

SAQ 4

In a rightly stained preparation of collenchyma, why do we encounter lamellations in the cell-wall?

SAQ 5

What is the chemical nature as well as the structure of the region that delimits a lacuna in a lacunar type of collenchyma?

SAQ 6

Write down five characteristics of collenchyma.

2.4 SCLERENCHYMA

Sclerenchyma constitute the third type of simple tissues. It comprises a group of thick-walled cells. Its main function is to provide mechanical strength to the organ in which it differentiates. The main peculiarities of this tissue are:

- At maturity, the sclerenchymatous cells generally lack protoplasm and are mostly dead.
- They may be both primary or secondary in origin. They may also differentiate from the parenchyma or collenchyma cells.
- Their thickened cell walls are mostly secondary in origin and are often lignified having a few to many simple-pits.
- They develop in any or all parts of the primary or the secondary plant body.
- They have the ability to withstand various strains arising out of activities such as stretching, bending, addition of weight, and pressure and so on. This ability is attributed to their elastic nature.

The sclerenchyma has two distinct kinds of cell types, the **fibres** and the **sclereids**.

(A) Fibres

The fibres are long cells; in fact many times longer than they are broad. They are elongated elements with tapering ends which overlap and often are fused to each other. Their secondary cell walls are usually lignified leaving a narrow lumen or cell-cavity. They often lack live protoplasm at maturity. However, certain xylary fibres may retain live protoplasm for several years.

Fibres may occur in roots, stems, leaves, or fruits, and in association with the different tissues of these organs. In fact, they are also principle components of vascular tissue.

Classification

a) Fibres are classified based upon their occurrence in the plant body as xylary and extra-xylary fibres.

   i) **Xylary fibres:** Fibres associated with xylem by origin are called xylary fibres.
   ii) **Extra-xylary fibres:** Fibres that occur in plant body in any place other than the xylem are called extra-xylary fibres, e.g., phloic, pith, cortical and pericyclic. Extra-xylary fibres are often very long cells.

Your Notes

Xylary-fibres are *further classified based upon their structure.*

They may be:

*1 **Libriform-fibres:** They resemble phloem fibres. They show extremely thick cell walls and simple pits. They are longest of all kinds of xylary fibres.
*2 **Fibre-tracheids:** They are intermediate between tracheids and libriforms fibres. Their cell walls are of medium thickness. The pits on their walls are bordered. Their cell-lumens may possess protoplasts which are often degenerated.
*3 **Septate fibre-tracheids:** They are similar to fibre-tracheids except that their protoplasts are divided by one or more pseudo-septae.
*4 **Gelatinous fibres:** In such fibres, the innermost layer of cell wall has depositions of cellulose and is poorly lignified. This layer may absorb much water and may swell and fill the lumen. On drying, they shrink irreversibly. They are also known as **mucilaginous fibres**.

Some of the extra-xylary fibres such as phloic-fibres can be septate and are called **septate bast-fibres**.

(B) Sclereids

These are highly variable in shape and very hard in texture. They also take the form of stone cells. They occur singly or in groups. They may be associated with xylem, phloem, cortex, pith, and mesophyll. They are also found in fruits and seeds.

The sclereid cells have heavy deposition of secondary cell walls which are highly lignified. The pits on the walls are simple but often highly branched or ramified. The cell lumen generally lacks protoplast at maturity. Sclereids are generally classified on the basis of their form:

i) **Brachysclereids:** Commonly called stone cells, they are isodiametric, occur as idioblasts/in groups. They are very hard cells.
ii) **Macrosclereids:** They are rod-shaped, often forming a continuous layer in the testa of seeds.
iii) **Osteosclereids:** These are bone-shaped (dumb-bell shaped). The ends are enlarged.
iv) **Astrosclereids:** These are variously shaped, with many arms of unequal lengths.
v) **Trichosclereids:** These are long, hair-like elongated cells.

Objectives

On the completion of this sclerenchyma-based exercise, you should be able to:

- identify the constituent cells of sclerenchyma;
- classify the sclerenchyma cells as fibres or sclereids;
- identify the various kinds of fibres and sclereids; and
- differentiate between simple-pits, ramified pits and bordered pits.

(A) Fibres

Materials required

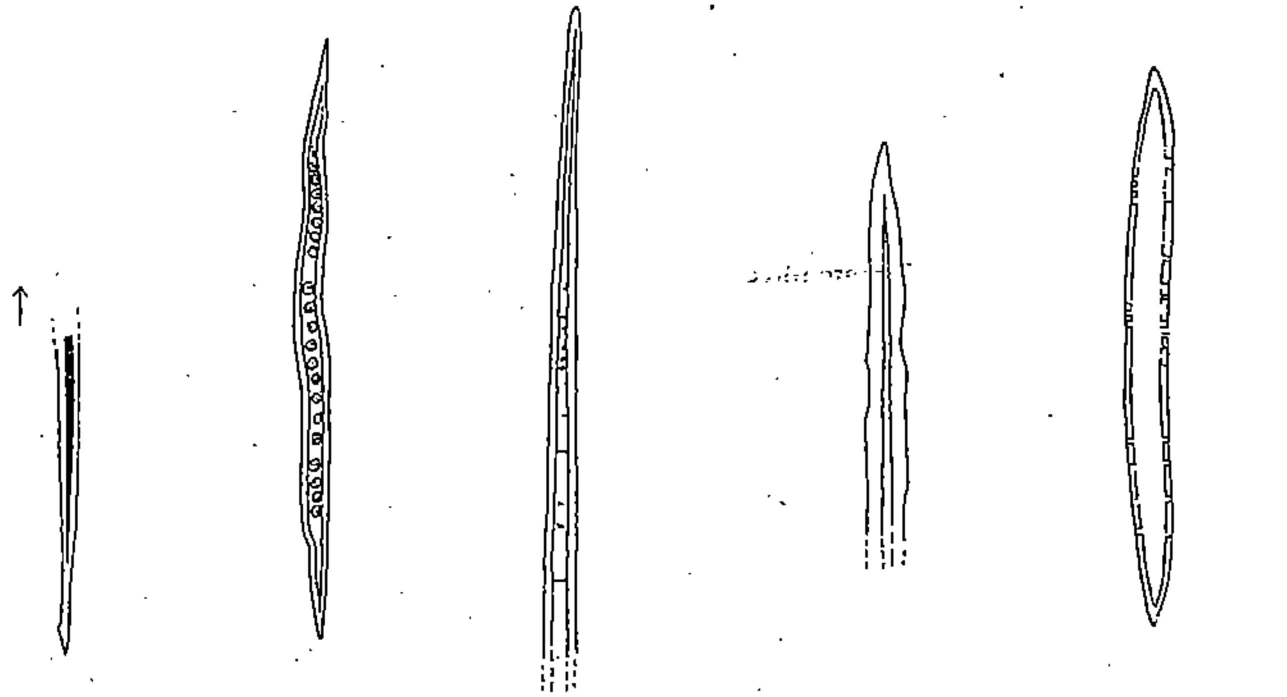
1. Macerated materials of wood/stem for:
   i) **Libriform fibres:** *Cannabis sativa, Linum usitatissimum, Corchorus, Quercus*
   ii) **Fibre-tracheids:** Xylem of *Ephedra, Malus pumila*
   iii) **Mucilage fibres:** Secondary xylem of *Aristolochia, Quercus*
   iv) **Septate fibres:** Secondary xylem of *Vitis vinifera, Aristolochia*
2. Permanent/temporary stained slide of T. S. of *Linum, Corchorus, Helianthus* stems.
3. Watch glass
4. Slides
5. Coverslips
6. Dropper
7. Safranin
8. Glycerine
9. Compound microscope
10. Your instruments kit

Procedure

1. You may be provided with temporary or permanent slides. Observe them carefully under the compound microscope.
2. Alternatively you may be provided with macerated materials. If so, proceed as follows:
   i) Wash the macerated material provided thoroughly in water by placing it in a watch glass.
   ii) Draw out water with the help of a dropper.
   iii) Stain it with safranin (1.0% aq. solution).
   iv) Wash the excess stain. Take a clean dry slide and place a small piece of stained material on it. Tease the materials well with a pair of fine needles. Mount in glycerine and observe under the compound microscope.

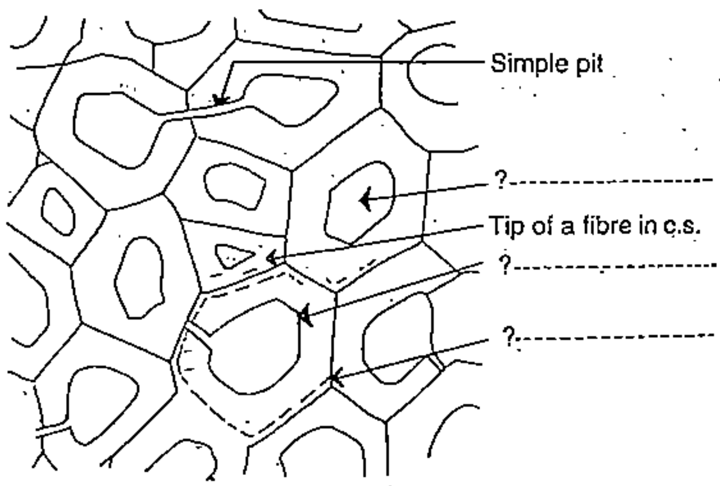
Observations and Interpretations

- When you observe a macerated material, it may contain many cell types other than the fibres. Ignore them. Identify the elements of fibres and correlate them with the diagrams in Worksheet # 2.7.
- Look for a libriform fibre in your preparation or permanent slide and complete the diagram 2.4 a.
- Draw atleast one of the other kinds of fibres as shown in Fig. 2.4 a-e in the space provided in the Worksheet # 2.7.
- Look for a septate fibre. Is the septum true? Record your observations in the description space.
- For studying the fibres in cross-section (Fig. 2.4 f), focus the phloem in t.s. stem of *Linum/Corchorus* or the pericycle in t.s. stem of *Helianthus*. Compare Fig. 2.4 f and the structure, and observe under the microscope. Complete the labelling of the given figure. Correlate the structures in the figure and in the slide. If you have any other observations, record them as well.



a) Libriform fibre b) Fibre-tracheid c)Septate-fibre-tracheid d) Gelatinous fibre e) Septate bast fibre.

Q.1: Complete the diagram a.



f) A portion of bundle of fibres in c.s.

Q.2: Identify the various 'areas' marked in the diagram.

Diagram space

Q.3: Draw the fibre types (a-e) seen in your preparation.

Description space

Fig. 2.4: a-e) Types of fibres in a macerated material.

(B) Sclereids

Materials required

Macerated materials of the following:

1. **Brachysclereids:** Pulp of fruit of *Pyrus*, seed coats of *Juglans*.
2. **Macrosclereids and Osteosclereids:** Seed coat of leguminous seeds, e.g., *Pisum sativum, Phaseolus*.
3. **Astrosclereids:** Leaves of *Nymphaea, Dendrophthoe, Thea, Trochodendron*.
4. **Trichosclereids:** Leaves of *Olea*, aerial roots of *Monstera*.

Procedure

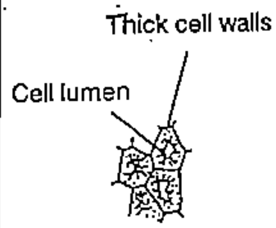
Same as given for fibres.

Observations and Interpretations

- Look at Fig. 2.5 a – i in your Worksheet # 2.8.
- Observe your preparation/slides under compound microscope, and correlate the structures and the given figures.
- Follow the instructions given on the Worksheet.

Your Notes

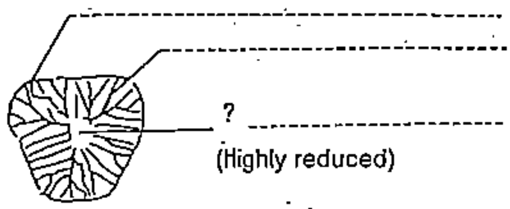
Worksheet # 2.8: Study of sclerenchyma – sclereids.



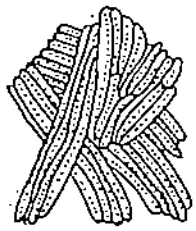
a) Brachysclereids - an aggregate

Diagram space

Q.1: Draw a few brachysclereids from your slide.

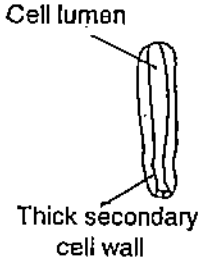


b, c) Brachysclereids showing ramified simple pits.
Q.2: Label the areas marked in the above figures.

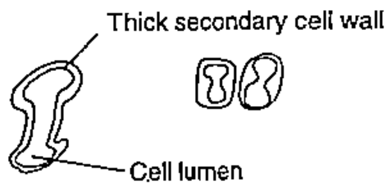


d) An aggregate of macrosclerids.

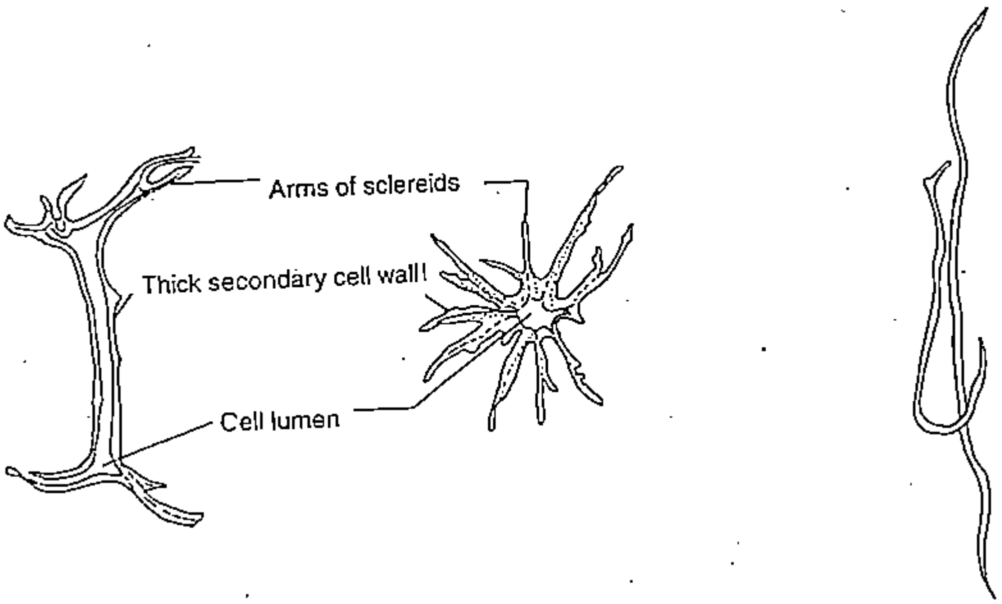
Diagram space



e) Macrosclereids.
Q.3: Draw a macrosclereid from your preparation.



f) **Q.4:** Identify the type of sclereids in the above figure.
....



(g)............................... (h)............................... (i) ....

g, h, i) **Q.5:** Identify and name the type of sclereids represented in the above three diagrams (g – i).

Fig. 2.5: Sclerenchyma - sclereids.

SAQ 7

You have now studied the simple tissues that is, parenchyma, collenchyma and sclerenchyma. Based on your observations, answer the following questions:

1. A cell type which is living even at maturity – what is its name? ....
....
2. A cell type which is mostly dead at maturity – write its name. ....
....
3. A cell type which always has secondary cell walls lignified– which is this cell? ....
....
4. A cell type which is always primary in origin – write its name. ....
....
5. Which of the tissues that you have studied is the most versatile? ....
6. Which tissue can revert to the meristematic state? ....
7. Which tissue can never revert to the meristematic state? ....

SAQ 8

Write a minimum of two characters and miximum as many as you can, to differentiate the following:

a)

	Collenchyma		Sclerenchyma
i)	....	i)	....
ii)	....	ii)	....
iii)	....	iii)	....
iv)	....	iv)	....
v)	....	v)	....
	....		....
	....		....

b)

	Fibre		Sclereid
i)	....	i)	....
ii)	....	ii)	....
iii)	....	iii)	....
iv)	....	iv)	....
v)	....	v)	....
	....		....
	....		....

2.5 XYLEM

In this and the next sections you will study complex tissues. A complex tissue is the one that is made up of more than one kind of cell type and they have similar origin. The two most prominent complex tissues in a plant are **xylem** and **phloem**. The xylem functions primarily in transport of water and minerals, while through phloem, the transport of food/organic metabolites takes place. Together, they both constitute the vascular tissue of the plant body.

The xylem is characteristically present in all the vascular plants. In addition to its role in translocation of water and minerals within a plant, it also aids in providing mechanical support to the plant body and also acts in storage of nutrients. It is both primary and secondary in origin. It consists of **four different kinds of cell types,** namely: **parenchyma cells, fibres, vessels,** and **tracheids.** The basic structure of parenchyma and fibres is similar to the one you studied in Sections 2.2 and 2.4. These are not therefore repeated in this exercise.

* The vessels and tracheids have several features in common and are often referred to as tracheary elements. Their common features are:

- Both of them are elongated along the axis of the organ in which they are differentiated.
- Both of them are dead at maturity.
- The have lignified secondary cell walls. The lignin is deposited in a number of patterns leaving some/large areas of primary cell wall uncovered through which water is transported across the cells.
- The chief differences between vessels and tracheids are as follows:

Tracheids	Vessels
1. They are always one-celled.	1. They are always more than one-celled. The individual cell of a vessel is termed as vessel member/vessel element.
2. Their ends are tapering.	2. The ends of a vessel member may be tapering, inclined or even horizontal.
3. They are joined to one-another through their side (lateral) walls. The ends of the cells overlap with each other.	3. The vessel members in a vessel are joined together by a transverse/end wall called perforation plate: Within a perforation plate, the dissolution of cell wall provides characteristic pattern to end wall. A vessel joins another vessel through the side walls of its vessel members.

- The pattern of secondary wall depositions in the tracheids and vessels, varies according to the stage of elongation of the organ in which they are situated at the time of differentiation. Some **patterns of secondary wall depositions** are:

Annular:	They are in the form of separate rings and are characteristic of the elongating state.
Spiral:	The thickenings are in a continuous spiral.
Scalariform:	The thickenings are rings-like, just as the steps of a ladder.
Reticulate:	The thickenings are net-like secondary cell wall depositions. It generally takes place when the elongation of the cell type is over. The pits are simple or bordered.
Simple-pitted:	The secondary cell wall deposition is dense leaving numerous small simple pits as openings.

- The **perforation-plates** of a vessel member may also have different types of secondary cell wall depositions. The resultant patterns commonly seen are:

1) Scalariform – ladder-like
2) Foraminate – circular-discs
3) Simple – one large opening

The xylem which **originates** from procambium is called **primary xylem**. The primary xylem which matures earlier than elongation of the axis in which it occurs is called **protoxylem**. The primary xylem which matures concurrently or later than the axis in which it occurs is named as **metaxylem**. The secondary xylem originates by the activity of vascular cambium. It has axial as well as ray systems.

The elements of primary and secondary xylem are similar.

Objectives

At the end of this exercise on xylem tissues, you should be able to:

- understand the concept of complex tissues in the context of xylem;
- identify the various xylary elements;
- differentiate between xylary fibre and tracheary element or tracheid;
- differentiate between a tracheid and a vessel;
- identify a vessel member;
- differentiate between various kinds of thickenings in tracheary elements; and
- identify the various kinds of perforation plates.

our Notes

Cell types

Materials required

Macerated materials of secondary xylem of *Aristolochia* / any wood sample and/or permanent slides of the same.

Procedure

Follow the same procedure for the preparation of temporary mounts for macerated materials as in Section 2.4 (see the 'Procedure' for 'Fibres').

Observations and Interpretations

The preparations you make, or the permanent slides that are provided to you, are to be observed under the compound microscope. As you observe the slides, you may see many kinds of cells. *Some of them may not be xylary in nature. So, be careful.* Scan the slide and look for the various xylary elements as are shown in worksheet in Fig. 2.6 (a-e). Identify, correlate and fill-in your responses in the spaces provided in the Worksheet # 2.10.

You should concentrate, particularly on the relative sizes, volumes, lengths/breadths of the various cell types. Also, focus your attention on the relative thickness of cell walls, size of cell lumen, number, kind and position of pits.

Your Notes

Worksheet # 2.10: Study of xylem – cell types.

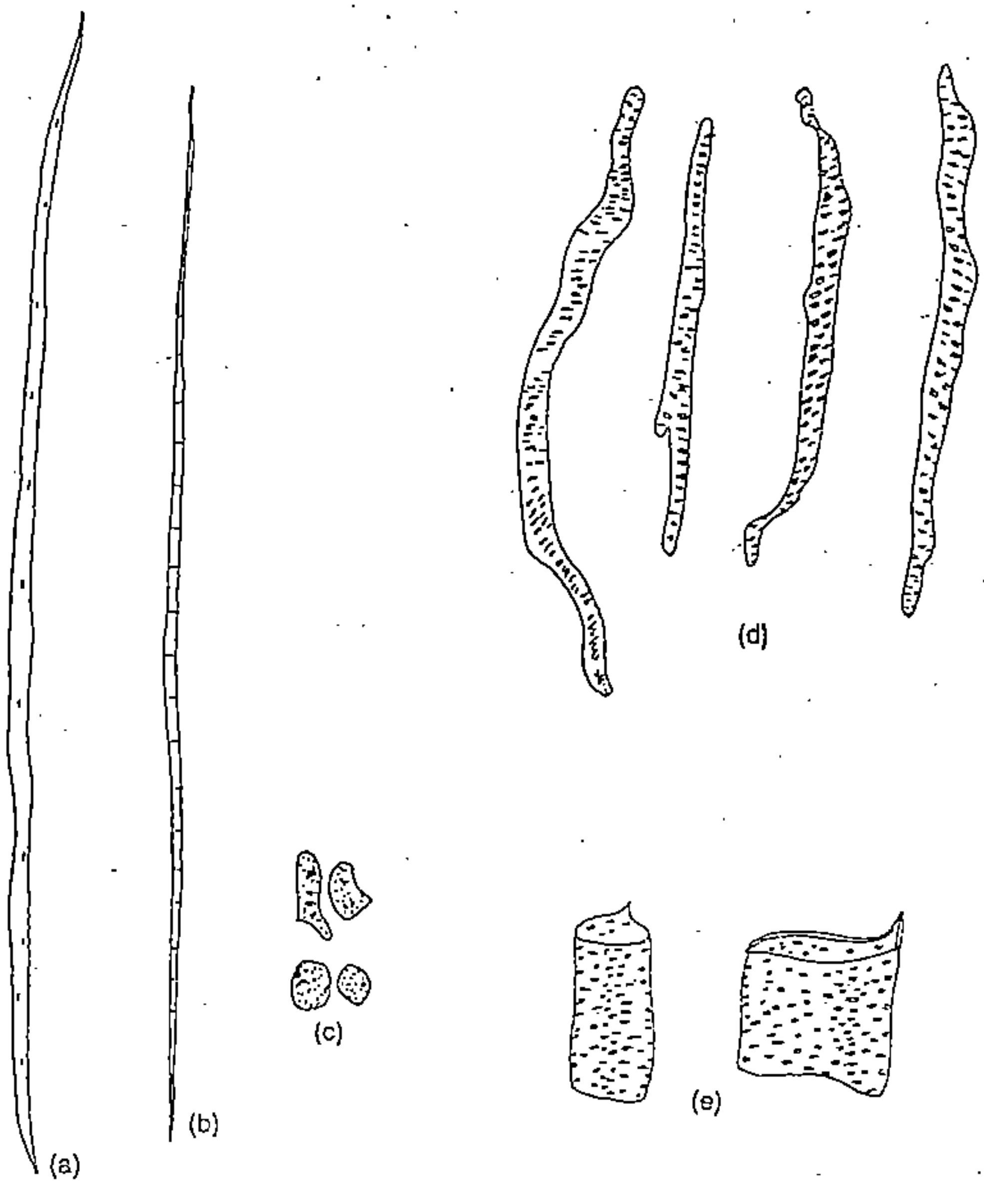


Fig. 2.6: a-e) Xylary elements isolated from macerated secondary xylem of *Aristolochia*.

Q.1: Observe the above figures (a-e) and identify the various xylary elements. Write their names in the space provided below:

a) ....

b) ....

c) ....

d) ....

e) ....

....

....

Materials required

Macerated materials and/or Permanent slides of the following:

1. **Tracheids:** Secondary xylem of *Aristolochia*, *Pinus*.

2. **Annular thickenings:** Fruit of *Arisaema*, protoxylem of *Zea* stem, Primary xylem of *Phaseolus* stem.

3. **Helical or spiral thickenings:** Primary xylem in stem of *Phaseolus*.

4. **Scalariform thickenings:** Xylem of stem of *Dryopteris*, *Polypodium*.

5. **Reticulate thickenings:** Primary xylem in stem of *Phaseolus*.

6. **Simple pitted:** Primary xylem in stem *Phaseolus*.

7. **Scalariform perforate plates:** Xylem of *Phoenix dactylifera*, *Rhoeo discolor*, *Pteridium*, *Liriodendron*, *Betula* (all stems).

8. **Foraminate perforation plates:** Secondary xylem in stem of *Ephedra*, *Gnetum*.

9. **Simple perforation plates:** Secondary xylem in stem of *Vitis*, *Malus*.

10. **Horizontal perforation plates:** Secondary xylem in stem of *Quercus*.

11. **Perforation plates with tails:** Secondary xylem in stem of *Malus*.

Procedure

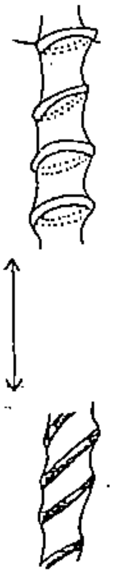
Same instructions as in Section 2.4 (i.e., the 'Procedure' of 'Fibres').

Observation and Interpretations

Study carefully as many (preferably all) preparations as possible that are prepared in your class, and the permanent slides provided to you. Study the characteristics of various xylary elements and correlate with the given diagrams. A word of caution! The diagrams (in Fig. 2.7 a-k) given in the Worksheet # 2.11 are representative in nature. What you observe may not be exactly like what is drawn in these outline illustrations. Nevertheless, these figures can be used as your ready reference and for making a comparative study of the two. Observe, correlate and follow the instructions given in the Worksheet # 2.11.

Your Notes

Worksheet # 2.11: Study of xylem – cell details.



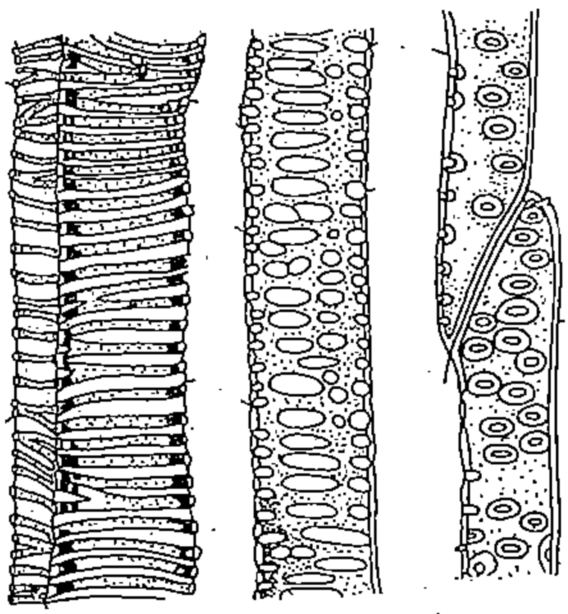
(a)

a) A part of tracheary element with annular thickenings.

Q.1: Complete the diagram (Middle portion)

(b)

b) Tracheary element with partly annular and partly spiral thickenings.



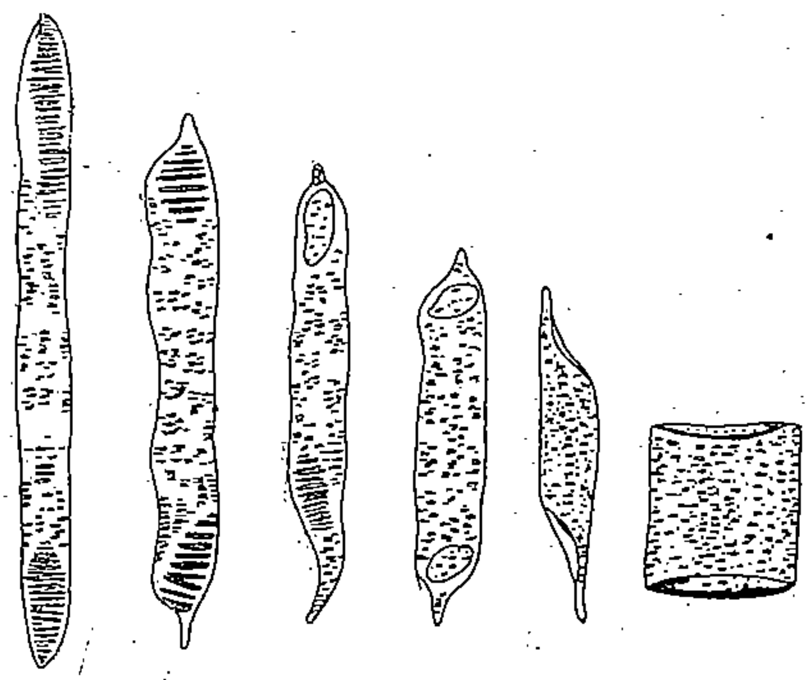
(c) (d) (e)

Q.2: Identify the types of thickenings depicted in the above figures (c,d,e).

c) ....

d) ....

e) ....



(f) (g) (h) (i) (j) (k)

Diagram space

Q.3: Draw two vessel members from your slides.

Fig. 2.7: a–e) Tracheary elements from a young stem, showing wall thickenings and pits on the lateral cell walls.
f–k) Vessel members with perforation plates, taken from the macerated stem of a dicotyledonous plant.

SAQ 9

If you observe a tracheary element, how would you confirm whether it is a tracheid or a vessel number?

....

....

....

....

....

....

SAQ 10

Which of the two, tracheids or vessels, are more advanced? Discuss.

....

....

....

....

....

....

SAQ 11

Name two angiosperms that lack vessels.

i) ....

ii) ....

SAQ 12

Name two gymnosperms which possess vessels.

i) ....

ii) ....

SAQ 13

What is the role of parenchyma in xylem? Discuss.

....

....

....

....

2.6 PHLOEM

Phloem is another example of complex tissue. Unlike xylem it is a softer tissue. The phloem can be of both primary and secondary origin. The one that originates from procambium is called **primary phloem**. The primary phloem that matures earlier than the axis of the organ where it is being differentiated is known as **protophloem. Metaphloem** matures concurrently or later than the axis of the organ where it is being formed. **Secondary phloem** is formed due to the activity of vascular cambium. The structures and functions of different cell types present in both the primary and the secondary phloem are generally similar.

The various **cell types constituting the phloem** are: **phloem parenchyma; phloem fibres; sieve cells** (present in pteridophytes and gymnosperms); **sieve-tubes; albuminous cells** (present along with the sieve cells), and the **companion cells** (differentiate along with sieve elements). The sieve cells and sieve tubes together are also termed as sieve elements, and are primarily the sites of translocation of organic metabolites within a plant body.

Sieve elements: These are live but possess highly modified/degenerating protoplasmic contents at maturity. The various disorganized protoplasmic cell contents in a mature sieve element form a proteinaceous slime body, which can be seen very prominently under a compound microscope. The plasmamembrane of the cell, however, remains intact. The cell, though living, is generally anucleate at maturity. The cell wall becomes thick, nacreous and is always primary.

The cell wall of sieve element at places develops specialized structures, called **sieve-pores**. A sieve-pore is the smallest unit through which the transport of food takes place. A number of sieve-pores formed together in a region of a cell wall is called **sieve-area**. On a cell wall, there might be one to many sieve-areas.

The sieve-areas in sieve cells are restricted only to their lateral cell walls. Such cells are often with tapering ends. The sieve-areas in a sieve-tube element are, however, restricted or characteristically formed on its end-wall, called **sieve-plate.** A sieve-plate with only one sieve-area is termed as **simple sieve-plate.** A **compound sieve-plate** has more than one sieve-area on a sieve plate.

Whereas, a sieve cell is a solitary cell, a sieve-tube consists of more than one cell placed one above the other. The individual cells of a sieve-tube are called sieve-tube elements or sieve-tube members. The two members of a sieve-tube are connected/separated by a sieve-plate.

Callose, a polysaccharide, which is formed during the development of a sieve-pore as well as a result of injury, is very often seen occupying the site of a sieve-area when we observe these cells under the compound microscope.

Albuminous cells: These are found adjacent to the sieve cells.

Companion cells: These are found adjacent to a sieve-tube member. They originate from the same initial from which the sieve-tube member arises. In t.s., only one companion cell per sieve-tube member can be seen. However, in l. s., more than one companion cell per sieve-tube member can be observed. The protoplast of both albuminous and companion cells is very dense and is nucleate.

Phloem parenchyma: These cells are live cells that are scattered among other cells of the phloem. They are generally narrower but longer than the parenchyma of simple tissues.

Phloem fibres: These are elongated cells and are generally lignified.

Whereas, the phloem in monocots contains mainly the sieve-tubes and the companion cells, all the cell types are characteristically present in the dicotyledonous phloem.

Objectives

On the completion of this exercise on phloem, you should be able to:

- explain the concept of complex tissues in context of phloem;
- identify the various phloic elements;
- differentiate between the sieve-tube members and the sieve cell;
- recognize the companion cells;
- identify sieve-pore, sieve-area, sieve-plate, slime bodies, and callose in a sieve element; and
- appreciate that a mature sieve-tube has a ubiquitous structure.

Materials required

Permanent slides of:

1. **Sieve cells, albuminous cells:** T. S. stem of *Pinus*
2. **Sieve-tube members, companion cells, simple sieve-plate:**
   T. S. stem of *Cucurbita,*
   T. S. stem of *Zea,*
   T. S. stem of *Vitis,*
   T. S. stem of *Pyrus,*
   L. S. stem of *Pinus,*
   L. S. stem of *Pyrus*
3. **Macerated phloem tissue in:** *Cucurbita/Zea/Pinus.*

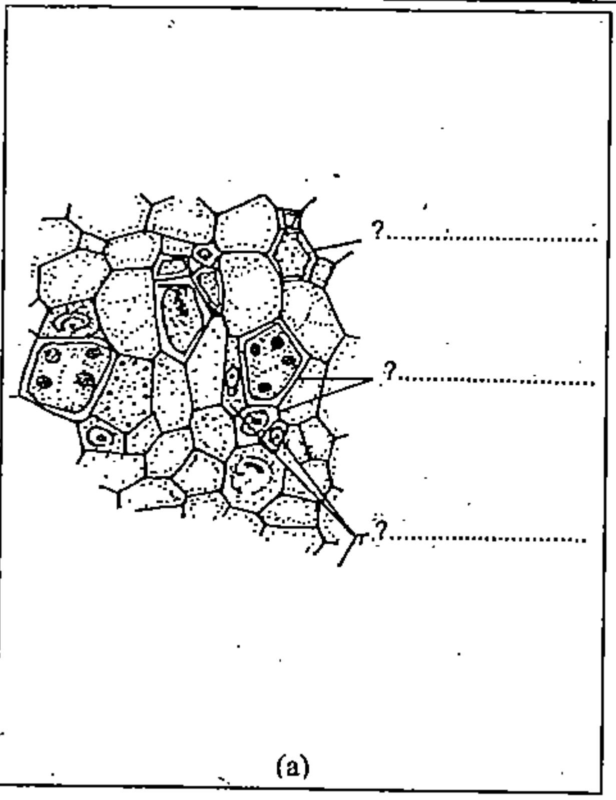
Procedure

You will study this exercise largely through permanent slides provided to you. If these are not available or are not of good quality, observe the temporary preparations provided to you/made by you.

Observations and Interpretations

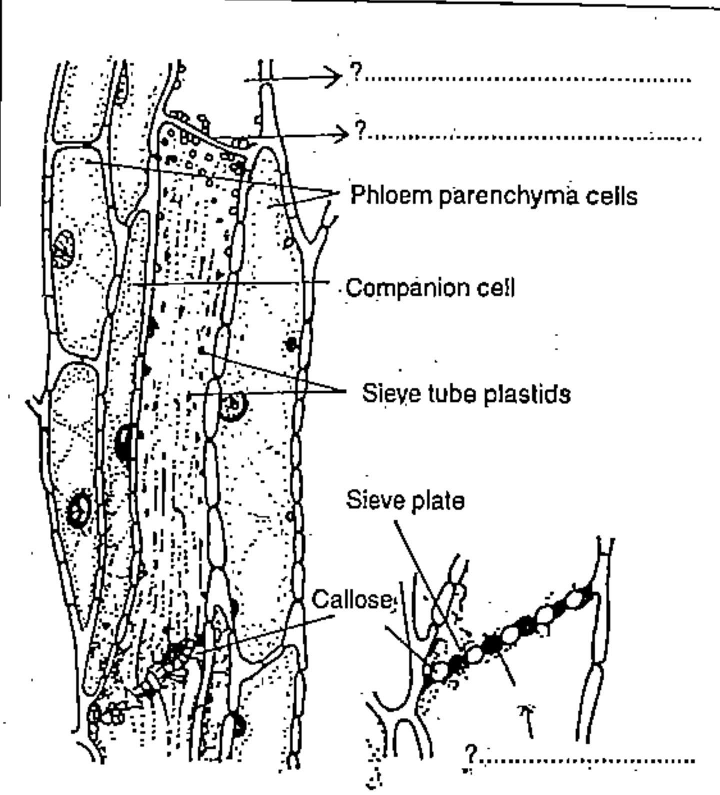
You will observe the given slide under the compound microscope. Focus the phloem region under the low power of the microscope. Now, turn to high power of the microscope. Look for, identify and label the different phloic elements as instructed on the Worksheet # 2.13 (Fig. 2.8 a-e).

Worksheet # 2.13: Study of the phloem.

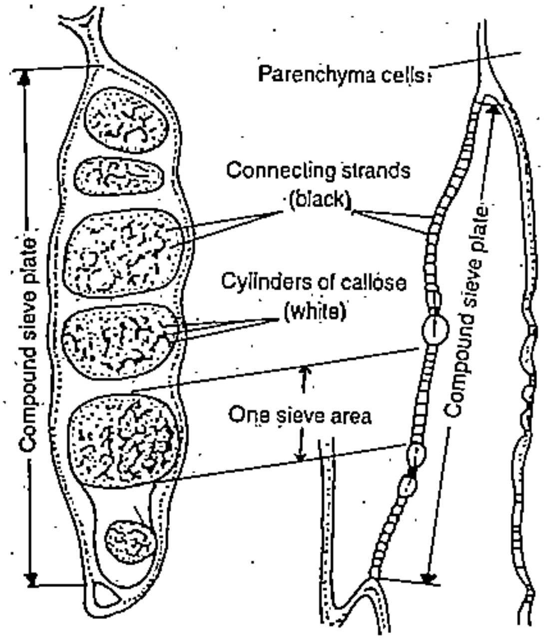


a) The phloem elements as seen in a cross section of a dicot stem.

Q.1: Label the areas marked in the figure.



b,c) The phloem elements from the l.s. of a dicot stem.
Q.2: Label the parts marked with '?'.



d) A compound sieve plate. e) A part of sieve-tube member and a phloem parenchyma cell.

Fig. 2.8: Various elements of phloem.

SAQ 14

Fill-in the blanks with appropriate words.

1. The phloem is a complex tissue. The various phloic elements that you observed were:

   ...., ..., ..., ...

   ....

   ....

2. In c.s. (cross section) of phloem tissue, the size of sieve-tube elements is .... than that of the companion cell.

3. You could observe dense, nucleated cytoplasm in a phloem element. Name this phloem element.

   ....

4. In l. s. of a phloem strand, the sieve-plates are confined to .... wall.

5. A companion-cell was always found contiguous to a ....

6. In a sieve-area, callose surrounds a ....

7. The callose/slime is observed more concentrated near the ....

Your Notes

2.7 EPIDERMAL SYSTEM

The root and shoot systems of all herbaceous plants are covered by an outermost epidermal tissue system. It constitutes the interface between the plant and the environment, including both its biotic and abiotic components. Functionally and morphologically, cells of this system are not uniform and exhibit a wide range of variation in structure and function. However, topographically and, to a certain extent, ontogenetically also, these cells form a uniform tissue.

The diverse functions this tissue system performs are regulation of water movement and gaseous exchange; protection from sunlight; protection from other organisms; protection from non-biological agents; secretions; and transpiration.

The epidermal system of a flowering plant is composed of **four kinds of cells:** the epidermal cells, the guard cells, trichomes, and the roots hairs. The epidermal cells are more in number and cover a greater part of the plant body. These exhibit a wide range of variation in shape, size and contents. These may be variously modified in relation to the organ and the environment where they occur. In the surface view they appear mostly rhomboidal or sinuous. These cells are firmly attached to each other but are less firmly attached to the tissue beneath. Hence, they could be easily peeled away as a sheet. The cells are living and are rich in protoplasmic contents, especially the leucoplasts and anthocyanins. The outer cell walls of these cells have low to heavy deposition of substances like the cutin and the cuticle. This layer helps in the regulation of water, and reflection of excess solar radiations due to its shiny nature.

In this exercise, you will also study two other important components of the epidermal system, namely, the **stomata** (singular: stoma) and the **trichomes.**

(A) Stomata

The continuity of the epidermis of aerial parts of the plant (especially shoot system) is interrupted by several minute openings known as **stomatal pores** or **stomatal apertures**. Each pore is surrounded by two specialized cells known as the **guard cells**. These guard cells differ from the background epidermal cells in their size and arrangement.

Sometimes, the cells adjacent to the guard cells are also different in size, shape and contents from the epidermal cells. Such cells are called **subsidiary cells.** The two guard cells, the stomatal pore within it, the subsidiary cells (if present) all together are termed as **the stomatal complex.**

Your Notes

C'assification

The classification of stomata that we shall follow in this exercise is based on the number and arrangement of the subsidiary cells.

a) **Anomocytic stomata:** The guard cells are surrounded by a certain number of cells that do not differ in size and shape from the background epidermal cells.
b) **Anisocytic stomata:** The guard cells are surrounded by three unequally-sized subsidiary cells.
c) **Paracytic stomata:** The guard cells are accompanied by the subsidiary cells, longitudinal axes of which are parallel to that of the guard cells and the stomatal pore.
d) **Diacytic stomata:** The guard cells are surrounded by two subsidiary cells, the common cell walls of which are at right angles to the long axis of the stomatal aperture.

Objectives

On the completion of this exercise pertaining to the study of stomata, you should be able to:

- prepare an epidermal peel mount;
- identify the epidermal cells and the stomatal complex;
- identify the various components of a stomatal complex, viz., guard cells, stomatal pore, subsidiary cells;
- identify major kinds of stomatal complex organizations, anomocytic, anisocytic, paracytic and diacytic; and
- differentiate and identify dumb bell-shaped guard cells, that are characteristic of the of family Poaceae (Gramineae).

Materials required

1. A pair of forceps,
2. a new razor blade,
3. a pair of mounted needles,
4. filter paper,
5. one or two fine camel-hair brushes,
6. two petridishes,
7. Slides,
8. Coverslips,
9. water,
10. 50% glycerine,
11. compound microscope
12. Plant materials:
    i) **Bean-shaped guard cells**: Leaves of *Rhoeo*, *Tradescantia*, *Zebrina*.
    ii) **Dumb-bell shaped guard cells**: Leaves of *Saccharum, Zea.*
    iii) **Anomocytic stomata**: Leaves of members of Ranunculaceae, Malvaceae, Papaveraceae, Cucurbitaceae, Geraniaceae, Capparidaceae, Scrophulariaceae.
    iv) **Anisocytic stomata**: Leaves of members of Brassicaceae, *Solanum, Nicotiana, Sedum, Bryophyllum.*

v) **Paracytic stomata**: Leaves of members of Rubiaceae, Magnoliaceae, *Arachis, Phaseolus.*

vi) **Diacytic stomata**: Leaves of members of Caryophyllaceae, Acanthaceae, *Dianthus.*

vii) Permanent slides of the above materials (from i to vi).

Modes of study

1. Through the study of permanent slides.
2. Through the study of preparations of temporary-stained, epidermal peel mounts.

Procedure

Preparation of the epidermal peel whole mounts

1. Peel off the abaxial (lower) epidermis of the leaf, from the laminar region, with the help of a fine forceps and a needle. Avoid peeling above the vein(s).
2. Put the peel in a watch glass/petridish filled with water.
3. If the peel is floating, gently submerge it in the water with the help of a brush. It helps in removing the air bubbles from the peel.
4. If the peel is of irregular outline, cut it to a rectangular piece with the help of a sharp razor blade.
5. Take a microslide, put a drop of 50% aq. glycerine on it. Place the peel over this drop with the help of a brush. Cover the peel with a coverslip. Gently tap it with a needle to remove the trapped air bubbles and the excess glycerine. Soak out extra fluid with the help of a filter paper.
6. Observe first under low and then under high power of compound microscope.

Your Notes

Observations and Interpretations

a) Stomatal complex of bean-shaped stomata:
   i) It consists of a pair of guard cells, a stomatal pore and subsidiary cells (if present).
   ii) The guard cells are usually reniform (bean-, kidney-shaped). The cell wall of guard cells towards the pore is called the dorsal wall and the wall of the guard cell towards the subsidiary cell is called the ventral wall.
   iii) The cell wall of the guard cell towards the stomatal pore is usually concave. The opposite placed, concave, dorsal cell walls of two guard cells of a pair of stoma give the stomatal aperture, a biconvex shape.
   iv) The dorsal cell wall of the guard cell is thicker than the ventral cell wall.

b) Graminaceous stomatal complex:
   i) The guard cells of the stomata in the members of families Poaceae and Cyperaceae are elongated and dumb-bell shaped.
   ii) The ends of these guard cells are expanded and thin-walled.
   iii) The middle-portion is elongated and thick-walled.
   iv) When the turgour pressure increases, the expanded ends swell and push apart the middle elongated portions of the cells.

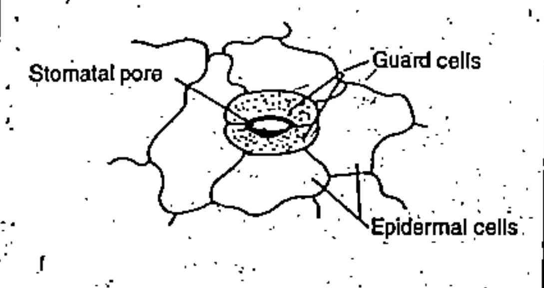
c) Guard cells are also characterized by the presence of chloroplasts.

Points for observation

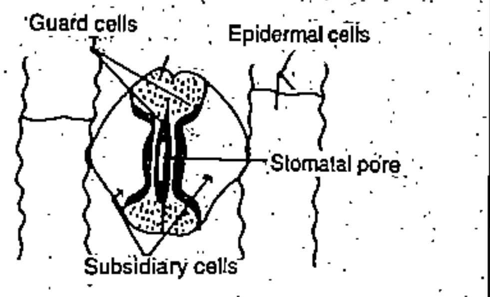
1. Correlate the observations you make with that of the diagrams given in Fig. 2.9 in the Worksheet # 2.15.
2. Follow the instructions as provided in the Worksheet # 2.15.
3. Also, write the name(s) of the plant(s) in which a particular observation was made.

Your Notes

Worksheet # 2.15: Study of epidermis

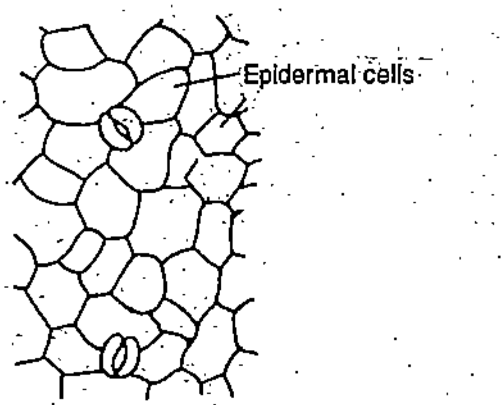


a) A stomatal complex of bean-shaped stomata.

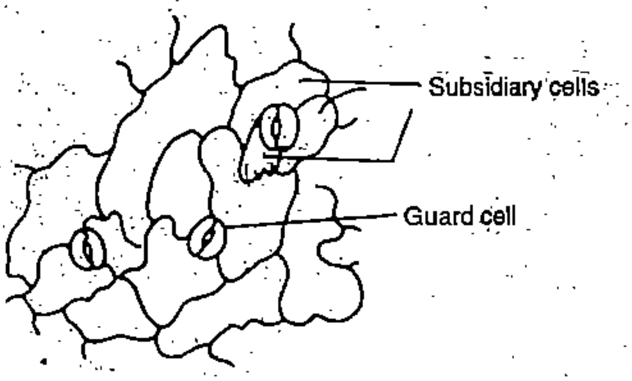


b) A graminaceous stomatal complex.

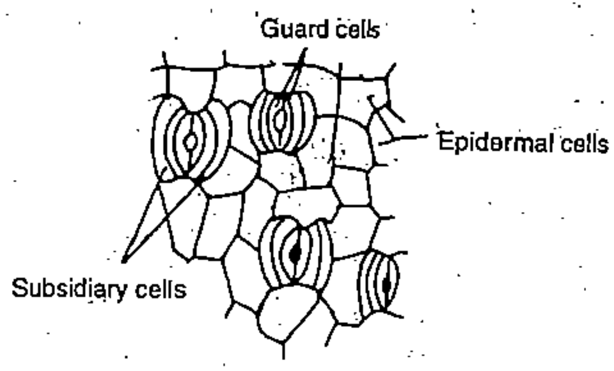
Q.1: Draw a stomatal complex from your preparation, and label its different parts.



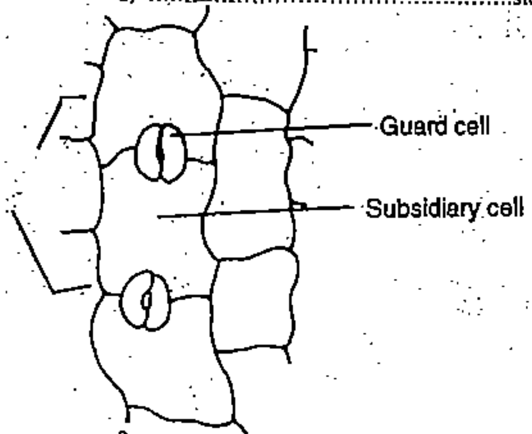
c) .... stomata



d) .... stomata



e) .... stomata



f) .... stomata

Q.2: Identify the various kinds of stomata depicted in the figures c-f. Write the names of their respective blank spaces.

Fig. 2.9: The epidermal tissue system – stomata.

(B) Trichomes

All unicellular or multicellular appendages of epidermal origin are designated as **trichomes**. They can be classified as: (i) **non-glandular;** and (ii) **glandular**, or **secretory**. The trichomes perform a wide range of functions ranging from secretion to protection.

Objectives

At the end of this exercise related to the trichomes, you should be able to:

- identify and differentiate between the background epidermal cells, stomata and trichomes;
- recognize that these appendages are a part of epidermal system;
- differentiate between non-glandular and glandular trichomes, and
- identify the various kinds of trichomes on the basis of their morphology.

Materials required

All requirements except plant materials are the same as for stomata.

1. Plant Materials:
   i) **Non-glandular**
   - **Simple unicellular** : Root hairs, leaves of *Cannabis, Triticum, Hordeum, Amaranthus, Pelargonium,* seeds of *Gossypium,*
   - **Simple multicellular** :
     a) **Uniseriate:** Leaves of *Lycopersicon, Chenopodium ;Mimosa,*
     b) **Uniseriate (upper cell bladder-like, vesiculate):** Leaves of *Chenopodium*
     c) **Squamiform (flattened and multicellular):**
        - **Peltate:** Leaves of *Olea*
        - **Dendroid/dendrite:** Leaves of members of Brassicaceae
   - **Branched multicellular:**
     a) **Tufted:** Leaves of *Dombeya*
     b) **Stellate:** Leaves of *Stryax, Sida, Althaea*
     c) **Candelabrum:** Leaves of *Platanus, Verbascum*
   - **Shaggy multicellular:** Base of petioles of *Portulacca, Schizanthus*

   ii) **Glandular:**
   - **Simple:** stigmatic papillae
   - **Salt-secreting:**
     a) **Bladder-like:** Leaves of *Atriplex,*
     b) **Multicellular:** Chalk glands of *Plumbago, Limonium*
     c) **Hydathode:** Young leaves/stem of *Cicer arietinum*
   - **Nectar secreting:** Calyx of *Abutilon,* corolla of *Lonicera Tropaeolum majus*
   - **Mucilage secreting:** Membranous sheath arising from leaf base of *Rumex, Rheum*

2. Permanent slides of the plant materials mentioned above.

Procedure

Follow the same procedure as described for the study of stomata.

The following morphological characters are useful in the identification/ classification of trichomes when you observe them under the compound microscope.

A) **Non-glandular trichomes:** They exhibit wide range of variations.

i) **Unicellular:**

- These are one-celled appendages.
- These are more common in root-epidermis, e.g., all kinds of root hairs.
- The specialized cells of the root epidermis which extends as root-hair is termed as **trichobast.**
- These are thin-walled, with thin-cuticle and are live at maturity.
- These are generally ephemeral.
- Cotton fibre is also an example of this kind of trichome.
- Papillae/bladder known as vesicular hairs in Crassulaceae are also examples of this kind of trichome.

ii) **Multicellular:**

a) **Uniseriate:**

- These are long, multicelled but with only one row of cells.
- These may be hard or soft in texture.
- The lower cells are wider and the upper cells are tapering.

b) **Vesiculate:** These are 2 or 3 celled, uniseriate but with their uppermost cell enlarged as a baldder.

c) **Ramulose:** These are branched, candelabrum-like in appearance. They could be dendroid with complex branching patterns.

d) **Stellate:** These are multicellular trichomes with one or more celled stalk, on top of which are present a number of cells radiating as various arms of a star.

e) **Peltate:** These are multicellular trichomes with a few-celled stalk which supports a multicelled, umbrella-like (shield-like) disc. This disc-like plate cells can be directly attached to the foot.

B) **Glandular trichomes:** These have a secretory role. These secrete oil, resins, camphor. These exhibit considerable variability and could be with uni-/multicelled glandular head.

i) **Unicellular Glandular trichomes:** These are single celled epidermal extensions, which become secretory.

ii) **Trichomes with Unicellular Glandular head:**

a) **Simple:** It has a row of cells, the terminal cell of which is secretory.

b) **Stinging-hair:** These are highly specialized glandular trichomes. They have a broad dilated base and a narrow pyriform or obpyriform upper part. The epidermal cells surrounding the base of such trichomes divide repeatedly to form a dome-shaped collar around the base.

iii) **Trichomes with Unicellular Glandular Heads:** These trichomes are not only multicelled but generally have an embedded foot and a projecting body.

a) **Capitate/glandular:** The secretory cell which generally occupies the terminal portion of the projecting body is either unicellular or capitate (when multicelled).

b) **Shaggy glands:** These trichomes have a core of cells surrounded by palisade-like elongated secretory cells.

c) **Nectar-secreting:** In these trichomes the cytoplasm at the time of secretion is very dense and is especially rich in endoplasmic reticulum (however, you cannot observe its details under the compound microscope).

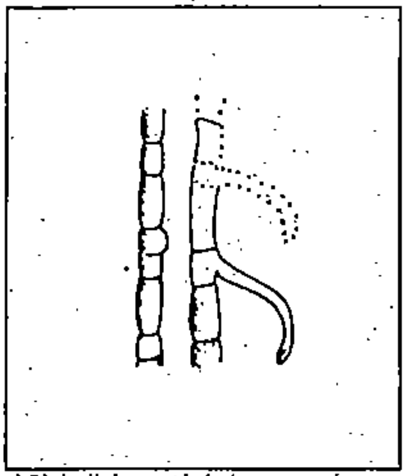
d) **Hydathode trichome:** The trichomes secrete aqueous solution containing inorganic and organic salts. Each one consists of:
- a uniseriate stalk and a multicellular oval head, and
- a sub-cuticular space formed at the time of secretion between the cellulose layer of the cell wall and the cuticle at the top of the gland.

Observations and Interpretations

- Prepare temporary preparations as directed by your Counsellor.
- Make use of the permanent slides or the temporary preparations made available to you by your Counsellor.
- With the help of compound microscope, observe, identify and correlate the trichomes with those drawn on the Worksheet # 2.16, Fig. 2.10.
- Mark out the trichome types that you can identify, paying special attention to their peculiarities.
- If you observe any variation(s) from the given figures / explanations, record them in the '*Your Notes*' space on p. # 82.
- Follow the instructions provided on the Worksheets # 2.16 and # 2.17.

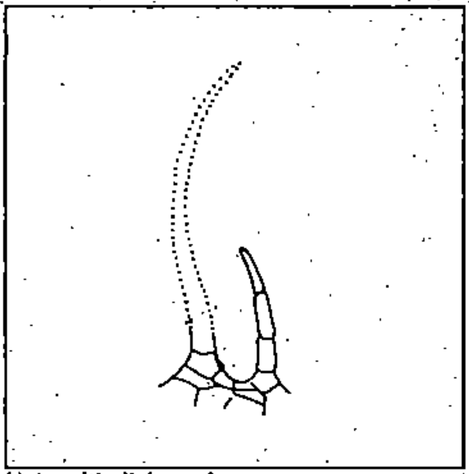
Your Notes

Worksheet # 2.16: Study of epidermis (cont.)



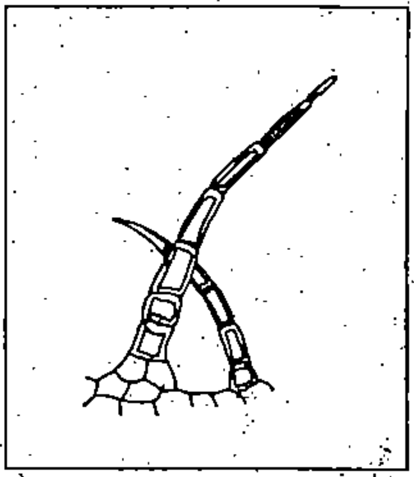
a) Unicellular root hair.

Q.1: Complete the above diagram by sketching on the dotted portion.



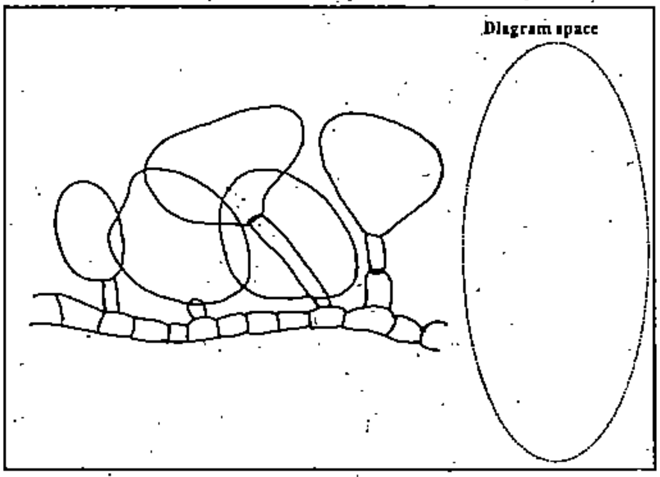
b) A multicellular, soft, ...

Q.2: Fill in the above blank space.
Q.3: Complete the dotted portion in the above diagram.



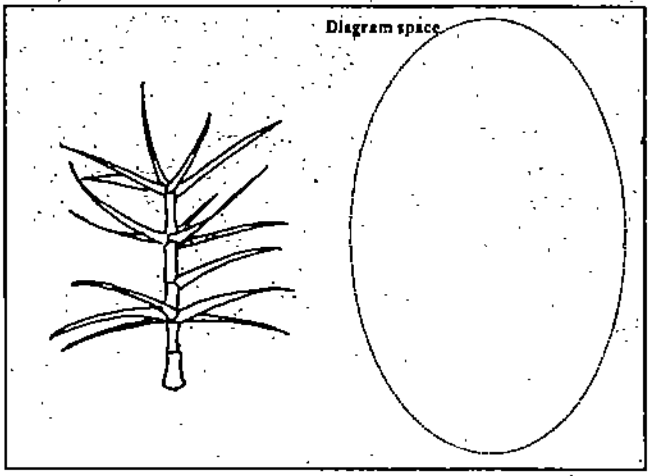
c) ...., uniseriate, hard trichome.

Q.4: Write the name of a plant material that would be a good source for making a preparation like the above.



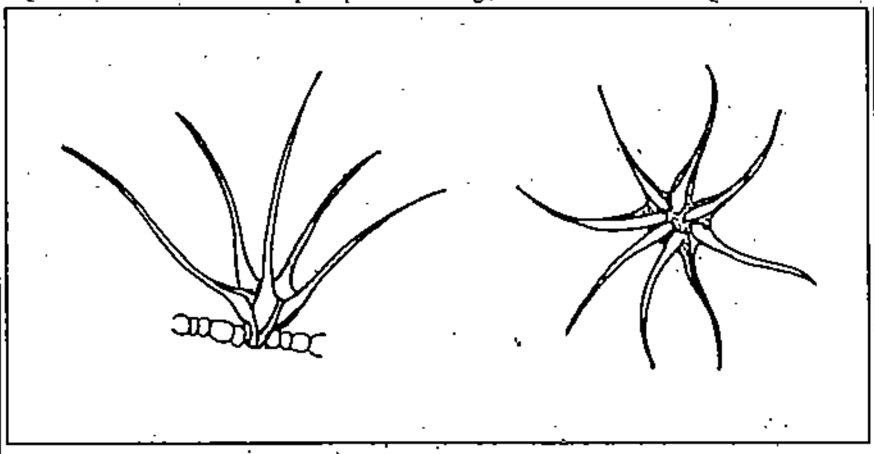
d) .... trichome, can be observed in .... plant.

Q.5: Fill in the blank spaces.
Q.6: Draw a trichome in the space provided on right-hand side.



e) Ramulose ....? ....

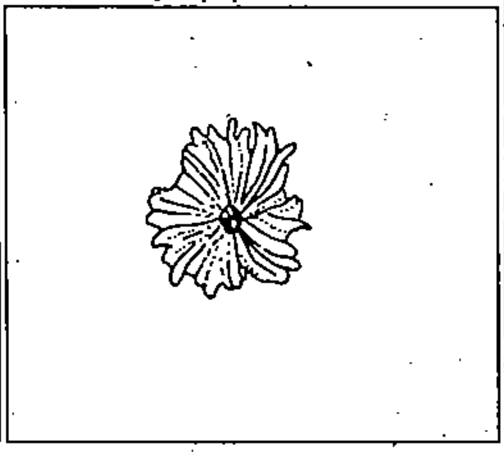
Q.7: Identify the above structure and write your response in the blank space.
Q.8: Draw one such structure from your preparation.



f,g) Stellate trichome in side view (f, left figure), and aerial view (g, right figure)

Q.9: Name the plants/organs in which you observed the stellate trichomes.

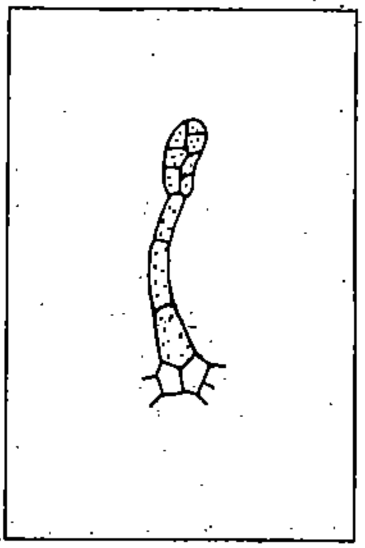
....



h) A peltate trichome in top view.

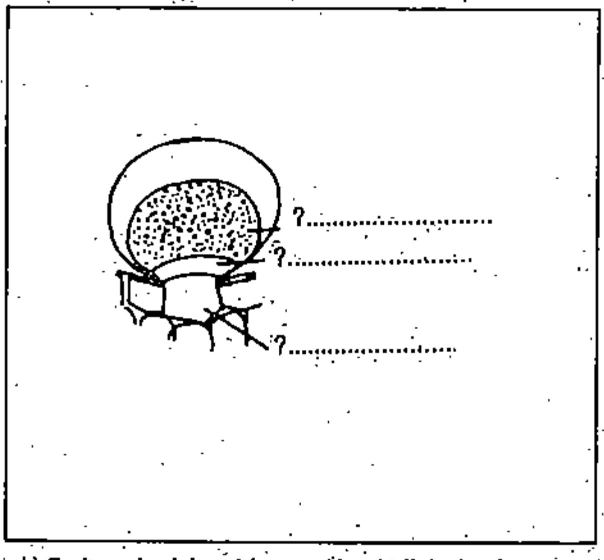
Q.10: Name the plant/organs that show such trichomes?..

Fig. 2.10: The epidermal tissue system - trichomes.



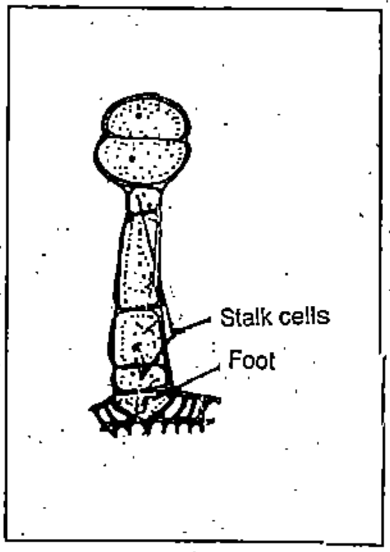
a) Glandular trichome with chloroplasts

Q.1: Write the name of one source plant for it. ....



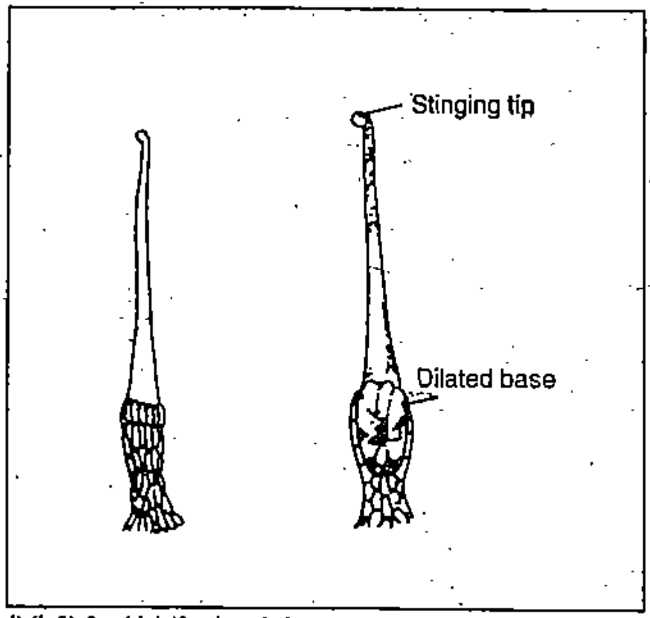
b) Capitate glandular trichome, with unicellular head .

Q.2: Label the different parts of the above trichome.

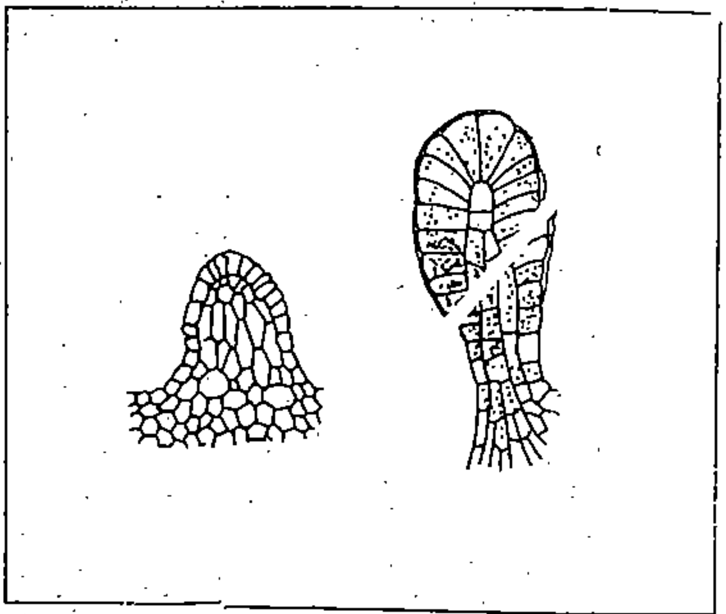


c) Capitate glandular trichome with multi-celled head.

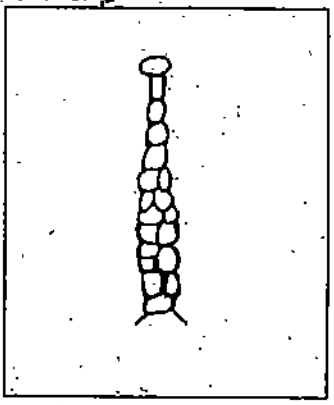
Q.3: Observe the above structure in your preparation / permanent slide.



d) (left) & e (right)]: stingy hairs



f) (left) & g (right)]: shaggy glands

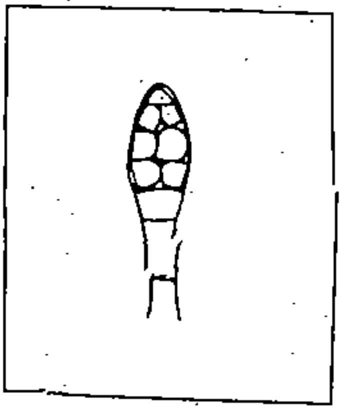


← h) Nectar secreting tri chome

....

i) Hydathode trichome →

....



Q.4: Write the names of source plants in which you observed the trichomes similar to those shown in figures h and i.

Fig. 2.11: The epidermal tissue system - trichomes.

Your Notes

EXERCISE 3 *CYCAS*

Date ....
Session #.........................
Time allocated - 1½ Hours

Structure **Page No.**

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in lab.

3.1 INTRODUCTION

After studying about the various tissues comprising the plant body you will now study two major groups of higher plants – the gymnosperms, and the angiosperms. We begin first with gymnosperms. The Exercises # 3 to 7 are devoted to this group. In this exercise, you will make a detailed study of a representative member of Cycadopsida, i.e., *Cycas*. It is abundantly distributed both in the Eastern and the Western Hemisphere. In our country, the members of this genus grow naturally, in the North-east and the Southern regions. However, in cultivated form, it can be seen throughout the country.

Objectives

After completing this exercise, you will be able to:

- identify the *Cycas* plants;
- describe the various structural specializations in *Cycas* at morphological level:
  - coralloid root,
  - remnant leaf bases on the stem,
  - scale and foliage leaves,
  - bulbils,
  - male cone, and
  - female strobilus;

- both diagrammatically depict and describe the following unique anatomical details of *Cycas*:
  - algal zone in the coralloid root,
  - leaf girdles in the stem,
  - omega-shaped (Ω) arrangement of vascular bundles in the rachis,
  - transfusion tissue and the xeric adaptations in the leaflet,
  - boat-shaped pollen grains, and
  - type of ovule, archegonium and nucellus.

Study Guide

- Read Unit-3 of LSE-13 Course, particularly the Sections 2.2 to 2.4 thoroughly before coming for this laboratory session.
- Also, read this exercise beforehand to know about the tasks to be accomplished.
- Make a time utilization plan so as to complete all your lab work in the allocated time frame of 90 min.

Your Notes

3.2 MORPHOLOGY

3.2.1 Sporophyte

Materials required

1. Photographs of male and female plants or live plants in nature.

Procedure

Study the morphological details of the male and female plant of *Cycas*.

Observations and Interpretations

Study the habit of the plant by focusing on the following aspects, detailed study at macro-level would be taken up in the subsequent sub-sections:

- the nature of the plant whether herb/shrub/tree,
- the relative size and structural peculiarities of various organs (like stem, leaves, bulbils, and the reproductive structures – these are elaborated below).

Stem – shape, branched/unbranched and any other organs/structures present on it.
Leaves – arrangement and structure of each leaf and the leaf bases.
Bulbils – present or absent, if present – their structure.
Male/Female reproductive structures - single structure or as a number of structures, arrangement, structural features.

Your Notes

Worksheet # 3.1: Sporophyte.

Diagram space

Q.2: Make an outline sketch of the given *Cycas* plant, and label its various parts. Mention whether it is a male plant or a female plant.

....

Classification

Class: ....

Order: ....

Family: ....

Genus: ....

Q.1: Write the classification of *Cycas*.

Description space

Habit:

Stem:

Bulbils:

Leaves:

Reproductive structure(s):

Any other features:

Q.3: List the salient features of the specimen drawn in the left hand column.

Q.4 Write five diagnostic features for the identification of the sporophyte of *Cycas*.

....

....

....

....

....

....

3.2.2 Normal and coralloid roots

Normal Root

1. The primary root persists and forms a tap root system.
2. It is well-developed, almost as long as the stem.
3. Most of the lateral branches of primary root mature and are called as normal roots.

Coralloid Root

1. These are the roots which develop near the surface of the ground and get impregnated with a blue green algae - *Anabaena cycadacearum*.
2. Some of the lateral roots give out branches which become apogeotropic, grow vertically upward from just below the ground level.
3. They branch repeatedly to form dwarfed, dichotomously branched coral-like masses. They are called the coralloid roots or corallorhiza.
4. The surface of the coralloid root is beset with lenticel-like apertures.

Materials required

1. Fresh or preserved specimens of normal and coralloid roots.

Observations and Interpretations

- On the basis of the above points, observe the given specimens and make outline diagrams of both the normal and the coralloid roots in Worksheet # 3.2.
- Also list their salient points in the description space.

Your Notes

Worksheet # 3.2: Study of normal and coralloid roots.

Normal Root

Diagram space	Description space

Q.1: Make an outline diagram of the normal root and write in points about its salient features.

Coralloid Root

Diagram space	Description space

Q.2: Make an outline diagram of a coralloid root and also write in points about its salient features.

3.2.3 Stem

1. The aerial trunk is straight, columnar and unbranched.
2. It is covered with a thick armour of regularly alternating bands of large and small rhomboidal leaf bases.
3. The larger ones among them represent the bases of the foliage leaves and the smaller ones are of the scale leaves in the male plants, and the scales and megasphorophylls in female plants.
4. The various leaf bases are spirally arranged and so closely packed that the surfaces of adjacent ones seem to be in superficial contact with each other.

Material required

1. Photograph or/museum specimen or the real plant (in the field).

Observations and Interpretations

Study the above-mentioned features in the given specimen and depict them in Worksheet # 3.3. Also, note down the main descriptive points.

3.2.4 Bulbil

1. The bulbils arise as adventitious buds from the lower fleshy portions of old leaf bases.
2. The bulbils serve for the vegetative propagation of the plants both artificially and in nature. By separating them and putting them in the soil for rooting, new plants can be easily grown.
3. To begin with, the bulbils only have a number of scale leaves around a small stem, but later they start producing crowns of leaves like the main trunk.
4. Many of the bulbils produce adventitious roots, usually on their lower side even while they are attached to the stem.

Material required

Fresh material or museum specimen.

Observations and Interpretations

Make an outline diagram of the given specimen, and label its parts in Worksheet # 3.3. Also, note down its diagnostic features.

Your Notes

Worksheet # 3.3: Study of stem and bulbil.

Diagram space	Description space
	Height of Stem .... Girth of Stem ....

Q.1: Draw a portion of stem as seen in surface view. Note down its salient features.

Diagram space	Description space

Q.2: Make an outline diagram of a bulbil, making a note of its salient features.

3.2.5 Scale and foliage leaves

1. There are two types of leaves:
   a) scale leaves, and
   b) foliage leaves.
2. The scale leaves are brown and are far more in number than the foliage leaves. They are persistent and protective in function and cover the stem apex and offer protection to the young foliage leaves.
3. Foliage leaves are produced in large numbers, are pinnately compound, showy, large, very thick and leathery. These are spirally arranged.
4. Young leaves are with its leaflets circinately coiled, and the apices of rachis incurved.
5. Leaves are attached to the stem by their transversely expanded rhomboidal leaf bases, each with a long petiole and long stout rachis.
6. There may be 80-100 pairs of leaflets in a single leaf.

Materials required

1. Fresh material or museum/herbarium specimen.

Observations and Interpretations

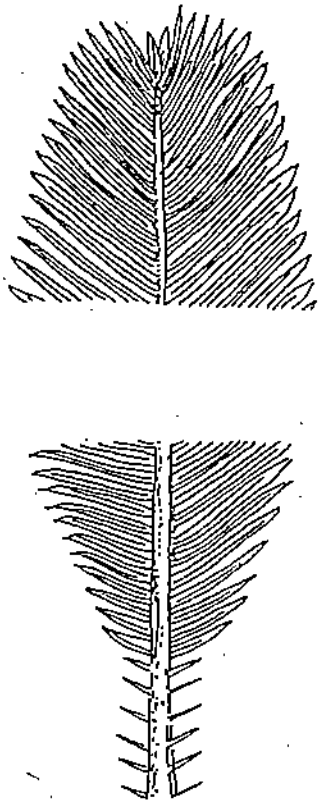
Study and record your observations on the given specimens focusing on their salient features as mentioned above. Complete the diagrams of a young and an old foliage leaf in the Worksheet # 3.4.

Your Notes

Worksheet # 3.4: Study of foliage leaves.

Diagram space	Description space
	

Q.1: Complete the above diagram of a young leaf showing circinate vernation. Write its salient features.

Diagram space	Description space
	

Q.2: Complete the above diagram of a mature foliage leaf, and note down its characteristic features.

3.2.6 Male Cone, Microsporophyll

a. Male Cone

- All living species of *Cycas* are dioecious.
- The male cones are borne singly and terminally on the main stem. The stem of male plant is sympodial.
- The male cones have short stalks, are woody, oval or conical, compact structures about 40-50 cm long in *C. revoluta*, even more in other species like *C. circinalis*.
- Each male cone consists of a central large woody axis bearing large number of microsporophylls, in a close and compact spiral, which are almost perpendicularly attached to the axis (this is visible in the l.s. of the male cone). The sporophylls at the apex and the base of the cone may remain sterile, while others are fertile.

b. Microsporophyll

- Each microsporophyll is woody, flattened, wedge-shaped structure consisting of a narrow lower portion broadened into a flat sterile end part, which usually tapers into a pointed upcurved apex called apophysis.
- In between the basal part of the microsporophyll and apophysis lies the fertile part.
- It bears several hundred microsporangia on its abaxial surface (lower or ventral surface).
- The microsporangia are arranged in clusters of three to six, each group is called a sorus (plural = sori). The sori are surrounded by few unicellular hairs. The microsporangia may number up to 1,000 in certain species.

Materials required

1. Fresh or museum specimen or a photograph of the male cone
2. Two dissected microsporophylls – the abaxial side up in one and the adaxial side facing upwards in the second. These can be viewed under the dissecting stereo-binocular microscope.

Fresh male cone is peculiar smelling.

Observations and Interpretations

1. Study the male cone, pay attention to its size, sporophylls, the number (approximate), and arrangement of sporophylls, colour of the cone, in fresh/preserved specimens. Note your observations in the Worksheet # 3.5.
2. In the l.s. of male cone, observe its central axis, the arrangement of microsporophylls, and the pattern of arrangement of the microsporangia on each of the microsporophyll. Note your observations in the Worksheet # 3.5.
3. Observe a microsporophyll in both the abaxial and adaxial views. Note the kind of details visible in each of these views in the Worksheet # 3.6.

Worksheet # 3.5: Study of a male cone.

Diagram space	Description space

Q.1: Make an outline, labelled sketch of a male cone and write down its diagnostic features.

Diagram space	Description space

Q.2: Make an outline diagram of a male cone in longitudinal section. Label its various parts. Note down its salient features.

Vorksheet # 3.6: Study of microsporopyll.

Diagram space	Description space

Q.1: Make an outline diagram of microsporophyll in dorsal view. Label its parts. Write its structural peculiarities.

Diagram space	Description space

Q.2: Draw a microsporophyll in ventral view, label its parts and write down the structural details visible in this view.

3.2.7 Female strobilus, megasporophyll

a. Female Strobilus

A compact female cone is not organized, therefore not present in *Cycas*. Instead, the female plant bears successively the foliage leaves, cataphylls and then the megasporophylls. This sequence keeps repeating and the whole cluster thus formed is termed as the female strobilus.

b. Megasporophylls

1. The megasporophylls arise spirally in acropetal succession and are loosely arranged on the stem like the crown of foliage leaves.
2. The stem in female plant is monopodial.
3. A megasporophyll is divided into:
   i) an upper or distal broad leafy part which is variously lobed or serrated,
   ii) a middle stalk-like portion bearing variable number of ovules (1-3 pairs), and
   iii) a proximal or lower sterile short or long stalk-like axis.
4. The ovules are sessile, orthotropous (erect), large in size (6-7 cm. in length), slightly flattened in the plane of the megasporophyll. They are ovoid or spherical.
5. The surface of ovule may be smooth or copiously covered with hairs but at maturity the hairs are lost and ripe seeds have soft orange, red colour (*C. revoluta*).

Materials required

Fresh or museum or herbarium specimens of at least two species of *Cycas*.

Observations and Interpretations

Observe the megasporophylls of the different species provided, note the differences between them. Make their outline diagrams and write their differences in Worksheet # 3.7.

Your Notes

Worksheet # 3.7: Study of megasporophyll.

Diagram space	Diagram space
Cycas	*Cycas* ....

Q.1: Make outline diagrammes of megasporophyll of two different species of *Cycas*. Label their parts. Write the names of the species in the blank spaces.

Description space	Description space
Cycas	*Cycas* ....

Q.2: Write down the structural peculiarities seen in the above illustrations. Also mention the name of the species in the blank spaces.

3.3 ANATOMY

3.3.1 Coralloid root (in transverse section)

1. The outermost layer is cork followed by phellogen.
2. The cortex is differentiated into three distinct zones:
   a) Outer cortex is composed of compact, polygonal, parenchymatous cells.
   b) Middle cortex has a conspicuous, broad, blue-green algal zone, usually one-cell thick, consisting of compactly connected thin-walled, and radially elongated cells.
   c) Inner cortex is composed of thin-walled parenchymatous cells.
3. Endodermis is single-layered.
4. The stele is diarch or triarch. The bundles are radially arranged and xylem is exarch.
5. Pith is highly reduced.

Materials required

1. Permanent slide of t.s. of coralloid root.
2. Compound microscope.

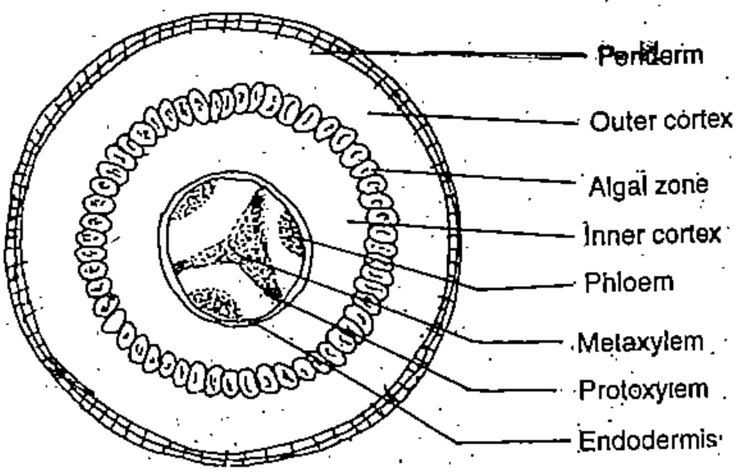
Procedure

Focus the slide under the microscope. Complete the missing zone, and the incomplete labelling in the cellular diagram given in the Worksheet # 3.8.

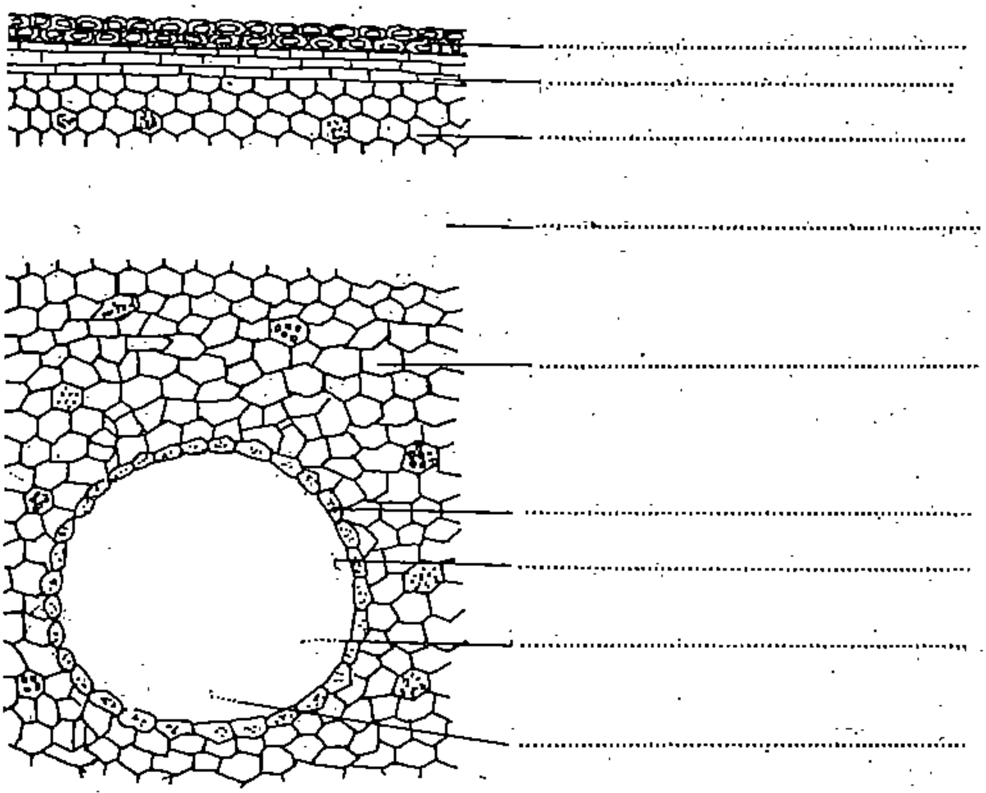
Observations and Interpretations

1. Observe the different zones of the coralloid root. The description given above, and the outline diagram of the transection of coralloid root given in the Worksheet # 3.8 (Fig. **a**) would both help and guide you in your study.
2. As you observe and study the permanent slide, particularly note the location of the algal zone, and the kind of cells composing this layer.
3. Draw 3 or 4 cells from the algal zone in the given, cellular diagram in the Worksheet # 3.8 (Fig. **b**).
4. Observe the nature of stele – diarch or triarch arrangement of vasculature, and see if the xylem is exarch or endarch. Write down about these points in the Worksheet # 3.8.

Your Notes



a) An outline diagram of a coralloid root cut in transverse section (t.s). Observe the characteristics of its different regions in the permanent slide.



b) This is a partially made cellular diagram of a coralloid root cut in transverse section.

Q.1: Draw 3 or 4 cells of the algal zone.

Q.2: Complete the stellar portion left blank in the middle, with its cellular details.

Q.3: Label the different zones of the above cellular diagram of the coralloid root.

Description space

Q.4: Write down the characteristic anatomical features of a coralloid root.

3.3.2 Stem

a) A young stem (in transverse section)

1. T.s. of young stem presents an irregular outline on account of the presence of numerous leaf bases.
2. The stem is manoxylic. The cortex is broad, consists of thin-walled parenchymatous cells that are filled with starch grains.
3. Numerous mucilagenous ducts are found in the cortex.
4. Girdle leaf traces and direct traces traverse the broad cortex.
5. Endodermis and pericycle are not distinct.
6. Vascular bundles are numerous, collateral, conjoint and endarch, radially elongated and are separated by broad parenchymatous rays.
7. Pith is well-developed and is made up of large parenchymatous cells filled with starch grains.

b) A mature stem (in transverse section)

1. The secondary growth in the stem results in a polycyclic condition. The primary cambium is short-lived, therefore, a number of secondary cambia develop. The transection shows 3, 4 or even more concentric zones of xylem and phloem.
2. An armour of persistent leaf bases is present on the outer surface of the stem.
3. Prominent leaf traces (girdles and direct) are present in the different parts of cortex.
4. Both in the cortical region and the pith are present a number of mucilage canals.

Materials required

1. Permanent slides of :
   i) t.s. of a young stem, and
   ii) t.s. of an old stem,
2. Compound microscope

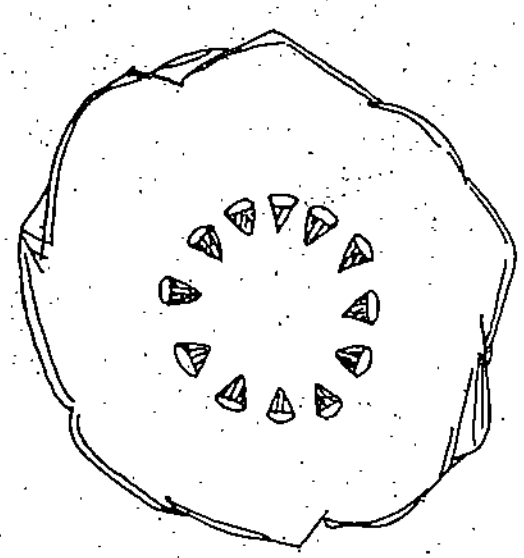
Procedure

Observe the slides after focusing under the microscope. Complete the illustrations and write their salient features.

Observations and Interpretations

1. Young stem – Observe the slide and draw a few girdle leaf traces, mucilage ducts, a few starch - filled cells in the cortex and the pith region in Fig. a of the Worksheet # 3.9.
2. Old stem – Observe the permanent slide, taking help from Figs **b** and **c** in the Worksheet # 3.9.

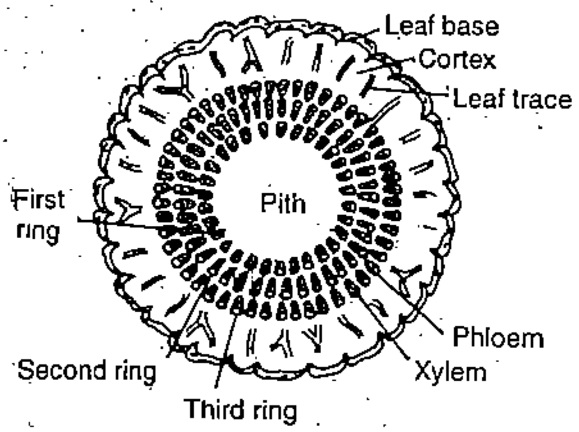
List the special features of secondary xylem and phloem in the corresponding description spaces in the Worksheet # 3.9.



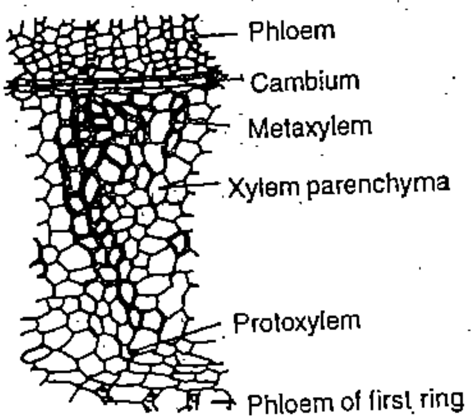
Description space

a) Outline diagram of a young stem cut in transection.

Q.1: In this diagram draw: i) girdle leaf traces, ii) mucilage ducts, iii) starch-filled cells in the cortex region. Label the different parts of the stem. Write down the salient points.



b) Outline diagram of t.s. of an old stem showing three rings of vascular bundles.



c) A portion of vascular bundle enlarged from an old stem cut in t.s.

Description Space

Q.2: List the special features of the elements of secondary xylem and secondary phloem.

3.3.3 Rachis

1. In a t.s., the rachis appears somewhat biconvex, cylindrical or flattened structure.
2. The outermost, thick-walled and single-layered epidermis is made up of rectangular cells. It is covered on its external surface by a thick cuticle, except in the region of stomata.
3. The hypodermal region is differentiated into an outer, narrow zone of collenchymatous cells, and an inner zone of thick-walled, compact, sclerenchymatous cells.
4. Hypodermis on its innerside is followed by a thin-walled parenchymatous zone. A number of mucilage canals and a few cells with crystals of calcium oxalate occur in this zone.
5. A varying number of vascular bundles are found embedded in the parenchymatous ground tissue.
6. Vascular bundles are more or less oval in shape, conjoint, collateral, open and arranged in the form of 'omega' (Ω) or horse shoe-shape.
7. Each vascular bundle is enclosed by a thick-walled sclerenchymatous bundle sheath, next to which is the pericycle. The xylem faces inwards, and is separated from the phloem by a thin strip of inactive cambium. The vascular bundle consists of a mass of centripetal xylem and a few elements of centrifugal xylem. The latter is separated from the protoxylem by parenchymatous cells and the protoxylem is pseudomesarch.

(For more details, see page 35, Block 1 of LSE-13 Course.)

Materials required

1. One or two permanent slide(s) of rachis cut in t.s.
2. Dissecting/binocular microscope
3. Compound microscope

Procedure

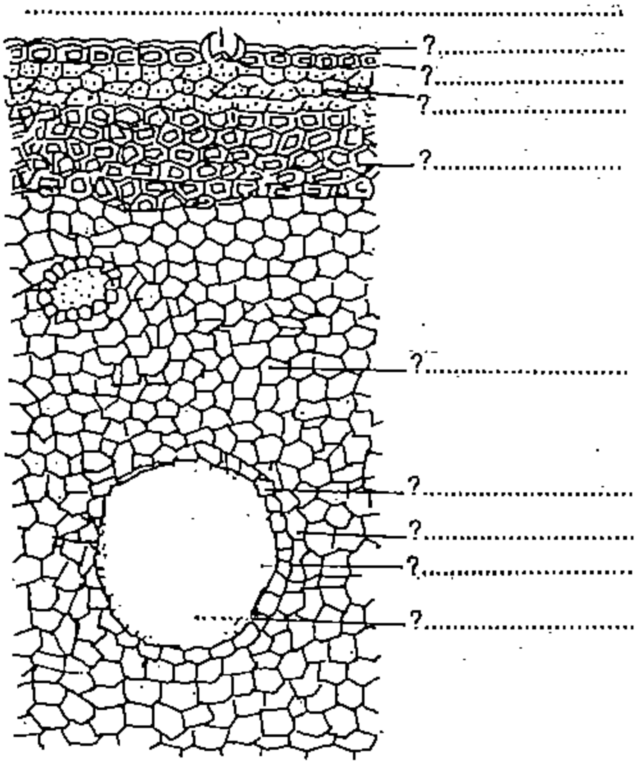
Focus and view one slide under a dissecting microscope. Complete drawing its outline diagram depicting the arrangement of vascular bundles in Worksheet # 3.10. Then, view it under a compound microscope and study its cellular details. Complete the cellular diagram (Fig.**a**) in the Worksheet # 3.10.

Your Notes

Worksheet # 3.10: Study of rachis. *Cycas*

Diagram space	Description space

Q.1: Draw an outline diagram of the rachis cut in t.s. showing particularly the arrangement of the vascular bundles.

Diagram space	Description space
	

a) A partially made cellular diagram of a sector of rachis cut in t.s.

Q.2: Label the various parts of the rachis in the above diagram.

Q.3: Draw the cellular details of a vascular bundle, and label its component parts.

3.3.4 Leaflet

The v.s. of a *Cycas* leaflet shows the following details:

1. The upper and lower epidermises are covered with thick layers of cuticle.
2. The epidermis is single-layered and its cells are lignified. The upper epidermis is continuous but the lower epidermis is interrupted by the presence of sunken stomata.
3. Internal to the upper and lower epidermis lies a single-layered thick-walled sclerenchymatous hypodermis, which in the region of midrib is two or more layered thick.
4. Next to the hypodermis is a zone of chlorophyllous mesophyll cells. The mesophyll is differentiated into the vertically elongated palisade tissue situated towards the upper side, and the loosely arranged spongy parenchymatous tissue towards the lower epidermis.
5. In between the palisade and spongy parenchyma occurs three or four layers of lignified tracheid-like, empty looking cells that show bordered pits on their walls and these run parallel to the leaf surface from the midrib to the margin. This constitutes the accessory transfusion tissue.
6. In the midrib region, there is a single large vascular bundle surrounded by a jacket of thick-walled cells. It consists of xylem facing the upper surface, and the phloem facing the lower surface, and it is in the form of an arc.
7. The xylem strand (centripetal xylem) appears like a wedge with the protoxylem located at its apex facing the phloem, and an arc of cambium lies on its outer side, i.e., towards the phloem. On either side of the protoxylem are present two or three tracheids, centrifugal xylem in separate groups. The latter is separated from the former by a few parenchyma cells. The vascular bundle is diploxylic showing pseudomesarch condition.
8. Transfusion tissue consisting of transfusion tracheids, transfusion parenchyma and albuminous cells, occurs on the sides of the vascular bundle. On the sides of the xylem, transfusion tracheids with bordered pits are present which are connected on either side by accessory transfusion tracheids.

Materials required

1. Preserved material of *Cycas* leaflets
2. Microslides
3. Coverslips
4. Safranin stain (1% in 50% ethyl alcohol)
5. Glycerine (10%)
6. A razor or a sharp blade
7. A pair of forceps
8. A pair of mounted needles
9. Fine camel hairbrushes
10. Compound microscope

Or

1. A permanent slide of v.s. of a leaflet
2. Compound microscope.

Procedure

Cut a thin, uniform vertical section of a *Cycas* leaflet, stain it with safranin, mount in glycerine after washing in acid water. The leaflets are tough, thick, and leathery, so pith is not required for cutting their sections. Observe your preparation or the permanent slide under the microscope, study its diagnostic features as listed above. See the Figs **a** & **b** in Worksheet # 3.11 and compare with your preparation or the permanent slide. Complete the tasks given in the Worksheet # 3.11.

Be careful while using sharp blade/razor for section-cutting.

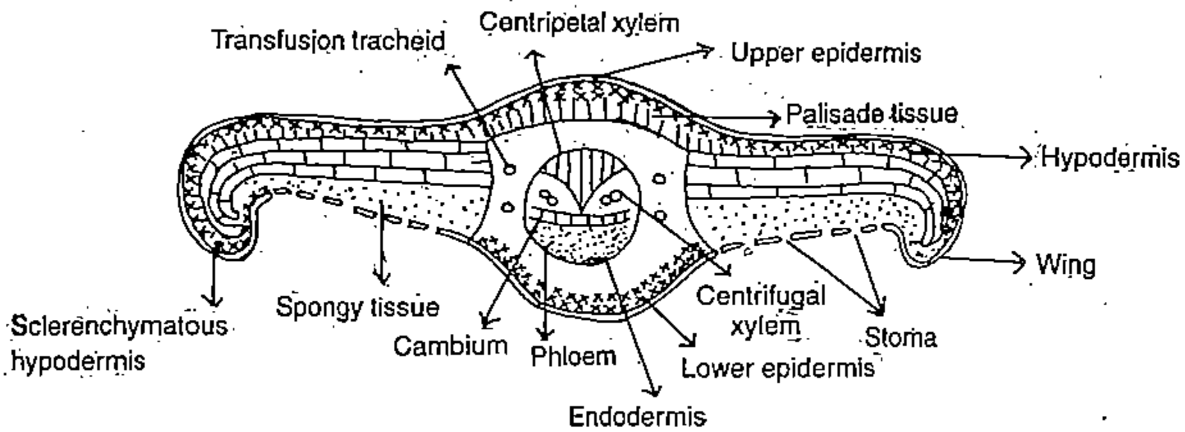
Observations and Interpretations

Observe and study the prepared or the permanent slide provided.

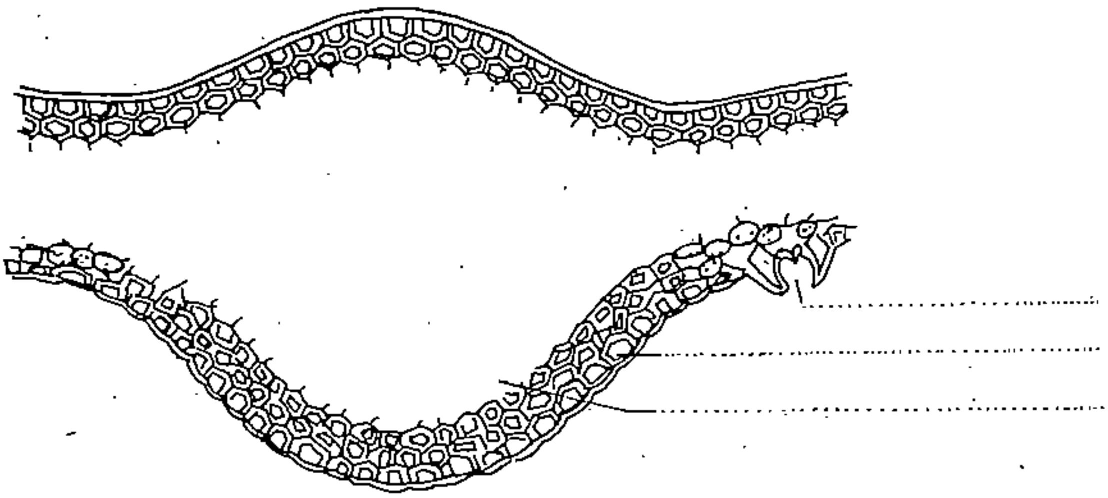
i) Identify the transfusion tissue and accessory transfusion tissue and make a few cells in Fig. **b** given in the Worksheet # 3.11.
ii) Complete the cellular details of Fig. **b** in the same worksheet.
iii) List the anatomical, xerophytic conditions – specific features of the leaflet, in Worksheet # 3.11 in the description space.

Your Notes

Worksheet # 3.11: Study of leaflet.



a) An outline diagram of v.s. of a leaflet.



b) A portion of the above figure (a) enlarged, with its partially drawn cellular details.

Q.1: Complete the cellular details in the portion left blank in the above figure.

Q.2: Label the parts in the above figure.

Description Box

Q.3: List the anatomical peculiarities found in the plants growing in xerophytic conditions that are exhibited by the leaflet of *Cycas*.

3.3.5 Pollen grains

You would study the pollen grains in two ways: in the microsporangia where they develop and mature, and the loose or free pollen grains in a squash preparation.

a) Pollen grains in microsporangia.

To know about the place of development of pollen grains, a transection of the microsporophyll can be studied. Its structural details are as follows:

1. The microsporophyll shows a coprously hairy epidermis, which has numerous stomata, distributed chiefly on the lower side.
2. The ground tissue is parenchymatous through which traverse numerous mucilage canals and vascular bundles.
3. The vascular bundles are arranged in a row parallel to its plane of flattening.
4. The peripheral parenchymatous tissue shows chloroplasts and the tannin containing cells occur in abundance.
5. The microsporangia occur on two flanks of the microsporophyll differentiated by a median sterile ridge.
6. The mature microsporangium is an oval sac with a short, stout stalk.
7. The wall of the microsporangium is four to seven-layered.
8. The cells of the outermost layer, that is, epidermis, are thin-walled; of uniform size and are filled with tannins. The epidermis is covered by a thick cuticle in young microsporangia.
9. The innermost wall layer differentiates as tapetum.
10. The tapetum degenerates during meiosis and microspore development.
11. At maturity, the cells of the epidermis become thickened, with the exception of two rows of cells along the abaxial route. These become elongated and mark the line of dehiscence.
12. The mature microsporangium contains large number of microspores. A mature microspore possesses two sharply distinguished coats known as exine (outer) and intine (inner).
13. The pollen grains are boat-shaped and bear a longitudinal slit or furrow on their distal sides.

Materials required

1. A permanent slide with v.s. of a microsporophyll whose microsporangia contain developed pollen grains.
2. Compound microscope.

Procedure

Focus the slide under the microscope and observe under low power and study the internal structure of microsporangium under high power and record your observations.

Observations and Interpretations

Observe the arrangement of microsporangia on the microsporophyll, note on which side they are found – abaxial or adaxial, and also study the tissue composition of the microsporophyll. Make its outline diagram and write the salient features in Worksheet # 3.12.

b) Temporary squash preparation of pollen grains

1. Pollen grains are produced in microsporanga.
2. Uninucleate microspore is the first cell of the male gametophyte.
3. The microspores are almost spherical in shape and thousands of these develop in each microsporangium.
4. Each microspore develops a thick exine and a thin intine.
5. The microspore nucleus divides and cuts off a small vegetative cell called the prothallial cell and a large antheridial initial. The latter agai divides and cuts off a small antheridial cell attached to the prothallial cell and a large tube cell.
6. The mature pollen grains are boat-shaped and bear a longitudinal slit c furrow on their distal sides.
7. You can also see pages 37-38, Block-1 of LSE-13 Course for more details.

Materials required

1. Preserved material of *Cycas* microsporophyll
2. Safranin
3. Glycerine
4. Coverslips
5. Slides
6. Watch-glass
7. A pair of mounted needles
8. A pair of fine forceps
9. Fine camel hair brush
10. Compound microscope

Procedure

Transfer the microsporophyll or a piece of microsporophyll from the preserved material into a watch-glass. With the help of the forceps pick up few microsporangia, place them in a watch-glass and add a few drops of safranin and let them be overstained. Now wash the material in tap water. On a clean slide put a drop of glycerine in the centre, transfer the stained microsporangia on it and rupture it with the help of a needle. Remove the debris and carefully put the coverslip over it. Place the slide between two filter papers and gently press the coverslip and let the filter paper soak the extra fluid. Observe the slide under compound microscope.

Note: The squash preparation of pollen grains can also be prepared using acetocarmine stain.

Observations and Interpretations

Draw different stages of microspores or pollen grains as observed by you.

Observe that the mature pollen grains become boat-shaped due to a depression on one side. Depending on the developmental stage of the microsporangium, you may find uni-, or bi-nucleate microspores, or the tri-nucleate microspores which represents their mature stage of development.

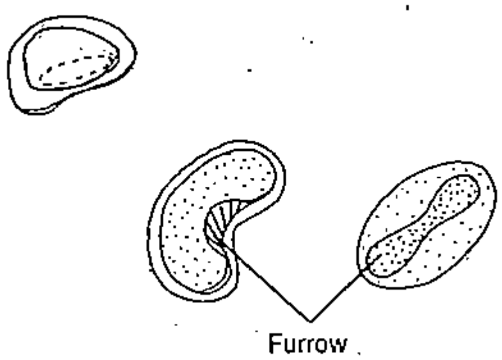
Your Notes

Worksheet # 3.12: Study of pollen grains.

Diagram space

Description space

Q.1: Draw an outline diagram of v.s. of a microsporophyll with its microsporangia containing pollen grains. Write its salient features.



a) A few mature microspores in w.m.

Description space

Diagram space

Q.2: Draw two microspores in different views.

Q.3: Write about the characteristics of the pollen grains that you have observed.

3.3.6 Ovule

You may recall the arrangement of ovules on the megasporophyll that you have studied in Sub-section 3.2.7. Refer to pages 39-40 of Block-1 of LSE-13 Course, for recapitulating its details.

1. The ovules are unitegmic, orthotropous and crassinucellate. These details are clearly seen in the l.s. of ovule.
2. The integument is differentiated into three layers:
   i) inner fleshy (inner sarcotesta);
   ii) middle stony (sclerotesta); and
   iii) outer fleshy (outer sarcotesta).
   On maturity the inner fleshy layer is left only as a dry papery layer.
3. The integument encloses a massive nucellus, which remains fused with the inner fleshy layer of the integument except at the micropylar portion.
4. The apex of the nucellus grows up into a beak like outgrowth – the nucellar beak, which projects into the micropyle. Some of the cells of the nucellar beak disorganise to form flask-like hollow cavity called pollen chamber. The pollen grains germinate here.
5. Within the nucellus is present an enlarged megaspore or the female gametophyte in a *young ovule*.
6. In a *mature ovule*, towards the micropylar end of the cellular gametophyte, just below the pollen chamber, a small depression appears where 3-6 archegonia develop.
7. The archegonium is a simple structure consisting of a short neck of two cells, a ventral canal cell (which degenerates later on) and an egg nucleus. The archegonia lie in the archegonial chamber, which is formed by the upward growth of the female gametophyte.
8. *Cycas* shows simple polyembryony. At this stage two, or three developing embryos with highly coiled suspensors can be seen.
9. In a *mature seed*, the integument hardens to form the seed coat. Its outer fleshy layer dries up and adheres firmly to the middle stony layer. The inner fleshy layer had already shrivelled. The nucellus is completely crushed. Within the seed coat lies the female gametophyte, which functions as endosperm. Lying embedded in the middle of the endosperm is the straight dicotyledonous embryo which extends the entire length of seed.

Materials required

1. A permanent slide of l.s. of ovule showing an archegonium preferably, or any other developmental stage
2. Compound microscope

Procedure

Focus the slide under the microscope, observe and record your observations.

Observations and Interpretations

Observe the structure of the ovule in the slide, note the neck of the archegonium – it is made up of two cells arranged in single tier. There are no neck canal cells and a degenerated ventral canal nucleus may be present. The egg nucleus is large, so much that it can be seen with an unaided eye.
Draw an outline diagram of the l.s. of ovule, label its parts, indicate the developmental stage of the ovule, and write down its salient features in the Worksheet # 3.13.

Your Notes

Diagram space

Q.1: Make an outline diagram of the l.s. of an ovule. Label its various parts clearly indicating the developmental stage of the ovule.

Description Box

Q.2: Write down the salient features of the ovule whose diagram you have made above.

Worksheet # 3.14: Test you understanding of *Cycas*.

SAQ 1

a) In nature, the *Cycas* plant reproduces more frequently by vegetative means. Give reasons for the same.

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b) The male plants of *C. revoluta* are not found in north India, hence no seeds are produced here. Still several plants are seen in many gardens. How are these plants propagated?

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SAQ 2

Explain how will you estimate the age of a *Cycas* plant?

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SAQ 3

What is the function of accessory transfusion tissue?

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SAQ 4

List the primitive features that can be seen in the *Cycas* leaflet.

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SAQ 5

In what respect do the ovules of *Cycas* distinctly stand out amongst the structures of the entire plant kingdom?

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Your Notes

EXERCISE 4 *PINUS*

Date: ....
Session # : ....
Time allocated: 2 Hours

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in the lab.

4.1 INTRODUCTION

In this exercise, you will study the most well known representative of the division Coniferophyta and of the family Pinaceae – *Pinus*. Pinaceae is the largest and the most recent of the modern Conifers. Geographically, the family is distributed mainly in the northern hemisphere and forms pine forests.

The genus *Pinus* is represented by over one hundred spp. of evergreen trees. The tree is tall and beautiful with horizontal branches arranged in whorls, giving it a pyramidal appearance. The branches are of two types, viz., the long shoots and dwarf shoots.

The foliage leaves are borne on dwarf shoots; they are needle like in appearance and are protected by another type leaves called scale leaves.

The tree is monoecious, but the male and female cones are borne on separate branches of the same tree. Generally, the male cones are in clusters on the lower branches and the female cones are in pairs, on the upper branches. Seeds are produced in the older female cones which become hard and woody. Seeds are released only when female cones open or fall on the ground.

In this exercise, you will be studying the morphology and anatomy of vegetative and reproductive parts of the plant so as to understand both the sporophytic and gametophytic generations of the *Pinus* life cycle.

Characteristics of seed plants

a) Megaphylls
b) Heterospory
c) A reduced *megagametophyte* retained within the *megaspore*
d) A *megaspore* retained within fleshy megasporagium called the *nucellus*
e) *Pollen* is a structur which carries the male gamete or sperm cells to the female gametes c egg
f) Seed plants do no require water for fertilization.

In this whole exercise, you have to do three types of experiments.

- Experiments based on external morphology which will be done by studying Herbarium/Museum specimens/video.
- Experiments which are based on temporary slide preparations.
- Experiments which are based on study of permanent slides.

Objectives

After doing this exercise, you will be able to:

- identify the plant of *Pinus*;
- describe internal structure of root, needles, stem, male and female cones, pollen grain, ovule, and seed,
- describe and distinguish between sporophyte and gametophyte,
- understand the life cycle of *Pinus*.

Study Guide

Before attending the lab, come prepared by reading this text and the theory part of this course.

- Study carefully Unit 3: *Pinus*. It will surely help you in understanding the morphology and anatomy of various parts of *Pinus*.

Your Notes

4.2 MORPHOLOGY

In this section, you will study the morphology of vegetative as well as reproductive parts of the pine tree. In *Pinus* the primary taproot is deep seated having large number of lateral roots called as long roots. The long roots in turn bear cluster of dwarf roots, which branch dichotomously and form corolloid masses and have ectomycorrhiza, and are also called Mycorrhizal roots (Unit 3, LSE-13).

4.2.1 Stem

Materials Required

- Museum/Herbarium specimens of *Pinus* twig with long and dwarf shoots

Procedure

- Study carefully the habit and morphology of *Pinus* tree from the video film or from museum specimen, freshly collected specimen (if possible) and record your observations.
- Observe the museum/herbarium specimens and complete the diagrams.
- Record your observations and label the diagrams as indicated in Worksheet # 4.1.

Observations and Interpretations

1. Hints : Observe. (i) If you see a living plant in the vicinity, you must observe monopodial branching and characteristic appearance of the main trunk.

Write diagnostic features of *Pinus* tree.

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Worksheet # 4.1: Morphology *Pinus* sp.

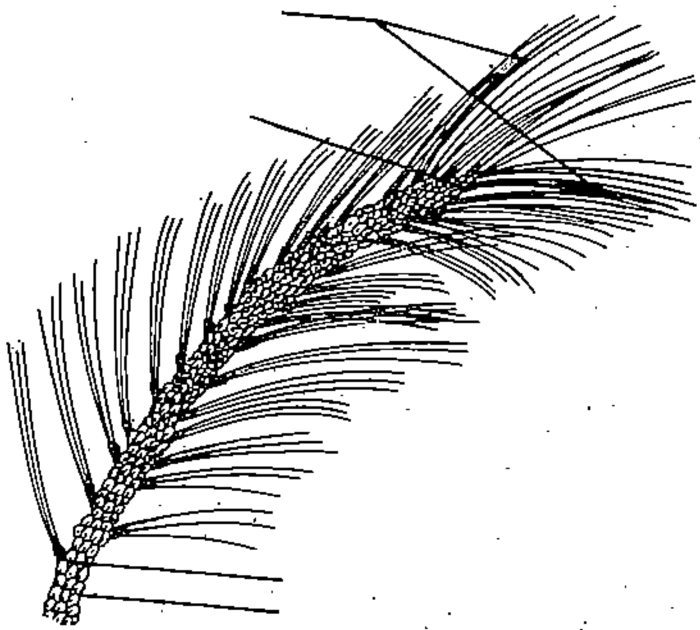
Class : ....

Order : ....

Family : ....

Genus : ....

Draw dwarf shoot bearing needles and label it



A long shoot bearing dwarf shoots
(label it)

Draw a part of long shoot bearing
dwarf shoot with needles and label it

4.2.2 Twig with long and dwarf shoot

Observe the following characteristics in the museum specimen.

1. The branches are dimorphic, the long shoots or branches of unlimited growth and the dwarf shoots or branches of limited growth.
2. The long shoots are the ordinary branches which continue indefinitely in active growth by means of an apical meristem. These branches arise as buds in the axils of scale leaves at the end of each year. In addition to these branches, there are numerous branches of limited growth, i.e., dwarf shoots, borne on the ordinary branches in the axil of scale leaves. The dwarf shoot consists of a short axis terminating in a cluster of three (*P. roxburghii*) (1-5 in different species of *Pinus*) green needle like leaves. The dwarf shoot is up to 2-3 cm in length and is covered with 10-12 scale leaves which are brown in colour. The opposite pair of scales initially borne on the dwarf shoot are called prophylls, followed by 5-13 scale leaves called cataphylls.
3. The leaves are also of two kinds. The foliage leaves being long, narrow (acicular), tough and green and are known as 'needles'. They are borne only on dwarf shoots. Second type of leaves are "scale leaves". They are brown, membranous and are protective in function.

Pinus monophylla	monofoliar spur	- 1 needle on dwarf shoot
Pinus merkusii	bifoliar spur	- 2 needles on dwarf shoot
P. roxburghii, P. gerardiana	trifoliar spur	- 3 needles on dwarf shoot
P. wallichiana, P. armandii	pentafoliar	- 5 needles on dwarf shoot

Dwarf shoot is also called as spur shoot

Observations and Interpretations

- Study a leafy branch and identify type of shoot on the basis of buds and leaves.
- Study the dimorphic nature of the branches.
- Identify the following leaves.
  i) Foliage leaves or needles?
  ii) Subtending or scale like leaves in the axils of which arise foliage leaves (needles).

4.2.3 Male cones

1. Male cones occur laterally in clusters, each in the axil of a scale leaf at the base of a terminal vegetative bud.
2. The male cones replace the dwarf shoots at the base of the developing bud or shoot of the current year and are spirally arranged on long shoot.
3. Each male cone is shortly stalked and consists of an elongated central axis, bearing a number of small spirally arranged and closely fitting scale like microsporophylls with their scaly apices upturned.
4. The microsporophyll is attached to the axis by a short stalk and bears two microsporangia on its lower (abaxial) side. The microsporangium dehisces by a longitudinal slit.
5. The young male cones of *P. roxburghii* are about 1.5 cm – 2 cm long and 1 cm in diameter. At the time of dehiscence, these become 2.5-3 cm in length and contain thousands of pollen grains.
6. Each tree sheds a large quantity of pollen (sulphur showers).

Observations and Interpretations

- Male cone
  - i) Observe a male cone. See on which shoot it is situated.
  - ii) Draw a male cone on the Worksheet # 4.2.
  - iii) If you are provided with fresh material record the length and diameter of the male cone.
- Whole microsporangia
  - i) Observe a microsporophyll with two elongate microsporangia with a longitudinal slit.
- Using a dissection microscope study several microsporophyll.
  - i) How many pollen sacs are there on each microsporophyll?

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  - ii) Are they on the upper side or on the lower side?

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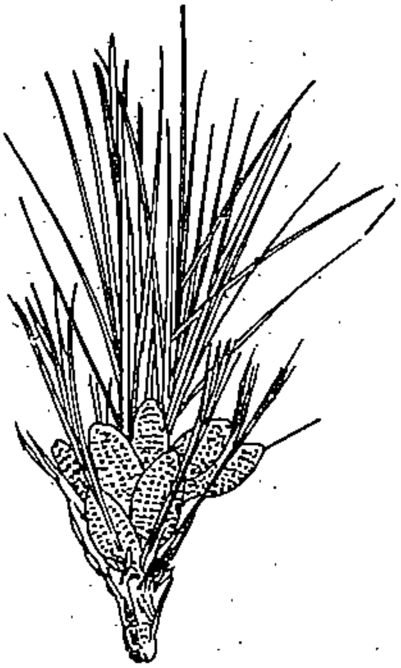
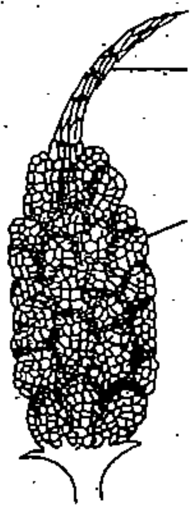
Your Notes



A shoot bearing a cluster of male cones (Label it)



Cluster of Male cones (label it)

Draw a cluster of male cone and label it

Draw a microsporophyll bearing microsporangia (dorsal, ventral and lateral view)

4.2.4 1st, 2nd and 3rd year female cones

i) Observe the 1st, 2nd and 3rd year cones and note down the differences in their size and shape.
ii) Find mature seeds on the upper (adaxial) surface. How many seeds are there on each megasporophyll?
iii) If possible, study a mature seed with its attached wing.

Observations and Interpretations

- Observe the museum specimen of female cone either from a specimen shown or on video or photograph/or from a plant growing near by (if possible) and write comments.
- Write down characteristic features of female cone of *Pinus* spp.

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4.2.5 Seed

1. Each megasporophyll which is also called as ovuliferous scale (which is woody and wedge – shaped with its broader sterile end, the apophysis directed outwards) bears two seeds on its upper (adaxial) side.
2. The seeds are winged.
3. The wings are thin and papery. The outer layer of the integument and the upper side of the ovuliferous scale take part in the formation of the wing.

Observations and Interpretations

- Study the mature embryo surrounded by the enlarged megagametophyte or endosperm (in permanent slides).
- Identify the parts of the embryo: radicle or first root (at the micropylar end), cotyledons or embryonal leaves, and the epicotyl and plumule (the first bud) (if possible, in permanent slides).
- Draw a well labeled diagram of the seed with ovuliferous scale and two winged seeds borne on adaxial side from the specimen/photograph.

1st year female cone

2nd year female cone

3rd year female cone

Draw ovuliferous scale
with two seeds

Seed
(Draw the diagram of L.S: seed)

4.3 ANATOMY

4.3.1 Root

T.S. of long root

1. The long root of *Pinus* spp. is diarch or tetrarch.
2. Epidermis is following by starch filled cortex having an outer zone of small and inner zone of larger parenchyma cells.
3. The endodermis is single layered with casparian strips and is followed by 6 or 7 layered pericycle.
4. There are eight to sixteen protoxylem elements with scalariform or scalariform – pitted thicknenings. Each protoxylem point is associated with a resin duct.
5. The pith cells are rich in starch, occasionally some of them are tanniniferous too.
6. Secondary growth starts very early. The structure of the root in later stages is much like that of the stem.

T.S. of dwarf root

1. The dwarf root of *Pinus* is anatomically similar to long root. It however, differs from the long root in the absence of a root cap, resin duct, starch in cortical cells and secondary growth.
2. The dwarf roots divide dichotomously and become modified into mycorrhizal system after fungal infection, when the entire rootlet is enclosed by mycelium.
3. The fungal hyphae penetrate the intercellular space in the cortical cells of the root forming the so-called hartig's net.
4. The pine fungal relationship is symbiotic.

Materials Required

- Permanent slides of young *Pinus* root,
- Permanent slide of Mycorrhizal roots.

Observations and Interpretations (permanent slide)

1. Observe and identify pith, primary xylem, rays, resin canals, vascular cambium, and phloem. Observe the primary vascular tissue.
2. Observe the prominent pith cells rich in starch.
3. Observe the mycorrhizal system in the dwarf roots and compare it with the diagram drawn on Worksheet # 4.4.
4. Compare your slide prepared with the diagram and try to draw on Worksheet # 4.4.

Draw T.S. Root of *Pinus*

Draw T.S. Root with mycorrhizal association (upper half)

4.3.2 Stem

a) Transverse section of a young stem.

T.S. of stem (Primary)

1. The primary stem shows irregular outline in transverse section and anatomically shows advance features.
2. A single layered epidermis covers outer surface of stem. Its cells are highly thickened and outer walls are cutinized.
3. The cortical cells beneath the epidermis are thick-walled to form the hypodermis. The inner cortex consists of thin walled parenchymatous cells. It is traversed by a large number of resin canals. Each canal is lined by a layer of thin walled parenchymatous glandular secretory cells constituting the epithelium.
4. The primary vascular tissue consists of ring of conjoint, collateral, endarch, and open vascular bundles. The narrow primary medullary rays connect the pith with the cortex.
5. The pith is parenchymatous.

Materials Required

- Preserved material of young *Pinus* stem,
- Slides, coverslips, safranin stain, glycerin (10% aqueous), razor or sharp blade, forceps, needles, camel hair brush
- Compound microscope.

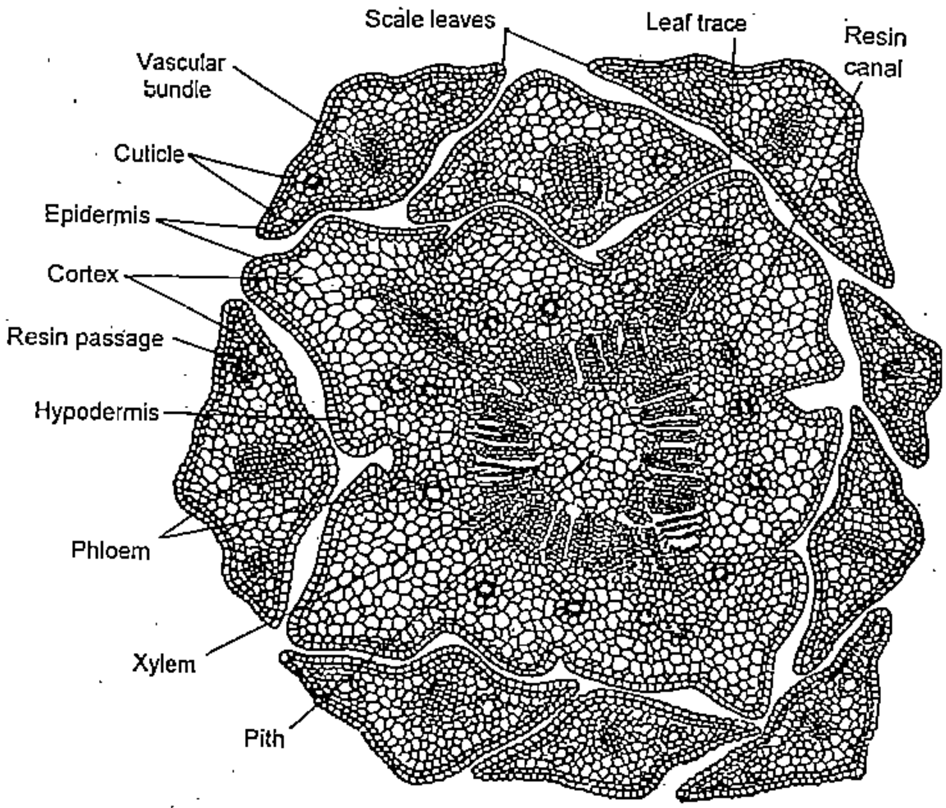
Procedure

Cut a transverse section of stem, stain in safranin and mount in glycerin (follow the instructions given earlier). The material of stem is quite hard. No pith is required for cutting sections. If you are unable to get a complete section, you can mount a part, properly trimmed with the help of blade. In this part of exercise, diagrams are drawn for you.

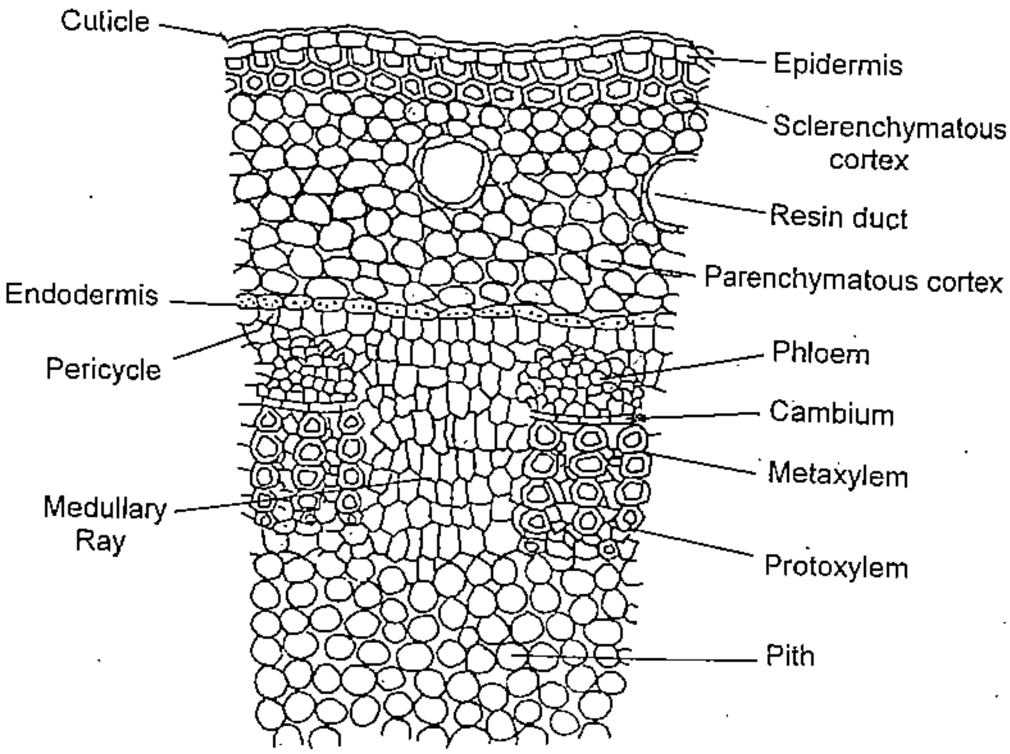
Observations and Interpretations

- Observe and identify resin canals, xylem and phloem, vascular cambium, rays, and pith.
- Compare your slide prepared, with diagram given and try to draw a well labelled diagram yourself.

Your Notes



Cellular representation of T.S. young stem of a *Pinus*.



A portion of young *Pinus* stem in T.S. (enlarged)

b) Transverse section of an old stem.

Materials Required

- Preserved material of mature/old *Pinus* stem
- Slides, coverslips, safranin stain (1% in 50% Ethyl Alcohol), glycerin (10% aqueous), razor or sharp blade, forceps, needles, camel hair brush
- Permanent slide of old stem of *Pinus*
- Compound microscope.

Procedure

Cut a transverse section of stem, stain in safranin and mount in glycerin (follow the instructions given earlier). The material of stem is quite hard, therefore, pith is not required for cutting sections. If you are unable to get a complete section you can mount a portion, properly trimmed with the help of blade. In this part of exercise diagrams are drawn for you.

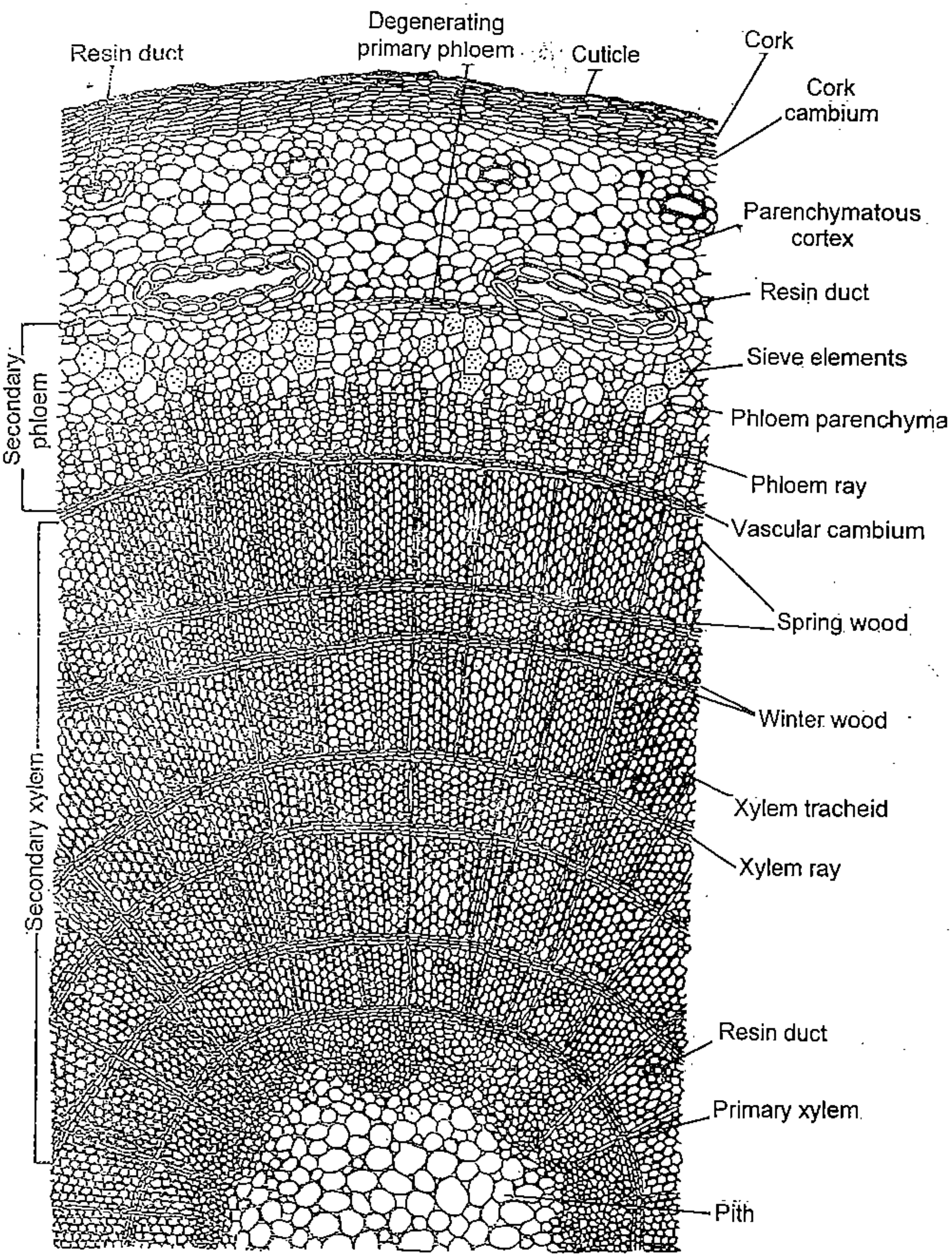
Observations and Interpretations

- Observe your prepared and stained slide or permanent slide provided to you.
- Observe normal secondary growth, you will see annual rings differentiated into autumn and spring wood.
- Identify resin ducts.
- Diagram has been provided to you with the help of diagram and the slide prepared by you, write your comments.

Your Notes

Comment on salient features of T.S. stem (Old)

Worksheet # 4.6: Stem (Old)



T.S. old stem.

4.3.3 Tangential Longitudinal Section (TLS) and Radial Longitudinal Section (RLS) of wood

Radial longitudinal section (RLS) of wood

1. It shows secondary xylem and xylem rays.
2. Secondary xylem is composed of tracheids and the tracheids possess bordered pits on their radial walls which are uniseriate in arrangement.
3. Bars of sanio or crassulae are special thickenings of primary wall. They are present between bordered pits.
4. Xylem rays are made up of ray tracheids and ray parenchyma.
5. The ray parenchyma cells are rectangular containing cytoplasm, nucleus and starch grains. They possess simple pits.
6. At the upper and lower ends of these rays are elongated, horizontally situated one or two rows of short tracheidal cells. These are called *ray tracheids* and have bordered pits on their lateral ends.

Tangential longitudinal section (TLS)

1. Both uniseriate and multiseriate rays are present.
2. The uniseriate rays vary from 1-12 cells in height and are only one cell broad.
3. The multiseriate rays are associated with a resin duct which is present in the centre.
4. Xylem rays are composed of centrally placed ray parenchyma and at the margins ray tracheids.
5. The walls of the tracheids shows bordered pits in sectional view.
6. A bordered pit shows pit cavity to which secondary wall form an overarching roof with a narrow pore in the centre. It encloses in the centre a small aperture called torus.

Materials Required

- Preserved material of old *Pinus* stem
- Slides, coverslips, safranin stain (1% in 50% Ethyl Alcohol), glycerin (10% aqueous), razor or sharp blade, forceps, needles, camel hair brush
- Compound microscope.

Procedure

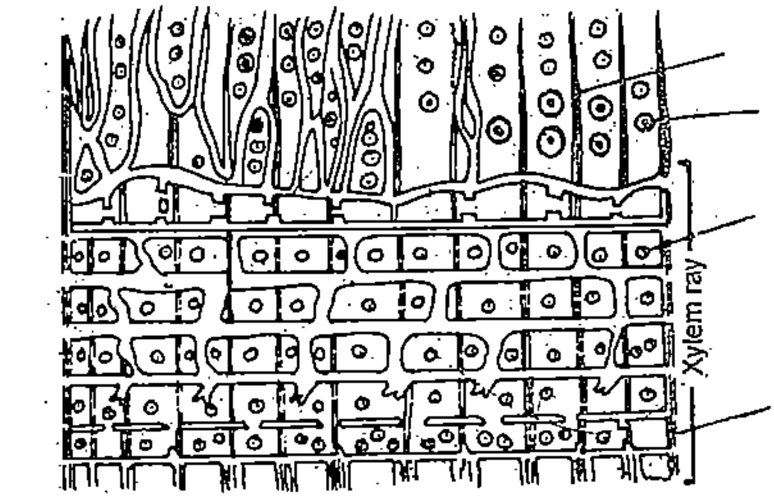
Take a piece of stem and remove bark from it. Hold the material in proper position and cut longitudinal sections. Sections along the periphery will give you TLS and those cut near the centre will give you RLS. Select a thin section trim it properly, stain in safranin and mount in glycerin. Observe the slide under the microscope, compare it with the diagrams and label the parts. If time does not permit, students can use permanent slides for this part of exercise.

Observations and Interpretations

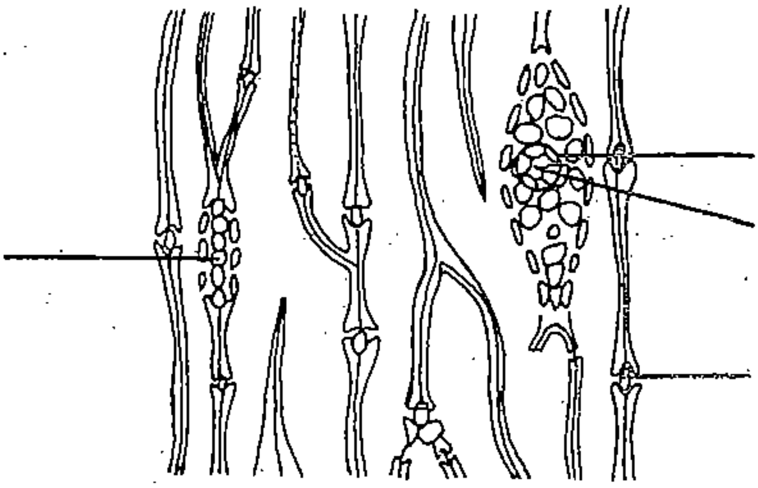
You can study RLS and TLS from the permanent slides.

- Observe and identify the uniseriate and multiseriate rays and label them in the diagram provided in Worksheet # 4.7.
- Observe, identify and label the bordered pits.
- Make a chart and write different things you observed in RLS and TLS.

Your Notes



R.L.S. of *Pinus* wood (A portion)
(label the diagram)



T.L.S. of *Pinus* wood (A portion)
(label the diagram)

4.3.4 T.S. of needle

1. The needle shows a complex internal structure.
2. In a cross-section the shape is like a tri-sector of a circle (*P. roxburghii*) with the curved surface facing outwards and the vertex inwards.
3. A single layered epidermis forms the outer boundary. Its cells are thick walled, lignified and are covered on the outside by a thick cuticle.
4. The deeply sunken stomata are present on all sides of needle i.e. amphistomatic.
5. Below the epidermis, one or more layers of sclerenchymatous hypodermis is present which is frequently interrupted by airspaces beneath the stomata.
6. Mesophyll tissue lies in between hypodermis and endodermis and shows no differentiation into palisade and spongy tissue. Its cells are peculiar in that their walls have numerous small infoldings which project into the cavities of the cells. These cells are thin walled and contain numerous chloroplasts. The mesophyll contains a number of resin ducts immediately under the hypodermis. The number varies in different species.
7. The central portion of the needle is occupied by a stele which is enclosed by a conspicuous endodermis which delimits the mesophyll. Its cells are large, oval with thickenings on the outer walls.
8. The pericycle follows the endodermis. In the centre vascular bundles are present which are disposed at an angle to each other. They are separated by band of sclerenchymatous tissue. Each bundle contains xylem and phloem. The phloem faces the curved or outer side and the xylem lies facing inwards i.e. towards pointed end. The vascular bundle is collateral.
9. On either side of vascular bundles are present special kind of cells which constitute the transfusion tissue. Embedded in the parenchymatous pericycle are richly cytoplasmic cells which abut upon phloem, and are called albuminous cells. The other types of cells are radially elongated and resemble the tracheids. These are known as tracheidal cells. (the transfusion tissue consists of parenchymatous, albuminous and tracheidal cells) and help in the lateral transfusion since veins are absent.

Materials Required

- Fixed material of *Pinus* needle
- Slides, coverslips, safranin stain (1% in 50% ethyl alcohol), glycerine (10% aqueous), Razor or sharp blade, forceps, needles, camel hair brush
- Compound microscope.

Procedure

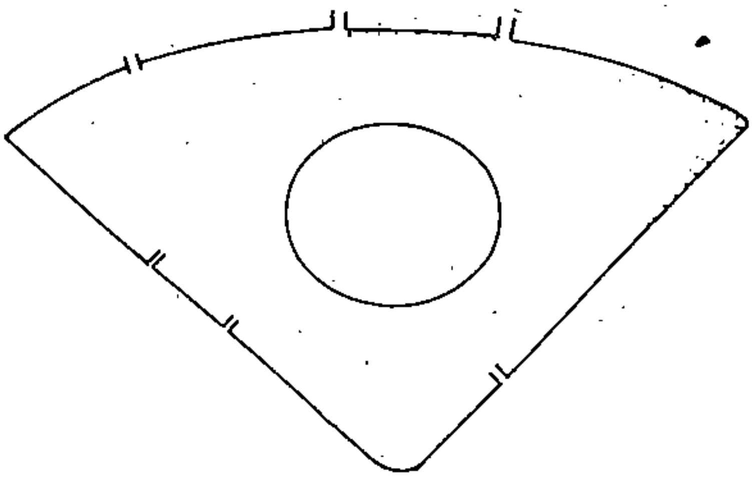
Place a piece (about 1-2 cm in length) of *Pinus* needle in the center of longitudinally slit pith (pith helps in holding the material straight) cut a transverse section, stain it in safranin and mount in glycerin after washing the excess stain in acid water. (Follow the instructions given in Exercise 1). Observe your preparation under the compound microscope, study the diagnostic features listed below and compare with your preparation and try to identify the different tissues. Complete the outline diagram and label it. The cellular diagram is drawn for you and you are required to label the different tissues and observe the focused, permanent slide of T.S. of the *Pinus* needle and try to see the above described features in the needle.

Observations and Interpretations

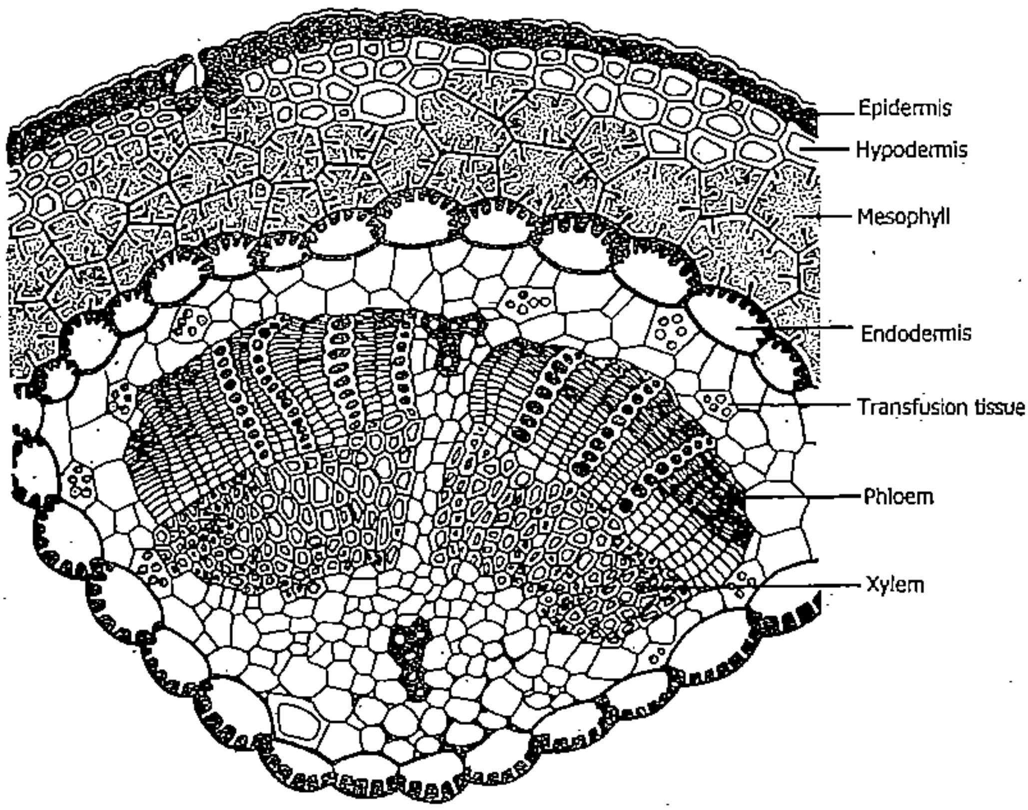
- Study the leaf section which you have prepared and stained.
- Identify the thick cuticle and sunken stomata each surrounded by a pair of guard cells.
- Also observe ordinary epidermal cells, mesophyll tissue and central vascular region with xylem and phloem and also transfusion tissue.
- Complete the cellular detail of the Fig. A in the Worksheet # 4.8.
- Label the parts of the Fig B in the Worksheet # 4.8.

Your Notes

Worksheet # 4.8: Needle



T.S. needle, diagrammatic representation (complete the diagram)



T.S. needle, cellular diagram (label the parts)

4.3.5 Pollen Grains

1. Each male cone produces a large number of pollen grains present inside microsporangium.
2. The pollen grains consists of a body or 'corpus' and two air sacs or 'sacci'. It has a single aperture or colpus at its distal end.
3. The microspore wall is differentiated into two layers, the exine and the intine. The exine consists of an outer sexine and an inner nexine. The sexine covers the spore along the proximal side only. The inner intine continuous whereas the outer intine is incomplete. The intine is thinner at germinal pore (distal end). The wings or sacci are separated from the body by the nexine. The saccus becomes beautifully marked by the formation of delicate irregular ridges over the entire inner surface.
4. The uninucleate microspore is the first cell of male gametophyte. The pollen grains are shed at four celled stage.

Materials Required

- Preserved material of male cones of *Pinus*
- Safranin, glycerin, coverslips, slides, watch glass, needles, forceps, camel hair brush
- Compound microscope.

Procedure

- Pick up few microsporophylls from the central portion of male cone with the help of forceps and transfer them on to a watch glass. Add a few drops of safranin and let them get stained. Wash the material with water taking care that the pollen grains does not wash off. You can use the brush for holding the material on watch glass. Now on a clean slide, put a drop of glycerin in the centre, transfer the stained microsporophylls along with microsporangia (two or three). With the help of needle rupture the microsporangia. You will notice that stained pollen grains oozes out. Remove the debris and carefully put the coverslip. Place the slide between the filter paper and gently press the coverslip and soak the extra fluid.
- Observe the slide under the compound microscope. If the time does not permit, kindly see the permanent slides.

Note: The smear preparation of pollen grains can also be prepared using acetocarmin stain.

Your Notes

Observations and Interpretations

1. Draw the different stages of microspores/pollen grains observed by you.

Uninucleate Microspores

Mature Pollen grain

2. Observe the wings/air sacs on pollen grain.
3. Do all the pollen grains have two air sacs.

....

4.3.6 Male cones and Microsporophyll

L.S. of male cone

1. The male cone is shortly stalked and consists of an elongated central axis, bearing a number of small spirally arranged and closely placed scale like microsporophylls.
2. Each microsporophyll takes its origin from the central axis, runs out horizontally to end in a sterile flattened head, the tip of which is turned up so as to fit over the microsporophyll above. The latter is attached to the central axis by a short stalk.
3. The microsporophyll bears two microsporangia on the lower (abaxial) surface.
4. In a mature microsporangium the epidermal cells become radially elongated and its tangential walls develop bands of thickening. The cells of the middle layers remain thin walled and degenerate when the microspores are mature.

5. The mature microsporangia are filled with numerous winged pollen grains.

T.S. of male cone

1. The T.S. of male cone shows central axis in cross-section.
2. A number of microsporophylls are attached to central axis and each microsporophyll shows two microsporangia.
3. You will observe similar stages of development of microsporangium as described above.

Requirements

- Compound microscope
- Binoculars or dissecting microscope
- Permanent slides of:
  - i. L.S. of male cone of *Pinus*.
  - ii. T.S. of male cone of *Pinus*.

Procedure

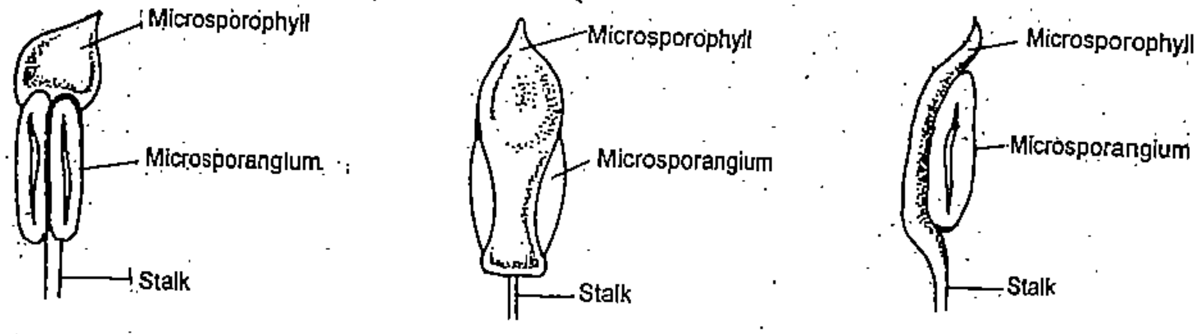
Focus the slide under low power of compound microscope. If the complete view of slide is not obtained you can use dissecting microscope to get a complete view of T.S. and L.S. of male cone. Draw labelled outline diagrams. Now focus the slide under compound microscope and under high power of microscope study the internal structure of microsporangium.

Observations and Interpretations

- Observe and identify the L.S. (longitudinal section) and T.S. (transverse section) of the male cone and label the diagram.
- Identify the strobilus axis, pollen sac wall and microspore mother cell under going meiosis.
- If you observe mature pollen, try to identify the two prothallial cells, generative cell and tube cell.
- Draw and complete the diagrams as indicated on Worksheet # 4.9.

Your Notes

Worksheet # 4.9: Male cones and microsporophyll

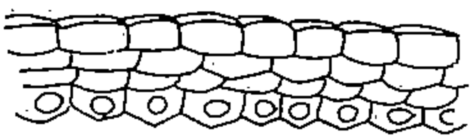


Dorsal view | Ventral view | Lateral view

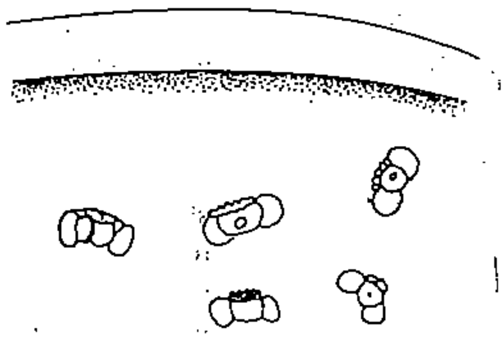
Dorsal, ventral and lateral views of microsporophyll showing both the microsporangia

L.S. of a Male cone
(Draw outline, labeled diagram of L.S. Male cone)

T.S. of a Male cone
(Draw outline, labeled diagram of T.S. Male cone)



L.S. of Microsporangium
(Complete the diagram from slide you observe)



T.S. of mature microsporangium
(Complete the diagram from slide you observe)

4.3.7 Female cone, ovule (megasporangium) and seed.

L.S. of young female cone

1. The young female cone is small, stands erect on short stalk and is covered with scales. It consists of a central axis which bears paired scales in a close spiral. The lower scale of the pair is small and directly attached to the cone axis and called as "bract scale". The upper scale of the pair is larger, thicker and stouter. It is the "ovuliferous scale". It develops from the upper surface of the bract scale and bears two ovules side by side on its upper (adaxial) side.
2. The bract scale is larger than the ovuliferous scale before pollination, but later it grows bigger than the bract scale. The ovuliferous scale is woody and wedge-shaped with its broader sterile end, the apophysis directed outwards.

Seed-Scale-Complex

The two scales, i.e., bract scale and ovuliferous scale bearing ovules, together have been termed the seed-scale-complex.

L.S. of ovule

1. The ovule is orthotropous and unitegmic. The integument is free from the nucellus except at the chalazal end. It encloses the nucellus completely leaving only a narrow passage, the micropyle at the top. The single integument differentiated into three layers: (a) outer fleshy (b) middle stony, and (c) inner fleshy layer.
2. At about the time of pollination, megaspore mother cell differentiates. It undergoes reduction division and forms a linear row of 4 megaspores. The chalazal megaspore undergoes free-nuclear divisions followed by wall formation and forms a massive female gametophyte.
3. The ovules from second year female cones show presence of archegonia. Towards the micropylar end of female gametophyte 2-4 archegonia develop.
4. Each archegonium consists of a short neck and a swollen venter. There are no neck canal cells. The venter contains the egg and the ventral canal cell which is ephemeral. The young archegonium is highly vacuolate. Later, the central cell undergoes rapid enlargement, cytoplasm becomes dense and at the time of fertilization the venter contains two types of inclusions: (i) the large inclusion (Proteid vacuoles) and (ii) small inclusions (para nuclei). There is a distinct jacket which surrounds the central cell. A well organised archegonial chamber is not formed.
5. *Pinus* shows both cleavage and simple polyembryony. During embryogeny number of embryos, with highly coiled suspensor can be seen. With further development, all these embryos degenerate and only one which is central in position attains maturity.
6. The mature embryo is polycotyledonous, and straight.

L.S. of seed

1. The seed consists of the hard testa, the papery tegmen, endosperm and the embryo with a nucellar cap at the micropylar end. (As the seed matures a thin layer of tissue from the upper surface of the ovuliferous scale separates as a membraneous wing which is attached to the testa and aids in seed dispersal)
2. There is the outer hard, stony seed coat, the *testa* which develops from the middle stony layer of integument.
3. Within the testa is a brown papery *tegmen* which surrounds the food laden female gametophyte or endosperm.
4. The nucellar tissue is invariably crushed except for a thin cap-like structure at the micropylar end of the endosperm, called the nucellar cap.
5. In the centre of the endosperm is a distinct central cavity in which lies the embryo.
6. The embryo consists of a short axis differentiated into the radicle towards the micropylar end, the hypocotyl forming a major portion below the cotyledons and the stem apex the epicotyl (plumule) which is surrounded by 8-13 cotyledons. The tip of the radicle is attached to the dried up suspensor.

Materials Required

- Compound microscope,
- Binoculars/dissecting microscope,
- Permanent slides of:
- L.S. of young female cone.
- V.S. through seed-scale-complex.
- L.S. of ovule at megaspore mother cell stage/female gametophyte stage.
- L.S. of ovule showing archegonia.
- L.S. of seed.

Option: Student can complete the study from the available slides.

Procedure

Focus the slides under the microscope, observe carefully, complete the diagrams, label the parts and write down the comments where indicated.

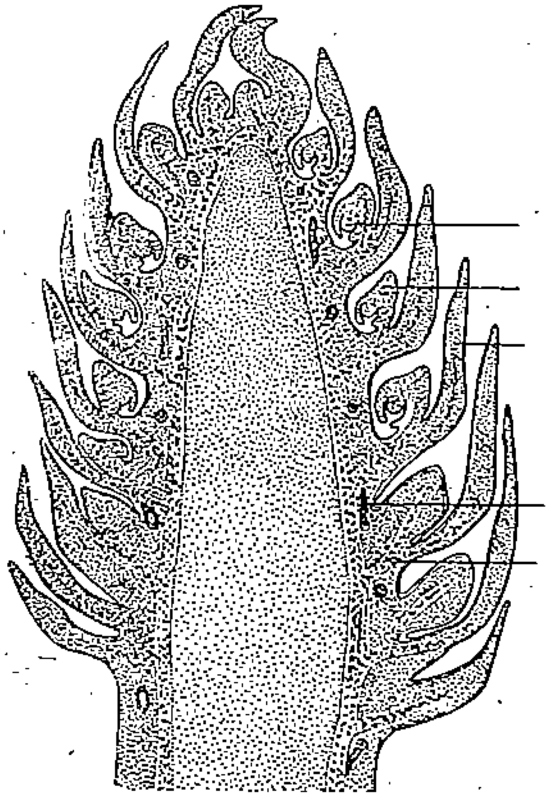
Observations and Interpretations

1. Observe, identify and draw the diagrams with the help of description given in the text on Worksheet #.
2. Ovule with a megaspore mother cell. Identify megastrobilus axis, ovule-bearing scale, and ovule, consisting of an integument, micropyle, megasporangium and a large megaspore mother cell.
3. Ovule with a young megagametophyte in the free-nuclear stage of development. Identify the integument and megasporangium, as well as the young gametophyte, in the free-nuclear stage of development, with a large space in the central portion.
4. Ovule with a mature megagametophyte. Using low power, identify the integument, micropyle, megasporangium and mature megagametophyte with portions of one or two archeonia at the micropylar end.

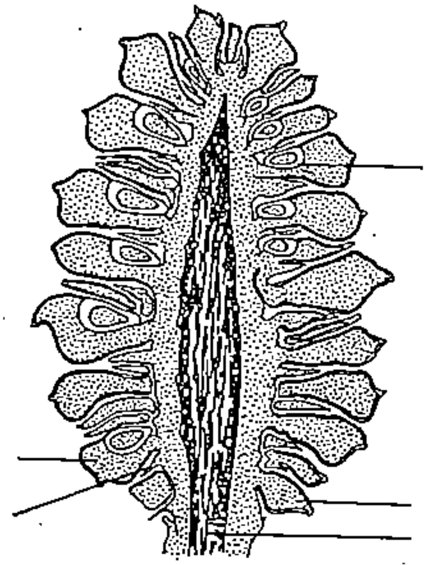
5. Immature seed. Identify the matured, enlarged megagametophyte containing a young embryo (proembryo). The young embryo is made up of suspensor cells and embryo-forming cells, which will develop into the embryo proper.
6. Mature seed. (The seed coat and what was left of the nucellus were removed before sectioning.) Find the mature embryo surrounded by the enlarged megagametophyte. Identify the parts of the embryo : radicle or first root (at the micropylar end), cotylendons or embryonal leaves, and the plumule (the first bud).

Your Notes

Worksheet # 4.10: Female cone and ovule

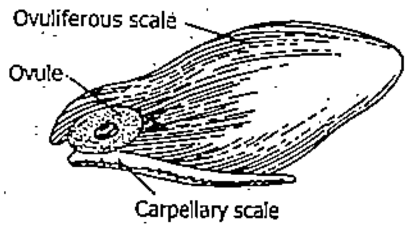


L.S. of young female cone
(label the diagram)

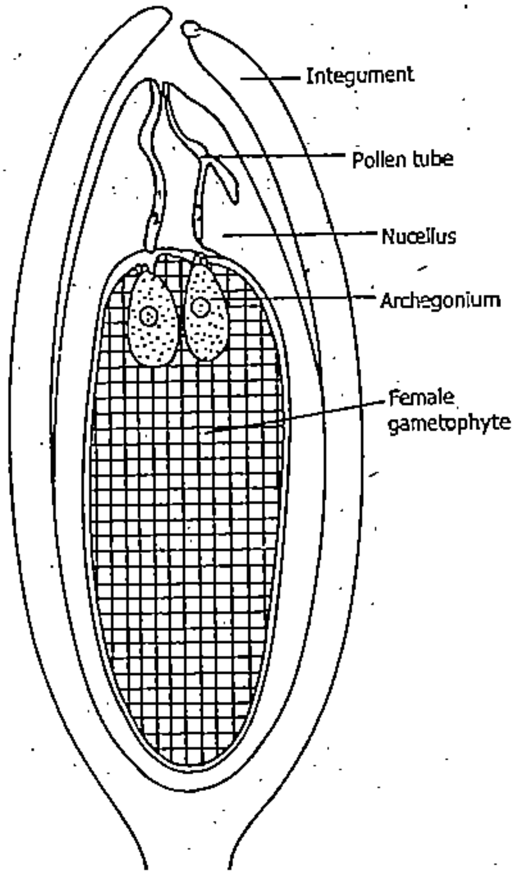


L.S. of mature female cone
(label it)

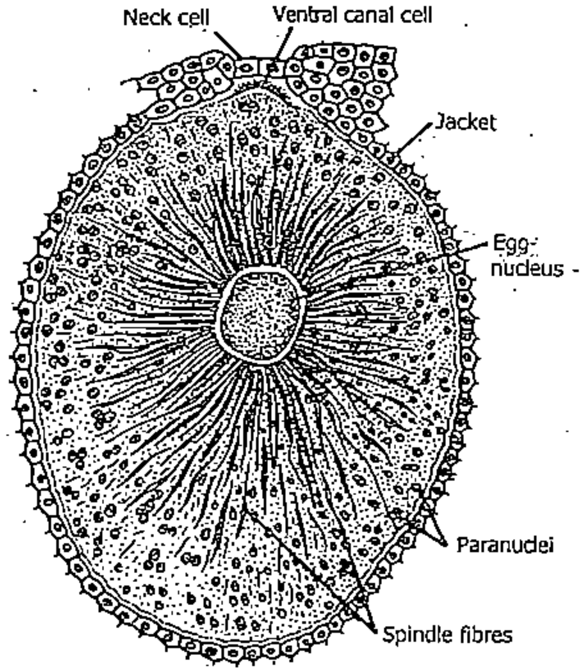
Draw L.S. of ovule with female gametophyte



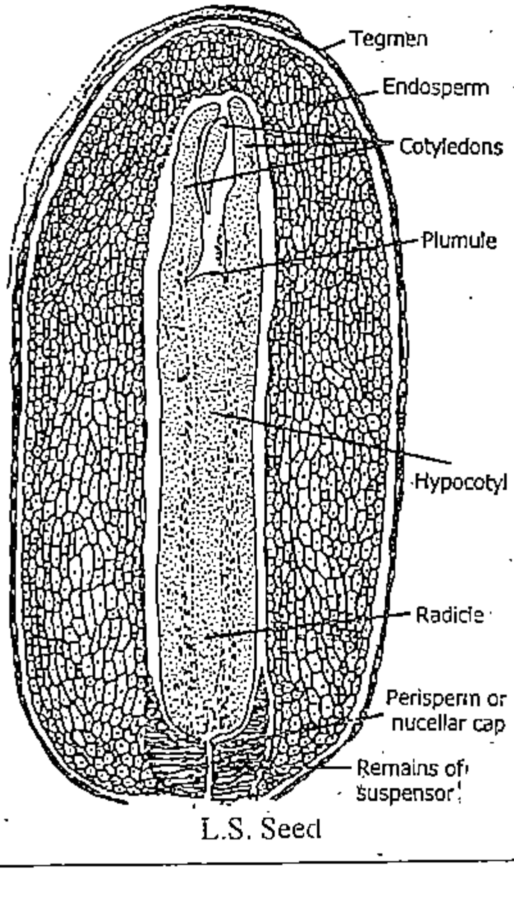
V.S. through seed scale – complex



L.S. of ovule showing Archegonia



A single archegonium enlarged



Draw W.M. of embryo

L.S. Seed

Your Notes

EXERCISE 5 *EPHEDRA*

Date: ....
Session #: ....
Time allocated: 1½ Hours

Structure **Page No.**

A thorough prior reading and work planning would be a good bet to accomplish the objectives of this exercise.

Check, are you wearing the lab coat? Right! Let's go on to do the exercise.

5.1 INTRODUCTION

Ephedra and *Gnetum* are the two representatives of Gnetopsida that you would study in this lab course, and the former would be the theme for this exercise. The approach and format would be the same as in the previous exercises. You might have well realised the advantages of refreshing the related theory details before the laboratory session. Continue this practice for this exercise as well!

Objectives

After completing this exercise, you should be able to:

- identify the sporophyte of *Ephedra*;
- differentiate an *Ephedra* plant from that of *Equisetum*;
- describe the morphological peculiarities in the following:
  stem, male strobilus, and female strobilus;
- diagrammatically depict, and describe the anatomical details of the following structures of *Ephedra*:
  stem, male strobilus, and female strobilus.

Study Guide

- Read the Sections 4A.2 to 4A.5 of the LSE-13 Course.
- To recall the details about the structure of *Equisetum*, refer to Block-4, Unit-16, Sub-section 16.5.6, of the LSE-12 Course;
- Give a quick reading to this exercise to get an idea of the work involved.
- Map out a time utilization plan for the allocated time frame of 90 minutes.

5.2 MORPHOLOGY

In this section, you would study the structural specificities of the plant body. No special equipment is required for the purpose except your focused attention.

5.2.1 Sporophyte

1. All the species of *Ephedra* are dioecious and bear male and female reproductive organs on separate plants. These plants do not show any difference in their vegetative organization and can be recognized as male or female plants only when their reproductive structures appear on them.
2. The stem is green (photosynthetic), hard, ribbed, glabrous and much-branched. It is distinctly jointed, slender and has long internodes.
3. The leaves are deciduous, opposite or whorled, more or less connate at the base and reduced to membranous sheaths at the top. Each node bears 3 to 4 leaves.
4. Each leaf is inervated by two unbranched veins that run parallel to each other.
5. The scale leaves bear a bud each in their axils. These axillary buds grow into branches.
6. The internodes grow by means of a basal or an intercalary meristem that is present at the base of each node.

Materials required

A vegetative twig from a museum/ herbarium specimen/ a live plant in nature.

Procedure

Observe the given specimen or the plant carefully and complete the given tasks in the Worksheet # 5.1.

Observations and Interpretations

Observe the plant carefully, and note its morphological peculiarities. Specially pay attention on the details that differentiate it from *Equisetum*. You would require these points for SAQ-1. Three tasks based on these observations are to be completed in the Worksheet # 5.1. First is the classification, then drawing a portion of the ridges found on the internodes, the arrangement of leaves and the branching pattern. Lastly, write the description in the space provided. Some leads for the writing the details are given in the Worksheet # 5.1.

Your Notes

Diagram space

Classification

Class: ....

Order: ....

Family: ....

Genus: ....

Q.1: Complete the classification details of *Ephedra*.

Q.2: Draw a twig of *Ephedra* (in the above diagram space). Enlarge a portion between its two nodes to show the ridges on the stem. Also depict the branching pattern, and arrangement of the leaves. Label the different parts.

Description Box

Height: ....

Habit: ....

Branches: colour - ...., internodes - .... erect or trailing?

Leaves: arrangement - ...., what is in the axil? ....

other feature(s) - ....

Sporophyte: monoecious or dioecious, and other details - ....

....

Xeromorphic features: ....

....

....

Q.3: Write the diagnostic features of its sporophyte as per the leads given above.

5.2.2 Male strobilus

1. The male or microsporiangiate strobilus is a compound structure.
2. Each strobilus arises in the axil of scale leaf present at the node of branches. The strobili arise in clusters and their number at the node depends upon the number of scale leaves.
3. The male strobilus consists of a central axis that bears two to eight pairs of decussately arranged, simple, broad and cupped *bracts*. The basal one or two pairs of these bracts are sterile, whereas each of the upper ones bears a solitary microsporangiate shoot in its axil. The shoot is continued into a short axis called *microsporangiophore* and bears at its base a pair of fused *bracteoles*. The microsporangiophore bears terminally 3-12 microsporangia that are sessile and they dehisce terminally. This strobilus is called as *simple male strobilus*, and the *compound male strobilus* consists of many simple strobili. The microsporangiophore bearing 3-12 sessile, bilobed microsporangia, and is also termed as male flower.
4. At maturity the microsporangia grow out of the bracteoles and are seen externally.

Material required

Museum or herbarium specimen of a twig bearing male strobili.

Procedure

Observe and study the specimen, draw the diagrams, label and write down the comments as instructed in Worksheet # 5.2.

Observations and Interpretations

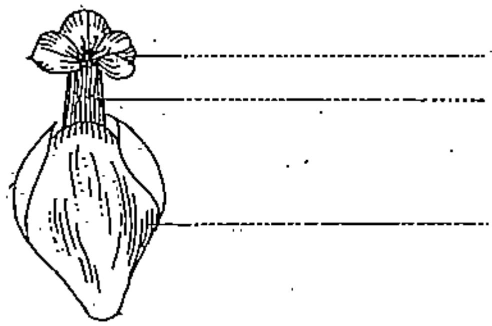
In the light of the above mentioned points, observe the twig bearing male strobili. Pay attention to the arrangement of the strobili. Draw a part of the twig with male strobili in the diagram space. Label the parts in the given figure of the male fertile shoot. Write the diagnostic features of the above mentioned structures, in the description space.

Your Notes

Worksheet # 5.2: Morphological study of the male strobili.

Diagram space

Q.1: Draw a twig bearing male strobili, depicting their arrangement.



Q.2: Label the different parts of a fertile male shoot (as seen after dissecting the male strobilus) in the above diagram.

Description space

Q.3: Write the salient features of the given twig bearing male strobili.

5.2.3 Female strobilus

Having studied the male strobili bearing shoot, you would now oberve closely the female strobili bearing shoot. Its diagram is given in the Worksheet # 5.3.

Materials required

Museum/herbarium specimen of a twig bearing female strobili.

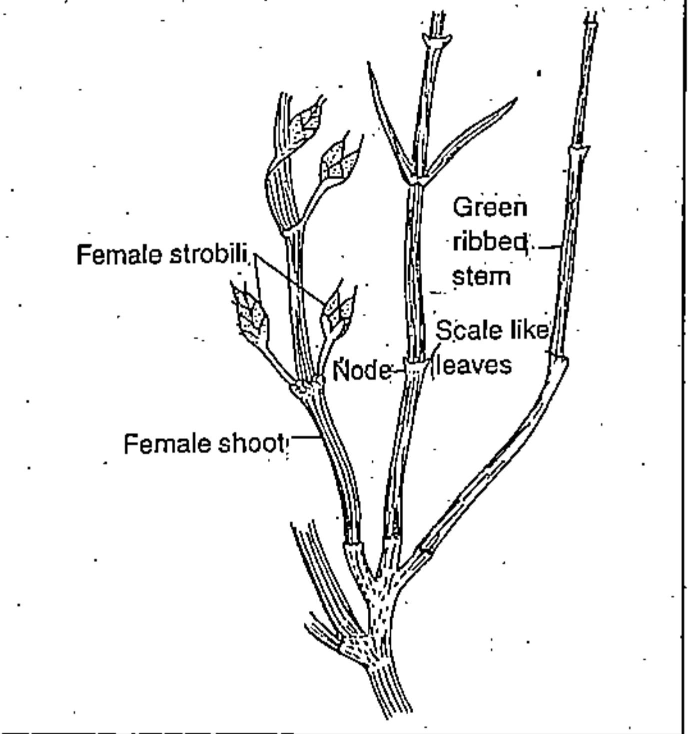
Procedure

Observe the specimen, and the two illustrations given in the Worksheet # 5.3. Write comments as instructed in the Worksheet # 5.3.

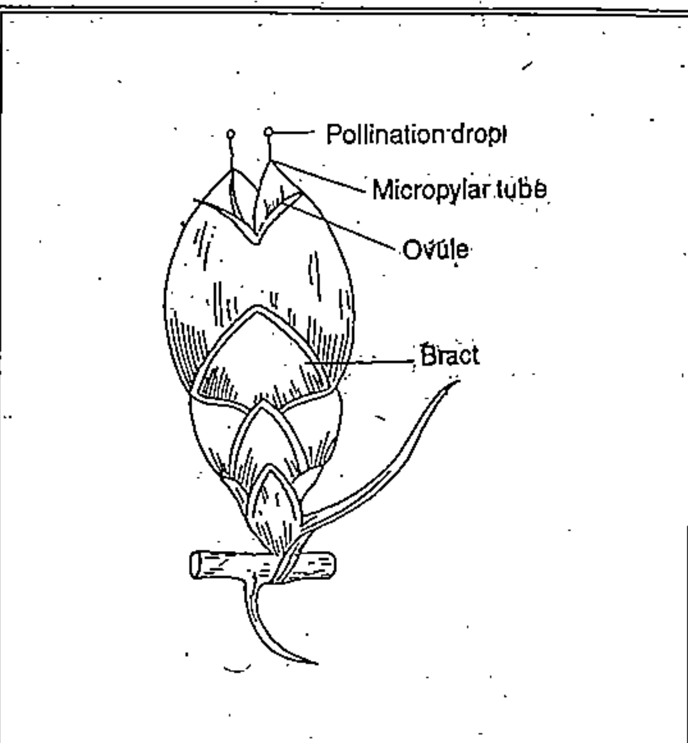
Observations and Interpretations

Observe the given specimen carefully. Learn to differentiate the male and the female strobilus. Write the diagnostic features in the description space.

Your Notes



A twig bearing leaves and female strobili.



A female strobilus in an enlarged view.

Description space

Q.1: Write the diagnostic features of female strobili-bearning twig, and a female strobilus.

5.3 ANATOMY

In this part of the exercise, our focus would be on the anatomical details of the plant. This means we have to have access to the inside of the plant body. And being a student of botany, you very well know about the techniques suitable for the purpose. Cutting sections in various planes and observing them under a compound microscope is the technique that is mainly employed for such studies. *Ephedra* presents interesting anatomical details that you would see for yourself in the sections that you may cut. If time is a constraint, you may use the already prepared or the permanent slides for your observations.

5.3.1 Stem

You would be studying both a young and a mature stem showing secondary growth. The salient features of stem in both the above stages are given below:

T.s. of stem (young)

1. A transverse section of a young stem has a circular outline with ridges and furrows.
2. The epidermis is made up a single layer of nearly rectangular parenchymatous cells. It is covered with a thick cuticle. The continuity of the epidermis is interrupted by the stomata that are sunken and are located only in the furrows.
3. Hypodermis consists of patches of sclerenchymatous cells present below the ridges.
4. The cortex is differentiated into two zones. The outer chlorenchymatous cortex consists of elongated, palisade-like, loosely-arranged cells, enclosing intercellular spaces. Next to it is the parenchymatous cortex which is made up of oval or elliptical cells that also possess chloroplasts.
5. The innermost layer of the cortex differentiates as endodermis. The pericycle is not clearly defined.
6. Vascular region consists of a ring of conjoint, collateral, endarch and open vascular bundles. There are about 8-12 vascular bundles in the internodal region. There are alternate pairs of large and small bundles. Each small bundle supplies to a leaf at the upper node.
7. The xylem consists of tracheids, vessels and xylem parenchyma. The phloem consists of sieve cells, phloem parenchyma and albuminous cells.
8. The pith occupies the center of the stem and consists of parenchymatous cells:

T.s. of stem showing secondary growth.

1. The secondary growth is brought about by means of vascular cambium present in between the primary phloem and the primary xylem. The cambium forms a complete ring and starts forming secondary phloem towards outside, and secondary xylem towards inside.
2. The cambium has two types of cells – the ray initials and the fusiform initials.
3. The secondary xylem consists of vessels, tracheids and scanty amount of xylem parenchyma. Xylem fibers are absent. The vessels are with foraminate perforation plates.

4. The secondary wood is distinct as it is ring-porous. The *spring wood* abounds in vessels, whereas the *autumn wood* has only a few vessels and more tracheids. The vessels and tracheids have bordered pits that may be uniseriate in arrangement or may be irregularly scattered.
5. The secondary phloem is typically gymnospermous, consisting of sieve cells, phloem parenchyma and albuminous cells.
6. The pith becomes narrow and ultimately disappears in very old stems.
7. In older stems, the epidermis is replaced by the periderm.

Materials required

1. Preserved material of young and mature stems of *Ephedra*
   i) Slides
   ii) Coverslips
   iii) Safranin stain
   iv) Glycerine
   v) A razor or a sharp blade
   vi) A pair of forceps
   vii) A pair of mounted needles
   viii) Camel hair brush
   ix) Compound microscope

Or

2. Permanent slides of t.s. of a young and a mature stem showing secondary growth – if material is not available, or time is a constraint.

Procedure

Cut transverse sections of the given stems, stain them in safranin and mount in glycerine. Follow the instructions given in Exercise # 1. Observe your preparations or the permanent slides under the compound microscope. Draw an outline diagram of the young stem, label its various parts. Cellular diagram is drawn for you in the Worksheet # 5.4. After studying the diagnostic features, compare the cellular diagram with your preparation and label the different tissues composing the stem.

Be careful while using sharp blade/razor.

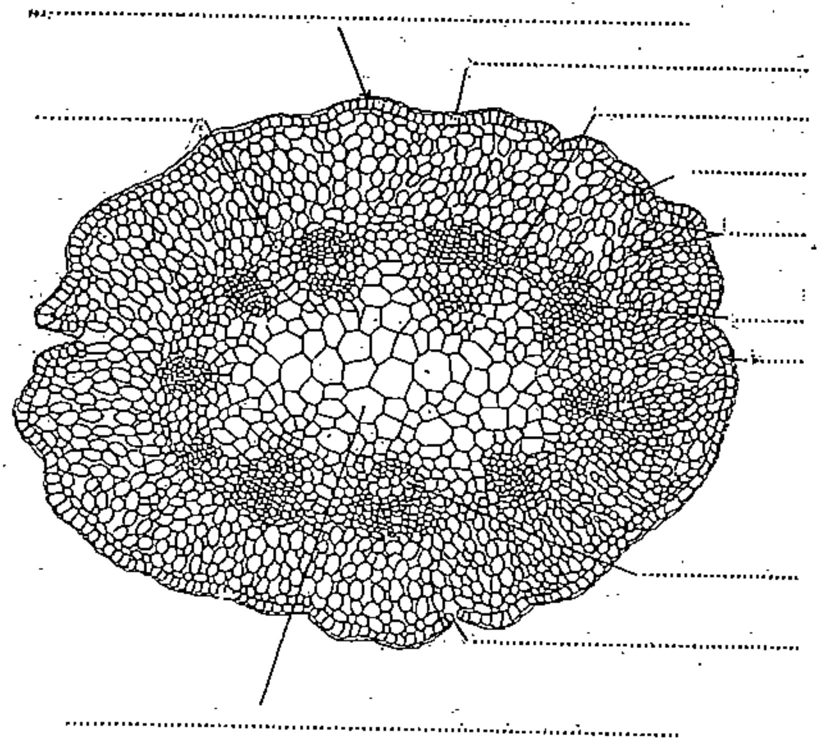
Observations and Interpretations

Young stem: After having clearly understood the above-mentioned features (discussed in Sub-section 5.3.1), observe the preparation and draw an outline diagram of the young stem, and label its different parts, in the Worksheet # 5.4. Next, label the various regions in the cellular diagram provided in the same worksheet. Write the salient points in the space provided.

Mature stem: As done for the young stem also have a clear understanding of the peculiarities of a mature stem, from the above-mentioned points (Sub-section 5.3.1). Then observe the preparation, focusing your attention on the types of cells, composing the different regions. i) Identify these regions and label them in the given cellular diagram in the Worksheet # 5.5. ii) Observe how the vessels look like in the t.s. Also note the important observation points in the worksheet.

Worksheet # 5.4: Anatomical study of a young stem.

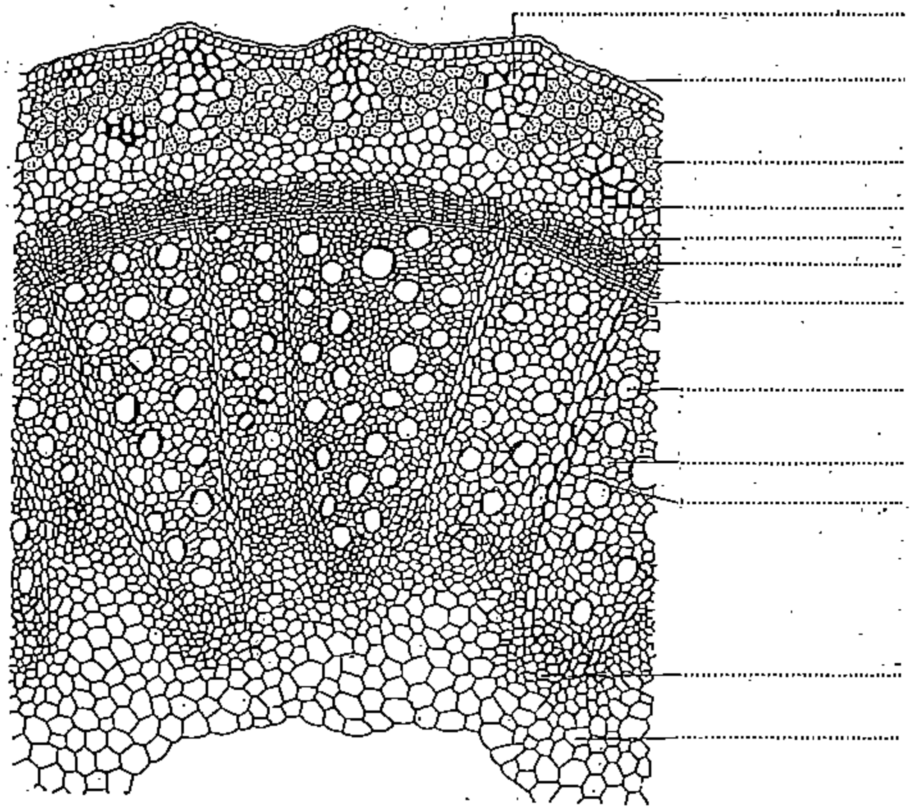
Diagram space	Description space
Q.1: Draw an outline diagram of t.s. young stem, and label its different parts.	**Q.2:** Write the diagnostic features of a young stem as seen in its transection.



Q.3: Label the different regions in the above cellular diagram of a young stem cut in t.s.

Diagram space

Q.4: Draw three or four vessels from your slide of t.s. stem.



Q.1: Label the different parts in the above diagram of transection of an old stem showing secondary growth (a cellular sector shown here).

Description space

Q.2: Write the diagnostic anatomical details of a mature stem.

5.3.2 Male strobilus

L.S. of male strobilus

1. The male strobilus consists a central axis which bears a number of (2-12) opposite and decussately arranged bracts.
2. Each bract bears a microsporangiate shoot (male flower) in its axil, (except the lower most bract). This shoot has a short axis or microsporangiophore and bears at its base a pair of bracteoles.
3. The microsporangiphore bears 2-6 microsporaniga which are two or three-lobed.
4. At the earlier stages of development, each microsporangium gets divided into two groups by the appearance of a band of sterile cells and thus a single microsporangium becomes two chambered.
5. The wall of the microsporangium is three-layered, outer epidermis, middle layer and an inner tapetum. Inside is a mass of sporogenous tissue, which later differentiates into microspore mother cells. The latter undergo meiosis to produce microspores.
6. In a mature microsporangium, only the thick-walled epidermis persists and the other wall layers degenerate. The pollen grains are elliptical and the exine has parallel ridges.

Materials required

1. Permanent slides of:
   i) L.S. of male strobilus;
   ii) T.S. of microsporangium showing pollen grains.
2. Compound microscope

Procedure

Focus the slide under the microscope, observe and record your observations as instructed in the Worksheet # 5.6.

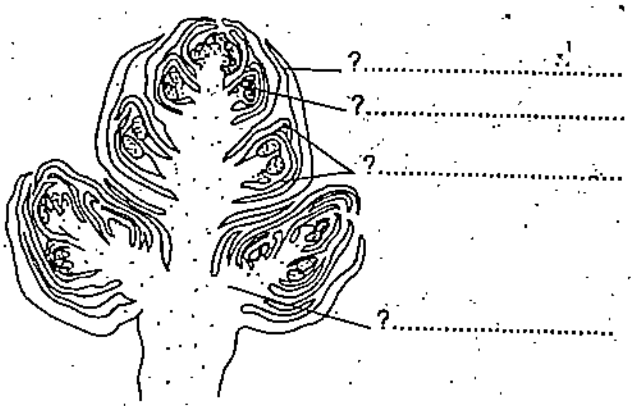
Observations and Interpretations

Observe the given permanent slides and label the figures a-c in Worksheet # 5.6. Keywords are also given. Use them appropriately for labelling the figures.

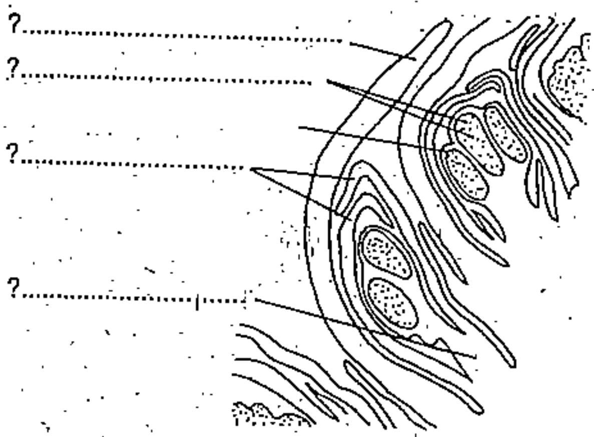
From the permanent slide of t.s. of microsporangium with pollen grains, draw its outline diagram making a part cellular to show the wall layers and the microspores in Worksheet # 5.7.

Your Notes

Worksheet # 5.6: Anatomical study of male strobilus.



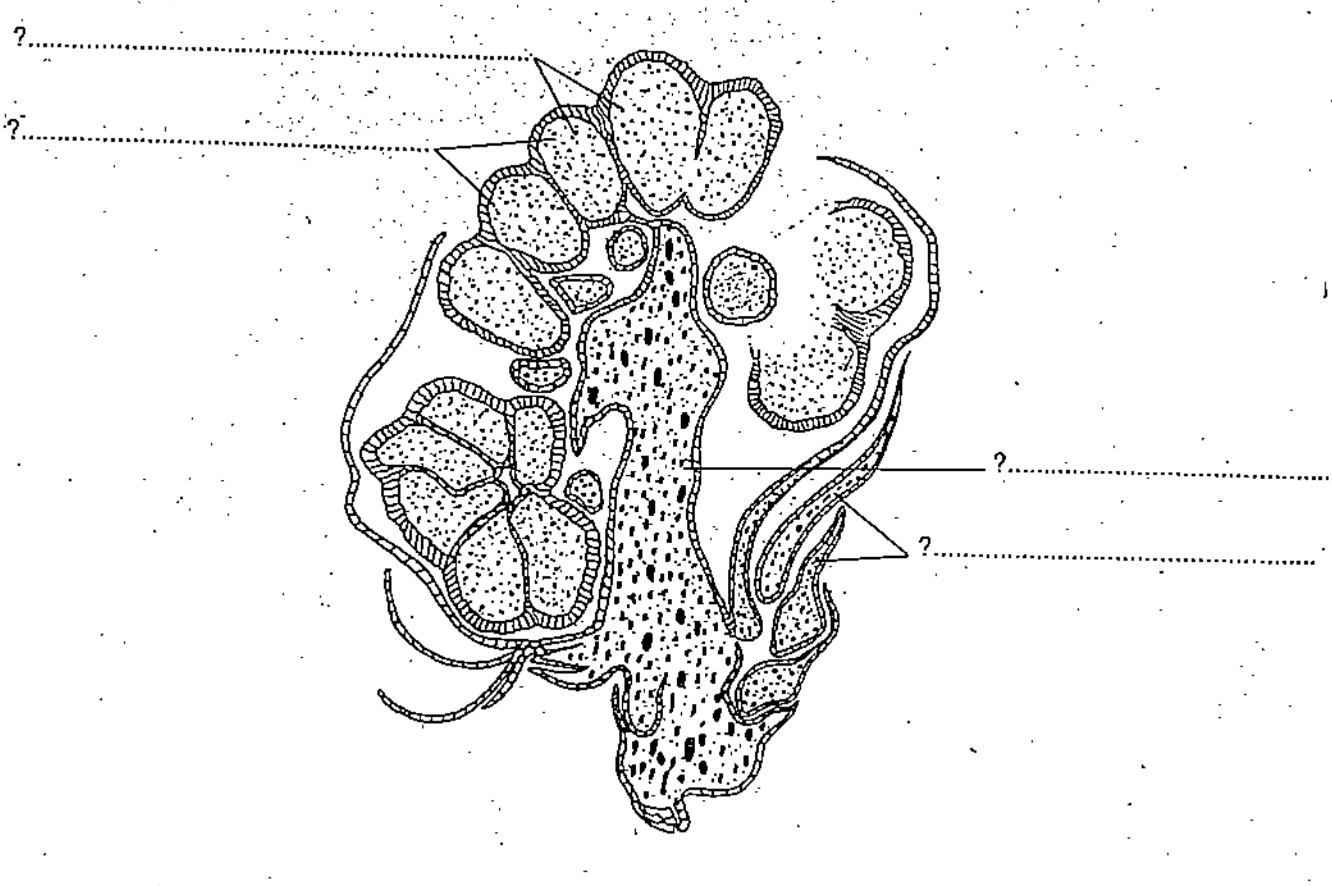
(a)



(b)

a, b) L.S. through the apex of male reproductive shoot showing microsporangiate strobili. Note each one is arising in the axil of a bract. Figure **b** shows an enlarged sector of **a**.

Q.1: Label the different parts in the above figures, particularly indicating the following features: bract, bracteole(s), sporangiophore, microsporangium, and microspores.



(c)

c) L.S. (off-median) male strobilus.

Q.2· Indicate the following regions in the figure: microspores, microsporangia, central axis, and bracts.

Diagram space	Diagram space
Q.1: Draw an outline diagram of l.s. microsporangium.	**Q.2:** Make a part cellular of the structure depicted in the outline diagram (left-hand). Draw an enlarged view of the wall layers of the microsporangium and also a few microspores.

Description Space

Q.3: Write the salient anatomical features of microsporangium and also the microspores.

Pollen grains

1. The pollen grains are elliptical or ovoid in shape, wingless and inaperturate.
2. The exine is thick with plicate surface and is provided with parallel ridges along the longer axis of the grain. The intine is smooth.
3. The nucleus of the uninucleate microspore is centrally located and it later moves to one end. It divides to form a small lenticular prothallial cell, and a large central cell. The latter again divides to form second prothallial cell and the large antheridial initial. The nucleus of the latter divides into an antheridial cell and a tube cell. The former divides by a perclinal wall into a stalk cell and a body cell. After some time, the prothallial cells start degenerating. At the 5-celled stage, the pollen grains are released.

Materials required

1. Preserved material of male strobilus of *Ephedra*
2. Acetocarmine
3. Glycerine
4. Coverslips
5. Slides
6. Watch-glass
7. A pair of mounted needles
8. A pair of foreceps
9. Camel hair brush
10. Filter papers
11. Compound microscope

Procedure

Pick up a few microsporangia from the male strobilus with the help of a forceps and tranfer them on to a watch glass. Add few drops of acetocarmine stain, let the microsporangia be stained, wash them to remove excess stain. Now take a clean slide, put a drop of glycerine in the center, and transfer the stained microsporangia on it. Rupture them with the help of needle and remove the debris. Carefully put the coverslip and place the slide between the filter papers and gently press the coverslip from the top with your thumb, and soak the extra fluid that oozes around the coverslip. Observe the slide under the compound microscope.

Observations and Interpretations

Observe and study the surface of the pollen grains, and note the morphology of the exine that has a distinct pattern of ridges and furrows. Draw the outline diagram of a pollen grain, depicting its exine morphology in the Worksheet # 5.8. Next, try to locate the nuclei of the pollen grains in your preparation. In case you are not successful, observe this in a permanent slide. Count and identify the different nuclei in the pollen grain. Depict them in the diagram space in the Worksheet # 5.8. Also, note down its salient features.

Diagram space

Q.1: Draw an outline diagram of a pollen grain to show its exine morphology.

Diagram space

Q.2: Draw the structures visible in the given developmental stage of the pollen grains. Identify these structures and label them in the figure.

Description Space

Q.3: Write the characteristic features of the pollen grains of *Ephedra*.

5.3.3 Female strobilus

L.S. of female strobilus

1. The female strobilus consists of a short axis to which four to seven pairs of opposite and decussate bracts are attached.
2. An ovule is present in the axil of each of the upper-most pair of bracts. Lower bracts are sterile.
3. The ovules are orthotropous, bitegmic and crassinucellate.
4. Each ovule consists of two envelopes or integuments. The inner integument is thin, grows at its tip into a long micropylar tube that projects through the apical opening of the outer integument. It is fused with the nucellus except in the upper region. The outer integument is thicker and is completely free from the inner integument.
5. The megaspore mother cell is differentiated in the center of the nucellus, it enlarges and divides meiotically to from a linear tetrad. The lower-most cell of the tetrad is functional (monosporic development).
6. The functional megaspore divides and redivides and forms a massive female gametophyte (free-nuclear divisions followed by wall formation through alveoli formation).
7. The cellular gametophyte can be demarcated into two zones, a broad micropylar zone and a narrow chalazal zone.
8. Three to four archegonia differentiate at the micropylar end of the female gametophyte. Each archegonium consists of a venter and a neck of 30-40 cells which merge with the female gametophyte. The nucleus of the central cell divides to form an ephemeral ventral canal nucleus and an egg nucleus.

Materials required

1. Permanent slides of:
   i) L.S. young female strobilus; and ii) l.s. ovule showing archegonia.
2. Compound microscope

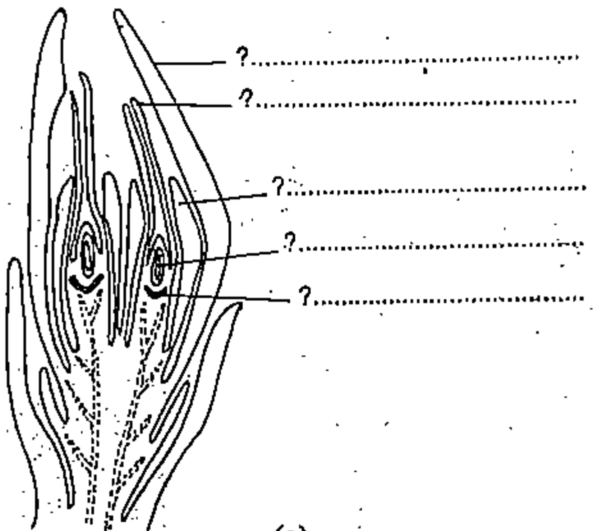
Procedure

Focus the slides under the microscope, observe them carefully, compare with the diagrams given in the Worksheet # 5.9. After reading the details given above, identify and label the different structures in the figures given in the worksheet. The keywords for labelling are given below the figures in the Worksheet # 5.9.

Observations and Interpretations

In the Worksheet # 5.9, three developmental stages of megasporangium are given. Note the placement of ovules in the strobilus. Observe the permanent slides corresponding to these stages. Note particularly the bitegmic condition, and the long neck of the archegonia. Compare the structures seen in the slide with the line drawings given in the Worksheet # 5.9. Label the marked areas. For your guidance and help, the keywords are given below the figures. Before you label a particular structure with a keyword, reason out in your mind first and write only after you are convinced.

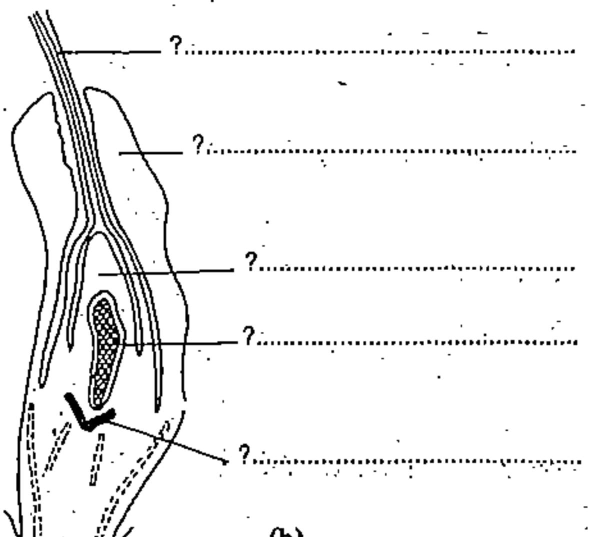
Worksheet # 5.9: Study of female strobilus.



(a)

a) L.s. female strobilus with ovules.

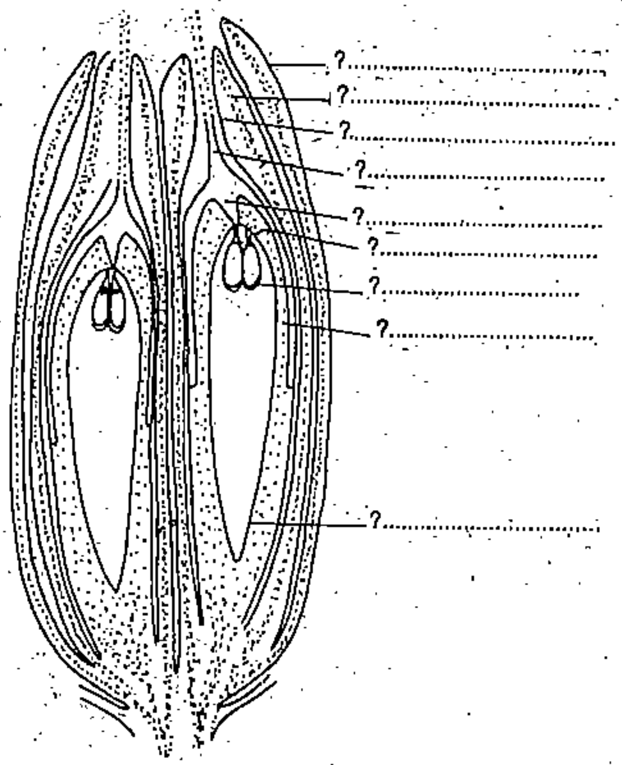
Q.1: Indicate the following structures in the figure: bract, inner envelope, outer envelope, female gametophyte, and hypostase.



(b)

b) L.s. ovule with cellular female gametophyte.

Q.2: Label the different parts of the figure with the following keywords: hypostase, nucellus, female gametophyte, outer envelope, and inner envelope.



Description space

c) L.s. of a female strobilus showing two well developed ovules each bearing two archegonia with long, prominent necks.

Q.3: By labelling, show the following parts in the figure: nucellus, female gametophyte, archegonium, neck cells, pollen chamber, micropylar tube, inner integument, outer envelope, and bract.

Q.4: Note the main points about the female strobilus and its structures in the description space.

Seed (in l.s.)

1. The seed contains a dicotyledonous embryo embedded in the tissue of female gametophyte (endosperm).
2. The seed coat consists of two distinct layers which are derived from the two integuments.
3. In a mature seed, the subtending bracts of the strobilus develop into a thick and fleshy layer as its third covering.

Materials required

1. Permanent slide of l.s. of seed
2. Dissecting microscope
3. Compound microscope

Procedure

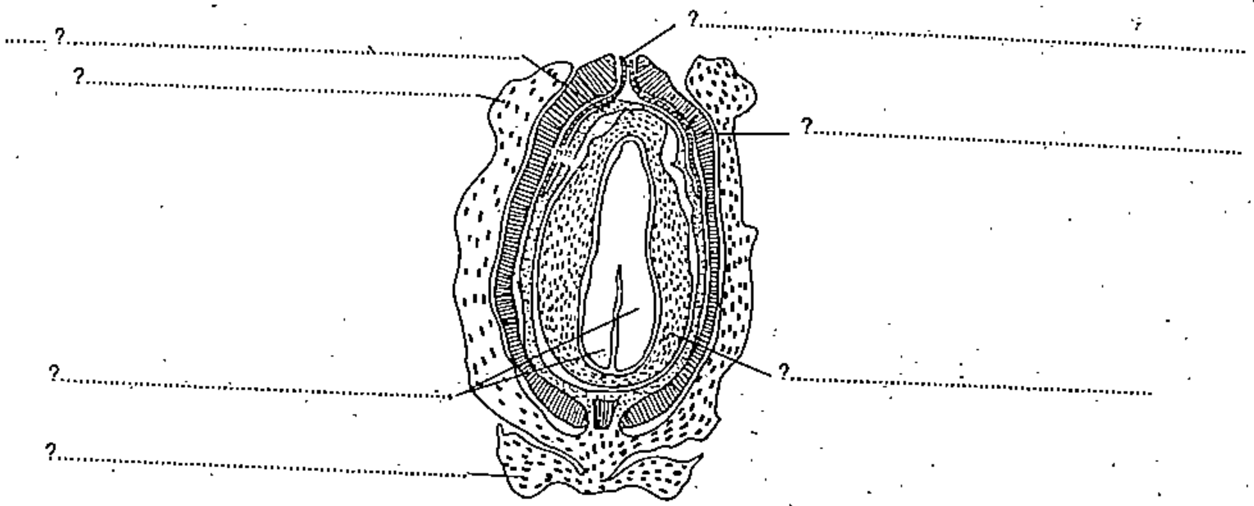
Focus the slide under the microscope and observe it carefully.

Observations and Interpretations

See the section first under the dissecting microscope. Try to identify its various parts as drawn in the given figure in the Worksheet # 5.10. Label the various parts. You can take the help of the keywords provided below the figure in the Worksheet # 5.10. Before labelling a particular structure, reason out in your mind as to why it is this one, and not anything else. Note down such points in the description space of the Worksheet # 5.10.

Your Notes

Worksheet # 5.10: Study of a seed.



Q.1: In the above outline diagram of l.s. of a seed, identify the following parts: outer integument, bract, inner integument, female gametophyte, nucellus, and colytedones.

Description space

Q.2: Write the characteristic features of a seed cut in l.s.

Worksheet # 5.11: Test your understanding of *Ephedra*.

SAQ 1

On the basis of which diagnostic features would you distinguish an *Ephedra* plant from that of *Equisetum*?

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SAQ 2

List the morphological and anatomical characteristic of the stem, on the basis of which you would deduce that *Ephedra* is a xerophyte?

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SAQ 3

What are the points that need to be attended to for making a good squash preparation of the pollen grains?

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(Cont.)

SAQ 4

Compare the anatomy of the stems of *Cycas*, *Pinus* and *Ephedra*. *Suggestion: Writing your points in a tabular form will enhance the clarity of your presentation.*

(Cont.)

SAQ 5

Differentiate the male strobilus of *Ephedra* from that of *Cycas* and *Pinus*. Present your points in a tabular form.

Your Notes

EXERCISE 6 *GNETUM*

Date ....
Session # ....
Time allocated –

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in lab.

Structure **Page No.**

6.1 INTRODUCTION

The Gnetales include only one genus the *Gnetum* – woody plants which are regarded to be highly evolved amongst the gymnosperms. They resemble the angiosperms in certain morphological and histological features. But some features like absence of an ovary, style, stigma and method of pollination are still gymnospermous.

Gnetum includes nearly 40 species which are found mostly in tropical and humid regions. An adult plant of *Gnetum* resembles a dicotyledonous angiosperm in appearance. In this exercise, you will observe the morphology and anatomy of sporophyte as well as gametophyte.

Objectives

After doing this exercise, you will be able to:

- identify and differentiate between vegetative and reproductive parts of *Gnetum*,
- describe the morphology of stem, leaves, male and female gametophyte,
- describe the anatomy of stem, leaves, and reproductive organs.

Study Guide

Read this exercise a day before you intend to do it.

- You should also study the Unit 4B *Gnetum*: it will help you to understand morphology and anatomy of *Gnetum*.
- Make the figure as you observe specimens and in the slides.
- Try to identify the various zones in T.S., L.S. or V.S. by yourself.
- If you find something interesting, report it to your counsellor.

6.2 MORPHOLOGY

6.2.1 Characteristic features of sporophyte of *Gnetum*

1. The adult sporophyte resembles a dicotyledonous angiosperm in appearance. It may be a small woody tree, or a woody climber, or a scandent shrub.
   Woody tree - *Gnetum gnemon*
   Woody climber - *G. latifolium, G. montanum, G. ula*
   Scandent shrub - *G. contractum*
2. Only woody climbers exhibit two types of branches, i.e., branches of unlimited growth and branches of limited growth. The shrubs and trees bear only one type of branches. Some species have articulate stem.
3. The shoots of unlimited growth are usually unbranched and bear 9 to 10 opposite decussately arranged leaves. The scale leaves occur only on long shoots.
4. The leaves are large, oval-shaped with reticulate venation and entire margin resembling a dicot leaf.
5. *Gnetum* is dioecious and bears male and female reproductive organs are borne on separate plants. These reproductive organs are organised into well defined strobili which are organised into inflorescences which occur as solitary or fasicled panicles in leaf axils of short branch.

Materials Required

- Museum/Herbarium or living specimens of *Gnetum.*
- A single twig with leaves.

Procedure

Study carefully the habit and morphology of *Gnetum* from video film/herbarium or living specimen and record your observations. Observe the museum/herbarium specimens, complete the diagrams, label them and write down the comments as instructed.

Observations and Interpretations

- Observe and record the
  i) the appearance of stem
  ....
  ii) types of branches
  ....
  iii) if scaly leaves are present or not
  ....
  iv) the shape of leaves, margin and venation
  ....
  v) presence of male and female reproductive organs.
  ....

- Work on the given Worksheet # 6.1 and draw the diagrams.
- Write diagnostic features of sporophyte.

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Your Notes

Worksheet # 6.1: Stem.

Class : ....

Order : ....

Family : ....

Genus : ....

Draw a diagram of branch with leaves

Draw a single leaf with venation and label it.

6.2.2 Twig with male cone (strobilus)

1. The stem is woody and branched. The branches are dimorphic only in the woody climber species.
2. The dwarf shoots are divided into nodes and internodes and bear foliage leaves in opposite decussate pairs. The number of leaves on a dwarf shoot may be 9 to 10.
3. The long shoots bear reduced and cup like pairs of scale leaves. The nodes are swollen and the branches become articulated in many species.
4. The leaves are subsessile or shortly petiolate. The shape of the lamina varies; it may be oblong, elliptical or even lanceolate. The lamina is traversed by a reticulate system of veins, has entire margin and acute apex.
5. The sporophyte bears male and female reproductive organs on separate plants which are organised into well defined strobili (loose cones).
6. These strobili are organised into well defined inflorescences which are usually panicles that arise singly or in fasicles in the leaf axils.
7. The cones arise in the axils of paired and decussate scale leaves which are fused at their bases. These are called bracts.
8. *Male strobilus* consists of an elongated axis, distinguishable into nodes and internodes. The internodes are short in young cones.
9. The nodes of the axis bear scaly bracts arranged in whorls. These bracts fuse together to form a cup-like structure called the cupule or the collar. The number of collars corresponds to the number of nodes on a cone axis. (number varies from 10-25).
10. Each collar bears above it three to six rings of male flowers, each ring possessing a number of male flowers, the male flowers in the rings are arranged alternately. Above the rings of male flowers there is one ring of abortive ovules.
11. The young male cone is completely enveloped within the basal bracts that are joined at base. Later the male cone grows and emerges out of the fused bracts.

Materials Required

- Herbarium or museum specimen of *Gnetum* twig with male strobilus.

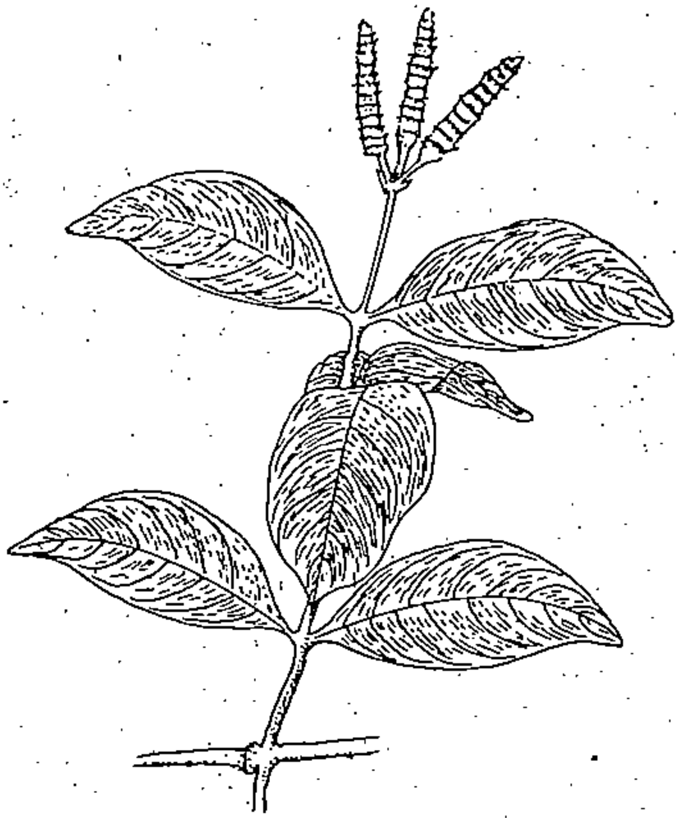
Procedure

Study carefully the twig with male strobili and complete the Worksheet #.

Observations and Interpretations

- Observe the characteristic shape of male strobilus.
- Identify the opposite pairs of bract.
- Observe the protruding microsporangia.
- Complete or draw the diagrams on the given Worksheet # 6.2.

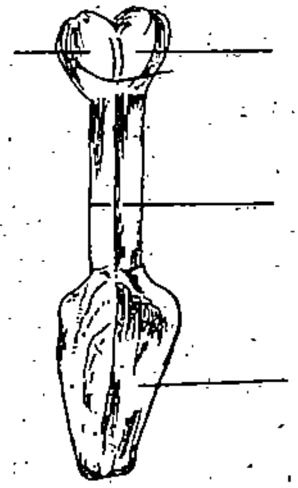
Worksheet # 6.2: Males cone.



A twig bearing a panicle of male cones.
(Label the diagram)

Male cone
(Complete the diagram)

Portion of male cone enlarged
(Label the diagram)



Male flower
(Label the diagram)

6.2.3 Twig with female cone (strobilus)

In young stage female strobilus looks similar to the male strobilus. As the strobili grow the distinguish becomes clear

1. in female strobilus this is a ring of four to ten female flowers (ovules) present above each collar
2. in the beginning all the ovules are alike but later only few grow to maturity
3. the upper few collars usually lack ovules and are sterile.

Materials Required

- Museum/Herbaruim or living specimen of *Gnetum* twig with female cone.

Procedure

Study carefully the twig with the help of diagrams provided and write your comments in the space provided to you.

Observations and Interpretations

- Observe and identify the characteristic shape of female cone. Identify the opposite pair of bracts.
- Write down comments on the twig with female cone with the help of diagrams given in Worksheet # 6.3 and museum or living specimens.

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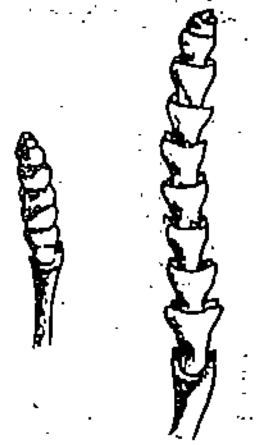
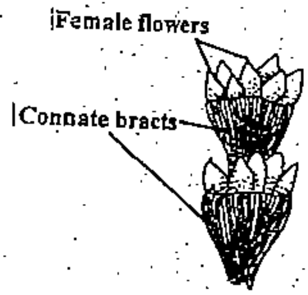
Worksheet # 6.3: Female cone

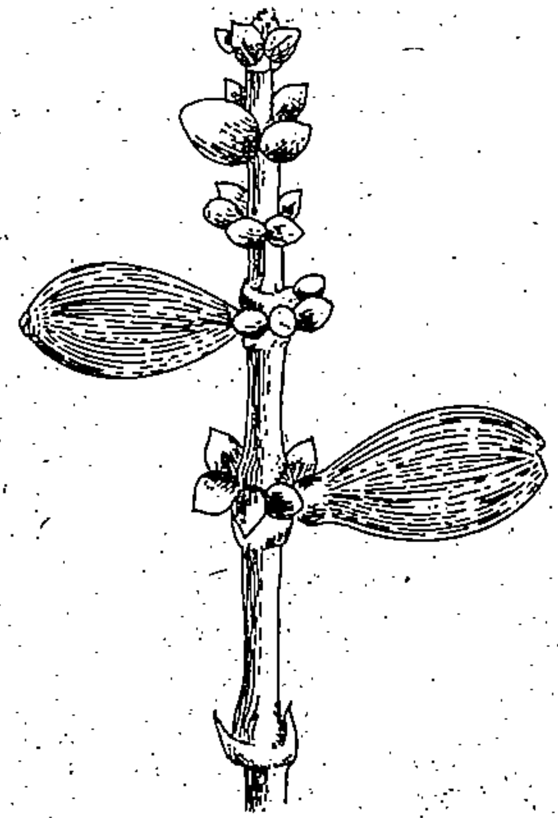
A twig bearing female cones



Young female cones



Portion of female cone enlarged



Female cone in which only two ovules have developed into seeds and rest have aborted.

6.3 ANATOMY

6.3.1 Stem

T.S. of young stem

1. A transverse section of the young stem presents a roughly circular outline.
2. The epidermis is covered by thick cuticle. It consists of single layer of rectangular cells and its continuity is interrupted by sunken stomata.
3. The cortex consists of three distinct regions: (a) the outer chlorenchymatous cortex made up of 5-7 layers of polygonal or rounded cells with small intercellular spaces, (b) middle parenchymatous cortex consists of few layers of thin walled compactly arranged cells which mainly store food materials, and (c) inner sclerenchymatous cortex that consists of 2 to 5 layers of thick walled cells, show branched as well as unbranched pit canals due to excessive thickness and are called as spicular cells or sclerotic cells.
4. The endodermis and pericycle are not distinct.
5. The vascular region consists of 20-24, conjoint, collateral, endarch and open vascular bundles, arranged in a ring. The xylem consists of tracheids and vessels. Xylem fibres are absent and xylem parenchyma is scanty or even absent. The phloem consists of sieve cells and phloem parenchyma.
6. The vascular bundles are separated by broad medullary rays.
7. The pith is extensive and parenchymatous.
8. Latcifer elements are seen in the pith as well as in cortex.

6.3.2 Stem with secondary growth

T.S. stem showing secondary growth.

1. The secondary growth in the trees and shrubs is of normal type. The cambium forms a complete ring and cuts off secondary xylem and secondary phloem in the usual manner. The ray initials form the secondary rays.
2. The secondary xylem consists of three types of elements – tracheids, xylem parenchyma and vessels.
3. The secondary phloem is composed of sieve cells and phloem parenchyma.
4. The vascular rays are broad.
5. The epidermis is replaced by periderm.
6. Latciferous cells are present in the cortex. The pith is narrow and may also contain latciferous cells.
7. **Anomalous secondary growth:** In the climbing species of *Gnetum* the secondary growth is normal in the beginning but, at later, successive rings of cambium distinguish in the deeper layers of cortex. The first ring of cambium stops functioning and the second ring appears outside it and produces a ring of secondary vascular elements separated by medullary rays into distinct bundles. It also stops functioning and the third cambial ring is formed external to the second and produces the third ring of vascular bundles. The process continues and successive rings of vascular bundles are formed. Sometimes, the successive rings are incomplete and result in the formation of ecentric rings.

Materials Required

Compound microscope, permanent slides of

- T.S. of young stem
- T.S. of stem showing secondary growth

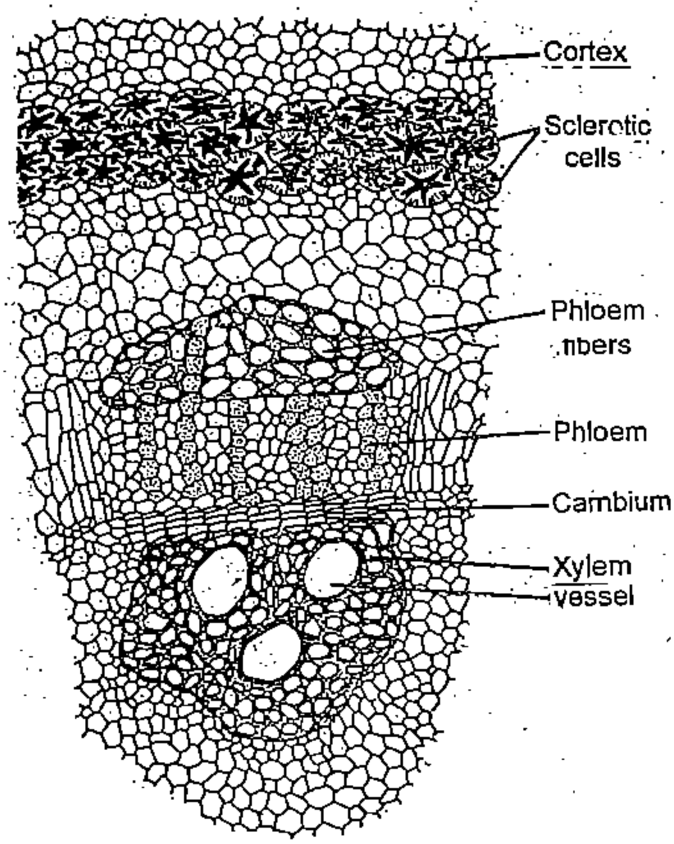
Procedure

Focus the slide under the microscope, observe it carefully. Diagnostic features are written for you. By comparing with the slide, complete the diagram and label the parts.

Observations and Interpretations

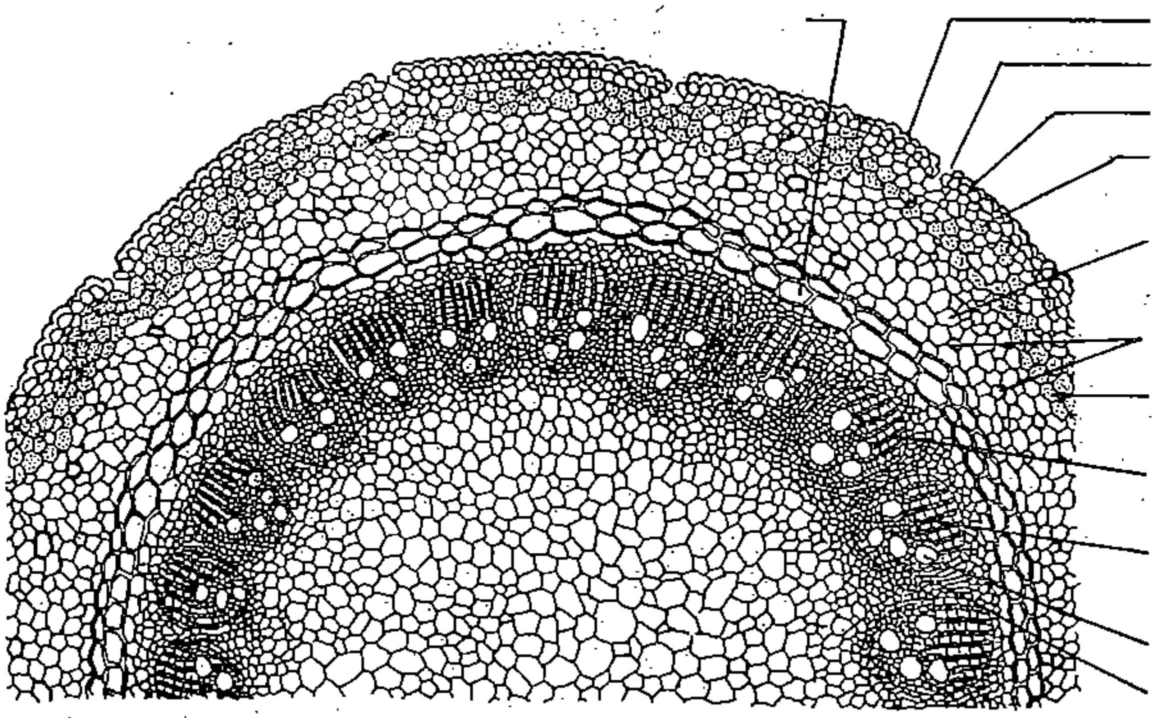
- Examine and identify stem of *Gnetum*.
- Identify cuticle, epidermal cells, stomata, cortex, primary and secondary xylem, primary and secondary phloem, vascular cambium, and pith.
- Label the diagram of young stem in the Worksheet # 6.4.
- Observe the single vascular bundle on the sheet and identify the zones.

Your Notes

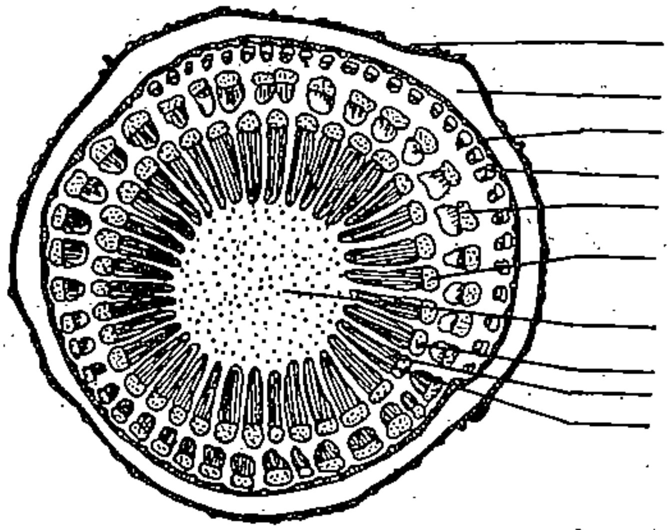


Draw the outline of young stem.

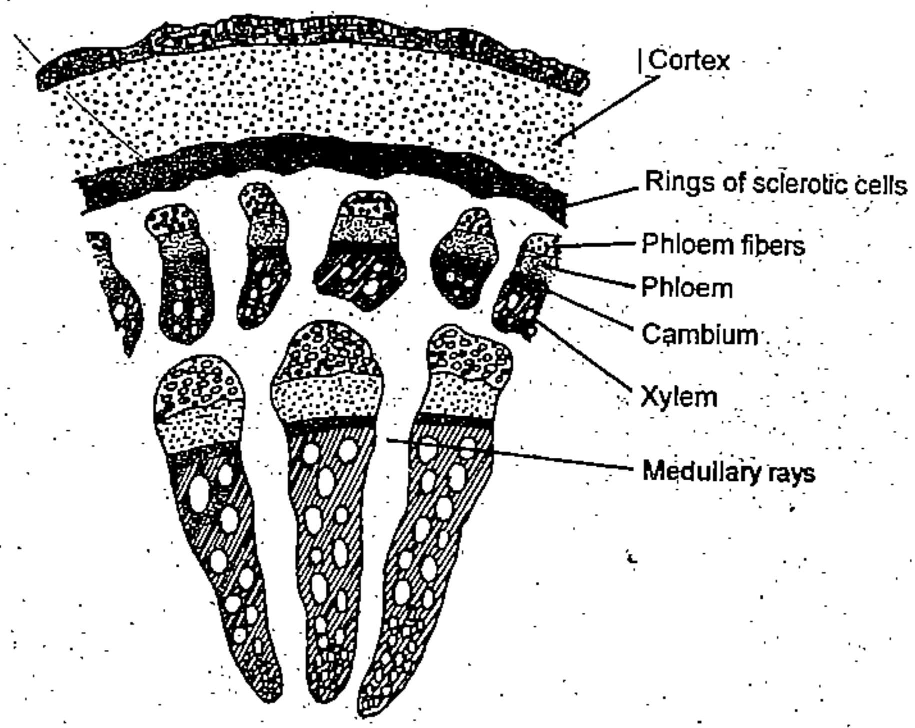
Cellular details on single vascular bundle.



T.S. of young stem showing primary structure, a portion.
(Label the given diagram)



T.S. of old stem showing abnormal
secondary growth (Diagrammatic label the parts)



Portion of stem that has undergone abnormal secondary growth.
It shows two rings of vascular bundles. (Cellular)

6.3.3 Leaf

V.S. of Leaf

1. The leaf is dorsiventral and consists of distinct upper and lower epidermis. The epidermal cells have undulated walls with a thick layer of cuticle.
2. The stomata are restricted to the lower epidermis (hypostomatic).
3. The mesophyll of the leaf is distinguished into palisade and spongy parenchyma. The palisade is composed of a single layer of elongated (columnar) cells that are full of chloroplasts. The spongy parenchyma consists of (a) Loosely arranged, lobed, thin walled, chloroplast containing cells that enclose large air spaces, (b) Stellate sclereids with thick and lignified walls, they are confined to a portion of the spongy parenchyma near the lower epidermis, (c) Scattered fibres with lignified walls occur in groups around the midrib regions and (d) Latex tubes found scattered around the midrib region. The spongy parenchyma cells around the midrib are compactly arranged.
4. The vascular region in the midrib consists of an arc of vascular bundles. The vascular bundles are conjoint, collateral. The phloem lies towards the lower epidermis whereas xylem faces the upper epidermis. The former consists of sieve cells and phloem parenchyma whereas the latter consists of tracheids, vessels and xylem parenchyma. Each bundle has a patch of thick walled cells capping the phloem and patches of thick walled cells are also present above the protoxylem.

Materials Required

- Compound microscope and permanent slides of V.S. leaf of *Gnetum.*

Procedure

Focus the slide under the microscope, observe it carefully. Diagnostic features are written for you. By comparing from the slide, complete the diagram and label the parts.

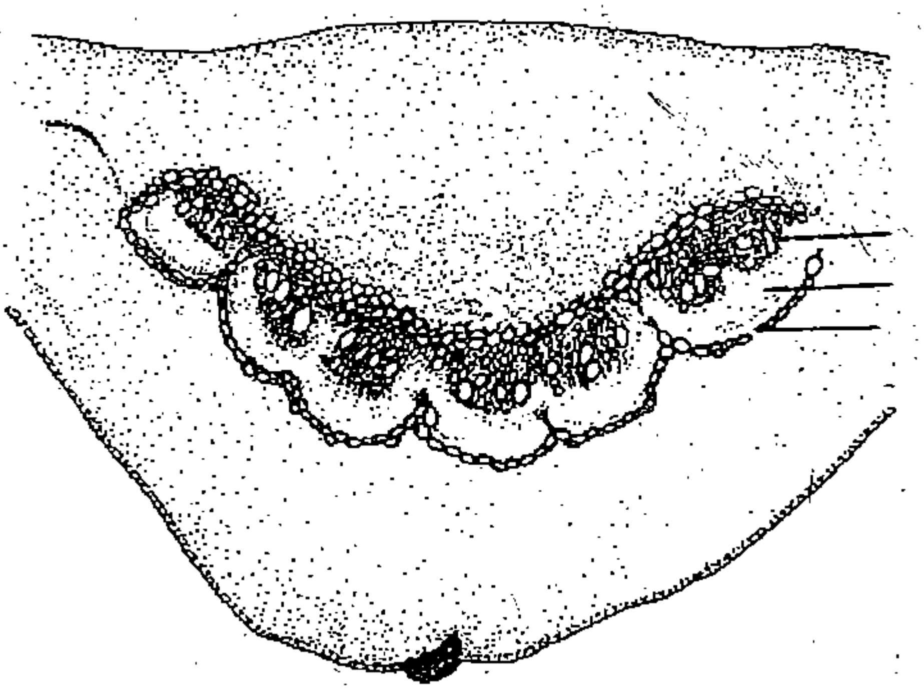
Observations and Interpretations

- Observe the leaf and identify the similarity of *Gnetum* leaf with dicot leaf.

Your Notes

Worksheet # 6.6: Leaf

Draw an outline of V.S. leaf and mark the various zones



V.S. of leaf, a portion (Label the diagram)

6.3.4 Male strobilus and microsporangium

L.S. of male

1. L.S. of male strobilus shows an elongated axis with fused nodal bracts forming collars at each node.
2. In each collar, there are three to six rings, the lower ones different into male flowers and the uppermost ring formed abortive ovules (female flowers).
3. The collars also contain sclereids of various shapes and sizes. Laticiferous tubes are also present in the collars and axis.
4. Each male flower has two unilocular microsporangia, borne on a stalk called antherophore, enclosed in a sheath of perianth. The antherophore elongates at maturity and the anthers come out of the perianth cover through a slit.
5. The male flowers are interspersed with uniseriate and multiseriate hairs.
6. The wall of young microsporangium is three layered: the epidermis, the middle layer (sometimes 2 middle layers) and the tapetum. When the microspores have completely developed, the tapetum and the wall layers have disorganised.
7. At maturity, the epidermal cells persist and their outer walls become thick and cutinised. They become radially elongated and fibrous bands of the thickenings arise from the inner tangential walls and run upwards and touch the outer wall.
8. The pollen grains are roughly spherical in shape, and are enveloped by a thick and spiny exine and a thin intine. The pollen are shed at three celled stage (prothallial cell, tube nucleus and spermatogenous cell).

Materials Required

Compound microscope, Permanent slides of

- L.S. of male strobilus
- L.S. of microsporangium showing pollen grains

Procedure

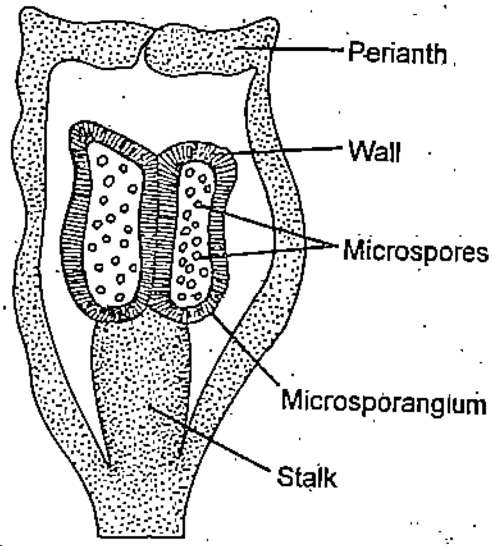
Focus the slides under the microscope, observe carefully and complete the diagrams with labelling. Focus a single microsporangium under high power of microscope to see detailed structure of microspores/pollen grains and draw the diagram.

Observations and Interpretations

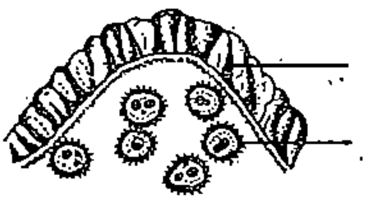
- Observe and identify the given material by detail description given in text and diagrams given on Worksheet # 6.7.
- Draw the L.S. of microsporophyll, observe in the axil of each bract a pair of bracteoles enclosing a microsporophyll.
- Examine pollen grains and notice their surface.

Worksheet # 6.7: Male strobilus

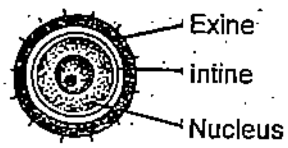
Draw L.S. of male strobilus (a portion)



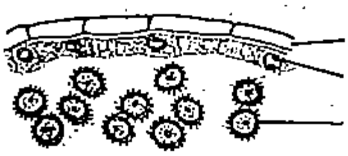
L.S. male flower



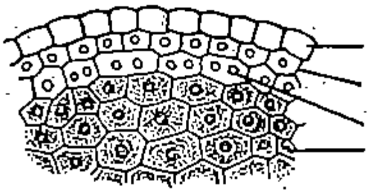
L.S. of microsporangium showing wall layers and sporogenous tissue (label it)



Uninucleate microspore



L.S. of microsporangium at uninucleate microspore stage (label it)



L.S. portion of mature microsporangium (label it)

Draw mature, three nucleate pollen grains (Shedding stage)

6.3.5 Female strobilus and megasporangium

L.S. of female strobilus

1. L.S. of female strobilus shows a ring of female flowers (ovules) above each collar. There is total absence of any male flowers.
2. Each ovule consists of central nucellus surrounded by three envelopes. The inner envelope grows beyond the middle one and forms a narrow and cylindrical tube called micropylar tube. The nucellus contains the female gametophyte.
3. Out of the three envelopes, the outermost is called the perianth, the middle is designated as the outer integument whereas the innermost is called the inner integument. The inner integument is fused with the nucellus in its lower part and free above.
4. Stomata, sclereids and laticiferous ducts are abundant in the outer two envelopes and are absent in the inner envelope.
5. The female gametophyte is tetrasporic in development. It is comparatively broader towards micropylar end and tapers towards the chalazal end. The free nuclei (as many as 256-1500 in number) are peripherally disposed with a big central vacuole. There is no wall formation in the upper part whereas the lower part becomes cellular.
6. There is no archegonia formation. Few enlarged nuclei of the female gametophyte act as eggs.
7. The seed consists of three envelopes. The outer enevelop is green in colour and becomes succulent. It is made up of parenchymatous cells and contains many sclereids and fibres scattered in it. The middle layer is stony and is the main protective covering of seed. Sclereids, fibres and latex tubes are present in this layer. The inner layer is made up of parenchymatous cells and lacks stomata, laticifers and sclereids. These enclose the massive endosperm in which lies embedded the dicotyledonous embryo. A hump appears in the embryo between the stem tip and the root tip; it enlarges and is called the feeder.

Requirements

Compound microscope, Permanent slides of:

- L.S. of young female strobilus
- L.S. of ovule
- L.S. of seed.

Procedure

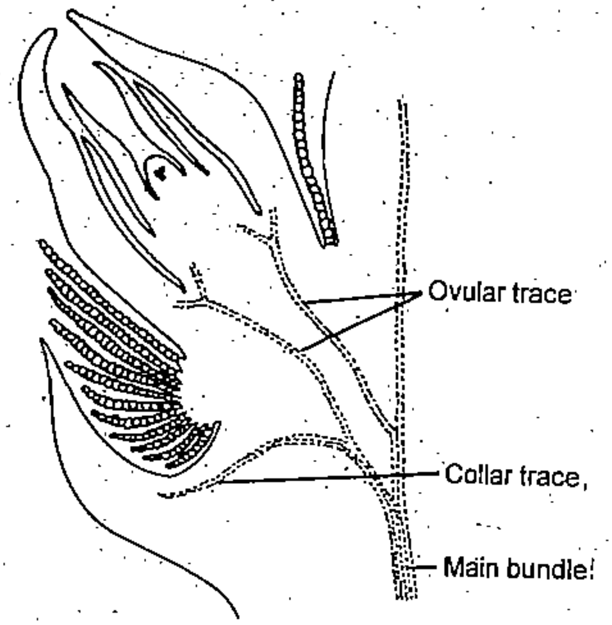
Focus the slides under the microscope and observe them. Diagnostic features are written, read them carefully. Identify the stage in the slide as seen by you and draw outline and label the diagrams.

Note: It is not essential to study all these slides. Students can do their study from available slides.

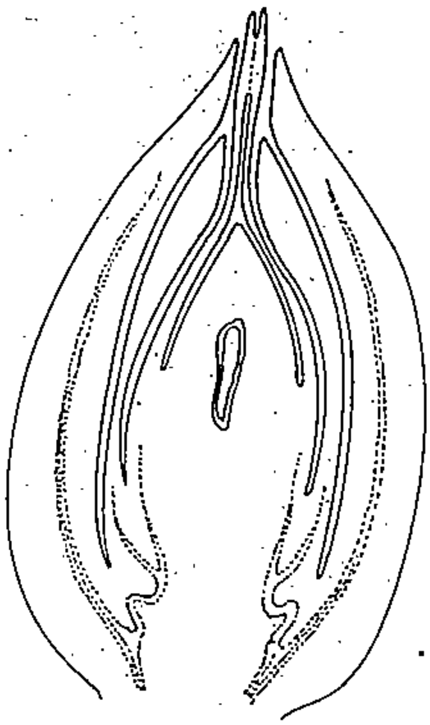
Observations and Interpretations

- With the help of the text and diagram identify, ovule, microsporangia and perianth. Also see the vascular traces, three envelopes, cellular nucellus and free nuclear portion of female gametophyte.
- Draw labelled diagram of seed on Worksheet # 6.8.

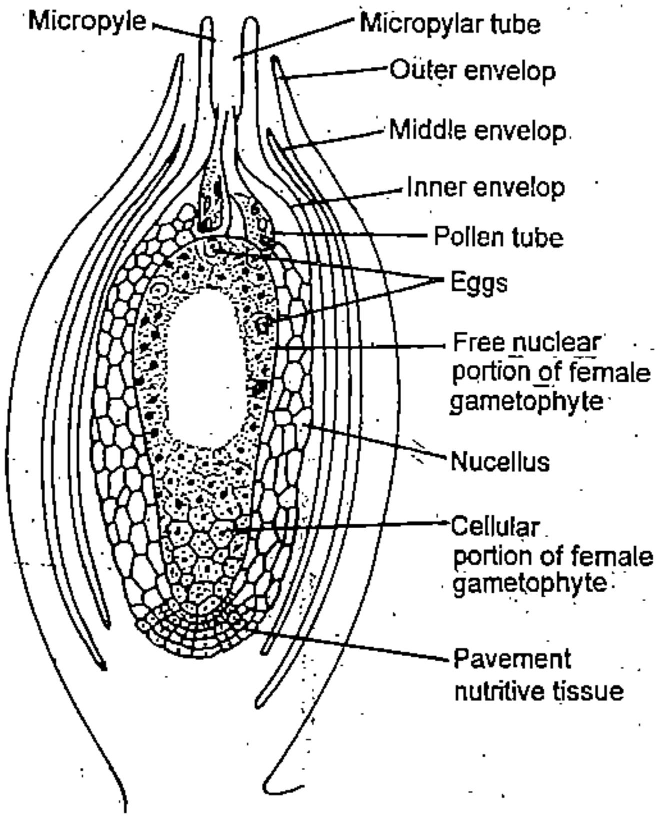
Your Notes



L.S. of female strobilus, (a portion)



L.S. of ovule showing three envelopes, nucellus and female gametophyte at free nuclear stage. (Label the diagram)



L.S. of ovule at the time of fertilization

Draw L.S. of seed and label it

SAQ

1. Give a comparative account of the leaf structure of *Pinus* and *Cycas*.

....

....

....

....

2. How can the xylem of *Gnetum* be distinguished from that of *Pinus*?

....

....

....

....

3. Name a Gymnosperm where archegonia are not found.

....

....

....

....

4. What is the difference between endosperm of Gymnosperms and Angiosperms?

....

....

....

....

5. Mention two common characters shared by all Gymnosperms.

....

....

....

....

6. Why are the fruits not formed in Gymnosperms?

....

....

....

....

EXERCISE 7 COMPARATIVE STUDY OF XYLEM ELEMENTS OF *PINUS*, *EPHEDRA*, AND *GNETUM*

Date ....

Session #........................

Time allocated - 1½ Hours

Structure **Page No.**

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in the lab.

7.1 INTRODUCTION

In the previous three exercises, you have studied in detail the gymnosperms – *Pinus, Ephedra* and *Gnetum* wherein you have seen the different elements of xylem in transectional view. From such sections, one cannot get any idea as to how the complete elements look like. In this exercise, you will study the structure of various xylem elements, from the macerated materials provided to you. The techniques for maceration have been explained in the first exercise. To recall, in maceration the separation of the cells of fixed material is done by treating the tissue with certain chemicals. The plus point of macerated material is that one can study the three-dimensional structure of an element, the individual cells, and even groups of cells.

Objectives

At the end of this exercise, you should be able to write a comparative account of the structure of xylem elements in the wood of the above mentioned three genera.

Study Guide

- Reading of this exercise before coming to the lab is strongly recommended. Figure 7.1 presents the morphological details of xylem elements like tracheids, vessel members and ray parenchyma of the above mentioned three genera.
- Brush up your memory regarding the xylem elements of these three genera by revising the related theory portions.
  For *Pinus*, see Subsection 3.3.2 on pp. 50-51;
  Ephedra – Subsection 4A.3.2, pp.70-72; and
  Gnetum – Subsection 4B.3.2, p.88.
- Make a prior work plan for the session.

7.2 THE XYLEM ELEMENTS

In this section, we shall briefly recapitulate the salient features of the xylem elements in context of the above three genera. These elements are illustrated in Fig. 7.1, and their explanations are given in the legend. Spend a few minutes studying the illustrations and explanations before you begin to work on the macerated materials.

Materials required

1. Macerated material of wood of *Pinus, Ephedra* and *Gnetum*
2. Compound microscope
3. Slides
4. Coverslips
5. Mounted needles
6. A pair of forceps
7. Droppers
8. Watch glass
9. Safranin stain
10. Glycerine

Procedure

Wash the macerated materials provided to you thoroughly with water by placing each one separately in a labelled (name of the source plant) watch-glass. Use droppers for drawing water during washing. Next, stain the material with safranin for 5 min. and wash the materials well in water until no stain oozes out. Take a clean, dry slide and place small piece of the stained material on it. Tease it out well with needles and mount in a drop of glycerine. Place a coverslip over it. In the same manner, prepare slides for the remaining two materials also. Label each of the slide indicating the material's name. Observe these slides under the compound microscope.

Observations and Interpretations

Observe the slides one by one, and study the structural features of the tracheids and/or the vessels in each of these three genera. The illustrations given in Fig. 7.1 would be helpful in your study. After having clearly perceived the differences in the xylem elements of the three genera, note down their diagnostic points, along with their outline diagrams in the Worksheets # 7.1 to 7.4.

Your Notes

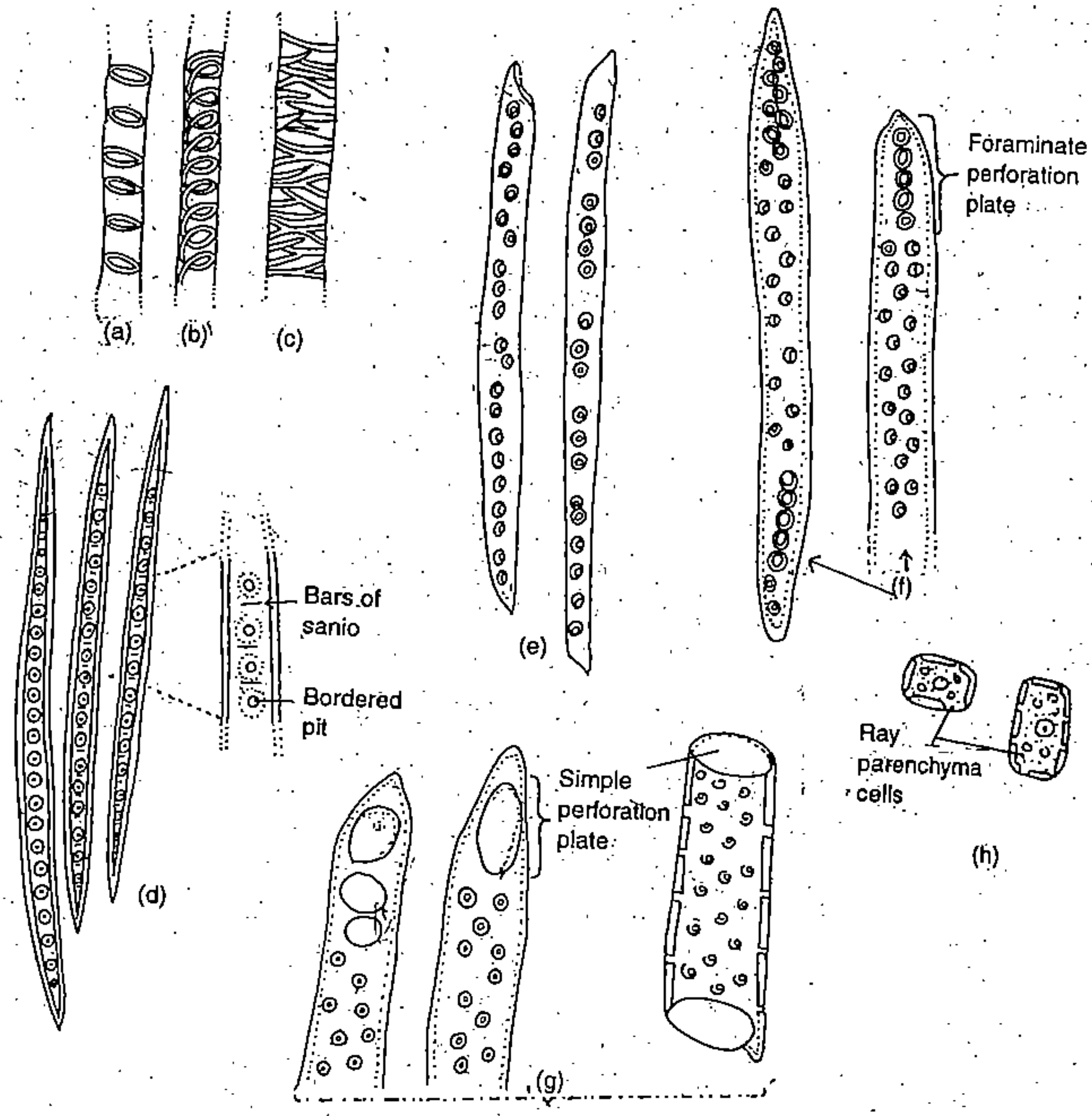


Fig. 7.1: The features of different xylem components:

a-c) Parts of tracheary elements showing annular (a), spiral (b), and reticulate (c) thickenings.

d) Tracheids having tapering ends and bordered pits. Bars of sanio are present between the bordered pits. These can be seen in *Pinus*.

e) Blunt-ended, long tracheids with bordered pits, e.g., *Ephedra*.

f) Vessels with bordered pits, and foraminate perforation plate at the tips, e.g., *Ephedra*.

g) Three vessel members, two incomplete (on left hand side) and one complete (on extreme right); showing simple perforation plates at the ends, e.g., *Gnetum*. Note the distribution of bordered pits.

h) Two ray parenchyma cells in transection showing pits on their walls.

Worksheet # 7.1: Comparison of xylem elements of *Pinus*, *Ephedra*, and *Gnetum*.
Xylem elements under study – 1. Tracheids.

Attribute	*Pinus*	*Ephedra*	*Gnetum*
i) Present / absent			
ii) Length			
iii) Type of ends – tapering / blunt			
iv) Type of thickenings – annular / spiral / reticular			
v) Pits – present / absent			
vi) Type of pit – simple / bordered			
vii) Location of pits – on tangential and/or radial walls			
viii) Arrangement of pits – uniseriate / random			
ix) Bars of Sanio – present / absent			
x) Any other feature(s)			

Diagram space

Note: Don't forget to write the name of the plant and its labelling for each of the illustrations.

Worksheet # 7.2: Comparison of xylem elements of *Pinus*, *Ephedra*, and *Gnetum*.
Xylem elements under study – 2. Vessels.

Attribute	*Pinus*	*Ephedra*	*Gnetum*
i) Present / absent			
ii) Perforation plate – foraminate / simple			
iii) Pit type – simple / bordered			
iv) Location of pits – on tangential and/or radial walls			
v) Any other feature(s)			

Diagram space

Note: Don't forget to write the name of the plant and its labelling for each of the illustrations.

Worksheet # 7.3: Comparison of xylem elements of *Pinus*, *Ephedra*, and *Gnetum*.
Xylem elements under study – 3. Xylem parenchyma.

Attribute	*Pinus*	*Ephedra*	*Gnetum*
i) Present / absent			
ii) Any other feature(s)			

Diagram space

Note: Don't forget to write the name of the plant and its labelling for each of the illustrations.

Worksheet # 7.4: Comparison of xylem elements of *Pinus*, *Ephedra*, and *Gnetum*.
Xylem elements under study – 4. Ray parenchyma.

Attribute	*Pinus*	*Ephedra*	*Gnetum*
i) Present / absent			
ii) Any other feature(s)			

Diagram space

Note: Don't forget to write the name of the plant and its labelling for each of the illustrations.

Your Notes

EXERCISE 8 ANATOMY OF ROOTS

Date ....
Session # ....
Time allocated –

Structure **Page No.**

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in the lab.

8.1 INTRODUCTION

The root is commonly described as that part of the plant which grows beneath the surface of the soil. The principal function of the root is to anchor the plant to the substratum and to absorb water and soluble minerals from the surrounding environment and to transport these substances to stem, leaves, flower and fruits. In this exercise, you will study about the anatomical details of monocot and dicot roots.

Objectives

After completing this exercise, you should be able to:

- identify and differentiate between dicot and monocot root,
- identify and observe the following features in the monocot root,
  - various tissue systems comprising the monocot root, viz. the epidermal, the ground and the vascular tissues.
  - unicellular hair in the epidermal layer.
  - large cortex and the pith.
  - the distinct endodermal cells along with its casparian strips.
  - polyarch radial arrangement of the vascular bundles bundle with exarch protoxylem elements.
- identify and observe the following features in the dicot root,
  - unicellular epidermal hair.
  - massive parenchymatous cortex.
  - the triarch/tetrarch (vascular bundles with radial arrangement of xylem and phloem)
  - exarch condition of protoxylem.
  - either insignificant or no pith.

Study Guide

Before coming to do this exercises read it and Unit-8 of Course LSE-13, section 8.2.2 properly. Root structure of this will immensely help you to understand the structure and differentiation between monocot and dicot root.

- Try to finish the exercise in the stipulated time.
- Try to draw the cellular diagrams as you observe them in microscope. Do not copy them from any book.
- Try to understand differences in monocot and dicot root structure.

Box 8.1: Key for Root and Stem identification.

Root

i) The cuticle is absent/insignificant.
ii) The epidermal hairs are unicellular.
iii) The cortex is parenchymatous.
iv) The endodermis is conspicuous with casparian thickenings.
v) The vascular bundles are radial and proto xylem exarch.

Dicot Root

i) Xylem poles/bundles vary from 2 to 6 (di-to hexarch), rarely more.
ii) Pith is small or absent.
iii) The cambium appears later.

Monocot Root

i) Xylem poles/bundles are numerous varying from (12 to 20) (polyarch), rarely limited in number.
ii) Pith is large and well developed.
iii) The cambium is absent.

Stem

i) Cuticle is present except in hydrophytes.
ii) The epidermal hairs are uni- or multicellular.
iii) The cortex is differentiated.
iv) The vascular bundles are conjoint, collateral and with endarch protoxylem.

Dicot Stem

i) The vascular bundles are conjoint, collateral and open (*i.e.,* cambium present).
ii) The vascular bundles are arranged in a ring; generally they are uniform in size.
iii) Cortex is well developed.
iv) Pith well developed.

Monocot Stem

i) The vascular bundles are conjoint, collateral and closed (i.e., cambium absent.
ii) Vascular bundles are many, scattered, and the larger bundles are towards the center and smaller towards periphery; usually each bundle is surrounded by a sclerenchymatous bundle sheath.
iii) The ground tissue is present; it extends from periphery to center; hypodermis usually is sclerenchymatous.
iv) Pith is absent.

8.2 ANATOMY OF DICOT ROOT

8.2.1 Roots of *Cicer* spp.

Anatomy of primary root of *Cicer* spp.

In T.S., the outline of the root is almost circular. The tissue arrangement is as follows:

1. A single row of thin-walled, outermost layer of cells constitute epidermis/epiblema.
2. The several cell layers lying between the epidermis and the endodermis constitute the cortex or, the ground tissue. These cells are parenchymatous, with very prominent intercellular spaces in between them. The exodermis, may be differentiated in older region of the root axis.
3. The innermost cell layer of cortex differentiates as endodermis. It is observed as a ring of barrel-shaped cells. The radial and tangential walls of these cells exhibit distinct casparian band deposition. The cells of endodermis placed opposite to protoxylem elements do not have such deposition and remain thin-walled. These cells are termed as passage cells.
4. One to few cell layers of thin-walled parenchymatous cells immediately beneath the endodermis constitute pericycle (the pericycle in older dicotyledonous roots may actively participate in the origin and development of the lateral roots; the vascular cambium or even the cork-cambium).
5. The vascular tissue is the most important diagnostic feature of the root:
   - The vascular bundle, are radially arranged.
   - The xylem and the phloem occur in separate patches differentiating on alternate radii. Small patches of parenchyma may be present between them.
   - There are usually four xylem and phloem patches, hence the root is tetrarch (it can be diarch or triarch also).
   - Protoxylem elements are formed near/towards the endodermis hence it is exarch.
6. Pith is very small or even absent.

Materials Required

- Compound Microscope
- Fresh/fixed primary roots of *Cicer, Pisum*/any other dicot root.
- Permanent slides of
  i) T.S. root *Cicer* (young, primary)
  ii) T.S. root *Pisum* (young, primary)
  iii) T.S. root (primary) any dicot.
- Safranin stain (1% in 50% ethanol); glycerine (10% aq. solution); acid water; a sharp blade or a razor; foreceps; needles; camel hair brush; slides and coverslips chinadish/watch glass/petridish.
- Stem of *Calotropis*/ radish/potato tubers to be used as pith material for holding the roots.

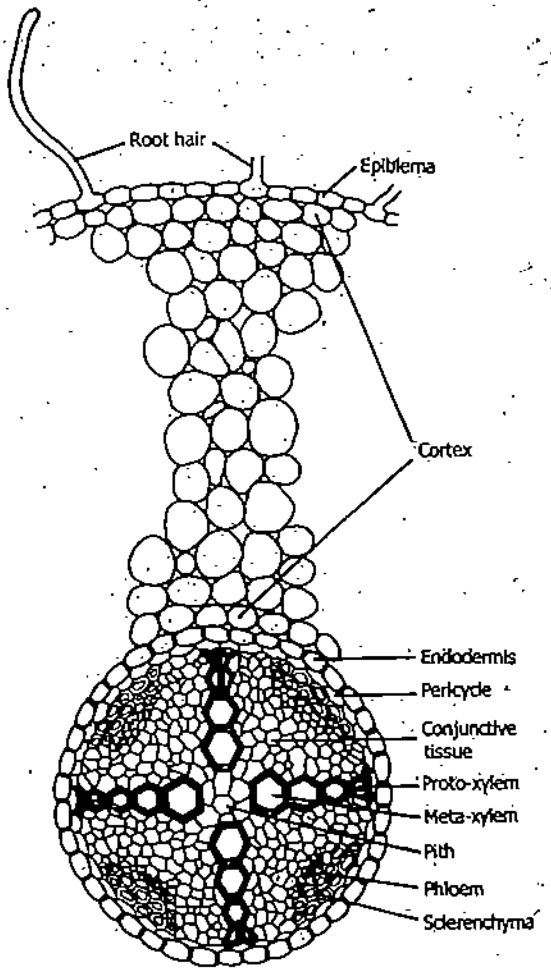
Procedure

You should prepare a temporary stained mount of any one of the materials even if both the materials are available and study the same in detail. You are advised, however, to use other materials for comparative study.

Observations and Interpretations

- Observe and identify the dicot root and draw. How is it different from monocot root?
- Draw the diagram on Worksheet # 8.1 and label it.
- Observe the approximate ratio of the stele diameter to the diameter of the entire root ....
- Study the cells of epidermis ...., study their shape ....what are the functions of epidermal cells?
  ....
  ....
  Does their structure or position relate to their function? Explain.
  ....
  ....
- Closely examine the cortex.
- Is it made up of simple or a complex tissue? ....
- How are they arranged? ....
- ....
- How many layers of cells comprise the cortex? ....
- .... What is the principal function of the cortex?
  ....
  ....
- Compare the epidermal cells with the cortical cells with respect to size and shape ....
  ....
  ....
- Observe the cells of endodermis – thick walled and thin walled cells.
- Relate the structure of endodermis to its function.
- ....
  ....
  ....
- Observe the central tissue/stele which consists of all the cells internal to endodermis and composed of several tissues.
- Observe the pericycle which is just internal to the endodermis.
- What type of cell is present in this tissue? ....
  ....
  ....
- Observe xylem. Do you find red staining cells that form center of the root and radiate outwards from the center as points or arms.
  How many xylem arms are there in your slide? ....
  Where are the larger cells found? ....
- Observe phloem in the area between the arms of the xylem:
  Are phloem cells as large as those of xylem?
  ....
  Are their walls thin or thick?
  ....

Draw an outline diagram of T.S. root of *Cicer* and label it



T.S. root of *Cicer* (a portion showing cellular details)

Draw T.S. root of *Cicer* (cellular details)

8.2.2 Roots of *Pisum*

Root of *Pisum* is circular in cross section. The tissue arrangement is almost similar to the one described for *Cicer* root. The only major variation is the triarch condition.

Observations and Interpretations

- Observe the permanent slides of primary root of *Cicer/Pisum*/any other dicot.
- Write the salient features of the dicot root you observe in slide.
- Try to identify the various tissues that you observe under the microscope and correlate them with the text as well as with the diagrams 8.2 on your Worksheet # 8.3.
- Complete the diagrams: write the labels as instructed.
- Write below **five** important anatomical diagnostic features on the basis of which you identify the given roots of *Pisum/Cicer* as dicotyledonous.

  i) ....

  ii) ....

  iii) ....

  iv) ....

  v) ....

- Why do you think the given specimen is a

  a) Root?

  i) ....

  ....

  ii) ....

  ....

  iii) ....

  ....

  iv) ....

  ....

  b) Dicot root?

  i) ....

  ....

  ii) ....

  ....

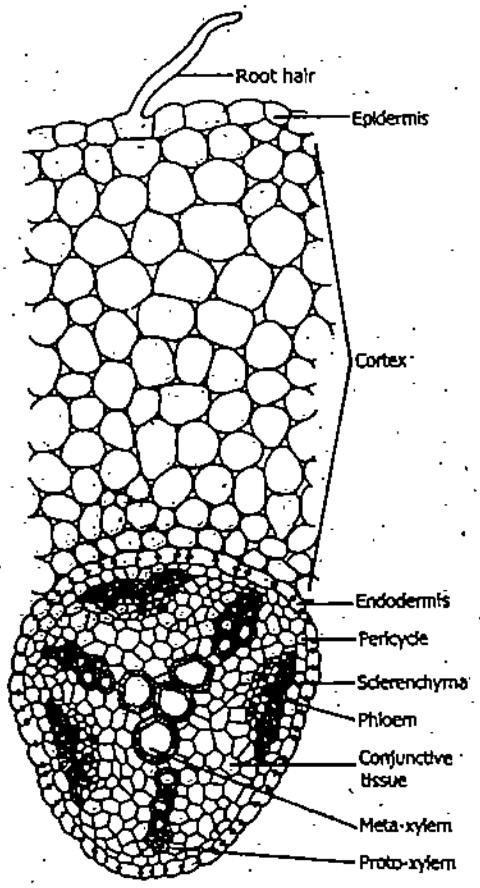
  iii) ....

  ....

  iv) ....

  ....

Draw an outline diagram of T.S. root of *Pisum* and label it



T.S. root of *Pisum* (a portion showing cellular details)

Draw T.S. of *Pisum* (cellular details)

8.3 ANATOMY OF MONOCOT ROOT

8.3.1 Root of *Zea mays*

Monocot roots – the anatomy of monocot roots is more complex than that of dicots. But there is variation which you can see in the stelar regions: (i) The monocot root has numerous protoxylem points (ii) The monocot root rarely develops cambium, and (iii) Pith is large and well developed.

In T.S., the *Zea* root has circular outline. The tissue arrangement is as follows:

1. An outermost layer of barrel-shaped, thin-walled cells constitute the epidermis without any cuticle. A number of unicellular hair can be observed if the T.S. is passing through root hair zone.
2. Below the epidermis, several layered, massive cortex can be easily seen. The majority of the cortical cells are thin-walled and parenchymatous with prominent intercellular spaces.
3. If the section is cut from the older proximal region of the axis, then the outer cortical layer may be seen differentiated as exodermis. The exodermal cells are thick-walled, suberized and act as protective layer in the event of epidermis being shed off.
4. The endodermis is very prominent. It is the innermost cortical layer forming a definite ring around the vascular tissue. The cells of endodermis are barrel-shaped and possess conspicuous casparian bands on its radial and tangential walls. A few of the endodermal cells, especially opposite to protoxylem elements remain thin-walled. These are called passage cells and are devoid of casparian thickenings.
5. One or a few layers of parenchymatous cells beneath the endodermis constitute pericycle. Pericycle is the outer limiting layer of the stelar region. These cells may play important role in the origin of lateral roots.
6. The vascular tissue arrangement is very remarkable:
   - It is radially arranged that is xylem and phloem are present on different radii with exarch protoxylem elements.
   - The number of xylem groups are more than five, hence polyarch.
7. A large, central, intrastelar pith is conspicuous, the cells of which are parenchymatous with prominent intercellular spaces.

Materials Required

1. Fresh/fixed roots of *Zea*, *Colocasia*/any monocot root.
2. Permanent slides of
   i) T.S. root of *Zea mays*
   ii) T.S. root of *Colocasia*
   iii) T.S. root of any monocot root
3. Safranin stain (1% in 50% ethanol); glycerine (10% aq. solution); acid water; a sharp blade or a razor; forceps; needles; camel hair brush; slides and coverslips; chinadish/watchglass/Petridish and compound microscope.
4. Stems of *Calotropis*/roots of radish/tubers of potato to be used as pith material for holding the roots.

Procedure

You have to prepare your own temporary-stained mount of T.S. of a monocot root, preferably the root of *Zea* for the study. For this purpose, follow the instructions provided in exercise 1. You may also use a permanent slide for the study.

Observations and Interpretations

Observe the preparations under the microscope. Try to identify as many kinds of different tissue types as you can. Complete the cellular diagram and label the diagrams on Worksheet # 8.3.

- Complete the diagrams and labelling as instructed on Worksheet # 8.3.
- Observe if there is any cortex .... a stele .... Is the stele relatively larger or smaller than in the herbaceous dicot root? .... How does the cortex compare with that of the dicot roots? ....
  ....
- Do you observe endodermis? ....
- Observe vascular bundles. What is their position? ....
- Observe xylem arms. How many xylem arms are present? ....
  How many layers does the pericycle consist of? ....
  Is the phloem similar to that of the dicot root? Explain. ....
  ....
  ....
- Observe the tissue at the center of the root. What is it? ....
- Is monocot root capable of secondary development? Yes or No. Explain.
  ....
  ....
- Describe in the space below the anatomical features based on which you identify the given specimen as:

  i) Root

  ....

  ....

  ....

  ....

  ....

  ....

  ii) Monocot root

  ....

  ....

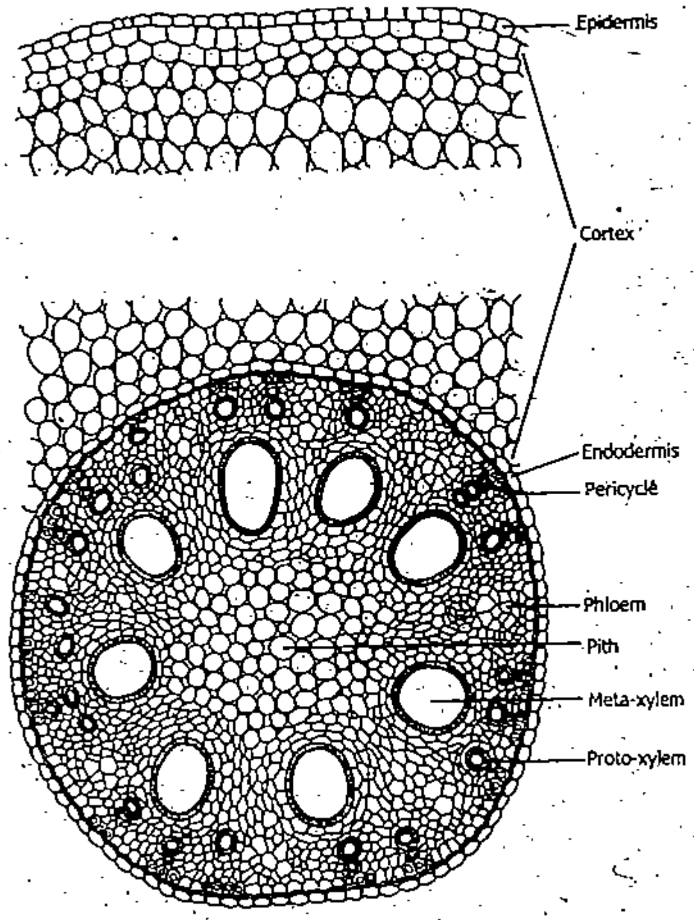
  ....

  ....

  ....

Worksheet # 8.3: Root of *Zea mays*

Draw a diagrammatic figure of T.S. root of *Zea mays*



T.S. root of *Zea mays* (a portion showing cellular details)   Draw T.S. root of *Zea mays* (Cellular details)

8.3.2 Root of *Colocasia*

Colocasia is easily available material in India. The procedure to study the *Colocasia* root is same as used for *Zea* root.

1. Observe and identify the monocot root and write comments on the following characters:
   a) Epidermis (Epiblema)

   ....

   ....

   b) Cortex

   ....

   ....

   c) Endodermis

   ....

   ....

   d) Pericycle

   ....

   ....

   e) Vascular tissue system

   ....

   ....

   ....

   ....

   ....

   ....

   ....

   ....

   ....

   f) Pith

   ....

   ....

2. Observe, study and completely follow the instructions given on Worksheet # 8.4.
3. Write below the reasons on the basis of which this specimen be identified as (i) root and (ii) monocot root.

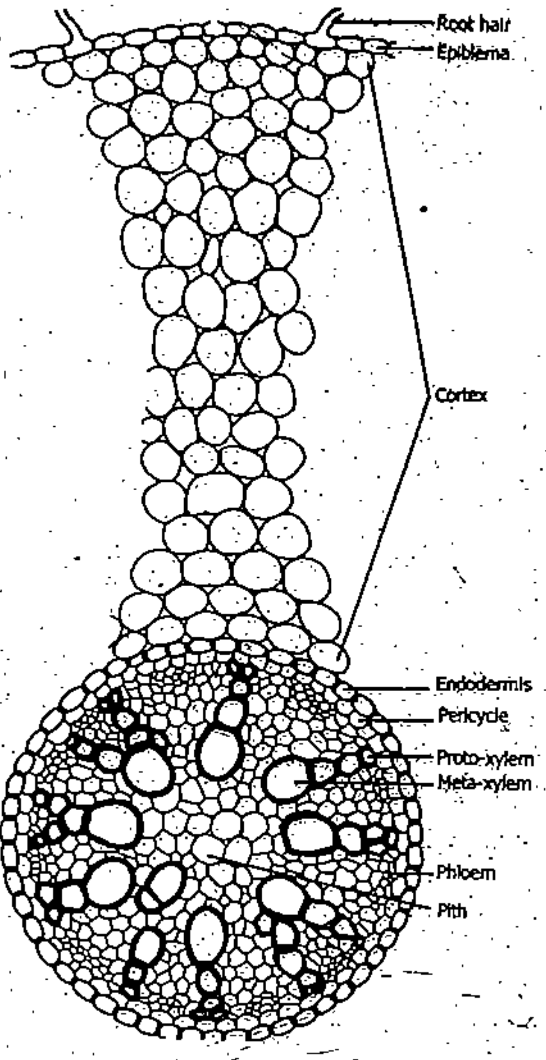
   ....

   ....

   ....

Worksheet # 8.4: Root of *Colocasia*

Draw a diagrammatic figure of T.S. root of *Colocasia*



T.S. root of *Colocasia* (a portion showing cellular details) Draw T.S. root of *Colocasia* (cellular details)

SAQ

In the chart given below compare the major structural features of the dicot and monocot root, and draw the cellular diagram while giving the differences.

Comparison of Dicot and Monocot root structure

Monocot root	Dicot root

In the chart give below compare the major structural features of the dicot and monocot root, and draw the cellular diagram while giving the differences.

Comparison of Dicot and Monocot root structure

Monocot root	Dicot root

EXERCISE 9 ANATOMY OF STEMS

Date ....
Session # ....
Time allocated –

Structure **Page No.**

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in the lab.

9.1 INTRODUCTION

In this exercise, you will study the anatomy of vegetative plant organ, the stem. Anatomically, stem is made up of various tissues (the ones you have already studied in (Exercise 2). Organized into three tissue systems, namely, the *epidermal* tissue; the *ground* tissue and the *vascular* tissue. The principal variation in structure of an organ depends upon the relative proportion and spatial arrangement of ground and vascular tissue systems. In this exercise, you will study about the anatomy of dicot and monocot stems.

Objectives

After doing this exercise, you will be able to:

- identify and differentiate between the monocot and dicot stems,
- identify and observe following features in the T.S. of a dicot stem,
  - different tissue systems, viz., the epidermal, the ground and the vascular tissues.
  - multicellular trichomes in the epidermal layer,
  - cortex and pith,
  - different zones of cortex,
  - a large number of conjoint, collateral/bicollateral, open vascular bundles with endarch protoxylem, and
  - arrangement of the vascular bundles in ring(s)

identify and observe following features in the T.S. of a monocot stem,
  - various tissue systems viz., the epidermal, the vascular and the ground tissues,
  - thick, cuticularized epidermis,
  - presence of prominent sclerenchymatous tissue beneath epidermis and around many vascular bundles as bundle sheaths,
  - large number of vascular bundles scattered around in the ground tissue,
  - ground tissue is not distinguishable into pith and cortex.

- each vascular bundle is conjoint, collateral closed (i.e. cambium is absent) with endarch protoxylem.

- analyze and compare the gross structure of woody dicot and gymnosperm stem,
- distinguish between woody dicot and woody gymnosperm stems, and
- identify and differentiate between monocot, dicot and gymnosperm stems.

Study Guide

Before doing this exercise, come prepared by reading this experiment in advance.

- Also, read the section 8.3 stem of unit 8 of LSE-13 course.
- This will help you to recognise and understand the anatomy of monocot and dicot stems.
- Try to finish your work in the given time.
- Make diagrams as you observe the slides in microscope. Do not copy figures from the text books.

Your Notes

9.2 ANATOMY OF DICOT STEM

9.2.1 Stem of *Helianthus* spp.

In T.S., the *Helianthus* stem has a wavy outline. The various tissues from periphery towards centre are arranged as follows:

1. The outermost, uniseriate, parenchymatous layer of cells constitutes the epidermis. It has distinct cuticle and also possesses many multicellular but uniseriate trichomes. At places, stomata in V.S. are also observed.
2. The ground tissue is distinctly segregated as cortex and pith. The zone between the epidermis and the stele is termed as cortex and the intrastelar zone is called pith. Pith is much larger than the cortex.
3. A few outermost layers of the cortex (count and write the number---) are collenchymatous, mostly lacunar type. The layers of inner cortex (count and write---) below the collenchyma zone are parenchymatous. These parenchyma cells have distinct intercellular spaces. A few oil ducts are also present in this parenchymatous zone. These are schizogenous cavities.
4. The innermost cortical cell layer is at places rich in starch grains. This layer is termed starch-sheath. Such cells are more conspicuous at places where vascular bundles are seen. This layer is also recognized as endodermis.
5. A large number of discrete vascular bundles are arranged in a ring. Each vascular bundle is typically conjoint, collateral and open (possesses fascicular cambium between metaphloem and metaxylem). The protoxylem is endarch. The metaxylem elements are larger, wider and many than the protoxylem elements. The primary xylem has vessels, tracheids, parenchyma and fibres. The sieve tubes, companion cells and parenchyma constitute primary phloem.
6. The pericycle is multilayered. It is both parenchymatous and sclerenchymatous. A sclerenchymatous (fibre) cap above every vascular bundle is characteristic of this stem and is a modified peircycle.
7. A large, conspicuous, parenchymatous pith occupies the centre of the stem.

Materials Required

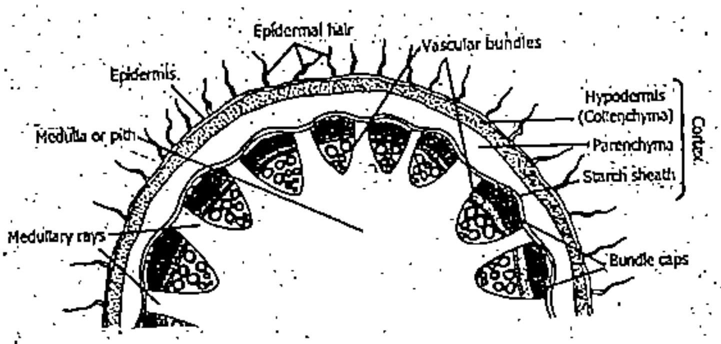
a) Fresh/fixed internodal stem pieces of *Helianthus annuus* (sunflower).
b) Permanent slides of
   i) T.S. stem of *Helianthus annuus* (young, primary/and mature)
   ii) T.S. stem of *Cucurbita* spp. (Optional)
c) Safranin stain (1% in 50% ethanol); glycerine (10% aq. solution); acid water; a sharp blade or a razor; forceps; needles; camel hair brush; slides and coverslips; chinadish/watchglass/petri dish and compound microscope.

Procedure

Take a piece of stem of *Helianthus* (about 1-2 cm in length) and cut transverse sections, stain with safranin and mount in glycerine after washing off the excess stain in acid water (follow the instructions provided in exercise 1). Observe your preparations under the compound microscope. Study the diagnostic features listed above and compare them with the structures you observe in your preparations. Make an attempt to identify as many kinds of different cell/tissue types as you can. Complete the outline diagram and label the diagrams. Foll v all other instructions given on Worksheet #s. The same procedure will be followed in staining all the dicot and monocot stems so we are not going to repeat it in every section.

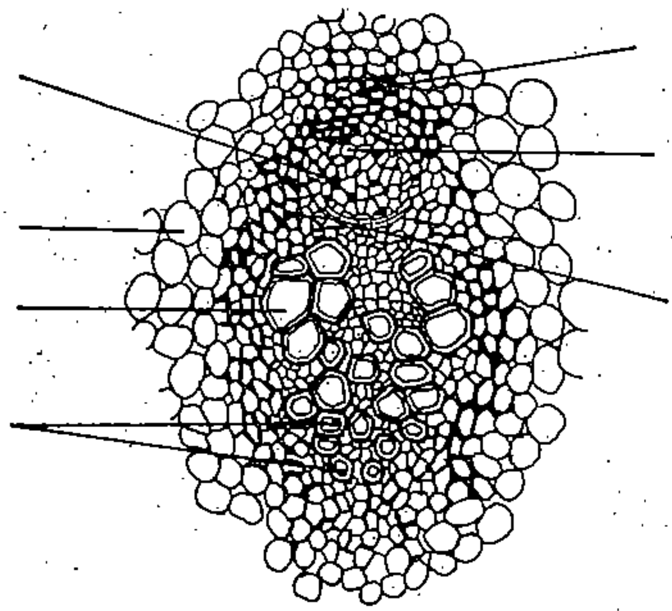
Observations and Interpretations

- Complete the diagrams given on Worksheet # 9.1.
- Label the diagram as indicated on Worksheet # 9.1.
- Observe the prepared slide of T.S. *Helianthus* stem and identify the following structure.
- Pith – location .... Are intercellular space present? ....
  Are these cells nucleated?..
- Xylem bundle – Describe the bundle. ....
  ....
  ....
- Xylem vessels and tracheids are present or not, locate them. What is its function? ....
  ....
- Phloem – Is there any evidence of phloem fibres or phloem parenchyma .... What is its function?
  ....
  ....
- Bundle cap – Describe its structure. Are cell walls lignified?
  ....
  ....
- Endodermis – How many layers constitute endodermis?.........................
  What is starch sheath? ....
  ....
- Cortex – Are all the cells of cortex alike?
  ....
- Epidermis – Is it continuous around stem? ....
  What are the openings called? ....
  What is their function? ....
  Are any epidermal hairs present? ....
- List the characters on the basis of which you claim that the given specimen is a:
  i) Stem
  ....
  ....
  ....
  ....
  ii) Dicotyledonous stem
  ....
  ....
  ....
  ....



Part of *Helianthus annuus* stem in T.S.
(Diagrammatic)

Draw a cellular diagram of part of *Helianthus annuus* stem
(label various parts)



An Enlarged vascular bundle of *Helianthus annuus*
(label the various parts)

Draw a diagrammatic representation of a vascular bundle of *Helianthus annuus*

9.2.2 Stem of *Cucurbita*

The stem is wavy in outline and in T.S. shows distinct ridges and furrows. The tissue arrangement is as follows:

1. The outermost layer is the epidermis. It is composed of compactly arranged barrel shaped cells. The cuticle is distinct. Many multicellular, uniseriate trichomes and stomata may be seen in younger stems. The stomata, if present, are likely to be seen in the furrows.
2. The ground tissue is distinctly segregated as pith and cortex. The region between epidermis and stele is called cortex. The pith is a intrastelar tissue.
3. The cortex is multilayered and has two distinct zones. (i) isolated patches of angular collenchymatous cells beneath the ridges, and (ii) parenchyma patches below the collenchyma at ridges and this is continuous with parenchyma beneath the furrows. Parenchyma below the furrows could be chlorenchymatous.
4. The inner-most cortical layer is starch-sheath layer. It is also referred to as endodermis.
5. A thick multilayered (2 to few) sclerenchymatous continuous band along with underlying parenchymatous cells constitute pericycle. It is present below the endodermis.
6. A large number of vascular bundles (generally 10) occur in two rings of five each. The vascular bundles in the outer ring are smaller and placed below ridges. The larger vascular bundles of inner ring are placed opposite to furrows.
7. Each vascular bundle is a typical conjoint, bicollateral (i.e. possessing two patches of phloem and occasional two strips of cambia on the either side of xylem), with endarch protoxylem. The vascular bundles are of open type.
8. The pith is parenchymatous, multicellular, but gets disorganized early forming a hollow central cavity.

Observations and Interpretations

- Observe the T.S. of *Cucurbita* stem under the compound microscope.
- Correlate the structure you observe with the diagram given in Worksheet # 9.2.
- Label and draw the bicollateral vascular bundle on given Worksheet # and label it.
- Follow the instructions given on Worksheet # 9.2.

1. Write diagnostic features of stem you have seen in the slide.

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....

....

2. Why do you think is the given specimen a dicot stem?

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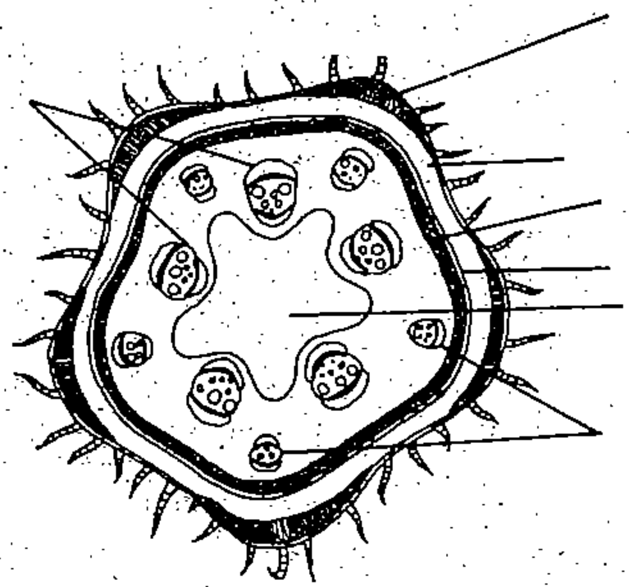

Draw diagrammatic representation of primary dicotyledonous stem of *Cucurbita* in T.S. (Complete the labeling)

Draw the cells of stem of *Cucurbita*.

Pith

Xylem

Phloem

Bundle cap

Cortex

Epidermis

Epidermal hair

Draw and label a portion of young *Cucurbita* stem in T.S. showing cellular details.

9.3 ANATOMY OF MONOCOT STEM

9.3.1 Anatomy of stem of *Zea mays*

In T.S., the stem of *Zea* is almost circular in outline. The tissue arrangement is as follows:

1. The epidermis is single-layered whose cells are small and tightly set. The outer walls are cuticularized. The trichomes are absent.
2. The ground tissue is very large and conspicuous, however, there is no distinction between the cortex and the pith. The outer peripheral cell layers of ground tissue, i.e. below the epidermis, are sclerenchymatous (fibrous). The rest of the vast ground tissue is made up of parenchyma cells with conspicuous intercellular spaces.
3. The large number of vascular bundles are found scattered in the ground tissue , those which are peripheral are smaller and more crowded than those which are in the central region. The vascular bundles in the central region are larger and widely spaced.
4. The individual vascular bundle is conjoint, collateral with endarch protoxylem, and are of closed type. The xylem occur in the form of 'Y'. The metaxylem with wider tracheary elements occurs along the two arms of Y. The protoxylem with usually one or two narrow tracheary elements occupy the base.
5. Since the protoxylem elements mature earlier than the stem, it soon disintegrates to form a lacuna or water cavity or lysigenous cavity (also called protoxylem lacuna/cavity).
6. Each of the vascular bundles is surrounded by sclerenchymatous bundle sheath.
7. Phloem occupies the central position between arms of the "Y"

Materials Required

a) Fresh/fixed stem pieces of *Zea mays, Triticum* spp.
b) Permanent slides of
   i) T.S. stem of *Zea mays*
   ii) T.S. stem of *Triticum* spp. (optional)
   iii) T.S. stem of *Asparagus* spp. (optional)
c) Safranin stain (1% in 50% ethanol); glycerine (10% aq. solution); acid water; a sharp blade or a razor; forceps; needles; camel hair brush; macroslides and microcoverslips; chinadish/watchglass/Petri dish and compound microscope.

Procedure

Follow the procedure as provided in section 9.1 except that you shall use stem of *Zea*. Complete the labelling in figure. Make special efforts to correlate Fig. on Worksheet # 9.3 with that what you observe in your preparations.

Observation and Interpretations

- Complete the diagram given on Worksheet # 9.3.
- Label the diagram given on Worksheet # 9.3.

- Observe the monocot stem of *Zea mays* and identify the following:
Are tissues such as pith, cortex and vascular cylinder delimited in specific zone or region? Describe briefly in the space below:

....

....

- Pith

....

....

- Cortex

....

....

- Vascular cylinder

....

....

Examine a vascular bundle

Arrangement ....

Xylem – Do you find any air spaces or lacunae or protoxylem cavity in xylem? Locate them.

....

Phloem ....

- Locate bundle sheath and describe it.
- List the characters on the basis of which you identify the given specimen as a:

i) Stem

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....

ii) Monocotyledonous stem

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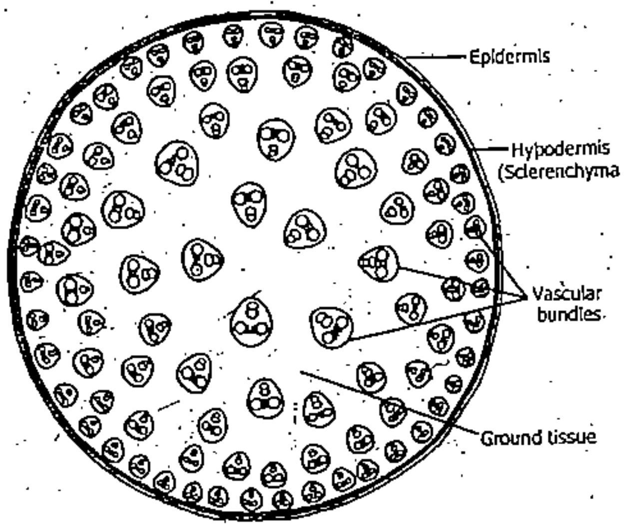
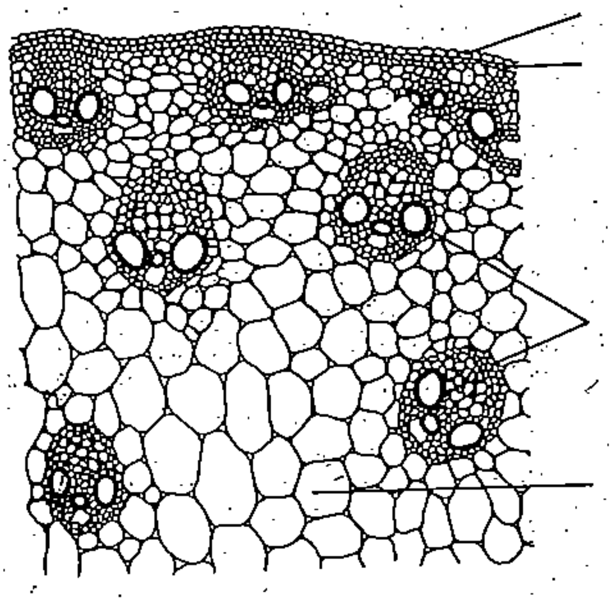
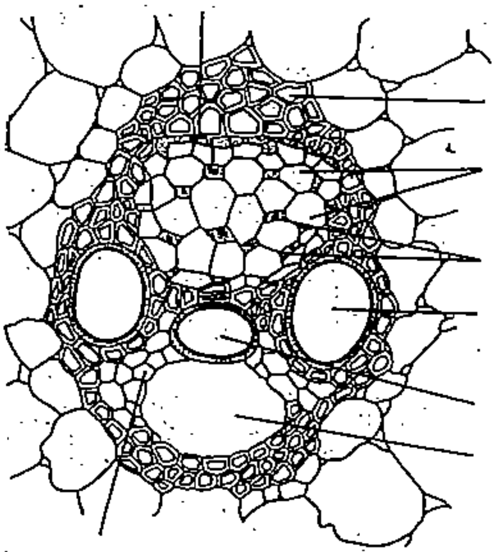


Transverse section of *Zea mays* stem showing the scattered distribution of vascular bundles



A portion magnified of T.S. of *Zea mays* stem (label the various layer of the stem)



A magnified vascular bundle of *Zea mays* (label the various tissues in vascular bundle).

9.3.2 Stem of *Triticum*

The outline of T.S. of stem is circular to oblong. There is a large pith cavity in the center. The tissue arrangement is as follows:

1. The epidermis is single-layered comprising of rectangular cells. These cells are heavily cuticularized. A few stomata may be present.
2. The entire region beneath epidermis up to central cavity comprises the ground tissue which shows no differentiation into cortex and pith. A few layered sclerenchymatous zone occur below the epidermis (external ground tissue). At places, these thick-walled layers of cells are interrupted by a few cells of chlorenchyma. The stomata are present in that region of epidermis which lies above this chlorenchyma. The rest of the ground tissue is made up of thin-walled parenchymatous cells with distinct intercellular spaces.
3. A large number of vascular bundles can be observed dispersed within ground tissue. These bundles are arranged in two series.
   - The vascular bundles of outer series are smaller than those of inner series.
   - The vascular bundles of peripheral series are mostly embedded in sclerenchyma that is present below epidermis.
   - The vascular bundles are conjoint, collateral and closed with endarch protoxylem.
   - Each vascular bundle is almost completely enclosed by a layer of sclerenchyma.
   - The bundle sheath is more prominent at the upper and lower extremities of the vascular bundle.
   - The xylary elements are arranged in Y-shaped organization.
   - The metaxylem elements are present at the arms larged, wider than those of protoxylem. The latter are situated near the inner face at the end of 'Y' of the vascular bundle.
   - The phloem occupies the region between the metaxylem. It consists of the sieve tubes and the companion cells.

Observation and Interpretation

- Observe the permanent slide, study the structure, compare it with description provided and the one given on the Worksheet # 9.4. Complete the labelling of the Fig. given on Worksheet # 9.4.
- Write below the diagnostic features on the basis of which you can identify the specimen as a
  i) Stem
  ....
  ....
  ....
  ....
  ii) Monocot stem
  ....
  ....

....

....

9.3.3 Stem of *Asparagus*

It is circular in T.S. The tissue arrangement is as follows:

1. The single layered *epidermis* consisting of tabular cells. The cells have cuticularized outer walls.
2. The ground tissue is not differentiated as *cortex* and *pith*. However, it comprises of three distinct zones:
   - **Outer:** Just beneath the epidermis, a few layers of chlorenchyma are present. This zone is *photosynthetic*. The inner most layer of this zone is rich in *starch grains* and is termed *starch sheath*. The cells of starch sheath are compactly arranged.
   - **Middle:** Below starch sheath is present a multilayerd complete band of sclerenchyma. These cells provide mechanical strength to the organ.
   - **Inner:** The rest of the ground tissue is made up of thin-walled parenchymatous cells. These cells have well developed intercellular spaces. This is the largest of the three regions.
3. A number of vascular bundles are scattered randomly in the inner ground tissue. The central vascular bundles are relatively larger than the peripheral ones. Each of the vascular bundle is *collateral*, *conjoint* and *closed*. The protoxylem is endarch. The xylem in the vascular bundle is usually U-shaped. The base of the U is protoxylem and the arms of U are made up of metaxylem. The bundle-sheath is not prominently. Sieve tubes and companion cells comprises the phloem.

Observations and Interpretations

- Observe the T.S. of stem of *Asparagus* under the microscope. Observe, study the description provided. Compare it with the diagram given on Worksheet # 9.4.

- Write below the diagnostic features

  ....

  ....

- Why do you think the specimen belongs to a monocot stem? Give reasons.

  ....

  ....

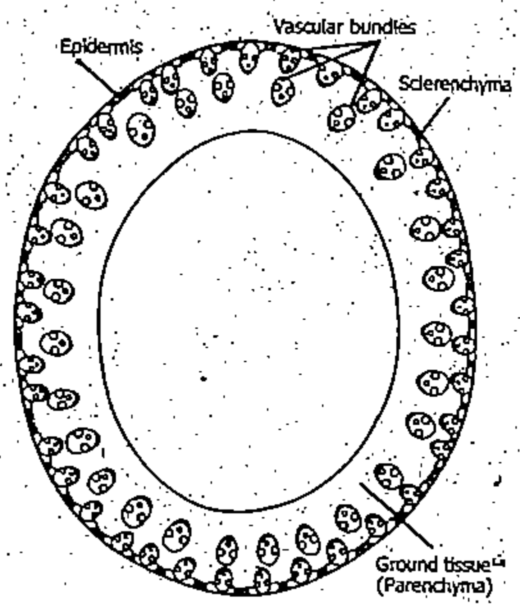
  ....

- Why do you think it can not be identified as dicot stem?

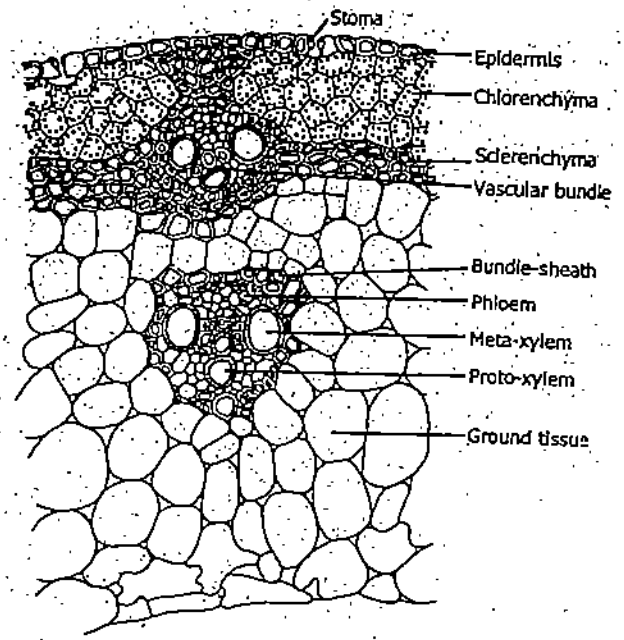
  ....

  ....

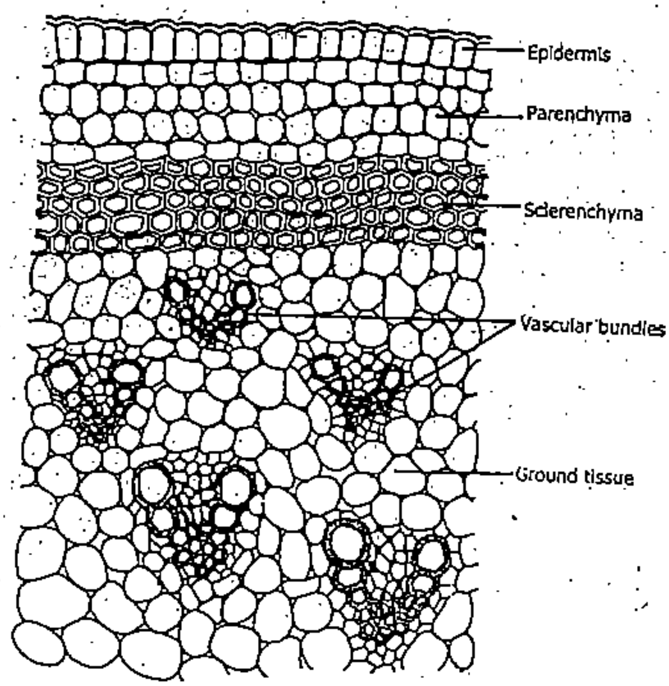
  ....



Diagrammatic representation of structure of a monocotyledonous stem in T.S. (*Triticum*). Complete labeling.



A portion of stem of *Triticum* in T.S.



Cellular diagram of a part of stem (T.S.) of *Asparagus*.

Your Notes

EXERCISE 10 ANATOMY OF LEAVES

Date ....
Session # ....
Time allocated –

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in the lab.

10.1 INTRODUCTION

The leaf is the main photosynthetic organ of the plant. The photosynthesis takes place mainly in the lamina. The leaf base, petiole, mid-rib, veins all carry out contributory functions. A mature leaf has three basic parts: the leaf base; the petiole, and the lamina. A wide range of morphological variations is reported in Nature. Since the lamina region is the main photosynthetic part of the leaf, the anatomical structure of leaf blade is more emphasized in this exercise. In this exercise you will study the anatomical details of monocot and dicot leaves.

Objectives

After doing this exercise, you should be able to:

- distinguish between the adaxial (upper) and the abaxial (lower) epidermis.
- identify different cell types, components of epidermal system: the cuticle; the ordinary epidermal cell; stomata; the trichome, the bulliform-cells, etc.
- differentiate between mesophyll tissue from the vascular tissue;
- identify palisade and spongy parenchyma and their relative/spatial distribution,
- identify xylem, phloem, bundle-sheath, bundle-sheath extension, and any other related structure of vascular bundles,
- explain the structure of mid-rib; and
- differentiate between a dorsiventral (bifacial) and an isobilateral leaf.

Study Guide

Before doing this exercise, come prepared by reading this experiment in advance.

- Also read the section 8.4 leaf of unit 8 of course LSE-13.
- This will help you to recognise and understand the anatomy of monocot and dicot leaf.
- Try to finish your work in the given time.

10.2 ANATOMY OF DICOT LEAF

10.2.1 Anatomy of Leaf of *Helianthus* : The leaf of *Helianthus* is dorsiventral.

(i) **Mid-rib**

1. It is the swollen region of the leaf blade.
2. In V.S., the abaxial region appears as swollen cap. The cells in this region are achlorophyllous.
3. The adaxial and abaxial epidermis are continuous with respective laminar epidermis.
4. The epidermis of lamina does not bear stomata.
5. The hypodermal cells on adaxial side (sometimes on abaxial side also) are collenchymatous.
6. A number of distinct (generally 3) vascular bundles are observed in the swollen abaxide side. The central vascular bundle of the three (group) is larger than the two side ones.
7. These vascular bundles are conjoint, collateral, open with protoxylem facing adaxial epidermis.

(ii) **Leaf Lamina**

1. The symmetry of the lamina is dorsiventral.
2. The dorsal surface is termed adaxial, while the ventral surface is called abaxial.
3. The adaxial epidermis has distinct cuticle, trichome and a few stomata.
4. The abaxial epidermis has thinner cuticle, trichomes, and a number of stomata.
5. The mesophyll tissue is differentiated as palisade and spongy parenchyma and is photosynthetic.
6. The palisade parenchyma occupies one to few layers below adaxial epidermis. These cells are more long than wide. In V.S., they seem to be tightly packed. They are placed at right angles to the epidermis. However, abundant air spaces can be seen in palisade parenchyma when the sections are cut parallel to surface of leaf.
7. Spongy parenchyma occupies lower part of the lamina. These cells are round, armed, lobed, irregular in shape and possess large air spaces between them.
8. The largest air spaces exists next to stomata in the abaxial epidermis. Such cavities are called sub-stomatal chambers.
9. The vascular bundles of small veins are located at the junction of palisade and spongy parenchyma.
10. Each of these vascular bundles has xylem and phloem surrounded by a ring of parenchyma cells, the bundle-sheath. The cells of the bundle sheath are closely attached to each other.

Materials Required

Permanent slides of:

i) V.S. leaf of *Helianthus* spp.
ii) V.S. leaf of *Mangifera* spp.
iii) V.S. leaf of *Tridax* spp.

Procedure

You are provided with permanent slides of leaves of *Helianthus* and *Tridax*. Observe them carefully under the microscope. Correlate the structure you observe to the description of the text and figures given on Worksheet # 10.1, 10.2, 10.3 and 10.4.

Observations and Interpretations

- Complete the labeling of the figures given on Worksheet # 10.1, 10.2, 10.3.
- Draw the figures as you observe them in the slides.
- Observe the cuticle covering the outer walls of upper epidermis. What is the function of cuticle?

  ....

  ....

- Next to it, observe the upper epidermis, observe its cell structure. Do the cells contain chloroplasts?

  ....

  ....

- Observe the stomatal apparatus. Observe the shape of guard cells. Do they vary in thinkness?

  ....

  ....

  Do guard cells contain chloroplasts? ....

  Are the stomata open or closed? ....

  ....

  ....

- Locate the palisade parenchyma. Of how many layers is it composed?

  ....

  What is the shape of the cells? Why are they so shaped?

  ....

  Do they contain chloroplasts? ....

- Observe the spongy mesophyll and air spaces. Why are these cells called spongy? ....

....

Do these cells possess more chloroplasts than the palisade cells? ....

How are they shaped? ....

Why are air spaces present? ....

....

....

What is the function of the spongy mesophyll? ....

....

....

- Observe the mid rib region and compare it with the description given in text.
- Do you find xylem? .... What is its function? ....

  ....

  ....

- Identify phloem. Are companion cells present? ....

  ....

  What is the function of phloem? ....

  ....

- Observe the lower epidermis, guard cells and air chambers and compare them with description given in text. What is its function?

  ....

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- Write the identification points of dorsiventral leaf.

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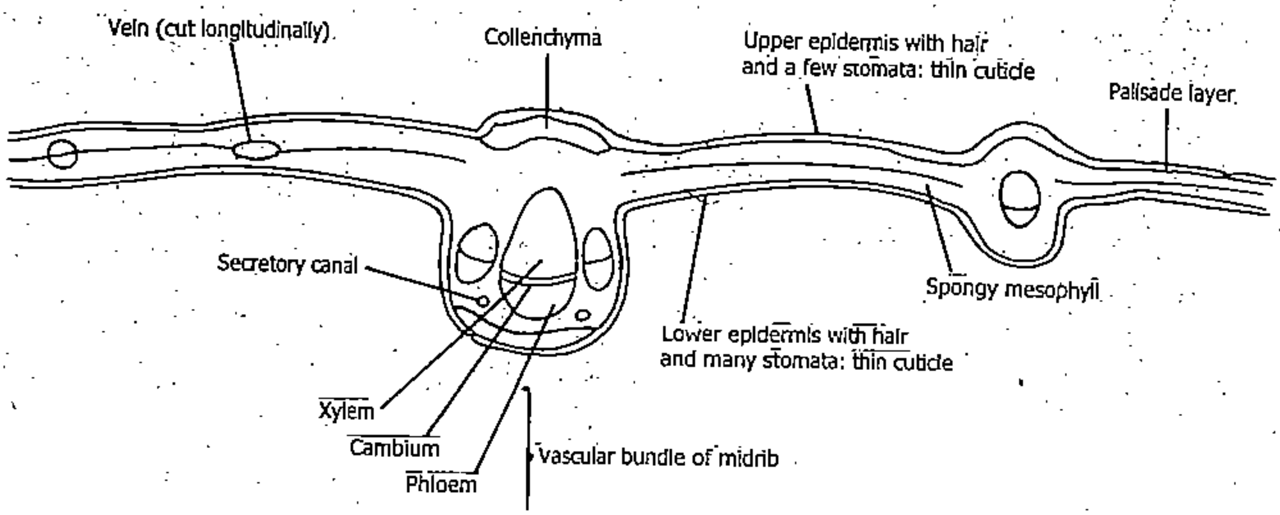
Worksheet # 10.1: Dicot leaf.

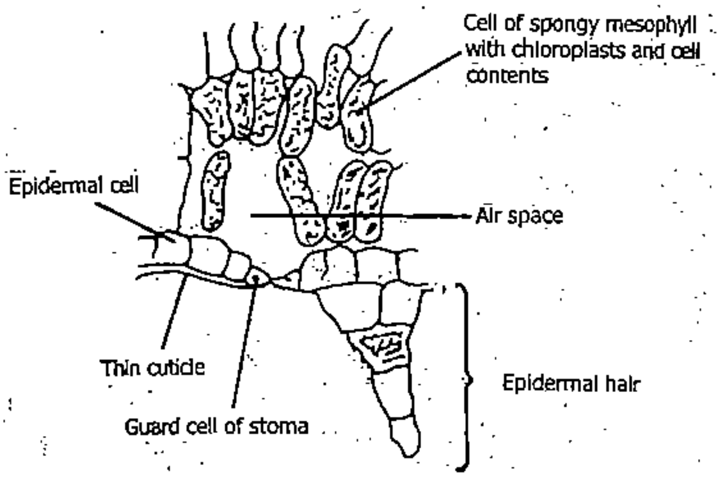


Diagrammatic transverse section of a typical dicotyledon leaf.

Draw cellular diagram of typical dorsiventral leaf and label the diagram

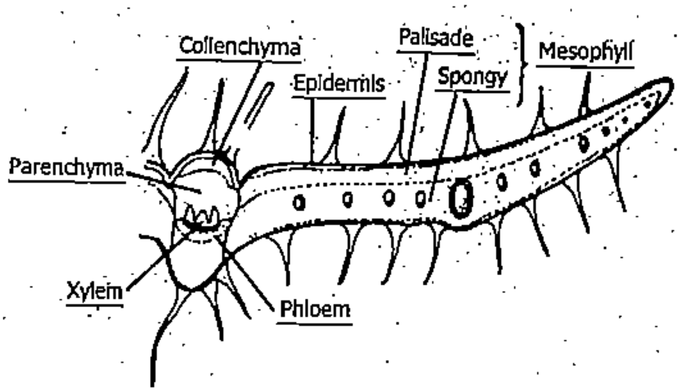
Worksheet # 10.2: *Helianthus* leaf.

Draw diagrammatic representation of a *Helianthus* leaf in *V.S.*

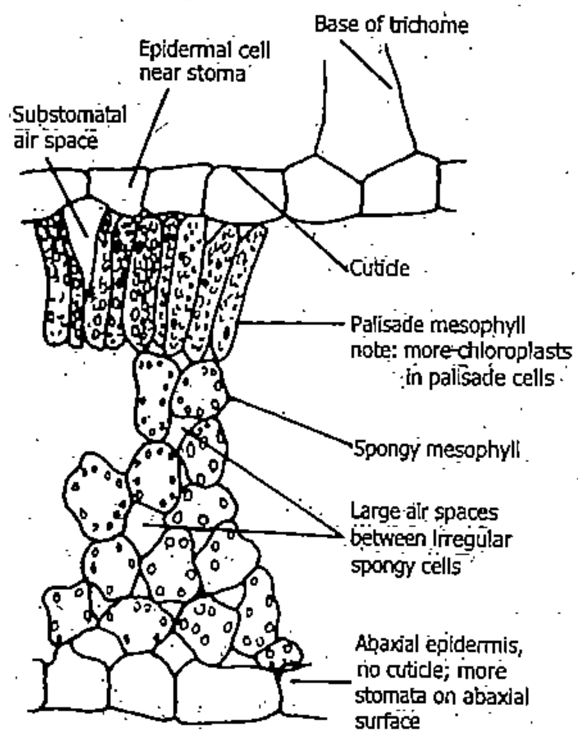


A part of abaxial region of lamina of *Helianthus* leaf modified to depict cellular details.

Worksheet # 10.3: *Tridax* leaf.



Diagrammatic representation of a part of a dicotyledonous leaf in V.S.*Tridax*.



A part of laminar region of *Tridax* leaf modified to depict cellular details.

10.3 ANATOMY OF MONOCOT LEAF

10.3.1 Anatomy of leaf of *Zea* spp.

In V.S., the leaf appears as ribbon-shaped expanse of cells. The tissue arrangement is as follows:

1. Both the epidermis, the adaxial and the abaxial, are made up of barrel-shaped cells arranged in single layer.
2. Both the surfaces are thickly cuticularized.
3. Stomata occur on both the surfaces.
4. A few large, empty, colourless cells, bulliform cells, occur on adaxial epidermis.
5. Mesophyll tissue is not differentiated into palisade and spongy parenchyma. It occupies all regions between two epidermis.
6. All the cells of mesophyll are isodiametric and chlorophyllous. They are compactly arranged with only a few intercellular spaces between them.
7. There are a large number of narrowly-sized vascular bundles arranged in parallel series.
8. Each of the vascular bundle is collateral, closed and possess a distinct bundle sheath.
9. The cells of bundle-sheath possess plastids and starch grains.
10. A patch of sclerenchyma is present above and below each of the vascular bundle. In larger vascular bundles, such sclerenchyma patches extends up to epidermis. Such extensions are termed bundle sheath extension.
11. The vascular bundles possess xylem on its adaxial side and phloem on its abaxial side.
12. **Bulliforms cells:** In grasses and many other monocotyledons, bulliform cells are found in epidermis. These cells are larger than the typical epidermal cells and are thin walled. They possess large vacuole. These cells generally form isolated parallel strips in the areas between the veins. In V.S. of the leaf, they appear fan-like. The central cell of the group is tallest. The bulliform cells are devoid of chloroplast but are rich in water. They are hygroscopic in nature and play important role in rolling and un-rolling of leaves. Their cell walls are cellulosic and pectic in nature and are covered by a thin cuticle.

Materials Required

Permanent slides of:

i) V.S. *Zea* leaf
ii) V.S. *Avena* leaf
iii) V.S. *Triticum* leaf

Procedure

You are provided with the permanent slides of leaves of *Zea* and *Avena*. Observe them under the microscope. Correlate the structure you observe to the description provided in the text and the illustrations in the figures given on Worksheet # 10.4 and 10.5.

Observations and Interpretations

- Complete the labeling as instructed in the figure.
- Draw the figures as you observe them in the slides.
- In the monocot leaf observe the features you have studied in a dicot leaf and differentiate the two on the basis of these features.

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Write about the special features found in monocot leaves.

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Observe the V.S. leaf of *Avena* and write your comments.

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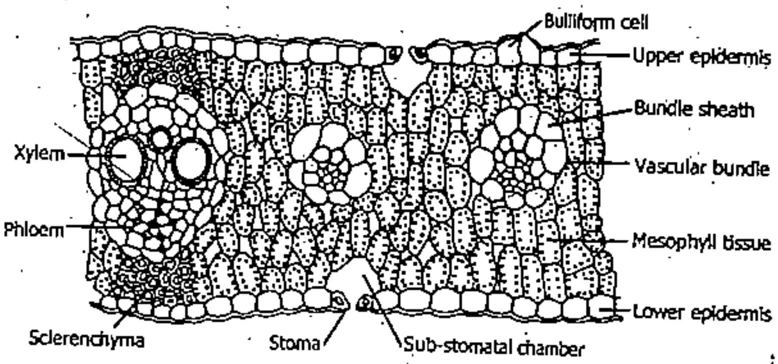
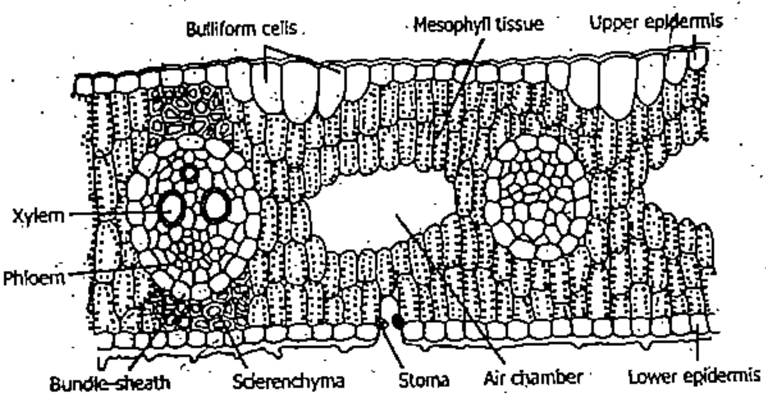
Worksheet # 10.4: Monocot leaf.

Draw a diagrammatic figure of
V.S. isobilateral leaf



A portion of leaf of *zea mays* in T.S.

Draw cellular details of a portion of a *Avena* in V.S. leaf



Cellular details of a portion of a *Bambusa* leaf in V.S.

Your Notes

EXERCISE 11 CEREALS AND MILLET

Date: ....
Session # : ....
Time allocated: 2 Hours

Structure

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in the lab.

11.1 INTRODUCTION

Cereals are the staple food of mankind. They were cultivated long before the beginning of the recorded history. In fact all important civilizations depended on one or other cereal. The cereals are a rich source of carbohydrates, proteins, fats, minerals and vitamins. Another excellent quality of cereals is that they can be stored for a long period because of their low water contents. Cereals are valued livestock feed also.

Cereals belong to family Poaceae. The edible part in the cereals is indehiscent and dry fruit caryopsis (grain), in which the seed coat is fused with the pericarp to form the husk. Wheat, rice, maize, barley and oats are the true cereals or major cereals. Sorghum, pearl millet, finger millet are examples of millet (small edible grains).

In this exercise, we will study the detailed morphological structure of plants and anatomy of grains of some very important cereals and a millet (sorghum).

Objectives

After doing this exercise you will be able to:

- identify some economically important cereals and millet,
- list characteristic features of some important cereals and millet,
- differentiate between different types of starch grains found in cereals, and
- draw the structural details of grains of cereals and millet.

Study Guide

- It is always better to come prepared in laboratory for doing an exercise by prior reading. Read this exercise properly so that you can finish the work in the given time.
- Read Block 3A: Economic Botany: Unit 11, Cereals and Millets; and Block 4: Families of Angiosperms, Unit 23, pp. 158-173.

11.2 WHEAT

Wheat is one of the most important staple food in India. There is a strong evidence that India may be the home of some kinds of wheat.

1. Cytotaxonomically the wheat can be grouped into three categories.

i) Diploid wheat	2n = 14 chromosomes	*T. monococcum*
ii) Tetraploid wheat	2n = 28 chromosomes	*T. dicoccoides*, *T. durum*,
iii) Hexaploid wheat	2n = 42 chromosomes	*T. aestivum*, *T. compactum*

   Diploid wheat is the oldest and the tetraploid and hexaploid varieties are evolved through hybridization. The bread wheat; *Triticum aestivum* L. is a hexaploid type.
2. Wheat is the most important crop of India.
3. Wheat is an annual grass with number of 'tillers' (secondary shoots). The stem and tillers have solid nodes and hollow internodes.
4. The leaves are alternate with basal sheath, the lamina is linear lanceolate with membranous ligule and pair of auricles. The inflorescence is spike with number of spikelets. Each spike consists of two to five florets. Depending on the presence of awn, the spikes are known as bearded (awned) or beardless (awnless). The awn is the extension of the lamellar midrib.
5. The grain is one seeded dry fruit called caryopsis, where the seed coat remain fused with the ovary wall (pericarp).

L.S. of wheat grain.

The grain consists of the following components:

i) **The seed coat** – Two layered, testa firmly fused with pericarp.
ii) **Nucellus** – Single layer of compressed cells.
iii) **Embryo** – (a) hypocotyl, having plumule at the apex which is surrounded by coleoptile and radicle at the base which is followed by coleorhiza.
   (b) Scutellum – It is fleshy shield like structure occupying the major portion of the embryo is synonym of cotyledons.
iv) **Endosperm** – The major portion of the grain is composed of endosperm containing starch and gluten. The outermost layer of endosperm is aleurone layer which is one celled thick and rich in protein.

Materials Required

- Herbarium/museum/fresh specimen of wheat
- Dried/fresh grains of wheat
- Hand lens/dissecting microscope
- Permanent slide of L.S. wheat grains

Procedure

- Study the museum specimen/s carefully and if possible identify them and confirm with your counsellor.

- Study the morphology of the grain with the aid of hand lens and write down your observations.
- Study the permanent slide of L.S. wheat grain under the microscope and draw the diagram on Worksheet # 11.1.

Observations and Interpretations

Handle the herbarium sheet with utmost care. Don't break any part of plant for observation. For minute details, use hand lens.

- Compare the diagram drawn on the Worksheet # 11.1 and museum specimen and try to identify the species.
- Study the uniqueness of the plant/s provided to you.
- Draw the structure of grain from dorsal and ventral view on the Worksheet # 11.1.
- Write down botanical as well as vernacular names of wheat.

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- Make a list of various varieties of wheat found in your area with their characteristic features.

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- Describe at least five uses of wheat.

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- Draw the figure of L.S. wheat grain as observed by you in microscope in the space provided on Worksheet # 11.1.

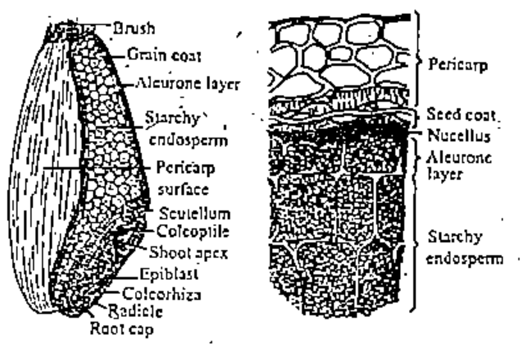
Worksheet # 11.1: Wheat

Family : ....

Botanical name of species: ....

Draw the various varieties of wheat

Dorsal and ventral side of seed
(Draw both the sides)



Morphology of plant with awn
(Draw the specimen and label it)

L.S. of wheat seed and magnified view of a section in T.S.

11.3 RICE

Rice is the staple food of the one-half of the world's population. China and India produce around 50% of the world's rice supply. Rice is an annual grass attaining a height of about 2-6 feet. Rice is one of the few crops where seeds do not have any dormancy, i.e., they can be sown immediately after harvesting.

1. The cultivated rice is divided into two groups: *Indica* and *Japonica.*
2. The rice plant is a semi-aquatic annual grass with fibrous roots.
3. The jointed and hollow stem bears series of nodes and internodes (culm). The tillers arise from the main culm. The membranous ligule and ear-like appendage called auricle are present at the junction of the leaf blade and sheath.
4. The leaves are alternate. The leaf blade is long, narrow.
5. The upper most leaf below the inflorescence is called the 'boot' or 'flag' which is shorter than other leaves.
6. The inflorescence is panicle containing spikelets. Each spikelet consists of two sterile glume and one fertile glume.
7. Like other cereals the rice grain (fruit) is a caryopsis. The grain with brown husk (covering of the caryopsis) is known as paddy.

Materials Required

- Herbarium/museum/living specimen/s of rice
- Hand lens/dissecting microscope
- Various varieties of rice from local market

Procedure

- Study the specimen of rice properly and compare it with the diagram given on Worksheet # 11.2.
- Study the inflorescence of rice and compare it with the diagram given on Worksheet # 11.2.
- Study the various varieties of rice with the help of hand lens.

Observations and Interpretations

- Observe the herbarium specimens with the help of description given and diagram drawn on Worksheet # 11.2.
- Describe any five characteristic features observed in rice plant.

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- Write the vernacular name(s) of rice.

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- Write the names of different varieties of rice found in your area. Draw the diagrams of various varieties of rice seed and note the difference (if any) by smelling them.

Comparison of local varieties of rice.

Varieties of Rice		Taste	Smell		
			–	++	+
1.					
2.					
3.					
4.					
5.					

- ++ Sweet smelling, + less sweet smelling, – without the smell.
- + Sweet taste, – without any taste

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- Describe any five uses of rice.

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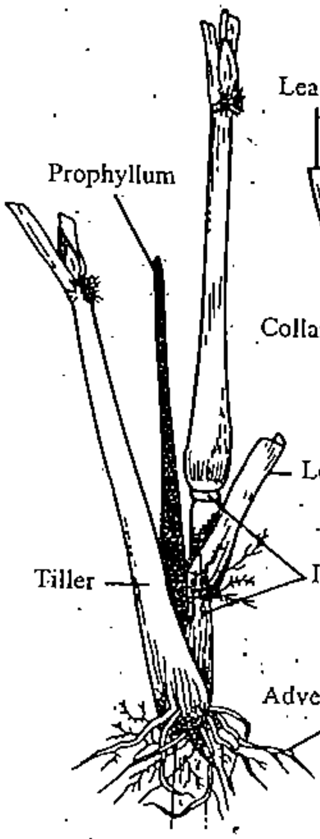
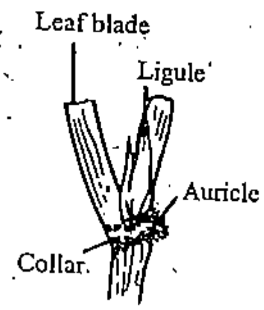
Family : ....

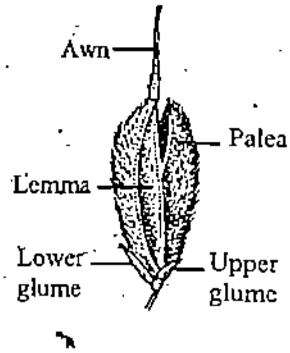
Botanical name of species: ....



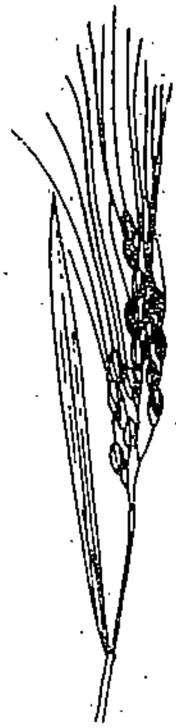
a) Basal part of rice culm



b) A leaf joint



Details of spikelets



Rice inflorescence with flag leaf

Draw the given specimen of rice plant and label it

Draw the varieties of rice seed according to their size.

11.4 MAIZE

Maize is undoubtedly a gift from the new world to the world. Due to its acclimatization powers, maize is now grown all over the world.

1. It is one of the most important crop of the world.
2. It is a fast growing tall annual succulent grass with few tillers.
3. The stem has prominent nodes and internodes. The internodal area is short at the basal region and elongates progressively upto the middle zone.
4. The leaves are linear, lanceolate with basal sheath, the lamina and the membranous ligule.
5. The plant is a monoecious:
   (i) The male inflorescence is a branched panicle (tassel) at the terminal position. The staminate spikelets occur in pairs and are two flowered.
   (ii) The female spike or "cob or ear" is terminal but from an axillary bud of the main stem and enclosed by a protective leaf sheath 'husk' or 'shucks'. The pistillate spikelets are sessile with one fertile and one sterile floret. The paired spikelets associated with a socket or 'cupule' and present in longitudinal rows on a thick axis known as cob. The styles or 'Silks' are very long and emerge from the top of the husk.
6. The grain is a caryopsis. The colour, shape and size of the fruit varies in different varieties.

L.S. of maize kernel

The grain is composed of the following:

i) **The hull:** Which is several layered and is made up of pericarp and seed coat

ii) **Tip cap:** This is the zone where kernel is joined to the cob.

iii) **Embryo:** It is small and lies at the base in close contact with endosperm and covering
   a) Plumule – which is surrounded by coleoptile
   b) Radicle – It is enclosed by coleorhiza
   c) Scutellum – This is oval shaped

Materials Required

- Herbarium/museum/living specimen of maize plant
- Maize cob, fresh/preserved
- Local varieties of maize grain
- Hand lens/dissecting microscope
- Soaked Maize grains

Procedure

- Study the specimen of maize plant, its stem, leaves and inflorescence.
- Study the cob of maize.
- Study the different varieties of maize seed and classify them (according to main groups given in LSE-13, Unit 11, pp. 12)
- Soak the grains overnight for hand sectioning

Observations and Interpretations

- Observe the specimen of maize and label the figure given on Worksheet # 11.3.
- Observe the cob of maize and label the figure given on Worksheet # 11.3.
- Write any 5 characteristic features of maize plant.

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- Write vernacular name(s) of maize.

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- Draw the various varieties of maize found in local area on the Worksheet # 11.3.
- Describe at least five uses of maize.

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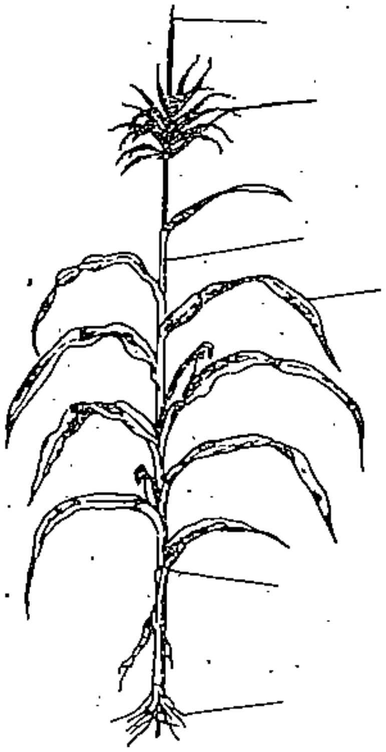
Your Notes

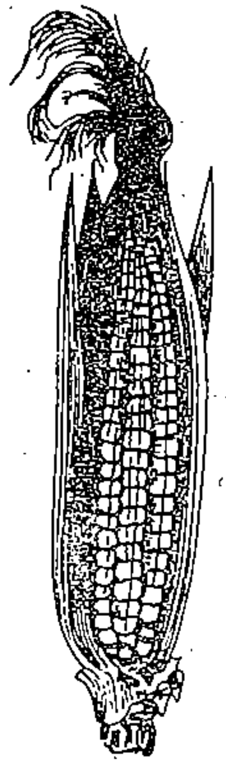
Worksheet # 11.3: Maize

Family : ....

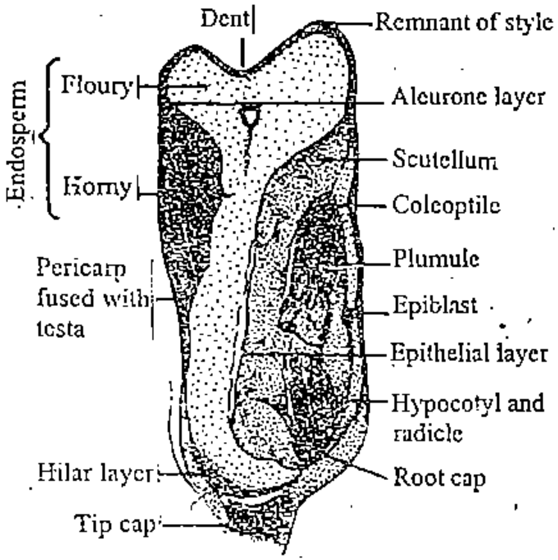
Botanical name of species: ....



Maize plant
(label the plant part)



Maize cob with grains
(label the parts of cob)



L. S. maize grain

Draw various varieties of maize found in local area

11.5 TRITICALE

1. *Triticale* is a man-made cereal. It is a hybrid between *Triticum* and rye (*Secale cereale*). In the beginning, hexaploid, wheat was hybridized but in recent years tetraploid wheat has been used.
2. The spike has many spikelets with three to five grains in each spikelet.
3. The grains are much larger than the wheat – but grains per spike are comparatively less, as a result the yield is less.
4. The protein content is more and gluten is less therefore, it is not used for making bread.
5. Research programmes are conducted in many countries to improve the quality and yield of the grains.
6. *Triticale* is more rust resistant and has lower tendency to lodging.
7. *Triticale* is more winter hardy than wheat.

Materials Required

- Herbarium specimen/photograph
- Handlens/dissecting microscope

Procedure

- Study the given specimen/photograph and observe the above given characteristics of *Triticale*.

Observations and Interpretations

- Observe the specimen or photograph properly and label the diagram given on Worksheet 13.4.
- Write uses of *Triticale* plant.

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- Write some characteristic features of *Triticale* plant.

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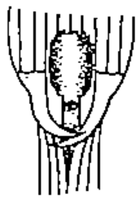
Worksheet # 11.4: *Triticale.*

Family : ....

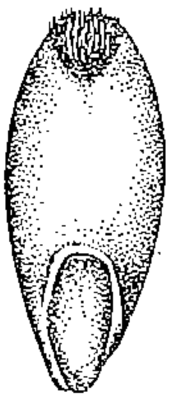
Botanical name of species: ....

Triticale
(label the plant part)

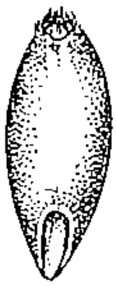
Spikelet



Auricle and ligule



a



b

c

Caryopsis of (a) *Triticale* (b) rye (c) wheat

11.6 SORGHUM

Millets are small seeded cereal crops forming the staple food for a large section of the rural and tribal folks as well as the main source of fodder for the cattle. In India sorghum, pearl millet, finger millet and several small millets are cultivated. Here, we will study sorghum in detail.

1. Sorghum is normally cultivated for fodder. In some areas it is also a food crop.
2. It is an annual grass with or without tillers. The leaves are alternate with sheath and pubescent leaf bases. The ligule is short and membranous.
3. The inflorescence is a panicle with two types of spikelets – **i) Sessile spikelet,** and **ii) Pedicellate spikelet**

   i) **Sessile spikelet:** It consists of two florets, the lower floret is reduced to lemma. The upper one is hermaphrodite, consisting of lemma, palea, two lodicules, three stamens and a centrally placed ovary with a long terminal or subterminal style and bifurcated plumose stigma.

   ii) **Pedicellate spikelet:** The lower floret is sterile reduced to lemma and the upper one is staminate or neutral, having lemma, three stamens. The palea is absent.
4. The grain (caryposis) is small and round. The colour, shape and grain pigmentation vary in different varieties. The anatomical structure of grain are like other cereals.
5. There are four main varieties:
   i) Sweet sorghum, ii) Grain sorghum, iii) Broom sorghum,
   iv) Grass sorghum

Materials Required

- Herbarium/Museum/Living specimen of sorghum plant
- Various varieties of sorghum
- Sorghum cob, fresh/preserved
- Hand lens/dissecting microscope

Procedure

- Study the morphology of sorghum plant (stem, leaves, inflorescence, grain)
- Study the cob of sorghum
- Study (if possible) various varieties of sorghum

Observations and Interpretations

- Observe the sorghum specimen and label the figure given on Worksheet # 11.5.
- Observe the cob and label the figure on Worksheet # 11.5.
- Write vernacular name(s) of sorghum.

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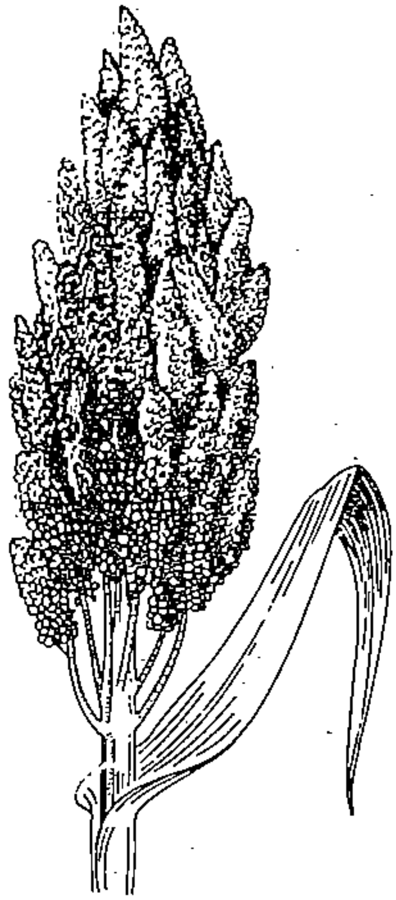
- If possible, draw various varieties of sorghum on the Worksheet # 11.5.

- Describe at least two uses of sorghum.

- Describe any five characteristic features of sorghum plant.

Family : ....

Botanical name of species: ....



Mature head of sorghum

Draw a mature sorghum plant

Magnified portion of sorghum head

Draw various varieties of sorghum.

11.7 MICROCHEMICAL TESTS

As cereals are rich in carbohydrates you have to perform microchemical tests for carbohydrates and protein. The detailed method has been dealt in exercise – 1. Please go through the same for doing this test.

Materials Required

- Seeds of:

  Wheat,
  Rice,
  Maize,
  Sorghum
- Test tubes, test tube stands, petri dish, burner and spirit lamp.

Reagents for micro-chemical lists. (Refer to Exercise 1)

Procedure

- Take overnight soaked seeds of each sample in different petri dishes.
- Grind each seed sample separately into paste with water
- Take 1 ml of paste of each sample and place in separate test tube and label the test tube indicating the name of plant.
- Perform the test for carbohydrates and proteins as described in Exercise – 1.
- Note your observations in Table 10.1.

Observations and Interpretations

- Observe the presence/absence of carbohydrates and protein in seeds.
- Denote presence of carbohydrates and protein by using + sign and – sign to denote the absence of carbohydrates.

Table 10.1: Microchemical tests.

	Tests for carbohydrates		Tests for proteins	
	(+) Presence	(–) Absence	(+) Presence	(–) Absence
1. Wheat				
2. Rice				
3. Maize				
4. Sorghum				

11.8 STUDY OF STARCH GRAINS

Starch grains are made up of insoluble carbohydrates and are the most common reserve materials found among green plants.

Materials Required

- Seeds of Wheat
  Rice
  Maize
  Sorghum
  Microscope
  Slides
  Coverslips
  Test tubes
  Labels
  Gum tubes
  Procedure
- Same as in section 11.7 Micro-chemical tests up to making paste of the seeds.
- Take 1 ml of paste in test tube of each seed simple and stain it with Potassium iodine solution.
- Take a drop of stained material from each tube and place it on slide. Cover it with coverslip and observe it under microscope.
- Make the diagram of the starch grains which you observe under microscope on the given Worksheet # 11.6.

Your Notes

Worksheet # 11.6: Starch grains.

Draw starch grains of Wheat

Draw starch grains of Rice

Draw starch grain of Maize

Draw starch grains of Sorghum

EXERCISE 12 SPICES AND CONDIMENTS

Date: ....
Session # : ....
Time allocated: 45 minutes

Structure

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in the lab.

12.1 INTRODUCTION

Spices and condiments are important plant products that are extensively used for flavouring and seasoning food because of their aromatic value (essential oil) although they are less nutritive.

India is the 'home of spices'. The spices have played a very important role in Indian economy. Export of these flavouring materials earn good amount of foreign exchange. Spices have characteristic pungency, strong odour and sweet or bitter taste. We cannot imagine Indian food without spices. They enhance the aroma and flavour of the food and stimulate the appetite. They act as a preservative and also have valuable role in medicine, perfumery and cosmetics.

Condiments to have a sharp taste and are commonly added to food after it has been cooked.

In this exercise, spices are classified on the basis of the part used such as rhizome, roots, leaves, flower buds, fruits and seeds. We will study in detail the spices which are commonly used in India.

Objectives

After completing this exercise, you should be able to:

- describe parts of various plants used as spices or condiments;
- differentiate between the botanical name, common name and [illegible]me and family of the plants used as spices and condiments;

- explain the uses of the spices or condiments, and
- describe adulterants of different spices or condiments.

Study Guide

- Read this exercise before hand so that you will be able to do the work in time and achieve the set objectives.
- Also read unit 17 spices and condiments of LSE-13 course.

12.2 CLASSIFICATION OF SPICES

Spices are obtained from different plant parts for example from rhizome, leaves, flower, seed etc. The bulk of the dry matter of these spices consists of carbohydrates, proteins, tannins, resins, oleoresins, calcium oxalate, fixed oils and volatile oils.

Materials Required

i) Ginger, turmeric, saffron, clove, black pepper, chillies (Red and green), coriander, fennel, mustard, nut meg and mace.
ii) Hand lens/ dissecting microscope.

Procedure

Observe the displayed material and study closely with the help of hand lens and fill the table given below.

Observations and Interpretation

Table 12.1: Spices

Sl. No.	Name of spice	Colour	Plant part used	Any other important feature
1.	Ginger			
2.	Turmeric			
3.	Clove			
4.	Pepper			
5.	Chillies			
6.	Coriander			
7.	Fennel			
8.	Mustard			
9.	Nutmeg & mace			

12.3 GINGER

Ginger is one of the spices which has been used since ancient times. India still remains the world's largest producer and exporter of ginger. We will study the morphology and anatomy of the underground rhizome that yields ginger.

Materials Required

i) Herbarium/museum/fresh specimens of ginger plant bearing rhizome.
ii) Hand lens/dissecting microscope.

Procedure

Pick up the herbarium/museum specimens and study them with hand lens, if needed and write your observations in the space provided below and draw the diagram on the Worksheet # 12.1.

Handle the herbarium sheet with utmost care. Don't break any part of plant during observation. For minute details use hand lens.

Observations and Interpretations

- Observe the morphology of the ginger plant and label the diagram given in Worksheet # 12.1 and write at least five important characteristic features of ginger plant.

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- Observe the plant part which constitutes the spice. Why is it stem or root? Give reasons.

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- Draw the diagram of rhizome of ginger and label its part on Worksheet # 12.1.
- Cut a T.S. of ginger rhizome and draw the figure on the Worksheet # 12.1.
- Write at least five uses of ginger.

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- Write the local name of ginger in your area.

Worksheet # 12.1: Ginger

Family : ....

Botanical Name : ....

Ginger plant
(Label the diagram)

Draw the rhizome of ginger and
label its parts

Draw T.S. of ginger rhizome and label it

Draw a single leaf of ginger

12.4 TURMERIC

Turmeric is indigenous to Southern Asia and is the most popular condiment, medicine and dyestuff since time immemorial. Turmeric is one of the most important and ancient Indian spices and a traditional export article.

Materials Required

i) Herbarium/museum/fresh specimen of turmeric plant, turmeric.
ii) Hand lens/dissecting microscope.

Procedure

Study the morphology of turmeric plant herbarium/living specimen carefully.

Observations and Interpretations

- Label the plant parts given on Worksheet # 12.2.
- Write any five important characteristic features of the turmeric plant.

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- Draw a well labelled diagram of rhizome of turmeric on the Worksheet # 12.2 and label its various parts.
- Cut a T.S. of turmeric rhizome and draw a well labelled, diagram on Worksheet # 12.2.
- Write five uses of turmeric.

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- Write vernacular name(s) of turmeric.

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- Write the local names of turmeric in your area.

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Worksheet # 12.2: Turmeric

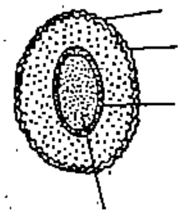
Family : ....

Botanical Name : ....

Label the various
parts of the turmeric plant

Leaf
(Draw the single leaf of the turmeric plant)

Rhizome
(Draw and label the diagram)



T.S. Rhizome (Label the diagram)
(Can use coloured pencil)

12.5 SAFFRON

Saffron is the most expensive and one of the oldest spices of the world. It is slow growing, perennial plant having an underground globular corm bearing sessile, linear and sheathing leaves. The commercial saffron is obtained from tripartite deep red, funnel – shaped stigmas of violet bluish solitary flowers.

Materials Required

i) Herbarium/museum/living/specimen of saffron plant/photograph of the specimen.
ii) Dried saffron.

Procedure

Study the Herbarium/museum/living specimen of saffron plant carefully. Living specimen of saffron is difficult to find thus you have to study saffron through herbarium/photograph of the specimen.

Observations and Interpretations

- Observe the diagram given on the Worksheet # 12.3 and label its various parts.
- Observe the herbarium of saffron (if possible) and write five characteristic features of the saffron plant.

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- Observe the tripartite funnel shaped stigma with adhered pollen grains and draw it on the Worksheet # 12.3.
- Write the uses of saffron.

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- Write the vernacular name of saffron.

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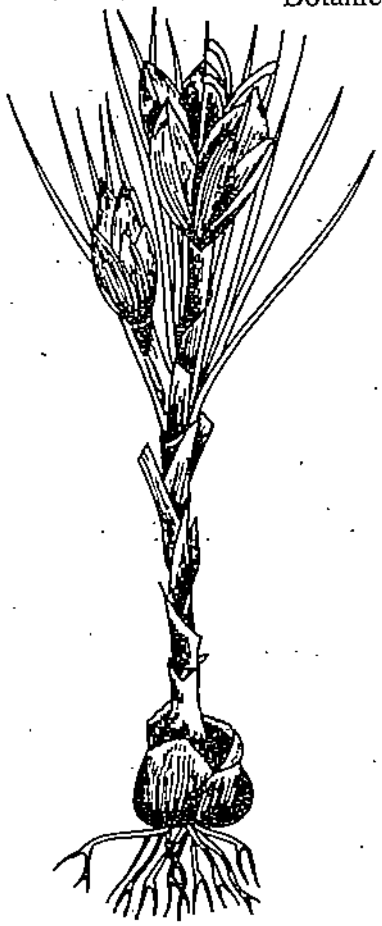
Worksheet # 12.3: Saffron

Family : ....

Botanical Name : ....



A flowering plant of saffron
(Label the parts of plant)

Draw a tripartite stigma of saffron.

12.6 CLOVE

Clove is believed to be a native of Moluccas – the spice island and was introduced in India around 1800 AD by the East India Company. The clove tree is evergreen attaining a height of 10-15 feet. The leaves are aromatic due to presence of numerous oil glands. The unopened flower buds which are highly aromatic yield the clove of commerce.

Material Required

i) Herbarium/Museum/Living specimen of clove buds.
ii) Dry clove buds
iii) Hand lens/dissecting microscope.

Procedure

- It is difficult to get a living specimen of clove throughout India. So you have to study it through herbarium specimens. Study the specimen carefully by the aid of hand lens.
- Cut a Median L.S. of clove bud and observe it.

Observations and Interpretations

- Observe the diagram given on Worksheet # 12.4 and label the plant parts.
- Observe the clove and make a diagram on Worksheet # 12.4.
- Write at least five characteristic features of the clove bud.

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- Give the vernacular name of clove if it grows in your area.

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- Observe and draw a figure of clove bud on the Worksheet # 12.4.
- Cut a L.S. of clove bud and observe.

  i) Shape ....

  ii) Sepal (number) ....

  iii) Stamens (number) ....

  iv) Ovary (number) ....

  v) Hypanthium ....

  v) Oil glands ....

  Also label parts of clove which are not labelled.

Describe the uses of cloves.

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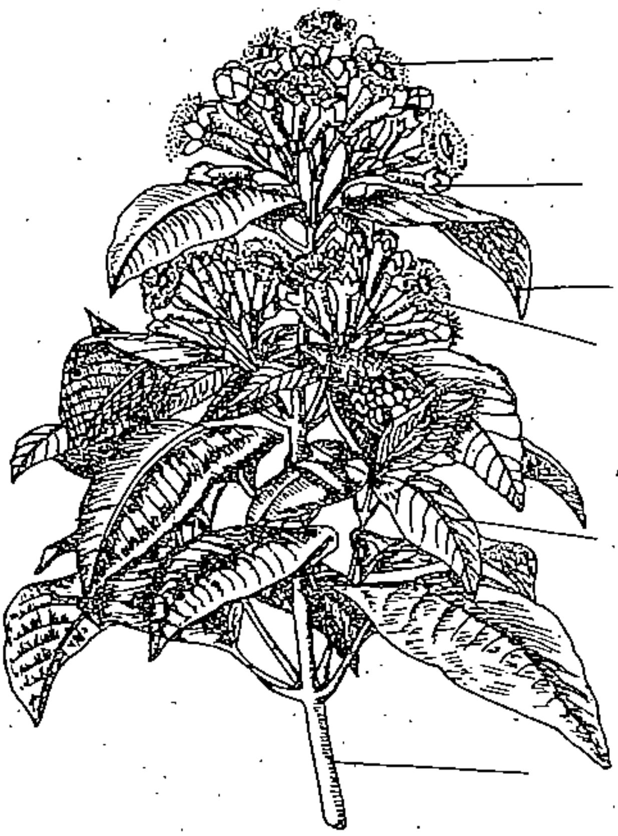
Your Notes

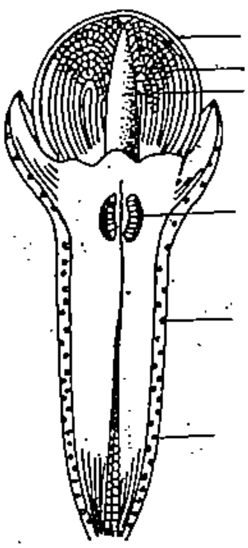
Family : ....

Botanical Name : ....



Flowering branch of clove tree
(Label the parts)

Draw (morphology) of a clove bud



Median L.S. of a clove bud and label.

(Draw M.L.S. a clove bud and label it)

12.7 PEPPER

Black pepper is indigenous to the moist tropical forests of the Malabar Coast of Southwestern India. Even today, pepper is the most important spice in India, in terms of world trade. Kerala is the most important pepper producing state of India accounting for nearly 97 percent of the total production.

The characteristic smell of pepper is due to the presence of a volatile oil in the cells of pericarp and the pungency is due to non-volatile oil present in oleo resin cells of perisperm.

Materials Required

i) Herbarium/Museum or living specimen of pepper plant, dry pepper.
ii) Hand lens/dissecting microscope.

Procedure

- Study the herbarium specimen carefully with the aid of hand lens. If you get a living specimen for study, you can use dissecting microscope for detailed study.
- Cut a T.S. of pepper corn and observe it under dissecting microscope.

Observations and Interpretations

- Observe the herbarium sheet and label the diagram given on Worksheet # 12.5.
- Draw the cluster of fruits (spike) and draw on the Worksheet # 12.5.
- Describe five characteristic features of pepper plant.

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- Label various parts of the seed given on Worksheet # 12.5.
- Describe uses of pepper.

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- Write vernacular names of pepper used in your area.

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- If possible write the names of pepper varieties found in your area.

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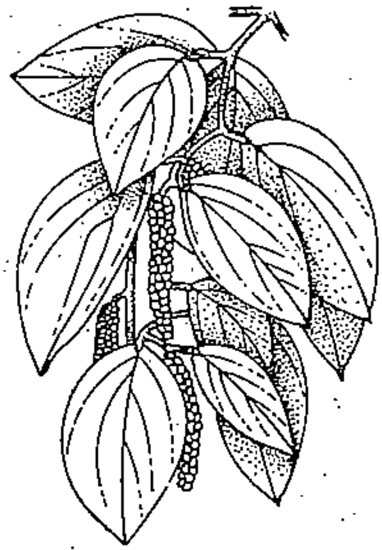
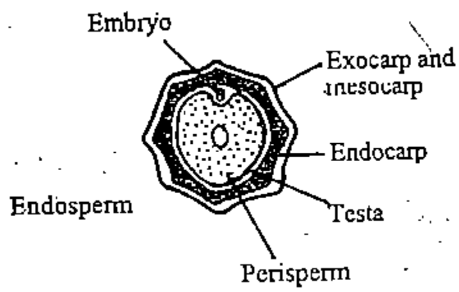
Family : ....

Botanical Name : ....



Fruiting branch of pepper.

Draw a cluster of catkin bearing pepper fruits



L.S. of pepper corn.

Draw and Label various parts of L.S. pepper corn fruit

12.8 CAPSICUM

In India chillies are grown in practically all states. They are grown from seeds. They are used because of their pungency or spicy taste. We are going to study two species of capsicum (i) *Capsicum frutescens* (Red pepper) and (ii) *Capsicum annuum* (Shimla mirch or Bell pepper) which is milder in taste.

Materials Required

i) Herbarium/museum/living specimen of *C. frutescens* and *C. annuum.*
ii) Hand lens, Dissecting microscope
iii) Other varieties of capsicum found in your area.

Procedure

Study the specimens carefully with hand lens or dissecting microscope. Study the flower also.

Observations and Interpretations

- Label the plants given on Worksheet # 12.6.
- Describe any five characteristic features of *C. frutescens* as well as of *C. annuum.*

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- Taste and smell both the varieties (if possible taste local varieties) and write your experiences.

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- Write five uses of both the varieties of Capsicum.

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- Write the vernacular names of capsicum.

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Family : ....

Botanical Name : (i) ....
(ii) ....

Draw a fruit of *C. frutescens*

Draw a fruiting branch *Capsicum frutescens*
(Label the parts)

Draw the T.S. fruit of *C. frutescens*.

Draw the fruit of *C. annuum*.

Draw a fruiting branch of *Capsicum annuum*

Draw a T.S. fruit of *C. annuum*.

12.9 FENNEL

In India, fennel is grown in winter upto 1830 m altitude. All the parts of this spice are aromatic. The inflorescence is compound umbel. The flowers are very small and white yellow. The schizocarpic fruit is oblong-oval or elliptical green, pale yellow or brown with a long pedicel and consists of two curved mericarps.

Material Required

i) Herbarium/museum/living specimen of fennel, dry seeds of fennel.
ii) Hand lens, Dissecting microscope.
iii) Median cross section C.S. through mericarp (Permanent slide)

Procedure

- Study the given material carefully. (If you are doing this practical in winter you may get living specimen for study)
- Cut a C.S. through mericarp and observe under dissecting microscope.

Observations and Interpretations

- Describe five characteristic features of fennel plant.

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- Draw the fruiting umbel and label it.
- Cut a C.S. through mericarp (or study C.S. through a permanent slide) and compare/study the structure with the help of diagram given on Worksheet # 12.7.
- Draw the morphology structure of fennel fruits on Worksheet # 12.7.
- Dissect the fennel fruit under dissecting microscope and observe the mericarps.

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- Give 5 uses of fennel fruits.

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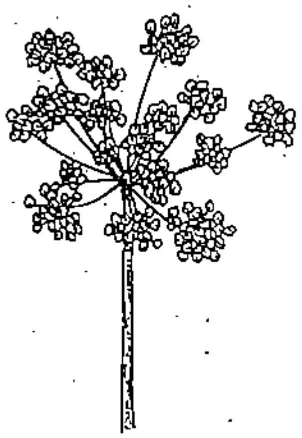
Family : ....

Botanical Name : ....

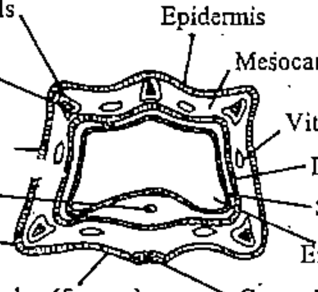


Inflorescence of fennel

Draw a diagram of dissected schizocarpic fruit with two mericarps.

Draw morphology of fennel fruits

Draw and label Median C.S. of fennel mericarp



Median cross-section of the mericarp of fennel.

12.10 CORIANDER

Coriander is a small aromatic herb 0.3 – 1 m high. In India, coriander is grown in almost all states and in winter it is used extensively.

The plants have characteristic dimorphic leaves. In the inflorescence (compound umbel), peripheral flowers are large and zygomorphic but the centrally located ones are small and actinomorphic. The dried coriander fruit is nearly globular and yellowish brown bearing the remnants of the calyx and stylopoduim at the apex with two mericarps attached to an undivided carpophore.

Materials Required

i) Herbarium/museum/living specimen of the coriander plant.
ii) Dried fruit of coriander.
iii) Hand lens/dissecting microscope.
iv) Permanent slide (Median C.S.) showing mericarp of coriander fruit.

Procedure

- Study the given material carefully by the aid of hand lens.
- Dissect a fruit and study the mericarps.
- Cut Median C.S. sections of fruit and observe under compound microscope.

Observation and Interpretation

- Observe the specimen and write characteristic features of coriander plant.

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- Observe the seed and draw the figure on the Worksheet # 12.8.
- Draw a figure of a fruiting branch on Worksheet # 12.8,
- Cut a M.C.S. of coriander seeds through mericarp. Observe and compare with the diagram given on the Worksheet # 12.8.
- Write the vernacular name of coriander.

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- Write any five uses of coriander plant.

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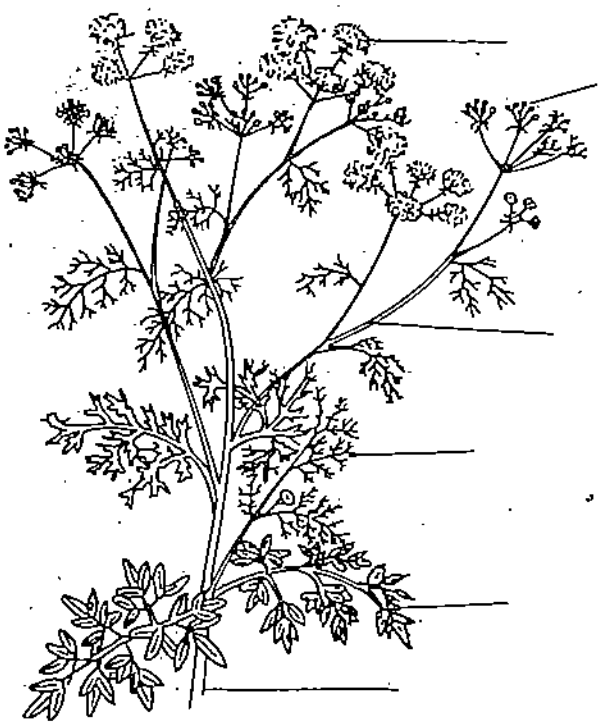
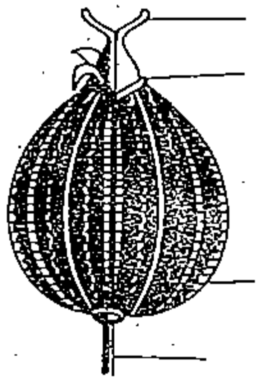
Family : ....

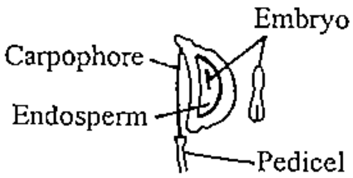
Botanical Name : ....



Coriander plant
(label the parts)

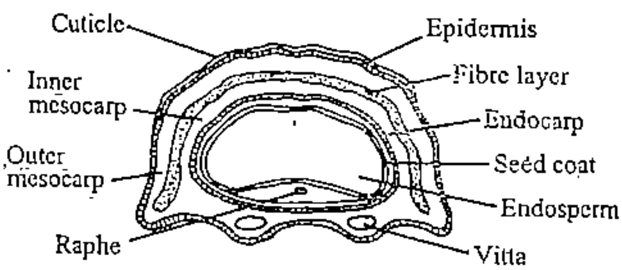


Coriander fruit with calyx and stylopodium
(label it)



Mericarp of coriander split longitudinally

(Draw a fruiting branch of coriander)



Mericarp of coriander seed in T.S.

12.11 CARDAMOM

Cardamom or lesser cardamom is an indigenous plant of India and has been used as a valuable spice since ancient times. India is the largest producer of cardamom.

The plant is a bushy, perennial with a thick ginger like underground rhizome. The stems are of two types: vegetative stem bearing numerous, alternately arranged, long, lanceolate leaves with sheathing bases and the leafless, reproductive stem usually growing horizontally and bearing numerous white flowers in the axils of leafy bracts.

The fruits are greenish light brown, trivalved with papery fruit wall. The capsule contains numerous dark reddish brown seeds, enclosed by a membranous aril. The seeds have a pleasant aroma and a warm, slightly pungent characteristic taste.

Materials Required

i) Herbarium/museum specimen/photograph of the cardamom plant.
ii) Dried fruits of small a lesser cardamom.
iii) Hand lens/dissecting microscope.

Procedure

- Study the herbarium specimen and museum specimen carefully.
- Study the dried fruits of cardamom.

Observations and Interpretations

- Observe the herbarium specimen and compare it with the figure drawn on the Worksheet # 12.9.
- Draw cardamom fruits and seeds on the Worksheet # 12.9.
- Write five characteristic features of the cardamom plant studied by you.

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- Describe five uses of cardamom.

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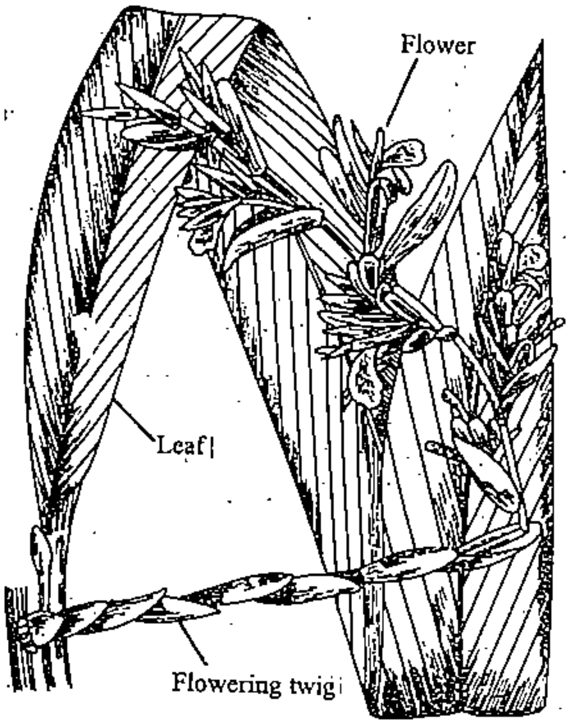
Family : ....

Botanical Name : ....



A leaf and flowering twig of cardamom

Draw dried fruit of cardamom

Draw dried seeds of cardamom

Draw and label seeds of cardamom

12.12 NUTMEG AND MACE

Nutmeg and mace are two distinctively different spices obtained from the same nutmeg plant.

Nutmeg tree is bushy in appearance about 30-40 m in height, bearing oblong-ovate, dark green, lustrous leaves with small, fleshy, pale yellow and aromatic flowers.

The ripe fruit is smooth yellow and fleshy and resembles a peach. It becomes dry and splits open disclosing a bright red, fleshy aril which encloses a thin lustrous deep brown shell containing a single seed or nutmeg. The crimson aril which encloses the nutmeg is the mace of commerce.

Materials Required

- Herbarium/museum/ living specimen of nutmeg plant.
- Nutmeg seed and mace.
- Hand lens/dissecting microscope.

Procedure

- Study the herbarium specimen properly. If flowers are found in herbarium study them with hand lens with utmost care.
- Study the seed and aril, note its colour and texture.

Observations and Interpretations

- Observe the herbarium specimen and compare with figure drawn on Worksheet # and label it.
- Observe the nutmeg seed and label the figure drawn on Worksheet # 12.10.
- Draw nutmeg seed and mace on the Worksheet # 12.10 (you can use coloured pencil).
- Describe any five characteristic features of nutmeg tree.

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- Write vernacular name of nutmeg and mace.

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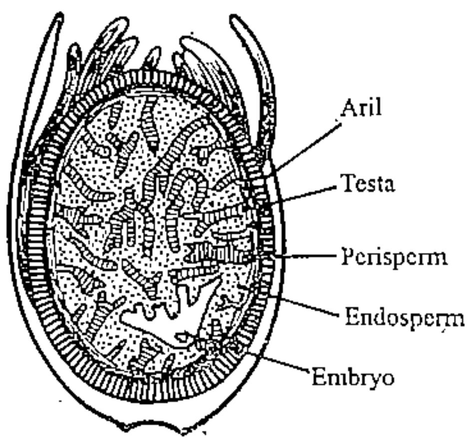
Family : ....

Botanical Name : ....

Twig of nutmeg with fruit cut open

Draw a nutmeg seed showing intact

Draw nutmeg a seed



Draw a nutmeg fruit split open
(label the fruit)

L.S. of nutmeg seed

SAQ

1. List the medicinal uses of spices.
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2. Make a table and write botanical, vernacular names and the family species you have read.

3. List the spices which are used in your area other than what you have read.
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4. Make a list of material used as adulterant in spices in your locality. Also write in which spices what adulterant is used.
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EXERCISE 13 LEGUMES

Date ....
Session # ....
Time allocated – 2 Hours

Structure **Page No.**

A thorough reading of this exercise before the lab session, would be very helpful to you to accomplish the laid down objectives.

Do not forget to wear your lab coat while working in the lab.

13.1 INTRODUCTION

A large number of species belonging to the three sub-families of Fabaceae (earlier name Leguminosae) are important to us, mainly in the following three ways:

1. food – as dry mature grains (pulses/dals), as young pods (e.g., beans), or as fruit mesocarp (e.g., tamarind);
2. forage – when leaves and young plants are fed to livestock; and
3. green manure – when young plants are ploughed in the soil to improve its fertility. Some legumes are also used as sources of gums, dyestuffs, and fuel.

In predominantly vegetarian diets, legumes particularly the pulses form the most important source of proteins, complementing the main course of carbohydrates obtained largely from the cereals. On per unit land area basis, legumes produce more proteins than any other plant, with the least input of nitrogenous fertilizers. This is owing to their capacity to fix atmospheric nitrogen in symbiotic association with the bacterium – *Rhizobium*. This soil bacterium, colonises the roots of legumes and forms nodules from their cortical tissue. The bacteria live in these nodules, derive carbon from the host plant and in turn supply the plant with nitrogen. You may recall that, in LSE-08 (L), you have done a taxonomy related exercise on legumes, and you have studied the theoretical details in Units 12 and 21, in the LSE-13 course. In this exercise, you will study some grain legumes (pulses) with special emphasis on their pods and seeds and also on their root nodules.

Objectives

After completing this exercise, you should be able to:

- identify some economically important legumes;
- list the characteristic features of some commonly used legumes;

- explain the exclusive features of the pods and seeds of the given legumes;
- compare in qualitative terms the amount of the macromolecules – proteins, starch, and oils/lipids in the given seeds;
- describe the structural specialities of the seed-coat of a leguminous member;
- describe the root nodules of a leguminous plant highlighting its morphological and anatomical peculiarities; and
- comment on the overall appearance, and nature of bacteriods from the root-nodules of a legume.

Study Guide

- To remind you once again, reading the exercise prior to the related lab session is very helpful in familiarizing with the tasks to be done within the given time-frame, and achieving the set objectives.
- To refresh the concepts and structural details of legumes, you may consult the following sources, that you have already studied.
  LSE-08 (L) Course: Experiment 16, pp. 66-67;
  LSE-13 Course: Unit-12, pp. 40-64; and Unit-21, pp. 26-40.
- To utilize the given 120 min. time-frame effectively, plan out a time-table for the tasks to be undertaken.

Your Notes

13.2 PLANT MORPHOLOGY

In this section, you would study the morphological features of some economically important legumes. The idea of doing this exercise is to know about the features that impart a common look to the legumes, whereby any leguminous plant is easily recognised. The second purpose of this exercise is to know the unique characters of the specific members belonging to this group. That is what makes us say that it is a pea plant, or a groundnut plant and so on. To sum up, our focus would be to look for the general characters of legumes as well as the specific characters of each of the leguminous members selected for study.

Materials required

1. Herbarium/live specimens of the following:

   i) Chickpea (Specimen A)
   ii) Lentil (Specimen B)
   iii) Pea (Specimen C)
   iv) Arhar (Specimen D)
   v) Groundnut (Specimen E)
   vi) Cowpea (Specimen F)
   vii) Mung (Specimen G)
   viii) A locally available member, in addition to the above mentioned members (Specimen H)
2. A hand lens/dissecting microscope

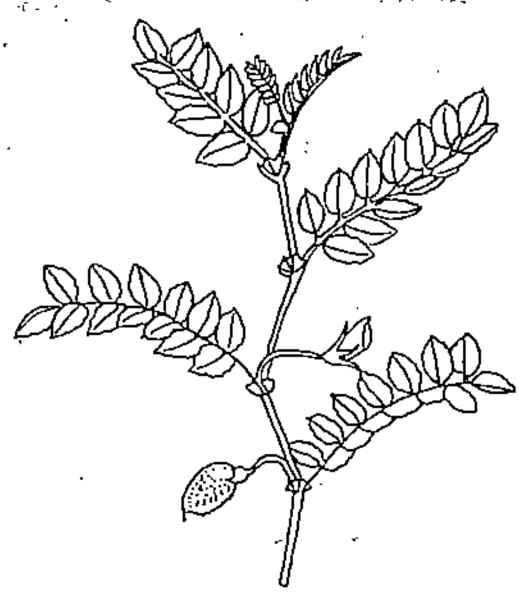
Procedure

You have to study 8 specimens in all. Pick up specimens one by one. Study them closely and record your observations in their respective Worksheets (# 13.1 to 13.8). The detailed guidelines for study are given below.

Observations and Interpretations

Take a specimen, observe it minutely for a couple of minutes. Use hand lens or the dissecting microscope to observe the surface details, like the trichomes and other microstructures. Reason out to yourself that on what basis is the specimen classified as a legume, and which of its unique characters makes it different from the other leguminous members. For example, in the context of which particular characters a plant of Pea is different from that of Arhar or Green gram and so on. Note three such specific characters of each specimen in its respective worksheet. In addition, you also have to write the botanical name, common/vernacular names of the given specimens. Outline diagrams of specimens **A-G** are given in the worksheet. Label their different parts. You may illustrate the details/features of these plants in the diagram space adjacent to the given outlined diagrams. For specimen **H**, that is of a locally available edible legume, you have to make its outline diagram similar to the ones given for the specimens **A-G** in the Worksheets # 13.1 to 13.7. *Note: include at least two nodes in this outline diagram along with all the structures on them.*

Worksheet # 13.1: Study of Specimen A – Chickpea.



Q.1: Label the various parts of the plant in the above diagram, highlighting (with a coloured pencil the characteristic feature(s).

Diagram space

Q.2: Depict/enlarge the morphological detail(s) of the given specimen.

Description space

Q.3: Fill in the following details.

Botanical name ....

Common/vernacular name(s) ....

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Specific characteristics ....

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Diagram space

Q.1: Label the various parts of the plant in the above diagram, highlighting the characteristic feature(s).

Q.2: Depict/enlarge the morphological detail(s) of the given specimen.

Description box

Q.3: Fill in the following details.

Botanical name ....

Common/vernacular name(s) ....

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Specific characteristics ....

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Worksheet # 13.3: Study of Specimen C – Pea.

Q.1: Label the different parts of the plant in the above diagram, highlighting the characteristic feature(s).

Diagram space

Q.2: Depict/enlarge the morphological detail(s) of the given specimen.

Description space

Q.3: Fill in the following details.

Botanical name ....

Common/vernacular name(s) ....

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Specific characteristics ....

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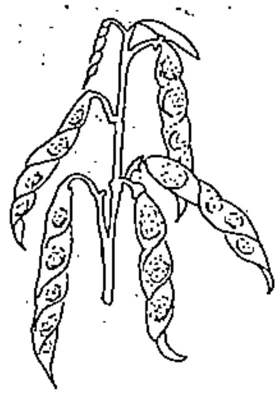
Worksheet # 13.4: Study of Specimen D – Arhar.



Q.1: Label the different parts of the plant in the above diagram, highlighting the characteristic feature(s).

Diagram space

Q.2: Depict/enlarge the morphological detail(s) of the given specimen.

Description box

Q.3: Fill in the following details.

Botanical name ....

Common/vernacular name(s) ....

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Specific characteristics ....

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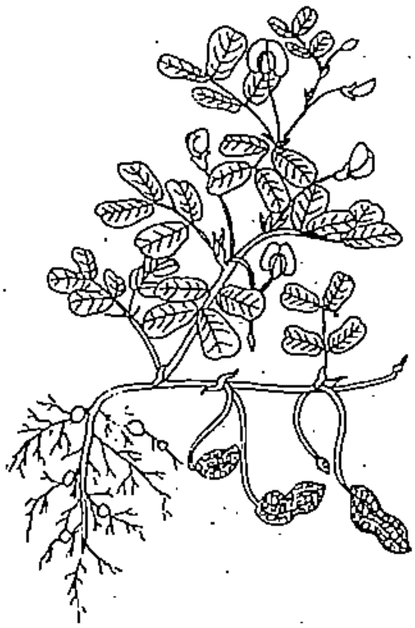
Worksheet # 13.5: Study of Specimen E – Groundnut.



Q.1: Label the different parts of the plant in the above diagram, highlighting the characteristic feature(s).

Diagram space

Q.2: Depict/enlarge the morphological detail(s) of the given specimen.

Description space

Q.3: Fill in the following details.

Botanical name ....

Common/vernacular name(s) ....

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Specific characteristics ....

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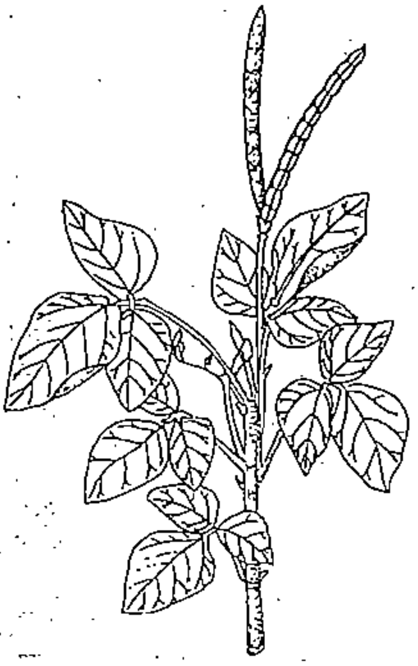

Q.1: Label the different parts of the plant in the above diagram, highlighting the characteristic feature(s).

Diagram space

Q.2: Depict/enlarge the morphological detail(s) of the given specimen.

Description box

Q.3: Fill in the following details.

Botanical name ....

Common/vernacular name(s) ....

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Specific characteristics ....

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Worksheet # 13.7: Study of Specimen G – Mung.

Q.1: Label the different parts of the plant in the above diagram, highlighting the characteristic feature(s).

Diagram space

Q.2: Depict/enlarge the morphological detail(s) of the given specimen.

Description space

Q.3: Fill in the following details.

Botanical name ....

Common/vernacular name(s) ....

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Specific characteristics ....

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Worksheet # 13.8: Study of Specimen H – A local member.

Diagram space

Q.1: Make an outline diagram of the given specimen and label its different parts, and highlight its characteristic feature(s).

Description space

Q.3: Fill in the following details.

Botanical name ....

Common/vernacular name(s) ....

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Specific characteristics ....

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13.3 PODS AND SEEDS

In this section too, you would continue morphological studies, but here the focus would be on the plant part used.

Materials required

1. Pods and seeds of the following:

   i) Arhar
   ii) Groundnut
   iii) Pea

   In case, any of the material(s) is/are not available, the other easily available materials can be used.
2. Seeds of the above materials soaked-overnight
3. Dissecting microscope
4. Forceps
5. Mounted needles
6. Coloured pencils

Procedure

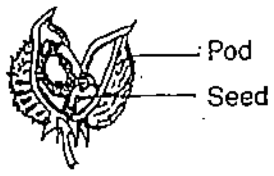
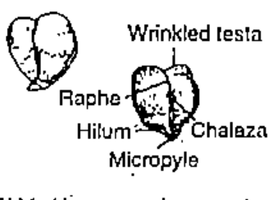
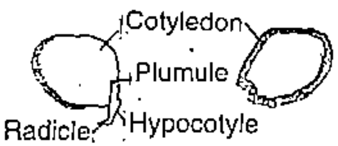
Observe the pods and seeds carefully and note your observations as instructed in the Worksheet # 13.9. A worked-out example of chickpea is given in the worksheet for your reference.

Observations and Interpretations

While having a closer look at the fruits and seeds of the given legumes, carefully note the structural details like – colour, texture, ornamentation, presence or absence of hairs, uni- or bi-sutured, number of seeds/pod, and the other peculiar feature(s). On comparing the details of pods of a few members, you would get a feel of the commonalities between species, and also the peculiarities of species. Similarly, interpret the common and unique features of their seeds also. Refer to the details of chickpea given in the Worksheet # 13.9. Give particular attention to the hilum.

Your Notes

Worksheet # 13.9: Study of economically important part(s) of legumes.

Part/s	1. Chick pea, chana	2.............................	3.............................	4.............................
FRUIT: Shape	Oval, inflated  A split fruit			
SEED: No. / fruit	One or two  W.M. *(draw more than one view)*			
Size	0.5 – 1.0 cm			
Colour of the seed coat	Straw, light or dark brown			
Split seed (illustration)				

Q.1: Record your observations, both in writing and in diagram forms of the given specimens in columns # 2 to 4. Don't forget to write the name of the source plant on the top of each column.

13.4 MICROCHEMICAL TESTS

In this part of the exercise, you have to perform microchemical tests for proteins, starch and oils/lipids. The detailed methods of performing these tests have been dealt with in Exercise # 1 which may be referred to.

Materials required

1. Take the seed of any two of the following materials:
   i) Chickpea
   ii) Cowpea
   iii) Lentil
   iv) Pigeon pea
   v) Groundnut
   vi) Soybean
   vii) Mung
2. Tests tubes
3. Test tube stands
4. Burner or spirit lamp
5. Reagents for microchemical tests (See Exercise # 1)

Handle the chemicals carefully.
Take all the precautions as mentioned in Exercise # 1.

Procedure

1. Take whole seeds/split grains of legumes and soak them overnight.
2. Grind paste of their cotyledons in water.
3. Make the paste of pouring consistency with the help of water.
4. Take 1 ml of paste (or take by weight) of each of the two samples in separate test tubes.
5. Label the test tubes, indicating the name of the source plant.
6. Perform the tests for proteins, starch and oils/lipids, as explained in Exercise # 1.
7. Note your observations in Worksheet # 13.10.
8. You can work in groups for speeding up the work.

Observations and Interpretations

1. Use '+' to indicate the presence, and '–' to denote the absence of the three selected macromolecules. You may use one to three plus symbols to represent the concentration.
2. Note also the observations recorded by the different groups in your class, and take the mean value of the entire class.
3. You can compare your observations with those of the other groups. If there are sharp differences, try to find out the reason for the variations.

Your Notes

Worksheet # 13.10: Microchemical tests.

Group #	Material	Proteins	Starch	Oils/lipids
#1.	1.			
	2.			
	3.			
	4.			
	5.			
	6.			
#2.	1.			
	2.			
	3.			
	4.			
	5.			
	6.			
#3.	1.			
	2.			
	3.			
	4.			
	5.			
	6.			
#4.	1.			
	2.			
	3.			
	4.			
	5.			
	6.			

- Use '+' to indicate he presence, and '–' to denote absence.
- You may use one to three + symbols to indicate the relative concentrations of the constituents.

Your Notes

13.5 SEED COAT

The seed coats of many legumes contains macrosclereids and osteosclereids. These have been dealt with in Unit 7 of LSE-13 course (see p. 39).

Materials required

1. Macerated seed coat materials of *Pisum sativum/Phaseolus multiflorus,*
2. Slides
3. Coverslips
4. Safranin
5. Glycerine
6. Blotting papers

Procedure

1. Place a small drop of the macerated seed coat material on the slide.
2. Add a small drop of safranin to it, and let it stain for a couple of minutes.
3. Make a temporary mount of the same by placing a drop of glycerine on the stained material and covering it with a cover slip.
4. Observe it under the microscope

OR

In case of paucity of time, a prepared temporary mount would be provided to you. Observe it under the microscope and locate the macro- and osteo-sclereids.

Observations and Interpretations

1. Study the features of the two types of sclereids, and learn to differentiate between the two.
2. Draw two cells each, of the macrosclereids and the osteosclereids in the Worksheet # 13.13. Also note their salient features.

Your Notes

Worksheet # 13.11: Study of sclereids in the seed coat.

Diagram space	Description space
Q.1: Illustrate a few (at least two) macrosclereids from the given seed coat.	**Q.2:** Write the salient features of the macrosclereids.
Diagram space	Description space
Q.3: Illustrate at least two osteosclereids from the given seed coat.	**Q.4:** Write the salient features of the osteosclereids.

13.6 ROOT NODULES

The great majority of leguminous species form nodules on their root surfaces. These nodules develop in response to the invasion by specific strains of bacteria.*Rhizobium* colonise pea, bean, clover, and alfalfa plants, and *Bradyrhizobium* prefers soybean plants. These nodules are functionally active, and are sites of nitrogen fixation. On cutting open a functional root nodule, the central region invariably has light pink colour due to the presence of a haem protein – *leghaemoglobin*. This is thought to regulate the supply of oxygen to the bacteroids (the transformed state of bacteria within the plant cell), whose nitrogen fixing enzyme nitrogenase, is readily inactivated by free oxygen. The bacteroids are able to fix nitrogen, using energy supplied as carbohydrate produced by the host and delivered via the nodule's phloem link with the root vascular system. The bacteroids in turn supply their host (via the xylem link) with nitrogenous products which are produced in excess of their own needs. Such a relationship of cooperation and mutualism is also termed as *symbiosis*. Both the organisms are benefited from the relationship. It is also a highly specialized one with the host demonstrating a number of features which accommodate and succour its symbiont – the bacteria. Some of these are: nodule structure, diverted vascular strands, leghaemoglobin, and the *Rhizobium*-attracting roots.

In this part of the exercise, the focus is on the morphological and anatomical study of the root nodule.

Materials required

1. Fresh/preserved specimens/photographs of roots of two leguminous plants having root nodules;
2. Permanent slide of a root nodule;
   i) **either** of cross-section (including the host root)
   ii) **or** longi-section (of the nodule intact on the root),
3. A compound microscope.

Procedure

Two aspects are to be studied:

First: Study the morphological structure of the root nodules of two leguminous members.

Compare the pattern, density of nodules, and nodule characteristics of each plant.

Second: Study the anatomical details of a root nodule from a permanent slide.

Note your observations as per the instructions given below.

Observations and Interpretations

1. Morphological studies – Observe the nodulated roots of the given plants, one by one. Focus on the following features of the nodules.
   i) *Position* – whether on the main root or its branches.
   ii) *Distribution* – are the nodules distributed evenly throughout the root system, or are they localized in a particular region?
   iii) *Appearance* – how do the majority of nodules appear – as globular structures or conglomerated structures or of some other form?
   iv) *Colour* – pinkish or otherwise. Study these features for each plant separately, and note down your observations – both in diagrammatic and descriptive forms in the Worksheet # 13.12.

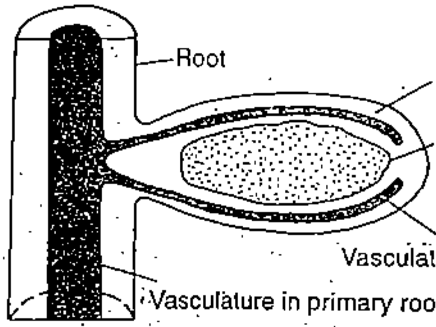
2. Anatomical studies – Observe the permanent slide of the root nodule (c.s. or l.s.) and *make an outline sketch as it appears in the given slide.* Outline diagrams of nodule both in c.s. and l.s. are given in the Worksheet # 13.13 for reference. Spend some minutes on studying the slide, imbibing the anatomical details, and note the important features in Worksheet # 13.14. Three lead questions are given in the same worksheet. Write precise answers for them, and jot down the additional anatomical details in the space provided for the purpose.

Your Notes

Worksheet # 13.12: Morphological studies of root nodules of two leguminous members.

Diagram space	Description space
Name of the plant	
Q.1: Illustrate the root nodules, highlighting their unique features. Write the name of the plant too.	**Q.2:** Write the salient features of the root nodules depicted in the adjacent left-hand box.
Diagram space	Description space
Name of the plant	
Q.3: Illustrate the root nodules, highlighting their unique features, and write the name of plant.	**Q.4:** Write the salient features of the root nodules depicted in the adjacent left-hand box.

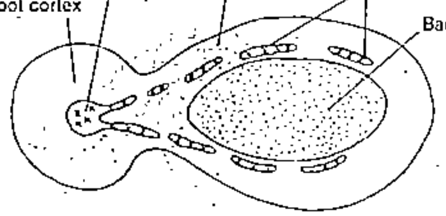
Worksheet # 13.13: Anatomical studies of root nodules.



a) Radial longitudinal section through a mature legume root nodule showing the central bacteria-colonized area. Note the connection of the vasculature of the root to the two strands in the nodule. (From: Noggle, 1989).

Description space

Q.1: Write the salient features of the root nodule cut in r.l.s, from the above figure (a).



b) An outline diagram of a typical root nodule, cut in transection so also the root. Carefully note the connection of the vascular supply of nodule to the root vasculature (From: Lewis, 1986).

Description space

Q.2: Write the salient features of the root nodule cut in a transection from the above figure (b).

Worksheet # 13.14: Study of anatomical details of a root nodule.

Answer the following questions based on your observation of the permanent slide:

Q.1: What is the anatomical location of the nodule?

....

....

Q.2: Is there any vasculature in the nodule?

....

....

Q.3: Describe the features of the bacteria-harbouring cells?

....

....

....

....

Description space

Q.4: List the characteristic anatomical features of the root nodule.

13.7 ROOT NODULE BACTERIA

In the previous section, you have seen that bacteria like *Rhizobium* and *Bradyrhizobium* inhabit the root nodules of specific leguminous plants. They differ in morphology in their free-living state and in the root nodules. They are mostly coccoids in free-living state whereas they are swollen and irregularly shaped inside the cells of root nodules. Groups (4 to 6) of these bacteroids become surrounded by membranes produced by the cell to form a number of isolated nitrogen fixing colonies within the cell. In this section, you would study these bacteria in a smear preparation of the root nodule, and stain with crystal violet to ascertain whether they are gram +ve or gram –ve.

Materials required

1. Fresh material of roots bearing nodules
2. Microslides
3. Coverslips
4. Crystal violet stain
5. Iodine solution
6. Safranin
7. Acetone
8. Glycerine
9. Compound Microscope

Procedure

1. Smear the nodules on a slide.
2. Pass the slide very briefly over a flame so that the material sticks on the slide.

Overheating will only burn the material

3. Put a few drops of crystal violet stain on the slide and allow it to remain for two minutes.
4. Wash with running water.

Wash gently, or the material will be washed away

5. Put 1-2 drops of iodine and keep for about ½ minute.

Irritant Iodine Solution

6. Wash with acetone.
7. Add to it 1 or 2 drops of safranin.
8. Wash with water, in case need be. It is usually done for removing the debris on or surrounding the material.
9. Place 1 or 2 drops of glycerine on it, and place the coverslip over it and observe under the compound microscope.

Observations and Interpretations

Focus on the above preparation under the compound microscope and note the appearance of bacteria.

i) Can you observe some swollen and irregular structures? Observe them very minutely.
ii) Note the colour of the Gram-stained bacteria and ascertain whether they are gram +ve or gram –ve. **Gram +ve bacteria stain blue, and Gram –ve bacteria, red.** Record the following aspects in the Worksheet # 13.15.

Worksheet # 13.15: Study of bacteriods from the root nodule.

Diagram space

Q.1: Illustrate a few bacteroids.

Description box

Q.2: Write the features of bacteriods as visible to you from your preparation.

Worksheet # 13.16: Self-assessment Questions.

SAQ 1

In what manner does a typical legume fruit differ from a follicle?

....

....

....

SAQ 2

Mention one unique feature of groundnut that makes it different from other legumes.

....

....

....

SAQ 3

Arrange the following legumes in order of increasing protein quantity:
mung, soybean, groundnut, and chickpea.

....

....

....

SAQ 4

Identify two major oil-yielding legumes amongst the following members:
urd, cowpea, groundnut, lentil, and soybean.

....

....

SAQ 5

What is the nature of bacteria in the root nodule: – gram +ve or gram –ve?

....

....

SAQ 6

Name two legumes each that have recently been identified as food/fodder/ afforestation species.

....

....

....

....

(Cont.)

SAQ 7

Name one legume species that provides gum in abundant amount.

....

SAQ 8

How do the legumes complement a cereal diet in terms of their amino acid composition? Explain.

....

....

....

....

....

....

....

....

Your Notes

EXERCISE 14 FRUITS AND NUTS

Date: ....
Session # :.........................
Time allocated: 2 hours

Structure **Page No.**

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in the lab.

14.1 INTRODUCTION

A variety of fruits and nuts form an essential part of our diet which provide essential minerals, vitamins and fibers. They form an important supplement to our daily food, and, amongst tribals sometimes fruits constitute the chief or the only source of food. Botanically all of them are products of post fertilization development of ovary and enclosed ovules. But they differ in being true or false; axillary or cauliforic; simple or aggregate; berry, drupe, pepo, hesperidium, etc. They show vast variety in colour, flavour and type of economically important region (mesocarp, seeds, aril, juice hairs, etc).

Generally, the term fruit is used for those which are eaten raw without cooking. In this exercise you will study the fruits as:

I. Tropical fruits of India
II. Temperate fruits of India

Tropical fruits are those fruits which can withstand hot and dry climate. They require a specific photoperiod as well as high temperature to produce. In this exercise we will discuss some important tropical fruits of India such as citrus, mango, banana, guava, papaya, custard apple, pineapple, litchi, pomegranate and water melon.

Temperate fruits are those fruits which grow in the regions having low temperature throughout the year. We will study some important temperate fruits of India such as apple, plum, cherry, pear, peach, grapes and apricot.

Objectives

After doing this exercises, you would be able to:

- identify the kind of fruit,
- identify the edible part of the fruit,
- distinguish between fruits and nuts,
- comment on compositional changes during fruit ripening,
- qualitative composition of some selected fruits,
- list the various uses of fruits keeping in mind their perishable nature.

Study Guide

Before doing this exercise, come prepared to the lab by

- reading this exercise,
- also read unit-13, Fruits and Nuts and recall all you have studied in theory,
- you can also study many other fruit and nut which are common in your area and whether they are growing wild or cultivated. This study you can also use as your project work (see unit 21).
- if you can visit an orchard and see the plant growing in nature, it will provide you better understanding,
- make colour diagrams wherever required.

Your Notes

14.2 CLASSIFICATION OF FRUITS

You will be provided with several types of fruits on the basis of the key (given below) identify the type of fruit.

Box 14.1: Classification of Fruits

I. Derived only from the ovary or ovaries of the flower A. Simple (derived from one ovary of one flower)	*Fleshy*	Berry:	pericarp fleshy throughout; pepo and hesperidium are special types of berries	
		Drupe:	pericarp distinctly divided into thin skinlike exocarp, thick flesh mesocarp, and hard stony endocarp	
	Dry	Dehiscent (splits open along definite seams when mature; contains several to many seeds)	Legume:	fruit of one carpel; splits along 2 seams
			Follicle:	fruit of one carpel; splits along 1 seam
			Capsule:	fruit of 2 or more fused carpels; splits in a variety of ways
			Silique:	fruit of 2 fused carpels that separate, leaving a persistent partition in between
		Indehiscent (does not open along definite seams or points when mature; contains usually only one or two seeds)	Achene:	bear one seed separable from ovary wall except at one point of attachment to inside of pericarp
			Grain:	bears one seed the coat of which is completely fused to the inner surface of the pericarp
			Samara:	an achene like fruit with one or two seeds; pericarp bears flat, winglike outgrowth
			Nut:	one-seeded fruit similar to achene but usually larger and with a very hard, thick pericarp.
B. Aggregate (derived from several ovaries)	The individual fruits may be a Drupe Achene Berry Nutlet and so on			
C. Multiple (derived from a cluster of several ovaries from several flowers crowded together on one stem)	The individual ovaries may be a Drupe Achene Berry Nutlet and so on			
II. Derived mostly from floral parts other than the ovary (such as calyx or receptacle); these parts are often fused to the ovary and are so well developed that they constitute the major part of the fruit.	Simple Accessory*: derived from one ovary and accessory part of one flower Aggregate Accessory: derived from a cluster of ovaries and accessory parts of one flower Multiple Accessory: derived from a cluster of ovaries and accessory parts of several flowers crowded together on one stem * Accessory refers to any part of the flower other than the ovary.			

Materials Required

- Various types of fruits such as mango, apple, plum, coconut, orange, almond, banana, cashew nut, etc.
- Ripe fruits of mango, banana, papaya, and citrus for making juice or pulp.
- Test tubes, labels, forceps, spoon.
- Reagents for microchemical tests for starch, protein, oil, sugars, vitamin.
- Safranin, test tubes, test tube stands, burner.
- Coloured pencils.

Observations and Interpretations

- Observe the fruits and classify according to the key.

Observe the fruits and fill the table given below:

Table 14.1: Classification of fruits.

S. No.	Name of fruit	True/False	Type of fruit
1.	Mango		
2.	Apple		
3.	Plum		
4.	Coconut		
5.	Orange		
6.	Almond		
7.	Banana		
8.	Cashew nut		

14.3 MANGO

Mango is a tropical as well as subtropical plant, attaining a height of 90 m and more. The evergreen tree bears small pink flowers in large panicles. The fruit is in fleshy drupe, which has thick, yellowish greenish or reddish epicarp, the mesocarp is fleshy and constitutes the pulp and endocarp is hard and stony.

Materials Required

- Herbarium specimen of flowering twig
- Herbarium specimen of fruiting twig
- An unripe fruit
- A ripe fruit

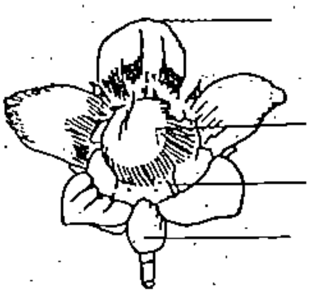
Observations and Interpretations

- Observe the flowering twig and note the following features
  i) Branching ....
  ii) Phyllotaxy ....
  iii) Shape, margin, tip, surface, etc. of leaf ....
  iv) Type of inflorescence ....
- Draw and label the figures as indicated in Worksheet # 14.1.
- Write at least 5 salient features that you observe in mango plant (its stem, leaves, inflorescence, flower and fruit).
  ....
  ....
  ....
  ....
  ....
  ....
- Write about various popular varieties found in your locality. If mangoes does not grow in your locality then write about the varieties found in India.
  ....
  ....
  ....
  ....
- Write at least five uses of mango.
  ....
  ....
  ....
  ....
  ....

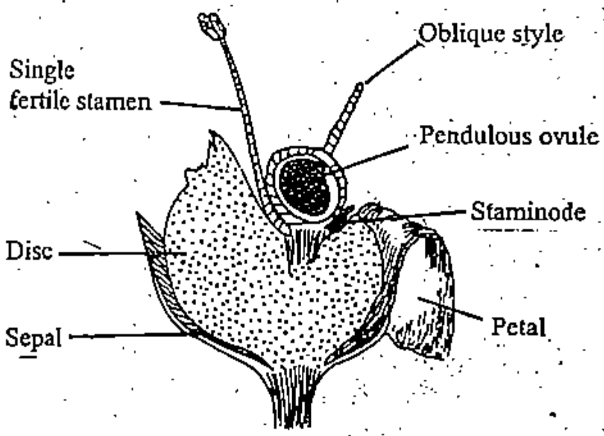
Worksheet # 14.1: Mango

Family : ....

Botanical name of species: ....



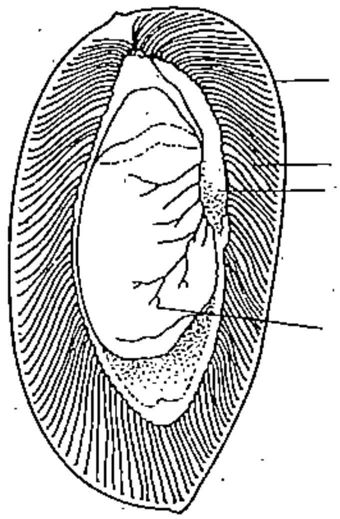
Flower of Mango (label the parts)



L.S. of a flower

(1) (2) (3)

Draw fruits of different varieties of mango.



L.S. fruit of mango (Label its parts)

14.4 BANANA

The cultivated banana is the oldest among the cultivated fruit plants. It is one of cheapest fruit tropical.

Materials Required

- A photograph of banana 'tree'
- If possible see the banana 'tree' in nature
- Herbarium specimen of terminal inflorescence/living specimen (in nature)/ photograph
- Banana fruits-ripe and unripe.

Observations and Interpretations

- The illustration of banana tree is given in Worksheet # 14.3. Label its various parts. If you are observing a part in nature measure its height (approx.).
- Observe the inflorescence and following features and write in given space.

  i) Kind of inflorescence

  ....

  ii) Arrangement of flowers (from top to bottom)

  ....

  iii) Number of rows of flowers at each node.

  ....

  iv) In the given illustration label □,♀ or ♀ flower.

- Write at least five salient features of banana plant.

  ....

  ....

  ....

  ....

  ....

  ....

- Draw the figure of the fruit of any local variety of banana and measure the following features of the fruit.
- Length ....

  ....

  Circumference ....

  Colour of peel ....

  Colour of mesocarp ....

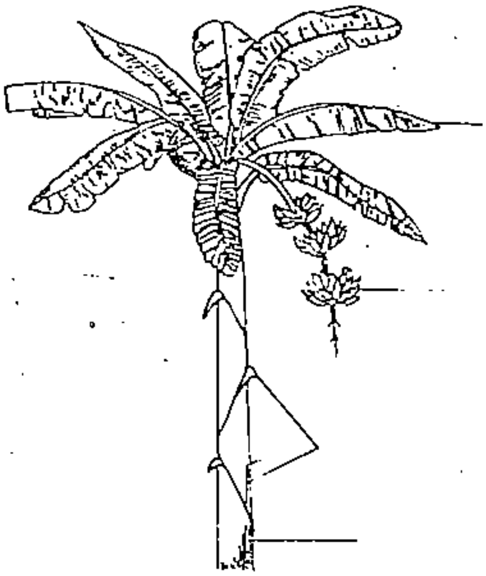
  Thickness of peel ....

  Any other ....

Worksheet # 14.2: Banana

Family : ....

Botanical name of species: ....



Banana 'Tree'
(Label the parts)

Draw Inflorescence of banana

Draw T.S. fruit of banana and label its parts

Draw the whole fruit of banana

14.5 PAPAYA

Papaya, a native of Mexico, now widely cultivated in India, is a very popular fruit of India. The fruit is a fleshy berry and variously shaped, oval, oblong or pear shaped.

Materials Required

- Illustration/photograph of male and female papaya tree/living specimen.
- Specimen of inflorescence and leaf.
- Papaya tree in nature (if possible)
- Ripe and unripe fruits of papaya.

Observation and Interpretations

- In the given illustration of papaya tree label the various parts.
- Observe the male and female inflorescences/flowers in herbarium or living specimen and fill in the blank.

	□	♀
Flower (color)	....	....
Calyx	....	....
Corolla	....	....
Stamens	....	....
Ovary	....	....
Style	....	....
Stigma	....	....
Placentation	....	....

- Label the various parts of L.S. fruit in Worksheet # 14.5.
- Take few seeds from the ripe papaya fruit and feel them in hand. How do they feel?

  ....

  ....

  ....

- Write some important features that you observe in papaya tree.

  ....

  ....

  ....

- Write the local name of banana in your area.

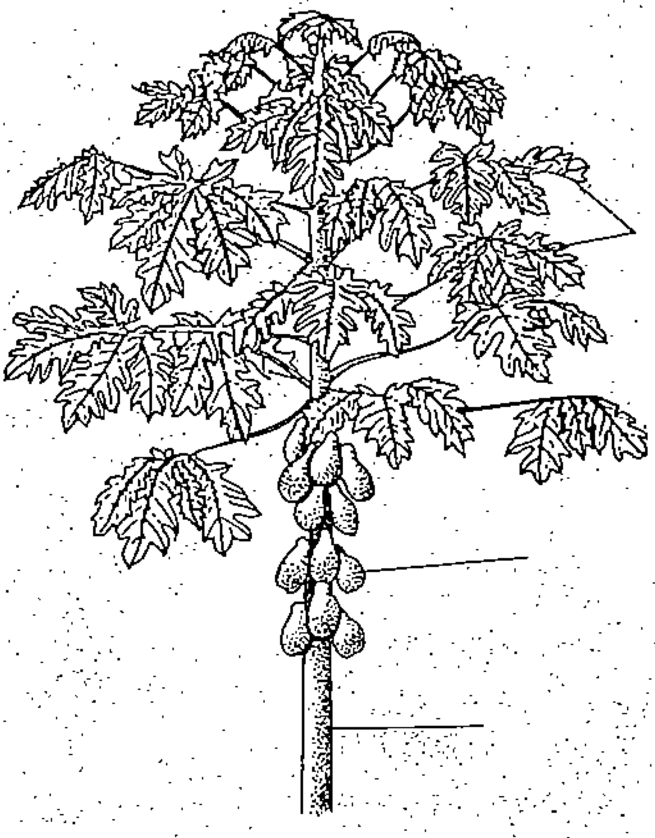
  ....

  ....

Worksheet # 14.3: Papaya

Family : ....

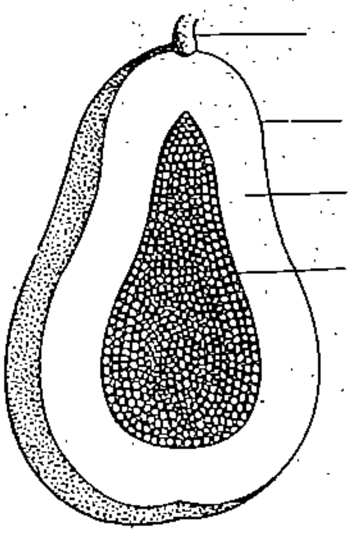
Botanical name of species: ....



Papaya tree
(Label the plant parts)

Female flower of papaya
(Draw and label the flower)

Male flower of papaya
(Draw and label the flower)



L.S. of papaya fruit (label the figure)

Draw and label a complete fruit of papaya

14.6 CITRUS

Citrus is an important part of winter fruits throughout India. The fruit is modified berry-hesperidium. There are several popular citrus varieties but *Citrus reticulata* or orange which is an important fruit of India.

Materials Required

- Herbarium specimen/live twig/photograph of fruit bearings twig of citrus.
- Varieties of citrus fruit found in your area.
- Flowering twig of citrus sp.
- Fruiting twig of citrus sp.
- Ripe fruit of citrus sp.
- Peel of the fruit.

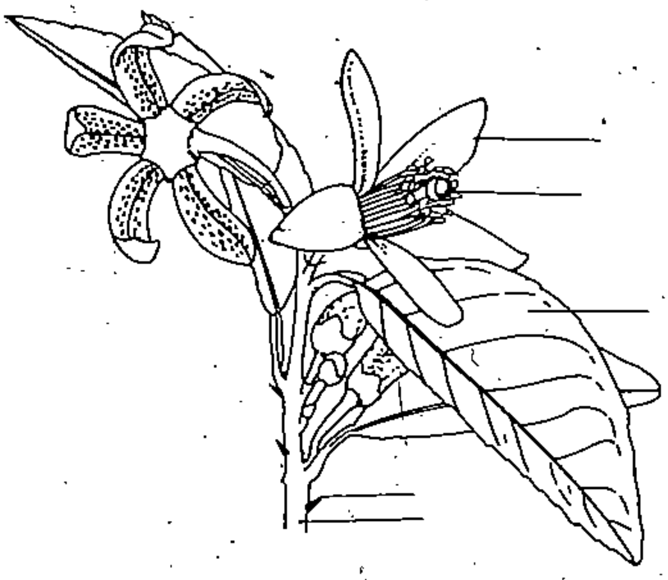
Observations and Interpretations

- Observe the herbarium species/live twig/ photograph of reproductive twig and write comments on the salient features of citrus.
- Draw figure of flower of citrus sp. on Worksheet # 14.6.
- Draw T.S. of citrus fruit in Worksheet # 14.6 and label the various parts.
- Peel the fruit. Cut a T.S. of the peel (rind), stain lightly with safranin and observe under microscope. Draw and label the diagram on Worksheet # 14.7.
- Mount one juice vesicle/hair on a slide gently . Observe and draw it on Worksheet # 14.7with labeling.
- Write some uses of citrus fruit.

Worksheet # 14.4: Citrus

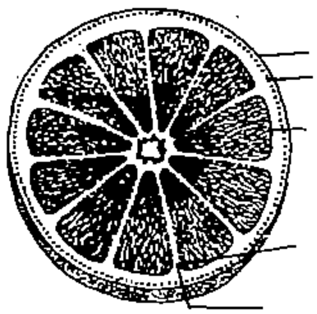
Family : ....

Botanical name of species: ....



Citrus twig
(Label the various parts of twig)

Draw T.S. citrus fruit



T.S. citrus fruit
(label the various part of fruit)

W.M. of juice hair of citrus fruit
(Draw the vesicle)

14.7 APPLE

Apple is the most popular and important temperate fruit cultivated in India. The fruit is technically a false fruit, as the fleshy edible part is formed from the thalamus which encloses the true fruit.

Materials Required

- Herbarium specimen/living twig (if possible) or photograph of apple fruiting twig.
- Fruits

Observations and Interpretations

- Observe a fruiting twig (specimen/living) and write down some special comments about apple and its habit.

  ....

  ....

  ....

  ....

  ....

  ....

  ....

  ....

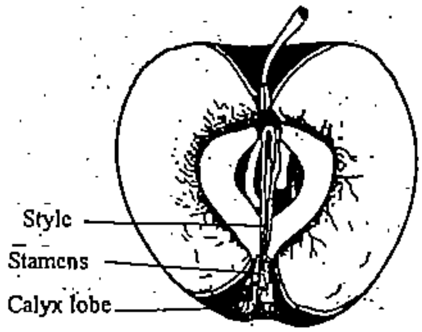
  ....

  ....

- Label the L.S. of apple fruit given in Worksheet # 14.8.
- Make a peel mount of the fruit to observe the lenticels. Draw a diagram of lenticels on Worksheet # 14.8.

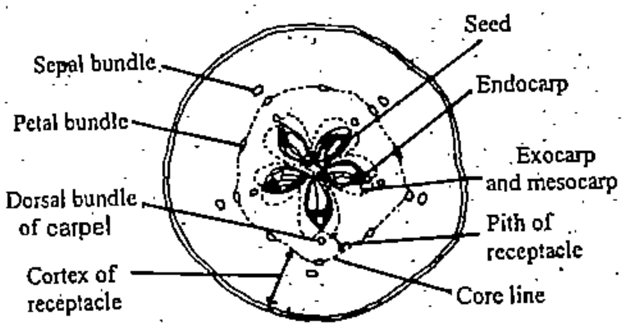
Family : ....

Botanical name of species: ....



Apple
(Draw the fruit)

L.S. of fruit of an apple



Peel mount of apple skin showing lenticels
(Draw and label the diagram)

T.S. fruit of apple

14.8 IDENTIFICATION OF EDIBLE PARTS OF FRUITS

Apart from the fruits we have studied so far there are several other fruits such as pineapple, fig, guava, water melon, musk melon, litchi, pear pomegranate etc. which also constitute an important part of our daily diet. Therefore we should study about the parts which are eaten.

Materials Required

Pineapple, fig, guava, watermelon, muskmelon, litchi, pear, pomegranate or any others fruit available in your area for display only.

Observations and Interpretations

- Note the economically important part of each fruit.

Sl. No.	Name of Fruits	Botanical Name	Part edible as fruit
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

14.9 MICRO CHEMICAL TESTS IN FRUITS JUICES

It is important to know about the nutrient value of the fruits which we eat. We all know that fruit are rich in water, carbohydrate, vitamin and mineral. To test them you have to perform some microchemical tests of the juices of the fruits which you have studied. In unit 1, section 1.6 of this course, you have studied about the mic.ochemcial texts.

Materials Required

- Ripe fruits of mango, banana, papaya, citrus, to make fruit juice or pulp of the above four.
- Test tubes, label, pipette/graduated cylinders.
- Reagents for micro chemical tests for starch, protein, oil, sugars, vitamin C (for vitamin c, use 2% Ag No_3 in glacial acetic acid.
- Safranin, test tubes, test tube stands, burner.
- Coloured pencils.
- Egg flakes.

Procedure

i) Test for fruit juices

Mash the fruit pulp of banana and papaya, extract the juice of citrus and mango and make long slits on fruit surface of mature but green papaya and collect the exudate. It contains an enzyme called papain. Take 1 ml each the fruit pulp or juice in test tubes and perform tests for starch, protein, oil, reducing sugars, non-reducing sugars and vitamin C. Tabulate your results in table given below:

Table 14.2: Tests for juices.

Test fruit	Mango	Banana	Citrus	Papaya
Starch				
Protein				
Oil				
Reducing sugars				
Non-reducing sugars				
Vitamin C				

+ traces, ++ present, – absent

ii) Test for papain enzyme

Take 1 ml of egg albumin solution in a test tube and add papaya pericarp exudate. Keep for ½ hr. To 1 ml of control and the treated albumin add 1 ml each of biuret reagent. Note the colour change.

Table 14.3: Test of enzyme papain.

Biuret test	Initial colour	Final Colour
Control (egg albumin solution)	Blue	
Treated (egg albumin + papain)	Blue	

Observations and Interpretations

- Do the microchemical test according to unit 1 section 1.6 of this course and fill the tables 14.2 and 14.3.

Your Notes

14.10 STUDY OF NUTS

Nuts in botanical sense can be defined as a one-celled, one-seeded dry fruit with a hard pericarp. Nut is a complete food in itself as it is rich in protein, carbohydrates, fats and minerals. We are going to study only cashew nut, almond and walnut as they are grown in India.

Materials Required

- Photograph/specimens of cashew apple and specimen of dry cashew nut.
- Specimen of almond
- Specimen of walnut

Observations and Interpretations

- Observe the illustration of cashew apple provided to you on Worksheet # 14.10 and label it.
- Draw a L.S. of cashew nut.
- Draw a L.S. of almond and label the parts.
- Draw a L.S. of walnut and label its various parts.
- List the various parts of walnut provided to you.
  1.
  2.
- Write 2 uses of each.
  i) Cashew nut
  ....
  ....
  ii) Almond
  ....
  ....
  iii) Walnut
  ....
  ....

Your Notes

Family : ....

Botanical name of species: ....

Cashew nut with apple
(Draw and label various parts).

(Draw and label the a cashew nut)

L.S. walnut
(Draw and label the figure)

L.S. almond
(Draw and label the figure)

SAQ

1. Match the fruit and classification given below:

Areca (supari)	Pepo
Muskmelon	Hesperidium
Pineapple	Drupe
Lemon	Nut
Mango	Berry
Banana	Multiple fruit

2. Name of edible part
   a) mango ....
   b) lemon ....
   c) banana ....
   d) litchi ....
   e) apple ....

3. Which of the following increases dramatically in ripe fruit as compared to unripe fruit?
   a) starch
   b) protein
   c) oil
   d) sugar

4. Of the following which has maximum vitamin C?
   a) Banana
   b) Papaya
   c) Orange
   d) Apple

5. Which is the most commonly used fruit for pickle?

   ....

6. Which of the following is most perishable? (tick one)
   a) apple
   b) banana
   c) pomegranate

7. Match the following:

Fruit	**edible region**
Pineapple	exocarp, mesocarp, endocarp and seeds
Fig	exocarp, mesocarp, endocarp and seeds
Guava	all floral parts and inflorescence axis
Watermelon	mesocarp and endocarp
Muskmelon	mesocarp and endocarp
Litchi	flesh receptacle
Pear	seeds
Pomegranate	aril

EXERCISE 15 VEGETABLES

Date: ....
Session # :.........................
Time allocated: 2 hours

Structure

Read this exercise thoroughly before beginning your work.

Don't forget to wear your lab coat while working in the lab.

15.1 INTRODUCTION

Vegetables may be defined as any part of the plants whether, roots, stems, leaves or fruits which store reserve food and are edible. The chief reserved food in vegetables is starch along with large amount of water (70-95%). The nutritive value of vegetables is because of their high content of vitamins and minerals. They are an important source of roughage. India, being an agricultural country, vegetables constitute a major part of our diet.

In India large varieties of tropical, sub-tropical and temperate vegetables are grown. Vegetables can be grouped into three categories:

1. Underground vegetables : i) Root vegetables
   ii) Stem vegetables
2. Leafy vegetables or Herbage vegetables.
3. Fruit vegetables

Most of the vegetables are annual and are nearly always eaten soon after harvest and are not generally stored for long periods.

Objectives

After completing this exercise you will be able to:

- differentiate between fruits and vegetables,
- identify some common economically important vegetables,
- list the characteristic features of some commonly used vegetables,
- describe the various economic uses of vegetables.

Study Guide

Before doing this exercise, come prepared to the lab by

- Reading this exercise beforehand to facilitate the work in lab.
- Studying unit-14, of LSE-13, Block 3A to refresh the structural details of vegetables.
- Utilizing your time effectively so that you are able to finish all the work given in this exercise in time.

Your Notes

15.2 CLASSIFICATION OF VEGETABLES

Vegetables are classified on the basis of plant part used as vegetable. You will study the plant parts which are used as vegetable and list them in the table given below:

Materials Required

Live specimen or museum specimen of

(1)	Potato	(5)	Carrots
(2)	Onion	(6)	Radish
(3)	Garlic	(7)	Turnip
(4)	White lotus	(8)	Sweet potato/beet root
(9)	Cabbage	(12)	Tomato
(10)	Cauliflower	(13)	Egg plant
(11)	Spinach	(14)	Lady's finger
(15)	Cucurbits	(15)	Capsicum

Hand lens/ dissecting microscope

Procedure

Observe the above given specimens and classify them one by one in the given table 15.1.

Observations and Interpretations

Take the vegetable one by one and observe it. Use hand lens to observe the surface details, if necessary.

Table 15.1: Classification of vegetables

S.No.	Name of vegetable	Botanical name	Plant part used

15.3 VEGETABLES FROM ROOTS

In a number of plants, the underground parts are modified into storage organ. Sometimes, this storage organ is root; sometimes, it is stem. Here, we are going to study the vegetables which are roots in their origin. Observe the plant carefully and study its characteristic features.

Materials Required

Herbarium specimen/living specimen of

i) Carrot
ii) Radish
iii) Sweet potato
iv) Beet root
v) Turnip

Procedure

Study (any two) the specimen in herbarium or living specimen properly given to you. Reason out yourself why the particular plant part used as vegetable is root.

- Write two characteristic features of the plants you are studying.

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- Draw the specimen (1, 2) which you are going to study and label its parts.
- Cut a T.S. of specimen (1, 2), observe and draw on the Worksheet # 15.1 in the given space.
- Write at least two uses of the specimens (1, 2) studied.

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Worksheet # 15.1: Vegetables from root.

Family : ....

Botanical name of species: ....

Specimen 1

Draw the specimen and label it

Draw T.S. of specimen and label it.

Specimen 2

Family : ....

Botanical name of species: ....

(Draw the specimen and label it)

(Draw T.S. of specimen)

15.4 VEGETABLES FROM STEMS

There are several vegetables that are obtained from stem (Kohlrabi, asparagus bamboo and white lotus); stem tubers (potato and yams), bulbs (onion, garlic). These are widely cultivated in India. Among these, potato is the most popular and is most important staple food plant of the world. We will study any two vegetables obtained from stem.

Materials Required

Herbarium specimens as well as living specimens of the following:
i) Potato
ii) Onion
iii) Garlic
iv) White lotus

Hand lens/ dissecting microscope

Procedure

You have to study any two of the specimens. Potato is an important crop of India and consumed almost daily. Thus, it is advisable to study potato. You can choose either onion or garlic as second vegetable for study.

Observations and Interpretations

- Draw and label the plants of potato/onion or garlic from the herbarium provided to you.
- Draw potato tuber and label various parts on Worksheet # 15.2.
- Draw bulb of onion/garlic and label the figure on Worksheet # 15.2.
- Explain why the specimen of potato studied by you is stem.

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- Write five characteristic features of the specimen (Potato plant) studied by you.

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- Write five characteristic features of onion/garlic.

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- Write botanical as well as local name of the vegetable studied by you.

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- Describe importance of vegetables in your food.

(i) ....

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(ii) ....

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Worksheet # 15.2: Vegetables from stem.

Family : ....

Botanical name of species: ....

Draw a tuber of potato

Habit of Potato plant
(Draw and label the plant)

T.S. potato tuber
(Draw T.S. of Potato)

Family : ....

Botanical name of species: ....

Habit of onion/garlic plant
(Draw and label it)

Onion/garlic
(Draw a single bulb)

15.5 HERBAGE VEGETABLES

Parts of the plant which grow above the ground and are edible are known as herbage vegetables. The herbage may be either fhe stem (Asparagus), leaves (spinach), leaf stalk (celery) or flowerettes (cauliflower). These vegetables are rich in proteins and carbohydrates and contain large amount of vitamins and mineral salts. They also constitute a big part of roughage value of our food.

Materials Required

i) Cabbage
ii) Cauliflower
iii) Knol kohl
iv) Mustard (Sarson sag)
v) Spinach
vi) Lettuce
vii) Celery

Hand lens/dissecting microscope

Procedure

Study any two vegetables of your choice. It will be better if you study spinach and cauliflower. In this section, we will describe spinach and cauliflower.

Observations and Interpretations

- Observe and draw the leaves of spinach and label, measure the leaves. Observe the thickness, colour, texture and margin of the leaves on the Worksheet # 15.3.
- Draw, if possible, different varieties of spinach of your area on Worksheet # 15.3 (you can use coloured pencil).
- Write at least five characteristic features of the spinach plant.

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- Write at least two uses of spinach.

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- Draw the diagram of cauliflower and label its part on the Worksheet # 15.3.

- Explain "Cauliflower is compact head of flowers".

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- Give five characteristic features of cauliflower.

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- Write at least two uses of cauliflower.

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- Make a list of vegetables that are obtained from family Brassicaceae. Write their botanical and local names.

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Family : ....

Botanical name of species: ....

Length of leaf ....

Size of leaf ....

Shape of leaf ....

Colour of leaf ....

Margin of leaf ....

Morphology of spinach
(Draw and label the plant)

Draw single leaf

Family : ....

Botanical name of species: ....

Morphology of cauliflower
(Draw and label the plant)

15.6 VEGETABLES FROM FRUITS

In this section we will study the vegetables that are botanically true fruits. Among these vegetables, cucurbits and solanaceous crops have a major part in our food.

Materials Required

Herbarium/living specimens of

i) Tomato
ii) Egg plant
iii) Lady's finger
iv) Capsicum
v) Some cucurbits

Hand lens

Procedure

You can select any one member from the above given specimen (i-iv) vegetables and any one cucurbit. Here, we will describe how to study tomato and cucurbit because they are found throughout India. Study it carefully, write down the comments and draw the diagram on Worksheet #.

Observations and Interpretations

- Observe and draw the figure of tomato plant from herbarium/living specimen and label its various parts on Worksheet # 15.4.
- Draw the tomato fruit (whole and T.S. and label it), observe its various sizes shapes and colour.
- Study the herbarium specimen of any cucurbit draw the figure and label it.
- Draw the fruit of any cucurbit which is easily available in your locality.
- Cut a T.S. of cucurbit fruit (if possible) and label the figure.
- Make a list of locally found cucurbits and write their local as well as botanical names.

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- Write any five characteristic features of tomato plants and fruit.

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- Write any five characteristic features of cucurbit plants and fruit.

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Your Notes

1. *Azadirachta indica* (Neem)

Azadirachta indica ❖

Bark:	Used in skin troubles.
Leaves:	Considered antiseptic, applied to boils in the form of poultice; decoction given for ulcers and eczema. Dried leaves placed in books for keeping away moths. Odour of burning leaves kills insects.
Flowers:	Tonic and *stomachic**.
Berries:	*Purgative**, *emollient**.
Seeds:	Yield a non-drying oil used for skin afflictions. Neem oil may be mixed with other oils and fats for the manufacture of soaps, for washing and for bathing purposes. Nimbidin is the chief bitter principle of the oil.
Upper part of the tree:	Neem toddy is occasionally obtained as an exudation from this region, and is used as a tonic.
Fresh/tender twigs:	Used to clean teeth particularly in *pyorrhoea**.

*

Stomachic	–	a drug that stimulates the appetite thereby promoting the functional activity of the stomach.
Purgative	–	an agent that stimulates peristaltic action and bowel evacuation.
Emollient	–	a drug that allays irritation of the skin and alleviates swelling and pain.
Pyorrhoea	–	a disease marked by purulent discharge from the gums.

i) Observe the given specimen, preferably of the reproductive phase (bearing flowers and/or fruits) closely. Illustrate a portion consisting of at least two nodes highlighting the plant part used for making the medicine. Note the arrangement of leaves, type of venation, leaf margin, aroma, arrangement of flowers and fruits and any other peculiar aspects.

ii) If it is a fresh twig, chew a leaf/flower/fruit and note the taste.

iii) Have you ever observed that neem leaves are often kept in storing containers of rice. Why it is so? (Write your comments in the worksheet)

iv) Note down the plant part(s) used.

❖

Box information sources:

1. **Ambasta, S.P.** (Editor-in-chief), 1986.
   The useful plants of India. PID, CSIR, New Delhi.

2. **Singh, U.; Wadhwani, A.M.; and Johri, B.M.,** 1983.
   Dictionary of Economic Plants in India. ICAR, New Delhi.

3. **Kochhar, S.L., 1998**
   Economic Botany in the Tropics. Macmillan India Ltd. New Delhi.

2. *Bacopa monnieri* (Brahmi)

***Bacopa monnieri*❖**

Entire plant:	Constitutes drug, said to improve intellect, used for epilepsy, insanity and other nervous diseases.
Leaves:	Used as a potent diuretic, cardio-tonic and nerve-tonic.

Active principle hersaponin resembles reserpine and chlororomazine in its central action, and is reported to be a promising new tranquillizer*.

*
Tranquillizer – a drug used to calm or soothe a person without directly inducing sleep.

i) Study the given specimen and illustrate a leaf.
ii) Highlight the details of the plant part used.
iii) What is its medicinal use?
iv) Write the brand name(s) of medicine made out of Brahmi (write your answer in the worksheet).

3. *Catharanthus roseus* (Sadabahar)

***Catharanthus roseus*❖**

Leaves:	Infusion used in menorrhagia*, juice applied for relief of pain due to wasp stings.
Root:	Contains about fifteen alkaloids. These possess hypotensive, sedative, and tranquillizing properties. This is used in diabetes, but in view of the presence of hypotensive* alkaloids, the drug is not safe remedy for diabetes. Three of the alkaloids – ajmalicine, serpentine and reserpine are of Rauwolfia group and are present in greater concentration in its roots than in the roots of *Rauwolfia serpentina*.
Root and thick basal stem :	Contain higher percentage of alkaloids and two of these, vinblastine and vincristine, are used in medicines in cancer therapy.

*
Hypotensive – an agent/drug resulting in low blood pressure.
Menorrhagia – excessive bleeding during menstruation; also known as hypermenorrhea.

i) Observe and illustrate a portion of the flowering twig of Sadabahar. Pay attention to the features mentioned in point – (i) of *Azadirachta indica*.
ii) Mention the plant part used and also diagrammatically depict it.

4. *Strychnos nux-vomica* (Strychnine)

***Strychnos nux-vomica*❖**

Seeds:	Are a source of drug, 'nux-vomica', that is used as a tonic, stimulant*, febrifuge*, and in the treatment of paralysis and nervous disorders. Seeds are prescribed in colic* and as an emetic*, also form a constituent of medicated preparations for the scalp.
Seeds, roots, wood, bark, leaves, fruit pulp and hard fruit-shells:	These all contain the alkaloids brucine and strychnine.
Leaves:	Are applied as a poultice on sloughing wounds and maggot-infested ulcers.
Root and bark:	As febrifuge. Decoction of bark is used in epilepsy.
Wood:	Juice of fresh wood is used in dysentery, fevers, cholera and dyspepsia.

Strychnine is extensively used for destroying stray dogs, rats, mice and vermin.

*

Febrifuge (= antipyretic)	–	an agent that reduces fever.
Colic	–	pain due to spasmodic contraction of the abdomen.
Emetic	–	an agent that induces vomiting.
Stimulant	–	drugs/chemical agents that stimulate or depress the central nervous system.
Dyspepsia	–	indigestion

i) Study and illustrate the specimen provided. Make outline diagrams of its seed in different views to highlight the features like hilum, appressed hairs and the concave surface.

ii) Indicate the plant part used for making medicine(s).

Your Notes

5. *Eucalyptus* sp. (Eucalyptus, Nilgiri taila)

Eucalyptus spp.❖

Three species are being considered here:

1. *E. citridora*
Leaves, terminal branches: A small proportion of this oil, when added to germicides and disinfectants made from other eucalyptus oils greatly improves their odour.

2. *E. globulus*
Leaves, terminal branches: The essential oil is used as an ingredient of germicidal and disinfecting preparations. Oil is used in the treatment of asthma, bronchitis, and diseases of respiratory tract as an expectorant* and antibiotic. Oil is also used as febrifuge and diaphoretic*, largely used as a mosquito and vermin repellent.

3. *E. camaldulensis*
Leaves, terminal branches: Yield an essential oil useful in dysentery.

Plant: Is a source of Eucalyptus Kino or Red Gum used in diarrhoea, to relax throat and in dentistry.

*
Expectorant – a drug that helps the removal of catarrhal matter and phlegm from the bronchial tubes.
Diaphoretic – drug which tends to induce copious prespiration.

i) Observe a reproductive twig. Note the features mentioned in point-i of *Azadirachta indica*, paying attention to the flower (details best visible in the longitudinally-split flower) and its ovary (in transection). Record your observations both in diagrammatic and in descriptive forms in the worksheet.
ii) Observe a leaf and note any special features (hint: its texture, oil glands, and other features).
iii) Crush the leaf between your fingers and smell it. Describe how does it smell. You may use as many adjectives to express your olfactory experience.

Your Notes

6. *Datura stramonium* (Datura)

Datura stramonium❖

Leaves and seeds:	Are narcotic and quite often employed for criminal poisoning (homicidal purposes).
Leaves (dried), flowering tops, and seeds:	Used in the treatment of asthma. The drug stramonium (hyoscyamine is the chief alkaloid) is used as expectorant, antispasmodic*, demulcent* and anodyne* in cough and asthma and is the chief ingredient of Kanaka Asva – an ayurvedic preparation. The alkaloid atropine, obtained from stramonium is used as stimulant for central nervous system, and in the form of sulphate, used for dilating pupil and increasing intraoccular pressure.
Leaves:	Used in cigarettes for asthma-prone/suffering people.

*

Antispasmodic – a drug which relieves muscular spasm and has sedative side effect on the nerves.
Demulcent – a drug having soothing action on the skin and mucous membranes.
Anodyne – analgesic

i) Illustrate a flowering and fruiting twig. Note the features of its flowers/fruits/seeds and the leaves in the description space.
ii) Mention the plant part(s) used for medicinal purposes.

7. *Adhatoda vasica* (Vasaka)

Adhatoda vasica❖

Leaves (fresh/dried):	Constitute the drug, Vasaka, used in bronchial troubles and as an expectorant (in the form of juice, syrup and decoction), rich in Vitamin C.
Leaf (juice):	Also used in diarrhoea, dysentry and glandular tumors. It also possesses anthelmintic* properties. Chief principle is vasicine, which is also found to be a promising uterotonic and abortifacient*. It may also find use in stopping postpartum haemorrhage*.
Leaves:	Its ether extract yields a resin which is toxic to grain insects, but is non-toxic to human beings.
Roots, leaves and flowers:	Yield an oil which is effective against tubercle bacilli.

*

Anthelmentic – a drug which is used for combating intestinal worms.
Abortifacient – an agent that promotes abortion.
Postpartum haemorrhage – the haemorrhage following childbirth.

i) Make an outline diagram of a flowering twig, highlighting the features of medicinal interest.
ii) Indicate the plant part(s) used..*(Cont.)*

iii) Write the common brand names of medicines wherein *Adhatoda* is used as an ingredient.

8. *Dioscorea* sp. (Yam)

***Dioscorea* spp.** ❖

The deails concerning medicinal value of three species are given below:

You can also refer to Block 3B, Unit 10, p.60, for details concerning its species occurring in India.

D.deltoidea	
Tubers:	Yield cortisone, steroid hormone which is used in rheumatic diseases and ophthalmic disorders. These also yield steroidal sapogenins which are considered as source material for manufacture of oral contraceptives.
D. esculenta	
Rhizomes (tubers):	Contain fairly good quantities of diosgenin that could be used for the manufacture of precursors of steroid hormones. Grated tubers used on swellings.
D. prazeri	
Rhizomes (tubers):	Are source of cortisone which is used in rheumatism* and ophthalmic disorders. These yield steroidal sapogenins which are considered as a source material for the manufacture of oral contraceptives.

*
Rheumatism – a term used for pain in the muscles, joints and certain tissues. Rheumatic fever is an illness that follows upper respiratory infection with the group A *Streptococcus* (*Streptococcus pyogenes*).

i) Draw a reproductive twig along with the plant part(s) used.
ii) Write the name(s) of the part(s) of the plant that are used for medicinal purposes.

Your Notes

9. *Papaver somniferum* (Poppy)

***Papaver somniferum*❖ (Opium poppy/poppy)**

Capsule (latex):	Obtained from immature fruits. Is source of opium, which is used to induce sleep, relieve pain and relax spasms. Opium contains many alkaloids, the chief being morphine, papaverine and narcotine. Morphine is a powerful analgesic, narcotic and stimulant. Papaverine has little analgesic action and narcotine is very mild narcotic. Whole opium is much less used, its pure alkaloids and their salts are preferred. Eating of opium creates a sense of euphoria and is habit-forming.
Capsule (infusion):	Is applied as a soothing application.
Capsule (extract):	Is used as a sedative against irritating cough.
Seeds:	Whole seeds used for culinary purposes. Seed oil also used for culinary purposes, it is free from narcotic action, and is used in diarrhoea and dysentery and in compositions for skin care.

i) Observe and illustrate a flowering (preferably with capsule) twig.

ii) Illustrate an unripe and a ripe capsule. Note the pores near the remnants of stigmatic disc in the capsule.

iii) If fresh, young capsule is available, make 2 or 3 long cuts on its surface. Leave it undisturbed for an hour or so. Observe and record your findings.

iv) Observe a few seeds from a ripe capsule under a dissecting microscope. Draw one seed.

v) What is the common name of the seeds? (Write your answer in the worksheet).

Your Notes

Worksheet # 16.1: Study of a medicinal plant: ………………………………

(Write the botanical name of the plant)

Diagram space

(Cont.)

Worksheet # 16.1: Study of a medicinal plant: .... (Cont.)
(Write the botanical name of the plant)

Description space

Nature of specimen provided: Fresh/Preserved
(Put a tick mark on the relevant choice)

Overall appearance ....
(Comment on the colour / odour / presence or absence of hairs or glands)

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....

Plant part(s) used: ....
[Write name(s)]

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Specific features of the economically important part of the plant :..

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Other points: ....

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Worksheet # 16.2: Study of a medicinal plant: ....
(Write the botanical name of the plant)

Diagram box

(Cont.)

Worksheet # 16.2: Study of a medicinal plant: ....

(Write the botanical name of the plant)

Description space

Nature of specimen provided: Fresh/Preserved :*(Put a tick mark on the relevant choice)*

Overall appearance :..

(Comment on the colour / odour / presence or absence of hairs or glands)

....

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Plant part(s) used: ....

[Write name(s)]

....

....

Spécific features of the economically important part of the plant : ....

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Other points: ....

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Worksheet # 16.3: Test your knowledge on medicinal plants.

Q.1 Write the name of the plant for each of the following plant parts (a-e) that go into making medicines/drugs.

Plant part		*(Write the name of the plant)*
a)	Root	....
b)	Leaf	....
c)	Bark	....
d)	Flower	....
e)	Seed	....

Q.2 What is the medicinal property of *Eucalyptus* due to? (Hint: the source / constituent)?

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Q.3 Write the common name(s) / vernacular name(s) / botanical name (optional) of any two locally available medicinal plants. Note: These plants should be other than the ones that you have studied.

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(Cont.)

Q.4 Name two plants which are used as well as abused (as hallucinogenic drugs).

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Q.5 From which part of the plant is opium extracted?

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Your Notes

EXERCISE 17 ESSENTIAL OIL PRODUCING PLANTS

Date ....
Session # ....
Time allocated – 30 minutes

Structure **Page No.**

Do not forget to read the exercise thoroughly before the lab. session.

Always wear your lab coat while working in the lab.

17.1 INTRODUCTION

A large number of plants produce essential or volatile oils (also known as aromatic substances) which impart a smell to the whole plant or its part(s) where they are present. The use of pure essential oils from plants dates back to many centuries. The Arabic countries are credited with first discovering the process of distillation of these oils around a thousand years ago and since then it has spread both eastwards through the Indian sub-continent and westwards to Europe. In modern times, these oils are extracted by processes like distillation, expression, or by the use of solvents. The essential oils thus extracted are used in perfumery, medicines and various other industries.

Essential oils are highly concentrated substances – it takes about 900 kg of roses to make ½ kg of rose oil! For this reason, they are treated with respect, and used sparingly in small quantities.

Objectives

After completing this exercise, you should be able to:

- list the identifying features of an essential oil-yielding plant;
- describe the peculiarities of the plant part used for extracting the essential oil; and
- demonstrate an essential oil extraction process.

Study Guide

- Prior reading of this text before the lab session, along with preparation of a work-plan would enable you to fulfill the objectives of this study.
- You may refer to Unit 19 (pp. 79-86) of LSE-13 Course for refreshing the theory-related details pertaining to this exercise.

17.2 PLANT MORPHOLOGY

Study any **one** of the following essential oil-yielding plants:

Rosa sp.	-	Rose
Vetiveria zizanioides	-	Vetiver
Santalum album	-	Sandalwood
Cymbopogon sp.	-	Lemon-grass

Materials required

1. Herbarium/museum/fresh specimens, and the products of any **one** of the above mentioned materials.
2. Dissecting microscope
3. Your instruments Kit

Procedure

Observe the specimen selected for study very carefully. Make its outline diagram in Worksheet # 17.1, and note its characteristic features.

Observations and Interpretations

The salient observation points for the above mentioned four plants are given below. You have to only make detailed study of **one** plant.

1. *Rosa* spp. (rose)
   i) Observe the given specimen preferably in its reproductive phase (bearing flowers and/or fruits) carefully. Illustrate a portion of the twig consisting of at least two nodes, highlighting (by encircling in the diagram, and then enlarging it), the plant part used for extracting the essential oils or the aromatic compounds.
   ii) Name the essential oil yielding part(s).
   iii) Mention two uses of its essential oil(s).

2. *Vetiveria zizanioides* (vetiver)
   i) Observe and illustrate a portion of a twig of vetiver with flowers. Pay attention to the features mentioned in point – (i) of *Rosa* sp.
   ii) Mention the plant part used and also depict it diagrammatically.
   iii) Mention a few products of vetiver in the Worksheet # 17.1. Note: these should be other than 'essential oil'.

3. *Santalum album* (sandalwood)
   i) Study and draw a leaf and a fruit of sandalwood plant in the Worksheet # 17.1. Also, note the features mentioned in point – (i) for *Rosa* sp.
   ii) List a few products (other than 'essential oil') of sandalwood, in the Worksheet # 17.1.

4. *Cymbopogon* sp. (lemon-grass)
   i) Study and illustrate the specimen provided to you. Also, pay attention to the features mentioned in point – (i) of *Rosa* sp.
   ii) Illustrate the economically important part in the Worksheet # 17.1.
   iii) By which method is the lemon grass oil extracted? Write your answer in the Worksheet # 17.1.
   iv) List a few products in which lemon-grass oil is used. Write your answer in Worksheet # 17.1.

Your Notes

Worksheet # 17.1: Study of an essential-oil yielding plant ....

(Write the botanical name of the plant)

Diagram space

Description space

Nature of specimen provided: Fresh / preserved
(Put a tick mark on the relevant choice)

Overall appearance (comment on the colour / odour / presence or absence of hairs or glands):.............................
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....
....

Plant part(s) used *[Write name(s)]*:
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Specific features of the economically important part of the plant: ....
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Other points: ....
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15-16~~A~~

17.3 ESSENTIAL OIL EXTRACTION PROCESS

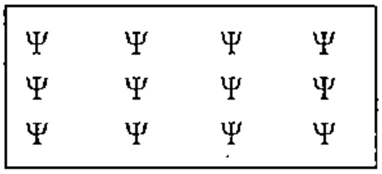
A number of processes are employed for the extraction of essential oils, each involving a sequence of steps, and substantial skill and patience. To give you an idea of one such process, we have included this exercise in this lab course. This activity will give you a broad idea of the "euchelle method" of essential oil extraction.

Materials required

1. Fresh jasmine flower – 12 in number
2. Four glass plates (~ 14 × 20 cm in size) / slides
3. Vaseline/petroleum jelly (without smell, that is, without any sort of additives like perfumes)
4. Scalpel
5. A bottle

Procedure

i) Smear one-side each of all the four glass plates with Vaseline/petroleum jelly/or any fat.
ii) Place jasmine flowers on the surface of a plate/slide and place another plate (with the jelly-coated side) touching the flowers. This set-up is depicted in Fig. A that is given below).
iii) Place the remaining two plates, with their jelly-coated sides facing each other. *Note: No flowers are to be placed in this pair of plates.* This set-up is demonstrated in Fig. B given below.
iv) Leave these two pairs of plates as such for 24 hours.



A

B

v) Observe these two pairs of glass plates or the given preset plates, after 24 hours. Smell the jelly from both the plates. Answer the questions given in the Worksheet # 17.2.

Your Notes

Worksheet # 17.2: Study of an essential oil extraction process.

Q.1 Why the flowers are placed only in between a pair of glass plates and not the other pair (As mentioned in the steps ii and iii above, and their respective set-ups depicted in Figs A & B)?

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Q.2 The jelly from which plate has a pleasant smell – A or B?

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Q.3 What is this method of extraction called?

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Q.4 Why have you used jasmine flowers in the extraction process?

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Q.5 Of the following, which one do you think yields more essential oil per unit weight of the flower? Rose / violet / saffron . *(Tick one)*

Worksheet # 17.3: Test your knowledge about the essential oils and their source plants.

Q.1 List the properties of essential oils from plants.
(Hint: Indicate the property because of which the oil was put to a particular use)

Q.2 What is aromatherapy? Describe, citing a specific example.

Q.3 How will you identify, by a simple test, an essential oil from that of a fatty-oil?

Q.4 Why are most essential oils expensive? Discuss.
[Hint: Essential oils are highly concentrated substances – pure oil of Rose, for instance, may requires about 5,000 roses to make just 5 ml (1 tsp) of oil!]

EXERCISE 18 FUMITORY AND MASTICATORY MATERIALS GIVING PLANTS

Date ....
Session # ....
Time allocated – 45 minutes

Structure **Page No.**

Prior-reading of exercise before the session is strongly recommended.

Do not forget to wear your lab coat while working in the lab.

18.1 INTRODUCTION

Fumitory and masticatory plant materials form the theme of this exercise. These are the materials that are smoked or chewed for pleasure; consumed to increase the functional activity of the body, or to produce illusions. These materials possess certain constituents that stimulate/depress the central nervous system thereby producing the corresponding effects. You would study two representatives of this category in this exercise.

Objectives

After completing this exercise, you should be able to:

- list the features of identification of *Cannabis* and *Nicotiana* plants;
- differentiate a male plant of *Cannabis* from a female plant, and list the peculiarities of both the kinds of plants;
- describe the peculiarities of the plant-part(s) of economic importance of *Cannabis* and *Nicotiana* plants;
- distinguish between the two economically important species of *Nicotiana*; and
- identify the constituents of various products of tobacco.

Study Guide

- Prior reading of this text, the corresponding unit (of LSE-13 Course, Unit-19, pp. 70-76), and planning a work-schedule would enable you to accomplish the objectives outlined for this exercise.

Your Notes

18.2 SOURCE PLANTS, AND PRODUCTS

Cannabis sativa (Indian hemp) and *Nicotiana* spp. (tobacco) are the two representatives selected for study.

1. *Cannabis sativa*

It is found both in wild and cultivated conditions. For more details refer to LSE-13 Course, Block 3B, pp. 70-71.

This being a dioecious species, the male and female plants differ from each other morphologically in a number of ways. Bearing this in mind, now you may proceed to study both the male and female plants in detail, and also compare them so that you can convincingly differentiate between the two.

Materials required

1. Fresh/herbarium specimens, or pictures/photographs of male and female plants
2. Dissecting microscope
3. Your instrument kit

Procedure

Critically observe both the male and female twigs one by one. Make their outline diagrams in their respective worksheets, and note their diagnostic features in the corresponding description spaces.

Observations and Interpretations

Examine the male and female plants/twigs provided to you. Note the following aspects carefully in the plants of both the sexes.

i) Overall appearance
   - odour (express your olfactory experience in words)
   - texture (move your hand gently over its surfaces, and record how you feel – is it smooth/rough, and so on)
   - comparative height
   - branched/unbranched; if branched, whether lightly branched or profusely branched

ii) Leaves
   - comparative size,
   - number of lobes; are the number of lobes the same throughout the length of the plant, or there is variation (3,5,7 or some other number)
   - comparative length of petiole
   - trichomes/glands – present or absent, if present, mention their features

iii) Inflorescence
   - type
   - texture
   - bracteate/ebracteate
   - axillary/terminal

- number of flowers/inflorescence
- flower details
- are any glandular trichomes present on the flower or its parts – note details

iv) Any other feature(s)

Make a diagrammatic and descriptive recording of your observations in the Worksheets # 18.1 and 18.2.

Present the contrasting features of the two types of plants in a tabular form in the Worksheet # 18.3, following which one could emphatically say whether the given plant is male or female.

Your Notes

Worksheet # 18.1: Study of a male plant of *Cannabis*.

Diagram space

(Cont.)

Q.1: Draw a portion of a twig of the male plant containing two nodes; a palmately-divided leaf; inflorescence; and a male flower in an enlarged view.

Description space

Q.2: Write the salient features of the structures of a male plant of *Cannabis* depicted in the adjacent left-hand sheet.

Worksheet # 18.2: Study of a female plant of *Cannabis*.

Diagram space

(Cont.)

Q.1: Draw a portion of a twig of the female plant with at least two nodes; a palmately-divided leaf; inflorescence; and a female flower in an enlarged view.

Description space

Q.2: Write the salient features of the structures of a female plant of *Cannabis* observed and depicted in the adjacent left-hand sheet.

Worksheet # 18.3: Comparative study of male and female plants of *Cannabis sativa*.

Q.1: Organize the information pertaining to the contrasting features of the male and female plants in a clear and unambiguous manner in the table so that the information can be easily followed at any point of time.

S. No.	**Plant part** (Feature/Character)	**Male plant**	**Female plant**

Q.2: Check your understanding of the male and female plants of *Cannabis sativa*.
Tick mark the correct choice in the following:

i) Infloresceence long with many flowers. Male/Female (*tick one*)

ii) Infloresceence with short, axillary, bracteate flowers. Male/Female (*tick one*)

2. *Nicotiana* (spp.)

Among the various species of *Nicotiana*, only *N. tabacum* and *N. rustica* are the sources of tabacco, and are of economic interest. You may look at the related theory portion given in Unit-19 (pp. 71-76) of LSE-13 Course for refreshing you memory.

In this practical exercise, you would study the above two species critically, and then draw out the comparisons between the two. This exercise would prepare you to promptly identify these species.

Materials required

i) Fresh/herbarium/museum specimens or pictures/photographs of *N. tabacum* and *N. rustica*
ii) Some tobacco-products, e.g., cigar, cigarette, bidi, chewing tabacco, snuff and so on
iii) Dissecting microscope
iv) Your instruments kit

Procedure

Observe the specimens of both the species provided to you very attentively. Make their outline diagrams in their respective worksheets, and note their diagnostic features in the corresponding description spaces.

Observations and Interpretations

Examine the specimens provided to you focusing on the following aspects:

1. Morphological details of the specimens provided.

   i) Overall appearance
      - herb/shrub,
      - height,
      - colour of various parts,
      - branched/unbranched,
      - any organs present in the given specimen.

   ii) Leaves
      - size,
      - simple/compound,
      - margin,
      - petiolate or sessile,
      - trichomes/glands present or not and if present describe their features. You can make a peel-mount of the leaf epidermis for this purpose.

   iii) Inflorescence
      - type,
      - colour (mention whether the specimen is fresh or preserved),
      - axillary/terminal.

iv) Flowers
  - their number
  - bracteate/ebracteate,
  - sessile/stalked,
  - other specific features.

v) Any other distinctive feature(s) of the plants.

Make a diagrammatic and descriptive recording of your observations pertaining to the two species separately in Worksheets # 18.4 and 18.5.

Present the contrasting features of the two species in a tabular form in Worksheet # 18.6, as you have done for *Cannabis* in Worksheet # 18.3.

Products of Tobacco

Study and list the components of the following tobacco products in the Worksheet # 18.7. Record your observations, both in diagrammatic and descriptive forms.

Details of some of the products are given below. You can add more points to these details.

Name of the product	Component(s)
i) Cigar	leaf (intact)
ii) Cigarette	leaf (powder), paper, filter
iii) Bidi	tobacco leaf, tendu leaf, thread, paper (label)
iv) Chewing tobacco	leaf powder and flavours
v) Snuff	tobacco leaf powder

Your Notes

Diagram space

(Cont.)

Q.1: Draw a portion of the specimen provided to you, including at least two nodes, a leaf, the inflorescence, and a flower in an enlarged view.

Worksheet # 18.4: Study of *Nicotiana tabacum* plant (Cont.).

Description space

Q.2: Write the salient features of the specimen of tobacco species studied and depicted in the previous sheet.

Worksheet # 18.5: Study of *Nicotiana rustica* plant.

Diagram space

(Cont.)

Q.i: Draw a portion of the specimen provided to you, including at least two nodes, a leaf, inflorescence, and a flower in an enlarged view.

Worksheet # 18.5: Study of *Nicotiana rustica* plant (Cont.).

Description space

Q.2: Write the salient features of the specimen of tobacco species studied and depicted in the previous sheet.

Worksheet # 18.6: Comparative study of two *Nicotiana* species.

Organise and present the information clearly and in an unambiguous manner so that it can refresh your memory at a later day.

One point you should keep in mind is that you may not have any specimen or a similar specimen with you after this lab session, so watch out while making any generalizations!

S. No.	**Plant part** (Feature/character)	*Nicotiana tabacum*	*Nicotiana rustica*

Worksheet # 18.7: Study of some products of tobacco.

Q.1 Of all the tobacco products used for smoking, which one do you think is the safest? Give reasons.

....

....

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....

....

....

....

....

Description space

Q.2: Write in points, about the various products of tobacco that you have observed, or you know of.

EXERCISE 19 FAT AND OIL-SOURCE PLANTS

Date ....
Session # ....
Time allocated – 1 Hour

Structure **Page No.**

Prior-reading of exercise would help you in making an effective study.

Make sure that you wear the lab. coat while working in the lab.

19.1 INTRODUCTION

The oils are chemically formed by the combination of glycerol with fatty acids. Glycerol forms the 'backbone' of all oils of plant origin. Different fatty acids combine with glycerol resulting in diverse types of oils.

The fatty acids commonly found in vegetable oils are palmitic, stearic (saturated fatty acid), oleic, and linoleic (unsaturated fatty acid). The oil is stored predominantly in the seed and it is also localized in fruits, stem and other plant parts.

The oils are liquids at room temperature whereas the fats are solid. The vegetable oils and fats have high caloric value. They play an important role in our diet.

The oils are classified into three categories depending upon their ability to absorb oxygen.

i) **Non-drying oils:** They do not react with atmospheric oxygen and are liquid at room temperature. Their Iodine number is less than 100. These are used in the manufacture of soaps, as lubricants, and are used in food, e.g., groundnut, palm, olive, castor, rape seed and almond oil.
ii) **Semi-drying oils:** They absorb atmospheric oxygen slowly. They have large amount of linoleic acid. Their Iodine number is between 100-300, e.g., cotton seed, sesame, sunflower, corn and croton oil.
iii) **Drying oil:** They readily absorb atmospheric oxygen and form tough elastic film when exposed to air. Their Iodine number is more than 130. They are used in paint and varnish industries.

Your Notes

Objectives

After completing this exercise, you should be able to:

- explain the morphological peculiarities of some of the common oil/fat yielding plants;
- describe the anatomical features of oil-yielding structures of various plants; and
- ascertain the presence or absence of fats/oils in given sample(s), with the help of microchemical tests.

Study Guide

- Familiarity with the tasks to be performed and making a work-plan for the given time-frame, would enable you to maximize your learning;
- You may refer to Unit-15, pp. 137-163, of LSE-13 Course, for refreshing your memory about the oil and fat-yielding plants.

Your Notes

19.2 MORPHOLOGY

In this exercise, the following fats/oil yielding plants have been selected for your study:

- Castor,
- mustard,
- groundnut,
- soybean,
- safflower,
- sesamum,
- cotton, and
- coconut

Seeds are the most common source of oils/fats in a large number of plants, but other structures like fruit too yield oils and fats in many plants.

Materials required

i) Herbarium/museum/fresh specimens, or the photographs of the above mentioned plants along with their seeds/fruits from which oils/fats are obtained
ii) A dissecting microscope
iii) Your instruments kit

Procedure

The common procedure for studying morphological aspects of these plants is given below. However, the contents for 'Observations and Interpretations, are written for each plant separately. You would find them after the description of each of these eight plants.

1. Study one specimen at a time, paying attention to the morphological features of the plant specimen provided. You may use the dissecting microscope to study the finer details of the specimens.
2. Once you are through with the observations, make outline diagram(s) as per given instructions in the worksheets, and write down the salient points of the specimens in their respective worksheets.
3. Similarly, observe the seeds/fruits of the remaining oils or fats yielding plant specimens given to you for study.

Your Notes

1. Castor

- Castor is a monoecious, perennial bush or a small tree.
- Leaves are large, alternate, and palmately-lobed.
- Flowers of both the sexes occur separately, but on the same inflorescence. The female flowers are at the upper part of the panicle, whereas the male flowers are at the lower end of the panicle.
- The inflorescence is of racemose type.
- The fruit is a three-lobed, spiny capsule, and has three seeds.
- The seed has mottled testa or hull. The tegmen is thin. The seed is albuminous, and it has two flat, distinctly nerved, papery cotyledons. The embryo is small with radicle and plumule. Caruncle is a prominent feature of the seed. The castor seed is commonly known as castor bean. The seeds are toxic to humans. The toxicity is due to ricine, ricin and a protein-polysaccharide mixture called CBA.
- The castor oil is a colourless or very pale greenish-yellow viscous liquid.
- For more details see the following reference:
  LSE-13 Course, Block 3A, pp. 159-161.

Observations and Interpretations

1. Observe the plant in nature/its photograph. From the fresh/herbarium specimen, note the arrangement of leaves and inflorescence; and the characteristics of leaves and flowers. Also see whether the flowers are unisexual or bisexual, and note their arrangement pattern. Record your observations in Worksheet # 19.1.
2. Take a mature fruit. Study its characteristics-like outgrowths on the fruit wall, number of chambers and seed(s) in each. In a split-open capsule, count the number of seeds. Record your findings in Worksheet # 19.1.
3. Take 4 to 5 seeds. Observe them under the dissecting microscope. Make note of the following features:
   - the ornamentation on seed surface,
   - caruncle, and
   - a distinct line from the caruncle to distal end of the seed. Draw these features in the Worksheet # 19.1. Compare the seeds and note the features of variability. Use the worksheet for noting the details.

Your Notes

Worksheet # 19.1: Study of castor plant and seeds.

Diagram space

Q.1: Make an outline diagram of the given twig of castor plant.

Diagram space

Q.2: Illustrate a fruit of castor.

Diagram space

Q.3: Make outline diagram of castor seed in two different views.

Description space

Q.4: Write the details of the following points.

Botanical name: ....
Family: ....
Local name(s): ....
....
....
....
The plant/twig: ....
....
....
....
Leaves: ....
....
....
....
Inflorescence: ....
....
....
....
Flower: ....
....
....
....
Fruit (complete): ....
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....
....
(split-open): ....
....
....
....
Number of seeds: ....
....
....
....
Seed (in various views): ....
....
....
....
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....
Caruncle (position - micropylar/ funicular) other features: ....
....
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....
....

2. Groundnut

- It is a herbaceous, annual. There are two varieties of groundnut:
  i) bunch or erect type, and
  ii) runner or spreading type.
- The roots bear nodules.
- The stems and leaves are hairy.
- Leaves are compound having two pairs of leaflets.
- Flowers are papilionate, yellow, arising singly or in clusters of two to four, in the axils of leaves.
- Post-fertilization development of ovary, forming geocarpic fruits is a unique feature of this plant.
- The fruit is a pod. The pericarp is fibrous, characterized by reticulate markings. Fruits usually have one to three seeds.
- For more details see Block: 3A, pp. 143-144, of LSE-13 Course.

Observations and Interpretations

Observe the following features in the plant specimen provided.

i) Overall appearance of the specimen – the branching pattern.
ii) Arrangement of leaves, flowers and fruits.
iii) The characteristic of leaves.
iv) Different stages of development of fruit (pod)
v) A split-open fruit to show the arrangement of seeds.
vi) Also observe the shell of the pod under the dissecting microscope.
vii) Take out one seed and focus on the following aspects:
  - the nature of seed coat (colour, thin or thick),
  - the number of cotyledons,
  - their colour,
  - location of the embryo, and
  - any other feature(s).

Record all the above observations in the Worksheet # 19.2.

Your Notes

Worksheet # 19.2: Study of groundnut plant and seeds.

Diagram space

Q.1: Make an outline diagram of a twig of groundnut plant highlighting a flower and a fruit.

Diagram space

Q.2: Draw groundnut fruits at different developmental stages.

Diagram space

Q.3: Make an outline sketch of a whole and a split-open seed.

Description space

Q.4: Write the details about the following points.

Botanical name: ....

Family: ....

Local name(s): ....

....

....

....

The plant/twig: ....

....

Branching pattern: ....

....

....

Leaves: ....

....

....

Flower: ....

....

....

Fruits: ....

....

....

Fruit at different developmental stages:

....

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....

....

A mature fruit (split-open): ....

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....

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Fruit shell: ....

....

....

Seed (whole): ....

....

....

Seed coat: ....

....

....

Cotyledons: ....

....

....

Embryo: ....

....

....

Other features: ....

....

3. Mustard and Rape

The three varieties of *Brassica campestris,* namely, yellow sarson, brown sarson and toria are collectively known as **Rape,** and *Brassica juncea* is known as **Mustard.**

The Rape plants are slender, erect, branched, annual herbs, generally covered with a waxy bloom.

- The height varies from 30-45 cm in some varieties of toria to about 1.5 m in yellow sarson.
- Leaves are auricled, generally lyrate, that is, pinnatipartite and stem-clasping.
- Inforescence is of corymbose raceme type.
- Flowers are small, variously coloured and have a typical cruciferous plan, i.e., with four free sepals, four free clawed petals, largely tetradynamous stamens, and a bicarpellary, syncarpous, superior ovary, initially unilocular but later becoming bilocular due to the formation of a false septum known as replum.
- The fruit is a siliqua or silicula, dehiscing from the base upwards with the seeds attached to the replum. The seeds are small, spherical, yellow (yellow sarson), or finely rugose (brown sarson and toria), mucilagenous (brown sarson), or non-mucilagenous (yellow sarson and toria).
- For further details, you may look at Block 3A, pp. 145-146, of LSE-13 Course.

The Mustard plants are herbaceous, annual with slender branched stems, 1-2 m high.

- The stem branches from the axils of the fourth or fifth leaf upwards.
- Leaves are lyrate, stalked and are about 15-30 cm long.
- The inflorescence is a corymbose raceme.
- Stamens are tetradynamous, and anthers introrse.
- Ovary is hypogynous, bicarpellary, syncarpous with a large number of ovules borne on parietal placenta.
- Fruit is a siliqua about 1-6 cm long, erect with short and stout beaks.
- Seeds are small, round, brown or dark brown and non-mucilagenous. Seeds show marked reticulations over the surface when examined under the microscope.
- For more details, refer to Block 3A, pp. 146-147 of LSE-13 Course.

Observations and Interpretations

Focus on the following aspects of the plant:

i) Overall appearance of the specimen – branched or unbranched;
ii) Arrangement of leaves, flowers and fruits;
iii) A split-open fruit to show arrangement of seeds;
iv) Take out one seed and study it under the dissecting microscope – study the nature of the seed coat, number of cotyledons (if possible), and position of embryo (if feasible)

Record all these observations in the Worksheet # 19.3.

Worksheet # 19.3: Study of rape/mustard plant and seeds:

Diagram space

Q.1: Make an outline diagram of a twig with inforescence and fruits.

Diagram space

Q.2: Illustrate a whole and a split-open fruit.

Diagram space

Q.3: Diagrammatically depict a seed as seen with unaided eyes, and as visible under a dissecting microscope.

Description space

Q.4: Write the details of the following points.

Botanical name: ....

Family: ....

Local name(s): ....

The plant/twig: ....

Leaves: ....

Inflorescence: ....

Flowers: ....

Fruits: ....

Fruit (whole): ....

(split-open): ....

Other features: ....

Seed (whole): ....

(split-open): ....

Other features: ....

4. Soyabean

- Soyabean is a much branched, annual legume with trifoliate leaves. It bears small, white or deep purple flowers on axillary racemes.
- The fruits are hairy pods containing two or three seeds.
- The seeds are small with variety of colours.
- There are two varieties of seeds:
  i) Black seeds – rich in proteins and low in oil content.
  ii) Yellow seeds – high in oil content and comparatively low in protein content.
- Soyabean is also known as 'wonder-bean' because of its high protein content, and numerous uses.
- For more details refer to LSE-13 Course, Block 3A, pp. 153-154.

Observations and Interpretations

Observe the following aspects.

i) Overall appearance of the specimen provided and also note whether it is branched or unbranched.
ii) Arrangement of leaves, flowers and fruits.
iii) The characteristic features of leaves.
iv) The placement of pods, whether single or in groups, the features of pods – shape, size, surface hairy or not, number of seeds per pod.
v) A whole seed, and an opened seed under the dissecting microscope, note the features of cotyledons and embryo.

Record your findings in Worksheet # 19.4.

Your Notes

Diagram space	Description space
Q.1: Make an outline diagram of a flower/fruit bearing shoot.	Q.3: Fill the details of the given points. Botanical name: .... Family: .... Local name(s): .... Overall appearance: .... Leaves: .... Flowers: .... Fruits: ....
Diagram space Q.2: Draw outline diagrams of seeds in different views.	Seed [whole (in different views)]: .... Seed [opened-up]: .... Other features: ....

5. Sesame

- Sesame plant is a herbaceous annual with sessile or petiolate leaves showing various shapes. The flowers may be white/pink/purple, and are solitary or in groups of two or three in the leaf axil. Pedicel usually short with nectarial glands at the base.
- The fruit originates from bicarpellate or quadricarpellate gynoecium. It is flat, deeply grooved capsule which contains numerous oval seeds.
- The seeds are white, brown or black in colour having smooth or rough surface.
- You can get more details on sesame in LSE-13 Course, Block 3A, pp. 161-163.

Observations and Interpretations

i) Overall appearance of the specimen, the branching pattern.
ii) Arrangement of leaves, flowers and fruits.
iii) The characteristics of leaves.
iv) Different stages of development of fruit starting from a flower.
v) Nactarial glands at the base of the pedicel.
vi) A fruit – whole, and longitudinally cut, note the arrangement of seeds.
vii) Observe a few seeds under a dissecting microscope and note their characteristic features.

Record your observations in Worksheet # 19.5.

Your Notes

Worksheet # 19.5: Study of a sesame plant and its seeds.

<table>
<tr><td>

Diagram space

Q.1: Illustrate a flowering shoot.

</td><td rowspan="3">

Description space

Q.4: Write the details of the followings points.

Botanical name: ....

Family: ....

Local name(s): ....

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Overall appearance: ....

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Leaves: ....

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Flowers: ....

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Fruits: ....

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A longitudinally cut fruit: ....

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Seed in different views: ....

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Other features: ....

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</td></tr>
<tr><td>

Diagram space

Q.2: Draw a longitudinally cut-open fruit.

</td></tr>
<tr><td>

Diagram space

Q.3: Make outline diagram of a few seeds in different views.

</td></tr>
</table>

6. Cotton

- Cotton plant is a shrub, with thick stem and palmately-lobed hairy leaves.
- The flowers are borne singly.
- The fruit (boll) is a capsule with numerous seeds.
- The seeds are dark brown or black in colour and are ovoid in shape. A seed has three main parts:
  - fuzz or linters (cotton fibre);
  - testa or hull (tough covering); and
  - embryo, (with long radicle and convoluted cotyledons).

  The seed is rich in oil and protein contents. Gossypol is present in the tiny, dark-coloured glands which are located on the kernel.
- You can get further details on cotton from LSE-13 Course, Block 3A, pp. 152-153.

Observations and Interpretations

Focus your attention on the following aspects of the specimen:

i) Overall appearance of the plant, branched or unbranched, and other features.
ii) Arrangement and specific features of leaves, flowers and fruits (bolls).
iii) An opened boll.
iv) Seeds in different views.

Record your observations in Worksheet # 19.6.

Your Notes

Worksheet # 19.6: Study of a cotton plant and its seeds.

Diagram space

Q.1: Illustrate a twig of a cotton plant.

Diagram space

Q.2: Make an outline diagram of an opened boll.

Diagram space

Q.3: Draw outline diagrams of seeds in two different views.

Description space

Q.4: Write about the given points.

Botanical name: ....

Family: ....

Common name(s): ....

Overall appearance: ....

Leaves: ....

Flowers: ....

Boll: ....

An opened boll: ....

Seeds: ....

7. Safflower

- Originally, this plant was cultivated for its orange dye. Only recently it has been grown as an oil seed crop.
- Two cultivars of safflower are used. One with spiny leaves is an excellent source of oil, and the other with spineless leaves is used for the extraction of dye. Here, we will focus on the spiny variety of safflower plant.
- The plant is highly branched, spiny, annual herb.
- The leaves are entire, alternate, spinulose, serrate, present in rosettes that form near the base of the stem.
- The inflorescence is colourful thistle-like head with homogamous tubular, bisexual, orange-red flowers.They do not have pappus.
- The fruit is one-seeded achene.
- The seed contains 24-36% drying oil.
- Two different grades of oils are obtained.
  i) Mono-saturated oil – used for frying
  ii) Poly-unsaturated oil – used as salad oil.
- You can get more details on this plant in the LSE-13 Course, Block 3A, pp. 148-150.

Observations and Interpretations

Note the following aspects in the given specimen:

i) Overall look of the plant, whether branched or unbranched, and so on.
ii) Arrangement and specific features of leaves, and inflorescence.
iii) A few seeds in different views.

Record your observations in Worksheet # 19.7.

Your Notes

Worksheet # 19.7: Study of safflower plant and seeds.

Diagram space

Q.1: Illustrate a flowering twig of a safflower plant.

Diagram space

Q.2: Make an outline diagram of a longitudinally cut-open flowering head.

Diagram space

Q.3: Draw outline diagrams of a few seeds as seen in different views.

Description space

Q.4: Fill the following blanks.

Botanical name: ....

Family: ....

Common name(s): ....

....

....

....

....

Overall appearance: ....

....

....

....

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Leaves: ....

....

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....

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Inflorescence: ....

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....

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Longitudinally cut-open infolorescence:

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Types of florets: ....

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A floret: ....

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Seeds: ....

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8. Coconut

- The coconut plant is known as 'wonder plant', or the tree of heaven – 'kalpavriksha', because all the parts of the plant have economic importance.
- It is a tall, unbranched palm with crown of peripinnate leaves.
- The inflorescence is spadix, and originates from the axil of the leaf. It is a monoecious plant, i.e., male and female flowers are found on one plant. The male flowers are numerous, and are located at the upper part of the floral axis. The female flowers are few, and are situated at the base of the same inflorescence. The most remarkable feature of coconut is that, it flowers all the year round.
- The ripe fruit is a fibrous drupe. The exocarp – outer zone of fruit is thick, smooth and green at the young stage and reddish brown at maturity. The mesocarp (middle) is fibrous, and endocarp (inner) is hard with three 'eyes' at the basal region. The embryo is located under the large eye. The testa is thin, and brown. It has an endosperm also known as 'meat', and it is solid in mature fruits. The large coconut cavity is filled with liquid endosperm, also known as 'coconut milk'.
- For further reading on coconut, you may see LSE-13, Block 3A, pp. 150-152.

Observations and Interpretations

Observe the following features in the specimen/photograph:

i) Overall appearance of the plant.
ii) A branch with fruits.
iii) A green and a mature fruit
iv) Both green and mature fruits cut-open into two halves. Study the various layers.

Record your observations in Worksheet # 19.8.

Your Notes

Diagram space

Q.1: Make an outline sketch of a coconut tree (in the field / from the photograph), highlighting the female inflorescence.

Diagram space

Q.2: Draw outline diagrams of a green and a mature fruit cut-open, showing their various layers.

Description space

Q.3: Write the details about the following points.

Botanical name: ……………………………

Family: ……………………………

Local name(s): ……………………………

Overall appearance: ……………………………

A fruit bearing branch: ……………………………

A green fruit (whole): ……………………………

A mature fruit (whole): ……………………………

Green and mature fruits cut into tw halves: ……………………………

19.3 ANATOMY

The purpose of this exercise is to observe the cellular details of the oil-storing cells, and understand their anatomical peculiarities.

Materials required

1. Seeds (fresh) or dried (soaked) seeds of groundnut or mustard. If time is a constraint, you can use permanent slides of the above two materials.
2. A sharp blade or razor
3. Your instruments kit
4. Safranin
5. Sudan III
6. Slides
7. Coverslips
8. Glycerine
9. Watch glass
10. Compound microscope

Procedure

i) Take fresh or soaked seeds of groundnut or mustard, and cut thin, transverse sections of any one material. Use pith for cutting sections of mustard seed as these are quite small.
ii) Pick two thin sections of the material you have cut, on two different slides.
iii) Stain one section with safranin and other one with Sudan III.
iv) Mount the section in glycerine.

Observations and Interpretations

i) Use the safranin-stained section for studying the gross anatomical details of the material (complete section of the seed, or part of it). Draw outline diagrams in the Worksheet # 19.9.
ii) Observe the Sudan III-stained section along with the safranin-stained section and observe the cells at different developmental stages. Note the cell-shapes, vacuoles, nuclei, and oil-droplets in the cells. As these cells grow further, the oil droplets coalesce and form big oil-masses or bodies. Look for as many developmental stages as you can by moving and observing the section in different fields of view.

Note your observations in the Worksheet # 19.9.

Your Notes

Worksheet # 19.9: Study of anatomical details of ....
(Write the name of the material).

Diagram space **Q.1:** Make an outline diagram of a few oil-storing cells.	**Description space** **Q.2:** Write the salient features of the oil-storing cells depicted in the adjacent left-hand column.
Diagram space **Q.3:** Draw a few cells at different stages in enlarged views depicting the storage materials.	**Description space** **Q.4:** Write about the details of oil-storage cells that can be seen in their enlarged view.

19.4 MICROCHEMICAL TESTS

You have already done this test partly in the previous exercise by staining the section with Sudan III stain. In this exercise, you would perform this test directly on three or four vegetable oils.

Materials required

1. Vegetable oils of:
   mustard,
   soybean,
   cotton,
   any other source(s)
2. Sudan III
3. Test tubes
4. Test tube stand

Procedure

i) Take 4 or 5 drops each of these oils in different test tubes.
ii) Add equal amount of Sudan III to each of the test tubes and shake them well. Keep these test-tubes in a stand for 5-10 minutes, and then observe.

Observations and Interpretations

Note the resultant colour formed in oils from different sources.

Record your observations in the Worksheet # 19.10.

Your Notes

Observation recording space

Q.1: Write your observations about the microchemical tests performed on the different vegetable oils.

(Cont.)

Q.2: Test your knowledge on fats and oil-yielding plants.

i) Mention the names of two non-drying oils.

....

....

ii) What is the botanical name of castor?

....

iii) Name an oil-yielding plant that bears geocarpic fruits.

....

iv) Which oil-yielding plant is commonly called 'wonder-bean'?

....

v) Describe the uses of the 'wonder-bean' plant.

....

....

....

....

Your Notes

EXERCISE 20 SUGAR-YIELDING PLANTS

Date ....
Session # ....
Time allocated – 20 minutes

Structure **Page No.**

Reading the exercise in advance would help you to complete your work in the given time-frame.

You are advised to wear a lab coat while working in the lab. because your safety and right training is our main concern.

20.1 INTRODUCTION

Carbohydrates, in varied composition, are present in all the plants. Sugars, starches and cellulose are the main constituents of plant carbohydrates. These can be divided into monosaccharides, oligosaccharides and polysaccharides. The monosaccharides are the building blocks of complex carbohydrates. Glucose and fructose are the most common monosaccharides. Oligosaccharides consist of two or more molecules of monosaccharides joined together by glucoside linkages, e.g., sucrose and maltose. These saccharides on hydrolysis yield simple sugars. Polysaccharides are complex molecules made up of a large number of monosaccharides which are linked by glucoside linkages, and have lost their sugar property. These too, on hydrolysis yield simpler forms. Starch and cellulose are the most prevalent polysaccharides in plants.

Sugars, the underlying theme of this exercise, are synthesized by green plants by the process of photosynthesis. Sugars are soluble carbohydrates and are the source of energy. These are stored in large quantities in the stem, e.g., sugarcane; in the root, e.g., carrot; and in the bulb, e.g., onion. In this exercise, you would make a detailed study of the sugarcane plant.

Objectives

After completing this exercise, you should be able to:

- identify a sugarcane plant specifying its various morphological features;
- pinpoint the position of intercalary meristem based on the morphological and anatomical interpretations; and
- test for the presence or absence of the characteristic metabolites of a sugarcane stem.

Study Guide

You may refer to the sugarcane related theory details in Block 3A, pp. 169-177, of LSE-13 Course.

20.2 MORPHOLOGY

In this exercise, you would study the morphological details of the different parts of sugarcane.

Sugarcane

1. It is perennial, rhizomatous, tall, erect plant with fibrous roots. It grows in clumps (stands). The colour of sugarcane varies from white to yellow to deep green, purple red or violet.
2. The stem is solid with distinct nodal and internodal zones.
3. At each node – area where leaf sheath is attached to the stem - an intercalary meristem is present. Root initials or primordia are present around the nodal region. Also a waxy band can be commonly seen.
4. The internodal regions are shorter near the base of the plant and these progressively increase upwards.
5. Stem is the economically important part: outer part of the stem known as the rind is made up of several layers of thick-walled lignified cells, that provide protection to the underlying cells. The rind encloses soft, light-coloured tissue that is known as pith. Numerous fibro-vascular bundles are embedded in the pith. The parenchyma cells surrounding them contain a high percentage of juice.
6. The leaves are attached alternately in two rows on either side of the stem, at the node. The leaf encloses a bud in its axil. The leaves are thin, blade-like, with serrate margin, and occasionally bear hairs.
7. Inflorescence is terminal, silvery tan-coloured and commonly called as 'tassel' or an 'arrow'. The leaf sheath immediately surrounding the inflorescence is quite long, while the blade (known as the flag) is short. The inflorescence is an open, feathery/woolly panicle and has a typical Graminaceous (or Poaceous) structure.
8. The spikelets are surrounded by silky hairs, which collectively give a silky or feathery appearance to the inflorescence.
9. Sugarcane is vegetatively propagated by stem cuttings.

Materials required

i) Museum/fresh specimens/photographs of sugarcane plant,
ii) Herbarium/fresh specimen of sugarcane inflorescence,
iii) A hand lens or binocular or a dissecting microscope,
iv) Your instruments kit.

Procedure

Observe and study critically the given specimens/materials.

If fresh specimen is available, study the structures present at its node by observing the stem with a hand lens or under the binocular/dissecting microscope.

Study the given sugarcane plant, and note details about the following aspects:

i) Colour of the stem.
ii) Relative length of the internodes from base upwards.
iii) Pattern of attachment of leaf to the stem,the leaf margin, and the presence of hairs on the leaf surface or lamina (observe under the dissecting microscope).
iv) At the node, see the attachment of leaf-sheath; the root band; intercalary meristem (from surface view; or in l.s. stem through node, in a permanent slide – *you would be observing the permanent slide in the next section*); and the lateral buds.
v) Waxy bloom in the internodal region.
vi) Inflorescence type, size, and its protective cover (of a long leaf-sheath, having a short blade)

Record your observations both in diagrammatic and written forms in the Worksheet # 20.1.

Your Notes

Worksheet # 20.1: Study of morphology of sugarcane plant.

Diagram space

Q.1: Draw outline diagram of the specimen provided to you.

Diagram space

Q.2: Illustrate a nodal region in an enlarged view.

Description space

Q.3: Fill the details.

Botanical name: ....
Family: ....
Common name(s): ....
....
....
....
Colour of stem: ....
....
....
Relative length of internodes (from base upwards):
....
....
....
....
Leaf-attachment: ....
....
....
- margin: ....
....
....
- hairs on the surface: ....
....
....
Any other feature(s): ....
....
....
....
....
Leaf-sheath: ....
....
....
....
Root-band: ....
....
....
Intercalary meristem: ....
....
....
....
Lateral buds: ....
....
....
....
Any other feature(s): ....
....
....
....

20.3 ANATOMY

This involves studying anatomical peculiarities of mainly two structures - the position of intercalary meristem, and the structure of stem in transection.

Materials required

1. Permanent slides of the following:
   - L.S. of stem through the nodal region
   - T.S. of stem through the internodal region
2. Dissecting microscope
3. Compound microscope

Procedure

Focus the first slide (l.s. stem) as mentioned above, under a dissecting microscope and observe. Focus the second slide (t.s. stem) under a compound microscope, and study its anatomical details.

Observations and Interpretations

i). In the l.s. stem, observe the position of the intercalary meristem in the nodal region and make an outline diagram in the Worksheet # 20.2.

ii) Study the anatomy of stem as seen in t.s. and make an outline diagram showing its different parts in the Worksheet # 20.2. You have read about it in point # 5 in the description of sugarcane plant.

iii) Draw a few cells from the rind; the parenchymatous cells from the pith, and the fibro-vascular bundles, in the Worksheet # 20.2.

Your Notes

Worksheet # 20.2: Study of anatomical details of sugarcane stem.

Diagram space	Description space
Q.1: Make an outline diagram of l.s. stem showing the position of intercalary meristem.	**Q.2:** Write the salient anatomical features of the sugarcane stem cut in l.s., focusing on the intercalary meristem.
Diagram space	Description space
Q.3: Make an outline diagram of a stem in transection. Enlarge a few cells from its different regions.	**Q.4:** Write the salient anatomical features of the details depicted in the adjacent column.

20.4 MICROCHEMICAL TESTS

In this part of the exercise, you would test the freshly extracted sugarcane juice for sugars.

Materials required

1. A fresh sugarcane
2. Fehling's Reagent
3. Test-tubes
4. Bunsen burner
5. Test tube stand
6. Test tube holder
7. Your instruments-kit

Procedure

i) After removing the rind from the stem, crush the pith and collect 10-15 drops of the juice in a test tube.
ii) Perform the microchemical tests for sugars. Refer to Exercise # 1.

Hold the test tube with a holder, and keep the mouth of the test tube away from you while heating.

Observations and Interpretations

i) Note whether it tests positive or negative for sugars.
ii) Try to identify the kind of sugars – reducing or non-reducing.

Note your observations in the Worksheet # 20.3 given below.

Worksheet # 20.3: Microchemical tests for sugars in the juice of sugarcane stem.

Your Notes

EXERCISE 21 STARCH PRODUCING PLANTS

Date ....
Session # ....
Time allocated – 40 minutes

Structure **Page No.**

Reading of this exercise prior to the lab. session is strongly recommended.

For protecting yourself and your clothes, wear a lab coat while working in the lab.

21.1 INTRODUCTION

Starches are complex insoluble carbohydrates, that are stored in the form of starch grains. These may occur in plant organs like stem, roots and leaves. The starch is deposited in concentric layers in the form of grains. The arrangement of rings in a grain is fixed for a species. Generally speaking, a starch grain contains a tiny point – hilum, which is the starting point of starch deposition. Starch is deposited in layers around the hilum. That's why distinct lines or stratifications are visible in starch grains when viewed under higher magnification.

The starch grains are of two types – **simple** and **compound**. The simple starch grains are further divided into two subtypes. One is **eccentric** (e.g., potato) where hilum is located at one end of the grain and the deposition of layers is unequal. The other is **concentric** (e.g., maize, wheat). As the name suggests the hilum is situated in the center and distinct layers are uniformly deposited around it. In **compound** grains, several grains are adpressed together to form a mass (e.g., rice).

Objectives

After completing this exercise, you should be able to:

- describe the diagnostic morphological features of a potato and a cassava plant;
- explain the morphological peculiarities of tubers of potato and cassava;
- compare potato tubers of different varieties based on their morphological features;
- describe the anatomical structure of a potato tuber;
- identify and compare the starch grains from different sources; and
- confirm the presence/absence of starch in the given plant material by performing microchemical tests.

Study Guide

- We again reinforce the usefulness of prior reading of the text before the lab session, along with drawing out a work plan for the session time available for study.
- You can get more details on potato and cassava in the following references: Potato – Block 3A; pp. 103-104, and 179-182 of LSE-13 Course. Cassava – Block 3A, pp. 106-107, and 183-186 of the same LSE-13 Course.

21.2 MORPHOLOGY

Two common sources of starch – **potato** and **cassava** have been selected for study. Information regarding their morphological characteristics is being given here for your ready reference.

1. Potato

1. It is a herbaceous plant.
2. The stem is erect in the early stages of growth but later it becomes more spreading. The underground portion of the stem is somewhat rounded and solid, sending forth horizontal branches known as stolons that arise from the axillary buds.
3. Adventitious roots are produced is groups of 3 or 4 at the nodes of the main underground stem as well as the stolons.
4. The first few leaves near the base are simple, but the subsequent ones are compound and irregularly imparipinnate. Each leaf has a terminal leaflet, 2 to 4 pairs of large, primary oval leaflets, with entire or serrate margins and small secondary leaflets known as folioles, interspersed between the primary leaflets. The leaflets are opposite, densely hairy when young, and the hairs confined to midrib and lateral veins at maturity. Two stipules are present near the point of attachment of the leaf to the stem.
5. Flowers may or may not be present. When present their colour ranges from yellow to purple.
6. The tuber, considered as a modified stem, arises from the apical portion of the stolon. In morphological sense, it is a short, thick stem bearing a number of buds or eyes in the axils of scale-like leaves. These leaves are shed at an early stage, leaving rudimentary leaf scars known as eyebrows or ridges. The eyebrows are well marked and can be seen as semicircular structures towards the heel or the attached end. The distal end of the tuber is known as the apical or the rose end. Each eye consists of the leaf scar, a cluster of at least three buds situated in the depressed cavity (shallow, medium, or deep). The eyes are arranged spirally around the tuber and are more crowded towards the apical or rose end of the tuber than the heel or basal end. The shape, size, colour and texture of tuber vary greatly.
7. Potato is a vegetatively propagated crop. It is propagated by means of tubers or part of tubers called 'seed potato'.
8. The fresh potatoes are important source of vitamin B and C. Deep peeling of potato should be avoided as it removes the valuable nutritional ingredients.
9. The green potatoes contain a poisonous glucoside solanin.

Materials required

i) Herbarium/museum/fresh specimens of a potato plant
ii) Potato tubers of atleast two different varieties
iii) Binocular/dissecting microscope/hand lens
iv) Your instruments kit

Procedure

1. Observe the specimen of the given potato plant very carefully checking for the morphological features mentioned above. If fresh material is given, you can observe it under the binocular/dissecting microscope. However, if the specimen is mounted on the Herbarium sheet, you can use a hand lens to study its leaf surface details. Avoid putting the specimen under the microscope lest it may get damaged.
2. Observe the tubers of two different potato varieties. Study their characteristic features. You may use binocular / dissecting microscope or hand lens for making observations.

⚠ Handle the Herbarium specimens gently.

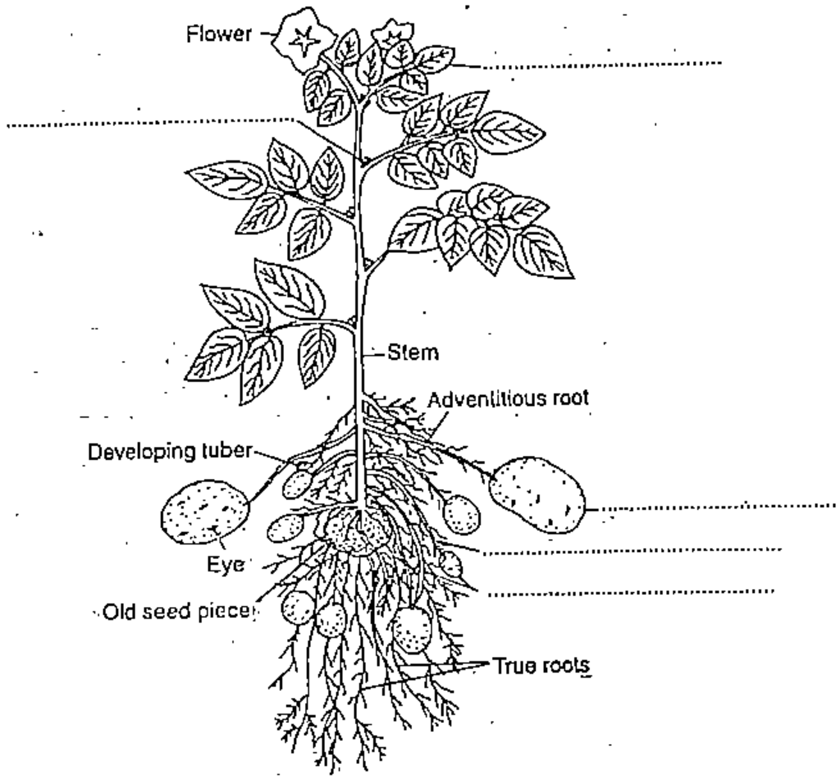
Observations and Interpretations

1. After studying the specimen of the potato plant, complete the labelling task of its various parts in the Worksheet # 21.1. Also, write the diagnostic morphological features of the plant in the worksheet. Some leads are given for your guidance.
2. After completing your observation of the two different types of tubers, present their comparative account in the Worksheet # 21.2.

Your Notes

Worksheet # 21.1: Study of morphology of potato plant.

Diagram space



Q.1: Identify and write the names of the plant parts that have been left unlabelled in the figure.

Description space

Q.2: Fill the details for the given points.

Botanical name: ....

Family: ....

Common name(s): ....

....

....

....

Salient features: ....

....

....

....

....

....

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....

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....

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....

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....

....

....

Q.3: Write the diagnostic features of a potato plant based on your observation of the specimen.

Overall appearance: ....

....

....

Stem: ....

Leaves: ....

....

....

Stolon: ....

Roots: ....

Tuber: ....

Other feature(s): ....

....

....

Worksheet # 21.2: Comparative study of potato tubers of two different varieties.

Features	Variety .... *(write the name)*	Variety .... *(write the name)*
1. Make outline diagrammes of potato plants reflecting their morphological peculiarities. Label their parts.	**Diagram space**	**Diagram space**
2. Colour	....	....
3. Size (length / diameter, etc.)	....	....
4. Texture	....	....
5. Shape	....	....
6. Arrangement of eyes	....	....
7. Number of eyes	....	....
8. Whether heel end / Rose end identifiable, write their features	....	....
9. 'Eye' details	....	....
10. Other feature(s)	....	....

2. Cassava

1. It is a shrub with latex in all its parts.
2. Stem is erect with prominent leaf scars.
3. The leaves are large, spirally arranged and palmately compound. The leaves are often variegated or tinged red, green and yellow. Petioles are usually longer than the lamina. The lamina is deeply palmate with 3-9 lobes. Petiole and midrib are green to deep red.
4. The monoecious flowers are in axillary racemes.
5. The adventitious roots develop swellings a short distance away from the meristem and form tubers. These store large amounts of starch. The number of tubers per plant, their colour, and shape varies in different varieties.
6. There are two varieties of cassava:
   i) Sweet cassava – having low hydrocyanic acid; and
   ii) Bitter cassava – having high hydrocyanic acid.
7. Its stem is also used in laboratories as a pith material for section cutting.

Materials required

i) Herbarium/museum/fresh specimen of a cassava plant, and its tubers
ii) Your instruments kit

Procedure

1. Study the given specimen(s) of the cassava plant, and tally your observations with the information given above.
2. Complete the tasks given in the Worksheet # 21.3.

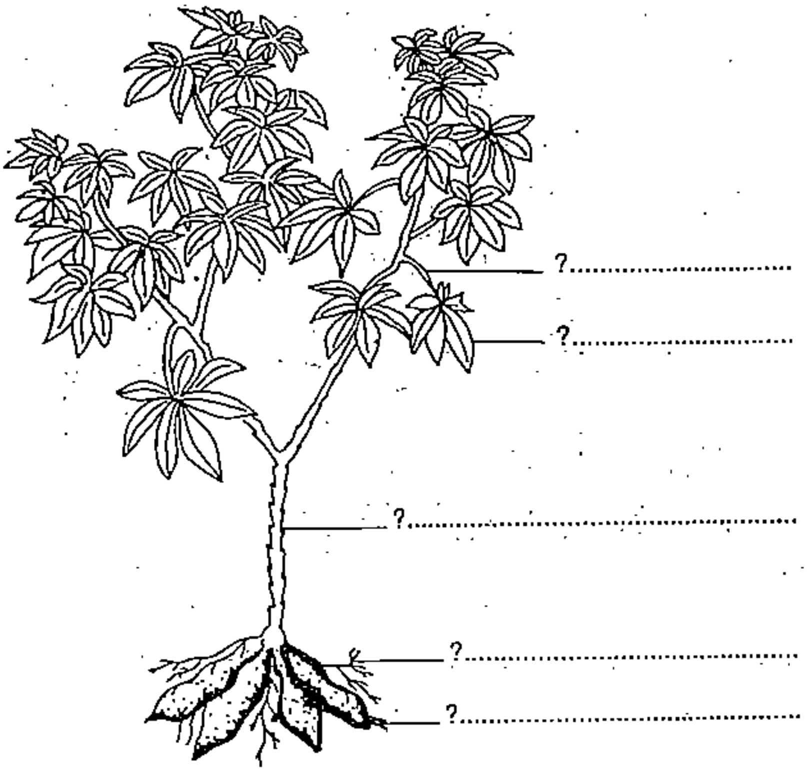
Observations and Interpretations

1. Complete the labelling of the figure depicting a cassava plant in Worksheet # 21.3. Also write the diagnostic features of the plant and the tubers (if provided) in the worksheet.

Your Notes

Worksheet # 21.3: Study of morphology of cassava plant.

Diagram space



Q.1: Identify and write the names of the plant parts that have been left unlabelled in the figure.

Description space

Q.2: Fill the details for the following points.

Botanical name: ....

Family: ....

Common name(s): ....

....

....

....

Salient features: ....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

Q.3: Write the diagnostic features of a cassava plant based on your observation of the specimen. Also write the salient features of the tuber (if provided).

Overall appearance: ....

....

....

Stem: ....

Leaves: ....

....

....

Stolon: ....

Roots: ....

Tuber: ....

Other feature(s): ....

....

....

21.3 ANATOMY

Two things are to be done in this exercise. *One*, a study of t.s. of potato tuber; and, *two*, study of different starch grains, and the identification of the plant sources, giving reasons.

1. T.s. potato tuber

1. Anatomically, tuber is a typical stem.
2. Moving from its surface inwards, it consists of periderm, cortex, vascular cylinder with patches of outer phloem and distinct xylem bundles (see the figure in the Worksheet # 21.4). The outer medulla is represented by the inner phloem, and the inner medulla or pith is made up of mainly parenchyma and is without phloem elements.
3. The phloem elements in totality (outer and inner) are in numerous groups. The internal phloem is rich in parenchyma and appears to be the principal storage tissue of the tuber.
4. The periderm and xylem bundles contain little storage parenchyma.
5. The thin corky periderm forms the outer protective layer (the skin) which can be easily peeled off.

Materials required

i) Permanent slide/hand-cut temporary preparation of t.s. of tuber
ii) Safranin, for fresh, hand-cut sections
iii) Microslides
iv) Coverslips
v) Petridish with water
vi) A sharp blade/razor
vii) Your instruments kit
viii) A compound microscope

Procedure

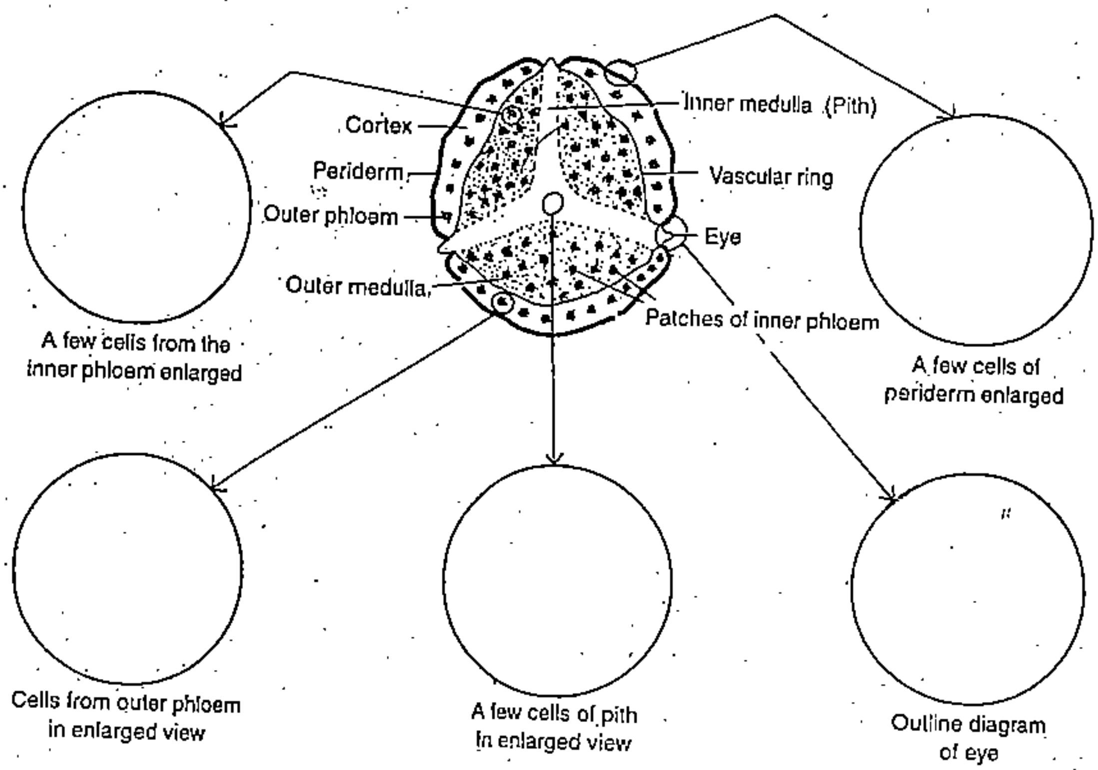
1. Fix the permanent slide under the compound microscope.
2. For making a temporary preparation, cut a thin t.s. of tuber. Stain it with safranin, mount in a drop of glycerine placed on a slide. Place a coverslip over it. Fix this preparation under the compound microscope.
3. Study the anatomical features of the tuber that are explained above.
4. Complete the related work in the Worksheet # 21.4.

Observations and Interpretations

1. The figure given in the Worksheet # 21.4 would help you in identifying and understanding the features of its different regions. Sketch a few cells in the encircled blank areas. Also, write the salient anatomical details of the tuber as seen in t.s.

Worksheet # 21.4: Anatomical study of a potato tuber cut in transverse plane.

Diagram space



Q.1: Illustrate a few cells from the areas marked in the figure – five blank areas are marked for this purpose.

Description space

Q.2: Write the anatomical highlights of a potato tuber as seen in transverse section.

Periderm: ....
....
....

Cortex: ....
....
....

Vascular ring: ....
....

Outer and inner phloem: ....
....
....

Pith: ....
....
....

Eye: ....
....
....

Other feature(s): ....
....

2. Study of starch grains

The basic structure of a starch grain has been described in Section 21.1. You may also refresh your memory about the structure of starch grains of various plant sources from the reference: Block 3A, LSE-13 Course, page # 179.

Materials Required

1. Any four of the following sources of starch
   - oats flour
   - wheat flour
   - maize flour
   - rice flour
   - potato tuber
   - raw banana
   - Any other source
2. Slides – 6
3. Coverslips – 6
4. IKI solution (see Exercise # 1)
5. Your instruments kit.
6. Glass-marking pencil
7. Labels for slide

Procedure

Irritant
Iodine solution

1. Take a small amount of flour, pin-head size, on a microslide and add a drop of water to it.
2. Add a drop of dilute IKI solution so that the starch grains get stained. You may have to adjust the dilution of IKI with water in case the stock solution is very concentrated for your material. Stain such that the internal details of the grains are clearly visible.
3. Similarly make preparations of the remaining three flours.
4. Label the different slides indicating the source of the material. This is to avoid any mixing up of materials.
5. For materials like the potato tuber or beans you may crush and take their juice in a little amount on a slide and stain with Iodine as indicated above. The other way is that you cut a very thin section of the tuber and stain in the same way.

Observations and Interpretations

1. Observe the preparations one by one. Note the shape; size; free/clumping nature; the position of hilum; the nature (eccentric/concentric) and number of layers or rings per grain. Record these observations in the Worksheet # 21.5. Also, make outline diagrams of each:

Worksheet # 21.5 Study of starch grains from different sources.

Materials → / ↓ Features	A	B	C	D
1. Outline diagram Diagram space →				
2. Shape	....	....	....	....
3. Size	....	....	....	....
4. Single/compound	....	....	....	....
5. Position of hilum	....	....	....	....
6. Shape of hilum	....	....	....	....
7. Nature of rings (lamellae) • eccentric/concentric; • complete/incomplete; • number	....	....	....	....
8. Any other feature(s)	....	....	....	....
Identification of source, giving reasons	....	....	....	....

21.4 MICROCHEMICAL TESTS

In the previous exercise, while you made the preparations of starch grains, you have already performed the microchemical tests for starch. In this exercise, you would perform tests for proteins and starch in potato. The greater part of proteins, minerals, tannins, crystals and pigments (in coloured varieties) is localized in the outer layer of the cortex. *Deep peeling of the potato should be avoided as it removes the valuable nutritional ingredients.* The cortex is rich in starch.

Materials required

i) A potato tuber
ii) Petridish
iii) A sharp blade
iv) Your instruments kit
v) Chemicals for tests for starch and proteins (see Exercise # 1)
vi) Dissecting microscope

Procedure

1. Cut thin sections of potato tuber.
2. Pick two sections one each, on two slides.
3. Stain one section for proteins and the other for starch.
4. Observe the sections under the dissecting microscope.

Observations and Interpretations

Note the distribution of proteins and starch in the tuber as seen in the transection. Record your observations in the Worksheet # 21.6.

Worksheet # 21.6: Microchemical tests of potato tuber.

Diagram space	Description space
Q.1: Make an outline diagram (t.s. tuber) showing the distribution of proteins.	
Q.2: Draw an outline diagram (t.s. tuber) showing the regions where starch is found.	Q.3: Describe the distribution of proteins and starch in a potato tuber.

EXERCISE 22 REVISION AND EXTENSION OF EARLIER STUDIED FAMILIES

Date ....

Session # ....

Time allocated – 2 hours

Structure Page No.

Prior-reading the exercise is strongl recommended.

Always put on your lab coat while working in the lab.

22.1 INTRODUCTION

Plant identification is central to the study of plant taxonomy and systematics. **Identification keys** which consist of a series of pairs of contrasting statements are used to identify unknown plant specimens. In this exercise, you will learn to identify and classify angiosperms till the family level. You have studied the hierarchical system of classification of living organisms in *Units 3 & 4* of *LSE-07 Course* and you must have recalled that an important step in the classification of plants is to group them into families. This process is governed by certain rules. Amongst plants, family is the smallest of the major classification categories and it represents a more natural unit than any of the higher categories. The families of angiosperms are very distinct and can be defined and delimited by a few *stable floral characters* such as *type of inflorescence, symmetry of flower, kind of stamens and pistils, number of carpels, type of placentation, and the fruit types.* These characters are less susceptible to adaptive modifications. Therefore, most angiospermous families can be easily identified by a set of diagnostic characters, which are more or less common to most of the members of the family.

Beginning with this exercise, along with the next two exercises, you will learn to describe plant specimens systematically and identify the families to which they belong, using the identification key provided in Block-2B, of this course. Through these exercises you will recognize the important characteristics of some dicot and monocot families. The first Exercise # 22 will help you to refresh your memory about the diagnostic morphological features of nine dicot and monocot families that you have studied earlier in the LSE-08(L) course. Using the recalled diagnostic features and the identification key, you will learn and practise the classification up to the level of family. Thus, in this exercise, you will extend your previous study further. In Exercises # 23 and # 24, you will study the taxa belonging to some more dicot and monocot families, select their diagnostic characters, classify and identify their families using the identification key.

Objectives

After completing this exercise, you should be able to:

- use an identification key correctly;
- classify the given taxa up to the category of family using the identification key; and
- list the diagnostic characters of the given families.

Study Guide

- A thorough reading of Exercise #14, of LSE-08 (L) Course, pp. 57-81, is recommended before you begin this exercise. Also, read this very exercise, to comprehend the kind of work involved here.
- An identification key, and a detailed glossary of technical terms used in taxonomic studies is given in Block-2B for your easy access and work for these three exercises, as well as for your subsequent referral use.
- *You may work on this exercise partly/wholly at your home, as this work does not require use of any laboratory equipment.* This way, you can address the problem of time constraint; and more time will be available for the subsequent exercises of taxonomy.

Your Notes

22.2 RECAPITULATION: TAXA STUDIED

Materials required

LSE-08 (L) Block, (pages 57-81)
Identification key (see Block 2B of this course)

Procedure

1. Complete the table given in the Worksheets # 22.1 and 22.2 after recalling the characters of the taxa that you have studied in the LSE-08 (L) Course.
2. With the help of the key (given in Block-2B) classify the taxa till the category of family. This is done by selecting the correct statement from the series of pairs of contrasting statements given in the key. You may also refer to Section 6.4 (p. 35), Block-2 of LSE-07 Course and the glossary of taxonomic terms given in Block-2B of this very course for any clarifications.

   Let us now understand as to how it is to be precisely done. Supposing the **taxon A** has petiolate, exstipulate leaves with reticulate venation and dichlamydeous flowers with 5 fused sepals and 5 fused petals, it can be classified in the following manner.

   Refer to the characters of the first pair of statements. The characters of taxon A match with those of the first statement of pair 1, i.e., leaves reticulate veined and flowers pentamerous.
   ∴ A belongs to ....**(2) Class Dicotyledons**

   To find out the subclass, check the characters of number **'2'** pair of statements. Characters of **A** correlate with those mentioned in the first lead statement, i.e., flowers have two perianth whorls that are distinguished into calyx and corolla. For further classification, you can refer to the 4th pair of statements. In this the characters in second lead statement, i.e., 'petals fused', matches with that of **A**, and
   ∴ A belongs to ....**Sub-class Gamopetalae**

   This procedure is followed till the family is identified.

3. Write down the characteristic features of the family by selecting and putting in order the important characters used in step # 2 in the identification and classification of the family.

Observations and Interpretation

Following the procedure as described above, complete the Worksheets # 22.1 and 22.2. This exercise will consolidate your earlier learning and, in the process, will prepare the ground to learn the method of using the identification key.

Worksheet # 22.1: Listing of characteristic features of the taxa belonging to families: Lamiaceae, Asteraceae, Papilionaceae, and Papaveraceae, based on your study of LSE-08 (L) Course.

Taxa → / Feature ↓	*Ocimum basilicum* (Lamiaceae)	*Tridax procumbens* (Asteraceae)		*Pisum sativum* (Papilionaceae)	*Argemone mexicana* (Papaveraceae)
1. Habit					
2. Stem					
3. Leaf					
4. Inflorescence					
5. Flower		Ray	Disc		
6. Calyx					
7. Corolla					
8. Androecium					
9. Gynoecium					
10. Fruit					
11. Floral formula					
12. Floral diagram					

Worksheet # 22.2: Listing of characteristic features of the taxa belonging to families: Ranunculaceae, Brassicaceae, Malvaceae, Liliaceae, and Poaceae based on your study of LSE-08 (L) Course.

Taxa → / Feature ↓	*Ranunculus sceleratus* (Ranunculaceae)	*Brassica campestris* (Brassicaceae)	*Malva sylvestris* (Malvaceae)	*Allium cepa* (Liliaceae)	*Triticum aestivum* (Poaceae)
1. Habit					
2. Stem					
3. Leaf					
4. Inflorescence					
5. Flower					
6. Calyx					
7. Corolla					
8. Androecium					
9. Gynoecium					
10. Fruit					
11. Floral formula					
12. Floral diagram					

22.3 LEARNING TO USE THE IDENTIFICATION KEY

After having recapitulated the diagnostic features of various taxa, you will now practise classifying these taxa by using the identification key in the Worksheet # 22.3 – 22.11.

Worksheet # 22.3: Classification of the taxa – *Ocimum basilicum* using the identification key.

Q.1: *Ocimum basilicum* belongs to:

Class – Dicotyledons

Because (i) ....

(ii) ....

....

Subclass – Gamopetalae

Because (i) ....

(ii) ....

Series – Bicarpellatae

Because (i) ....

(ii) ....

(iii) ....

Order – Lamiales

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

(v) ....

Family – Lamiaceae (Labiatae)

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

....

....

....

....

Worksheet # 22.4: Classification of *Tridax procumbens* using the identification key.

Tridax procumbens belongs to:

Class – Dicotyledons

Because (i) ....

(ii) ....

Subclass – Gamopetalae

Because (i) ....

(ii) ....

Series – Inferae

Because (i) ....

(ii) ....

(iii) ....

Order – Asterales

Because (i) ....

(ii) ....

(iii) ....

Family – Asteraceae (Compositae)

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

(v) ....

(vi) ....

....

....

....

....

....

....

Worksheet # 22.5: Classification of *Pisum sativum* using the identification key.

Pisum sativum belongs to:

Class – Dicotyledons

Because (i) ....

(ii) ....

Subclass – Polypetalae

Because (i) ....

(ii) ....

Series – Calyciflorae

Because (i) ....

(ii) ....

Order – Rosales

Because (i) ....

(ii) ....

Family – Leguminosae/Fabaceae

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

(v) ....

Subfamily – Papilionatae

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

....

....

....

....

Worksheet # 22.6: Classification of *Argemone mexicana* using the identification key.

Argemone mexicana belongs to:

Class – Dicotyledons

Because (i) ....

(ii) ....

Subclass – Polypetalae

Because (i) ....

(ii) ....

Series – Thalamiflorae

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

Order – Parietales

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

Family – Papaveraceae

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

(v) ....

(vi) ....

....

....

....

....

Worksheet # 22.7: Classification of *Ranunculus sceleratus* using the identification key.

Ranunculus sceleratus belongs to:

Class – Dicotyledons

Because (i) ....

(ii) ....

Subclass – Polypetalae

Because (i) ....

(ii) ....

Series – Thalamiflorae

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

Order – Ranales

Because (i) ....

(ii) ....

(iii) ....

Family – Ranunculaceae

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

(v) ....

....

....

....

....

....

....

Worksheet # 22.8: Classification of *Brassica campestris* using the identification key.

Brassica campestris belongs to:

Class – Dicotyledons

Because (i) ....

(ii) ....

Subclass – Polypetalae

Because (i) ....

(ii) ....

Series – Thalamiflorae

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

Order – Parietales

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

Family – Brassicaceae (Cruciferae)

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

(v) ....

....

....

....

....

....

....

Worksheet # 22.9: Classification of *Malva sylvestris* using the identification key.

Malva sylvestris belongs to:

Class – Dicotyledons

Because (i) ....

(ii) ....

Subclass – Polypetalae

Because (i) ....

(ii) ....

Series – Thalamiflorae

Because (i) ....

(ii) ....

(iii) ....

Order – Malvales

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

Family – Malvaceae

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

....

....

....

....

Allium cepa belongs to:

Class – Monocotyledons

Because (i) ....

(ii) ....

Series – Coronarieae

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

Family – Liliaceae

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

....

....

....

....

Your Notes

Worksheet # 22.11: Classification of *Triticum aestivum* using the identification key.

Triticum aestivum belongs to:

Class – Monocotyledons

Because (i) ....

(ii) ....

Series – Glumaceae

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

(v) ....

Family – Poaceae/Gramineae (Poaceae)

Because (i) ....

(ii) ....

(iii) ....

(iv) ....

(v) ....

(vi) ....

....

....

....

....

....

....

Your Notes

Worksheet # 22.12: List the characteristic features of the given families.

1. Labiatae (Lamiaceae)

(i) ....
(ii) ....
(iii) ....
(iv) ....
(v) ....
(vi) ....
(vii) ....
(viii) ....
(ix) ....
(x) ....

2. Compositae (Asteraceae)

(i) ....
(ii) ....
(iii) ....
(iv) ....
(v) ....
(vi) ....
(vii) ....
(viii) ....
(ix) ....
(x) ....

3. Papilionaceae

(i) ....
(ii) ....
(iii) ....
(iv) ....
(v) ....
(vi) ....
(vii) ....
(viii) ....
(ix) ....
(x) ....

4. Papaveracae

(i) ....
(ii) ....
(iii) ....
(iv) ....
(v) ....
(vi) ....
(vii) ....
(viii) ....
(ix) ....
(x) ....

5. Ranunculaceae
   (i) ....
   (ii) ....
   (iii) ....
   (iv) ....
   (v) ....
   (vi) ....
   (vii) ....
   (viii) ....
   (ix) ....
   (x) ....
6. Cruciferae (Brassicaceae)
   (i) ....
   (ii) ....
   (iii) ....
   (iv) ....
   (v) ....
   (vi) ....
   (vii) ....
   (viii) ....
   (ix) ....
   (x) ....
7. Malvaceae
   (i) ....
   (ii) ....
   (iii) ....
   (iv) ....
   (v) ....
   (vi) ....
   (vii) ....
   (viii) ....
   (ix) ....
   (x) ....
8. Liliaceae
   (i) ....
   (ii) ....
   (iii) ....
   (iv) ....
   (v) ....
   (vi) ....
   (vii) ....
   (viii) ....
   (ix) ....
   (x) ....
9. Gramineae (Poaceae)
   (i) ....
   (ii) ....
   (iii) ....
   (iv) ....
   (v) ....
   (vi) ....

Worksheet # 22.14: Write brief answers to the following questions.

Q.1: Write the differences between the ray and disc florets in a capitulum of *Tridax procumbens.*

Q.2: Which floral characteristics of *Ranunculus sceleratus* are considered primitive?

....

....

....

....

....

....

Q.3: Name a few important members of Poaceae, Asteraceae, and Papilionaceae.

....

....

....

....

....

....

....

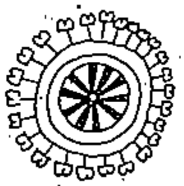
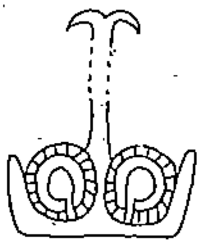
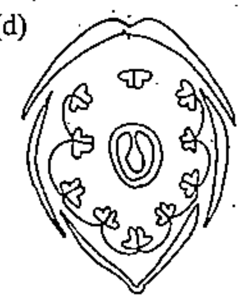
Worksheet # 22.15: Compare the floral characteristics of the following pairs of families.

(i) Papaveraceae & Malvaceae

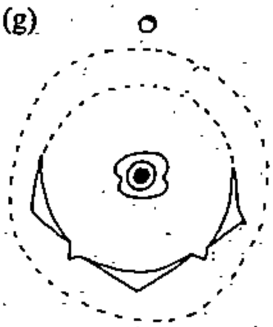
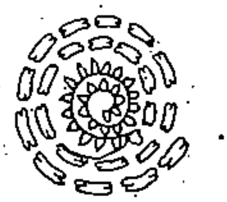
(ii) Lamiaceae & Papilionaceae

(iii) Liliaceae & Poaceae (Gramineae)

Worksheet # 22.16: Match the items of columns I, II and III, and write your answers in the triple-box-space provided.

I	II	III	Answers
(a) *Ranunculus sceleratus*	(a) $\oplus$ ⚥ $K_{2+2}\,C_4\,A_{2+4}\,\underline{G_{(2)}}$	(a) 	
(b) *Papaver somniferum*	(b) $\oplus$ ⚥ $K_5\,\widehat{C_5\,A_{(\infty)}}\,\underline{G_{(\infty)}}$	(b) 	
(c) *Brassica campestris*	(c) ·|· ♀ $K_{(pappus)}\,C_{(3)}\,A_0\,\overline{G_{(2)}}$	(c) 	
(d) *Malva sylvestris*	(d) $\oplus$ ⚥ $K_5C_5\,A_\infty\,\underline{G_\infty}$	(d) 	
(e) *Pisum sativum*	(e) $\oplus$ ⚥ $\widehat{P_{3+3}A_{3+3}}\,\underline{G_{(3)}}$	(e) 	(Cont.)

Worksheet # 22.16: Match the items of columns I, II and III, and write your answers in the triple-box-space provided (Cont.).

(f) *Ocimum basilicum*	(f) $\oplus$ ⚥ $K_3\ C_{3+3}\ A_{\infty}\ \underline{G_{(4\text{-}7)}}$	(f) 	☐☐☐
(g) *Tridax procumbens* (Ray floret)	(g) ·|· ⚥ $P_2\ A_3\ \underline{G_1}$	(g) 	☐☐☐
(h) *Allium cepa*	(h) ·|· ⚥ $K_{(1+4)}\ \overset{\frown}{C_{(4+1)}\ A_{2+2}}\ \underline{G_{(2)}}$	(h) 	☐☐☐
(i) *Triticum aestivum*	(i) ·|· ⚥ $K_{(5)}\ C_{1+2+(2)}\ A_{(9)+1}\ \underline{G_1}$	(i) 	☐☐☐

EXERCISE 23 DICOT FAMILIES

Date ....
Session # ....
Time allocated – 5 Hours

Structure **Page No.**

For completing the study of twelve specimens in the given time frame, you need to prepare a work schedule and a prior reading of the text of this exercise.

By now, you might have got into the habit of wearing a lab coat while working in the lab!

23.1 INTRODUCTION

After having revised the families studied earlier [in the LSE-08 (L) Course], and learning the method of using Identification Key in the previous exercise, in this exercise you would be extending your study of taxonomy further. You would study six more families of the dicots on the same lines as in the previous exercise. All these six families have been dealt with in Block 4 of the LSE-13 Course. While studying the various families therein, you would have got a fairly good idea about the range of variations in characters in each of these families. The families and the genera for your study in this exercise are so selected as to enable you to practically observe and familiarize yourself with some of these diverse characteristics. A good knowledge of the heterogeneity or variations existing in a family is a prerequisite to pin-point the key or diagnostic characters of the family, which should be common to most members of the family. Such diagnostic features help in the identification of any member of the family.

Objectives

After completing this exercise you should be able to:

- correctly describe the given plant specimens in semi-technical terms;
- select the diagnostic characteristics for the identification of family(ies) of the given specimen(s); and
- identify other members of the family(ies) that you have studied.

Study Guide

- You may refer to the Glossary given in Block 2B for clarifying the meaning of any technical or semi-technical term(s).

- Also, refer to the same Block for the Identification Key. Frequently refer to the Identification Key, so as to make it a habit for taxonomic studies.
- In case you are stuck with any of the detail of the families dealt with here, you may look at the corresponding theory portion in LSE-13 Course, Block-4. The complete reference for each family is given at the relevant-place.

Your Notes

23.2 MATERIALS AND GUIDELINES

Contents of this section:

Given below is the list of requirements, along with the guidelines for study. **The same guidelines apply for the study of monocots too that you would undertake in the next exercise.**

Materials required

The list of materials, except the plant specimen(s) for each family, is common for the entire exercise. So it is being given below and this would not be repeated in the subsequent families to save-on the space.

i) A sharp blade
ii) A pair of fine forceps
iii) Two dissection needles with sharp, pointed tips
iv) A dissecting microscope
v) A compound microscope
vi) A fine camel-hair brush
vii) Slides
viii) Coverslips
ix) Plant materials for the families: Cucurbitaceae, Apiaceae, Rutaceae, Apocynaceae, Amaranthaceae and Euphorbiaceae.

A list of suggested materials is given below. However, you are free to select any two materials for each family easily available in your locality.

1. **Family Cucurbitaceae**
   Luffa cylindrica
   Coccinia cordifolia
   Cucurbita maxima
   Cucumis sativus
   Momordica charantia

2. **Family Apiaceae**
   Coriandrum sativum
   Foeniculum vulgare
   Daucus carota
   Trachyspermum ammi

3. **Family Rutaceae**
   Murraya sp.
   Citrus sp.
   Aegle marmelos

4. **Family Apocynaceae**
   Catharanthus roseus
   Thevetia peruviana
   Nerium indicum
   Plumeria indica
   Tabernaemontana divaricata

5. **Family Amaranthaceae**
   Amaranthus sp.
   Achyranthus aspera
   Aerva lanata
   Gomphrena decumbens

6. **Family Euphorbiaceae**
   Euphorbia hirta/E. pulcherrima
   Acalypha/Ricinus sp.
   Jatropha sp.
   Phyllanthus fraternus
   Croton bonplandianum

Procedure

Just like the common 'materials required', the procedure too remains the same for the study of all the six families in this exercise. To save on the space, this would not be repeated in each of the families separately. Your study of the given plant specimen(s) involves three tasks: describing the given specimen; making the floral diagram; and writing the floral formula. The details for these are given below under the titles # I to III.

I. Description
II. Floral Formula
III. Floral Diagram

Contents of:

I. DESCRIPTION
   A. Habit
   B. Root
   C. Stem
   D. Leaf
   E. Inflorescence
   F. Flower
      F.1. Perianth
      F.2. Androecium
         F.2a. Stamen
         F.2b. Filament
         F.2c. Anther
      F.3: Gynoecium
         F.3a. Ovary
         F.3b. Style
         F.3c. Stigma
   G. Fruit
   H. Seed

I. DESCRIPTION

For taxonomic studies of this kind, usually the flowering and sometimes even the fruiting twigs of plants without the main stem or roots are provided. Sometimes when the plant is very small, and is available in abundance, the entire plant along with its roots may be given. These plants or twigs are generally obtained from nearby gardens or road-side. To describe the specimen correctly and completely, especially its habit, stem, and other features, observe the specimen carefully, and also be aware of the plants growing in your locality. This will help you to recall their habit and habitat.

A step-wise method for describing a plant specimen is given below. This involves selecting the appropriate term(s) from the list provided, or from the **Key & Glossary (in Block 2B)** wherever so indicated. You would be describing each of the family members in the following sequence and manner.

A. Habit – To describe this, you will have to recollect the general appearance of the plant, and then select the appropriate terms.
   1. Tree / shrub / herb / climber;
   2. cultivated / wild / ornamental;
   3. mesophyte / xerophyte / hydrophyte / parasite / saprophyte / epiphyte;
   4. tall / short;
   5. annual / biennial / perennial;
   6. erect / prostrate.

B. Root (if provided)
   1. Tap / fibrous root;
   2. specify any modification(s) if present (Key & Glossary p.# 31-32);

C. Stem

1. Aerial / sub-aerial / underground;
2. specify modification(s) if any (Key & Glossary pp.# 36-37);
3. branched / unbranched;
4. woody / herbaceous;
5. cylindrical / angular / ribbed / compressed;
6. solid / hollow;
7. with / without distinct nodes and internodes;
8. glabrous / with outgrowths / with excrescences / with trichomes (Key & Glossary pp.# 36-37);
9. solid / fistular;
10. colourless / coloured (specify colour).

D. Leaf

1. Ramal / cauline / basal or radical or rosulate;
2. alternate / opposite decussate / opposite superposed / whorled (Key & Glossary pp.# 40-41);
3. simple / compound (specify type, Key & Glossary p.# 43);
4. exstipulate / stipulate (mention type, Key & Glossary p.# 46);
5. sessile / subsessile / petiolate (specify type, Key & Glossary p.# 47);
6. shape of lamina (Key & Glossary pp.# 48-49);
7. shape of base (Key & Glossary p.# 51);
8. shape of apex (Key & Glossary p.# 50);
9. type of margin (Key & Glossary p.# 52);
10. texture of lamina (Key & Glossary p.# 23);
11. colour of lamina;
12. presence of any special structures, viz., hairs, glands, spines, wax deposition and so on (Key & Glossary p.# 23-27);
13. type of venation (Key & Glossary p.# 53).

E. Inflorescence

1. Solitary / racemose (specify type, Key & Glossary p.# 57) / cymose (specify type, Key & Glossary p.# 56);
2. homomorphic / heteromorphic;
3. homogamous / heterogamous / polygamous;
4. axillary / terminal / both.

F. Flower – Of each species, take at least one fully and one partially opened flower and two buds, still attached to the twig. Cut one bud or the flower vertically into two longitudinal halves as shown in Fig. 23.1, and the other bud horizontally into two transverse halves. You may be required to mention the position of the floral parts, especially the position of the bract/bracteole(s), the odd sepal or petal, the stamens and the carpels. In such a case, remember that the part of the flower towards the mother axis (inflorescence or stem axis) is the **posterior part** and the one away from the mother axis is the **anterior part**. The plane passing vertically through the center of the flower and the mother axis is the **median longitudinal plane**, and the one passing perpendicular to the median longitudinal plane is the **transverse** or **lateral plane**. A **diagonal plane** bisects the angle made by the intersection of the two planes. All the other planes are **oblique** ones.

A transverse section of the ovary should also be prepared. But first try to determine the position of the carpels either in the longitudinally or transversely cut, or in an intact flower / bud.

With the help of an intact flower / bud and its various sections, proceed to describe the flower.

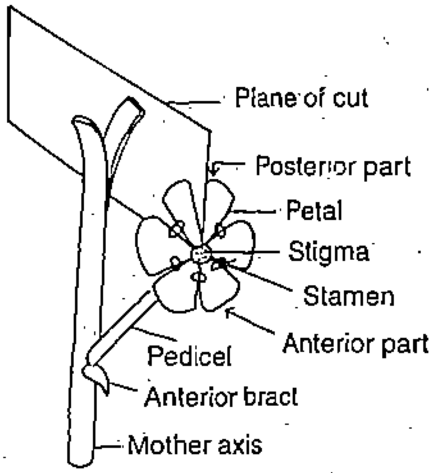


Fig. 23.1: Diagrammatic representation of splitting a flower in vertical plane.

1. Ebracteate / bracteate (specify their number, position and the type of bract);
2. sessile / subsessile / pedicellate (state long / short, glabrous / hairy, drooping / erect, hollow / solid);
3. complete / incomplete;
4. perfect / imperfect;
5. bisexual (hermaphrodite) / unisexual staminate / unisexual pistillate;
6. hypogynous / perigynous / epigynous;
7. achlamydeous / monochlamydeous apetalous / monochlamydeous asepalous / dichlamydeous heterochlamydeous / dichlamydeous homochlamydeous;
8. trimerous / tetramerous / pentamerous;
9. regular or actinomorphic / zygomorphic / irregular or asymmetric;
10. cyclic / spiral arrangement of parts;
11. white / coloured (specify colour);
12. conspicuous / inconspicuous;
13. describe any special feature associated with the flower, viz., dichogamy (protogyny / protandry) / herkogamy / heterostyly.

F.1. **Perianth** (if distinguishable, calyx and corolla should be described separately in the same manner).

1. 1 / 2 / 3 / 4 / 5 / 6 / ∞ (indefinite) number of tepals; in 1 / 2 / 3 / ∞ (many) whorls / spirals;
2. odd tepal anterior / posterior;
3. polyphyllous / gamophyllous (state structural form, see Key & Glossary pp. # 66,67);
4. valvate / imbricate aestivation (state type, Key & Glossary p.# 69);
5. white / coloured (specify colour, if large and coloured said to be petaloid, if small and green said to be sepaloid) / variegated;
6. mention, if any special features such as unequal lengths or sizes / incurved / deflexed / nectariferous / hairy / gland-dotted / appendaged / waxy;
7. persistent / ephemeral or caduceus / calcarate / carinate / coronate / unguiculate (Key & Glossary pp.# 66-67).

F.2. Androecium

F.2a. Stamen

1. 1 / 2 / 3 / 4 / 5 / ∞ number of stamens in 1 / 2 / ∞ whorls / spirals;
2. various whorls, antisepalous / antipetalous / antiphyllous, and diplostemonous / obdiplostemonous, if of two whorls;
3. didynamous / tetradynamous;
4. free (polyandrous) / fused (synandrous) / epipetalous / episepalous / epiphyllous / monadelphous / diadelphous / polyadelphous / syngenesious / fusion with gynoecium;
5. exserted / inserted;
6. mention if any structures present such as staminodes / corona / nectar glands / disc (inner or outer to stamen whorl) / androphore / gynandrophore.

F.2b. Filament

1. Equal / unequal length;
2. long / short;
3. flattened / petaloid / cylindrical;
4. glabrous / hairy / gland-dotted;
5. white / coloured (specify colour).

F.2c. Anther

1. Unilobed / bilobed;
2. monothecous / dithecous / multithecous;
3. introrse / extrorse / latrorse;
4. dorsifixed / basifixed / versatile / adnate / distractile / divergent / oblique / transverse;
5. mention if any special structures are associated with anther, viz, expanded connective / presence of glands / hairs / so on;
6. Type of dehiscence (Key & Glossary p. # 76).

F.3. Gynoecium

1. Mono- / bi- / tri- / tetra- / penta- / hexa- / poly-carpellary*[1];
2. syncarpous/ apocarpous;
3. mention, if any, special arrangement of carpels with respect to the mother axis;

F.3a. Ovary

1. Superior / inferior / semi-inferior;
2. uni- / bi- / tri- / tetra- / penta- / hexa- / multi-locular;
3. mention type of placentation after viewing in both t.s. and l.s. *[2], Key & Glossary p.# 79;
4. one- / two- / many-ovules or rows of ovules present per locule;
5. ovary wall glabrous / hairy / gland-dotted / warty / angular / ribbed / contains mucilaginous cavities / oil cavities or ducts;
6. any special structures associated with ovary, viz., nectar glands / discs / stipe / gynophore / carpophore;
7. any special structures associated with ovules, viz., jaculator / caruncle / aril.

F.3b. Style

1. One- / two- / three- / four- / five- / many- in number;
2. long / short;
3. cylindrical / angular / flattened;
4. glabrous / hairy / gland-dotted;
5. white / coloured (specify colour);
6. mention any special features such as gynobasic / eccentric / so on (see Key & Glossary p.# 81).

F.3c. Stigma

1. One / two / three / many in number, specify the type (Key & Glossary p.# 82)

G. Fruit

1. True / false fruit;
2. Type of fruit (Key & Glossary pp.# 84-89.

H. Seed

1. Study and mention the type (Key & Glossary p.# 90);
2. *If time permits*, embryo type, and its description (see Key & Glossary p.# 91).

---

*[1] The number of carpels in a syncarpous gynoecium can be determined by counting the:
(i) number of stigmatic lobes;
(ii) number of lobes of ovary;
(iii) number of placentae;
(iv) number of locules in an ovary with axile placentation.

*[2] Remember:
a) A monocarpellary gynoecium always has unilocular ovary with marginal placentation.
b) A multicarpellary gynoecium with multilocular ovary usually shows axile placentation.
c) A multicarpellary gynoecium with unilocular ovary can have parietal, central, free central, or basal placentation.

II. FLORAL FORMULA

Floral flormula is the representation of floral characteristics by the use of symbols. In other words, it is summary of description presented in terms of symbols. The abbreviated forms and symbols of floral characteristics and parts that are used in writing the formula are given below. Before going to that a few *important points* while writing the floral formula are given below:

Points to Remember

- *The number of parts constituting each whorl is placed on the bottom right-hand side of abbreviation.*
- *If the parts of a whorl are different morphologically in shape, and/or size, or functionally, they are written separately, by using comma (,) sign.*
- *If there are more than one whorl ina floral organ, then the number of parts in each whorl are written separately by putting plus (+) sign.*
- *The order of writing the whorls / parts, of each whorl are from the posterior to the anterior side.*

The **symbols** used for writing the floral formula are as follows:

Part/condition		**Symbol**
Bracteate	-	Br
Ebracteate	-	Ebr
Bracteolate	-	Brl
Ebracteolate	-	Ebrl
Actinomorphic	-	⊕
Zygomorphic		
- in median plane	-	·|·
- in transverse plane	-	÷
Asymmetric	-	As
Bisexual or hermaphrodite	-	⚥
Unisexual, staminate	-	♂
Unisexual, pistillate	-	♀
Calyx	-	K
Corolla	-	C
Perianth	-	P
Androecium	-	A
Gynoecium	-	G
Ovary	-	G
- superior	-	$\underline{G}$
- inferior	-	$\overline{G}$
- semi-inferior	-	G–
Connation of parts	-	( )
Adnation of parts	-	⌒ on top of parts of different whorls.

Some examples of the symbol use to represent particular floral conditions are given below:

1. In a flower, the 5 sepals are fused in one whorl, but the posterior one is larger than the remaining 4. This is represented as : $K_{(1,4)}$.

2. Similarly, 4 petals free in two whorls: C_{2+2}.

3. 6 stamens epiphyllous: $\widehat{PA}_6$ or $\overline{PA}_6$.

4. 10 stamens in two whorls of 5 each, diadelphous, 5 of outer and 4 of inner in one group, and the 1 stamen of the inner whorl separately present : $A_{(5+4),\ 1}$

5. Gynoecium is multicarpellary, and apocarpous, ovary superior : $\underline{G\ \infty}$

6. Gynoecium is bicarpellary, syncarpous and adnate with stamens; ovary semi-inferior; $\widehat{AG}_{(2)}$–

7. Floral formula is written as:
Br / Ebr Brl / Ebrl ⊕ / ·ı· / As ⚥ / ♂ / ♀ / K_n, C_n A_n G_n

• n denotes any number from 0 to ∞

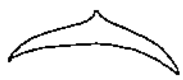
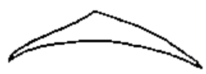
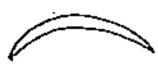
Your Notes

III. FLORAL DIAGRAM

This is a diagrammatic representation of the arrangement of floral parts of a flower, as seen in a **transverse plane** and **with respect to the mother axis.** An exception is the **terminal flower** whose **mother axis is not shown** in the diagram as there isn't any.

- The posterior part of the flower is the upper part of the flower, drawn towards the mother axis. And the anterior side forms the lower part of the floral diagram.
- To draw the floral diagram, draw the exact number of dotted circles/spirals equal to the number of whorls/spirals as seen in a flower.
- Generally, four whorls are present corresponding to the gynoecium, androecium, corolla, and calyx (from inner to outer whorl). If any of the organs is present in more than one whorl, then the number of whorls is increased accordingly.
- If bracts and bracteoles are present they are drawn outside the calyx whorl, the outermost being the bract(s).
- Indicate the mother axis on the top. Keeping in mind the number, size and position of the parts in each whorl, mark the parts on the circles using the symbols given below for different floral parts, and their conditions. Complete the floral diagram.
- The gynoecium is generally represented as the transverse section of the ovary.

The symbols for various floral parts and their different conditions are given below. These are used to draw the floral diagrams.

Parts/condition		**Symbol**
Mother axis	—	⊙ in general; but as ⊕ when the flower is actinomorphic; and ·|· when the flower is zygomorphic.
Bract / bracteolate	—	
Sepal	—	
Petal	—	
Stamen		
Single lobed	—	
Bilobed	—	

Extrorse — 

Introrse — 

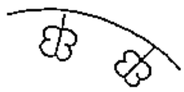
Latrorse — 

Staminodes — 

Absence of a part of a whorl — X

Fusion of parts is represented as a line or loop between the parts, e.g., gamosepalous condition is shown as — 

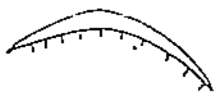
Epipetalous — 

Adelphous — 

Syngenesious / synandrous 

or

Special structures:
nectar glands — ○ or ●

Corona of petals — 

Observations and Interpretations

After describing the twigs given to you, select the common diagnostic characters and note them in their respective worksheets. Based on these characteristics, identify the families of the plants studied from the 'Identification Key' in the same manner, as in the previous exercise, i.e., # 23. Though the names of the families of the genera that you are going to study would be known to you, the whole idea of this exercise is to make you practice the identification method with some known families. What is important in this practice is that you reason out as to why the members of the family X belong to this very family, and not to the family Y or Z. Gaining confidence with the correct use of this method would enable you to handle any unknown material(s) independently.

Your Notes

23.3 FAMILY CUCURBITACEAE

Theory Reference: LSE-13, Block-4, pp. 45-49.

Worksheet # 23.1: Study of specimen A.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Male flower:

Calyx:

Corolla:

Androecium:

Gynoecium: Absent

(Cont.)

Female flower:

Calyx:

Corolla:

Androecium: Absent

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other features:

Worksheet # 23.2: Study of specimen B.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Male flower:

Calyx:

Corolla:

Androecium:

Gynoecium: Absent

(Cont)

Female flower:

Calyx:

Corolla:

Androecium: Absent

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other features:

Worksheet # 23.3: Interpretation and Analysis.

Q.1: List the common diagnostic characters of specimens A and B.

(i) ....

(ii) ....

(iii) ....

(iv) ....

....

....

Q.2: Classification and identification of the family of specimens A and B from the Key (Block 2B) giving reasons.

Class: ....
Characters: i) ....
ii) ....

Subclass: ....
Characters: i) ....
ii) ....

Series: ....
Characters: i) ....
ii) ....

Order: ....
Characters: i) ....
ii) ....
iii) ....

Family: Cucurbitaceae
Characters: i) ....
ii) ....
iii) ....
iv) ....
v) ....
vi) ....

....

....

Q.3: Prepare a list of other members of family Cucurbitaceae found in your locality. Write their common name(s), and botanical name(s), if possible.

....

....

....

....

....

....

....

....

(Cont.)

Diagram space

Q.4: Represent the habit of specimen A/B – diagrammatically. The name of the specimen is ....

Diagram space

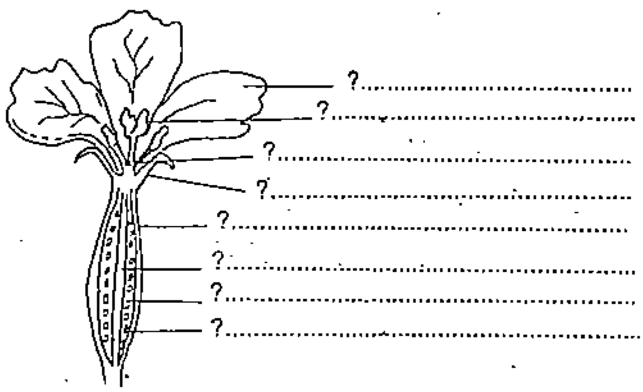
.... Specimen A

.... Specimen B

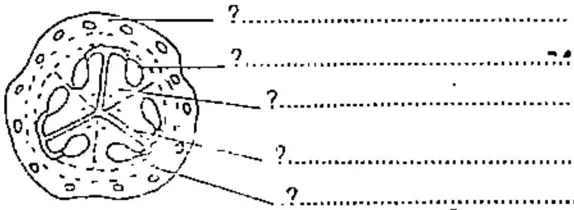
Q.6: Make outline diagrams of the androecial components of both the specimens, highlighting their variable features.

Diagram space

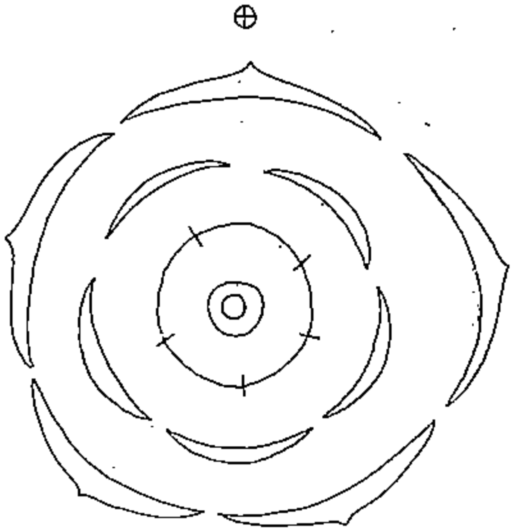
Q.5a: A male flower of .... in median longitudinal plane. Draw an outline diagram, and write the name of the plant.

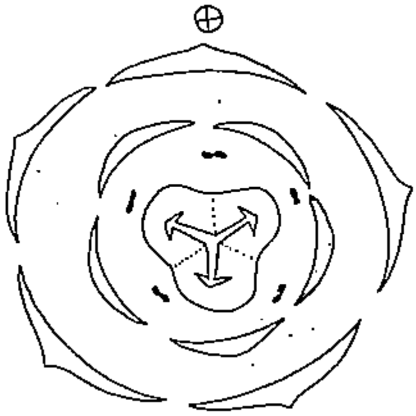


Q.5b: Label the various parts of a female Cucurbitaceous flower in the above schematic diagram of the flower cut in median longitudinal plane.



Q.7a: Identify and write the names of various parts of the ovary of a Cucurbitaceous flower, cut in transverse plane. b. Did you find this section resembling any of the specimens that you studied? If yes, which one? .... (Cont.)





Q.8a: Complete the floral diagram of the male flower. Write the name of the specimen

....

Q.8b: Complete the floral diagram of the female flower. Also write the name of the specimen.

....

Q.9: Write the floral formula of a male flower. Write the name of the plant.

Name of the plant: ....

Floral formula: ....

Q.10: Write the floral formula of a female flower. Write the name of the plant.

Name of the plant: ....

Floral formula: ....

Your Notes

23.4 FAMILY APIACEAE

Theory Reference: LSE-13, Block-4, pp. 50-53.

Worksheet # 23.4: Study of specimen A.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Calyx:

Corolla:

Androecium:

(Cont.)

Gynoecium:

Ovary:

Style:

Stigma:

If dimorphic flowers are present, as in coriander, describe the other type of flower as well.

Flower:

Calyx:

Corolla:

Androecium:

Gynoecium:

Fruit:

Any other features:

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Calyx:

Corolla:

Androecium:

Gynoecium:

Fruit:

Any other feature(s):

Q.1: List the common diagnostic characters of specimens A and B.

(i) ....
(ii) ....
(iii) ....
(iv) ....
....
....

Q.2: Classification and identification of the family of specimens A and B from the key (Block 2B) giving reasons.

Class: ....
Characters: i) ....
ii) ....

Subclass: ....
Characters: i) ....
ii) ....

Series: ....
Characters: i) ....
ii) ....

Order: ....
Characters: i) ....
ii) ....
iii) ....

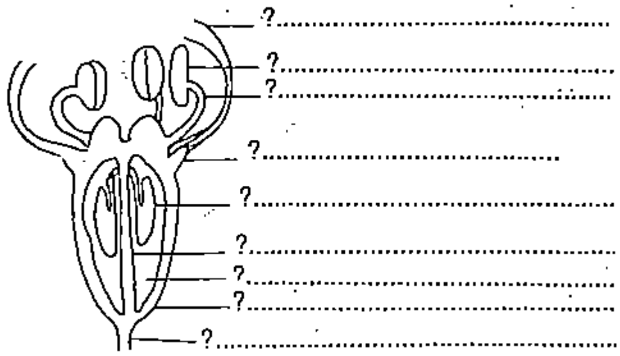
Family: Apiaceae
Characters: i) ....
ii) ....
iii) ....
iv) ....
v) ....
....
....
....
....
....
....
....
....
....
....
....
....
....
.... (Cont.)

Q.3: List some species of family Apiaceae found in your neighbourhood. Write their common name(s), and botanical names, if possible.

....
....
....
....

Diagram space

Q.4: Represent the habit of specimen A/B diagrammatically. The name of the specimen is ....



Q.5a: Complete and label the various parts of the above schematic diagram of an Apiaceous flower cut in the median longitudinal plane.

Diagram space

Q.5b: Draw an outline diagram of a flower of specimen A/B that is cut in median longitudinal plane. The name of the specimen is ....

(Cont.)

Diagram space

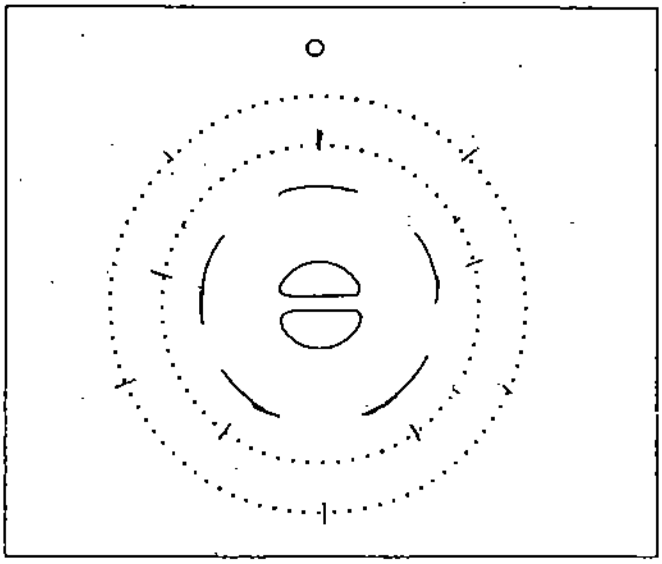
Diagram space

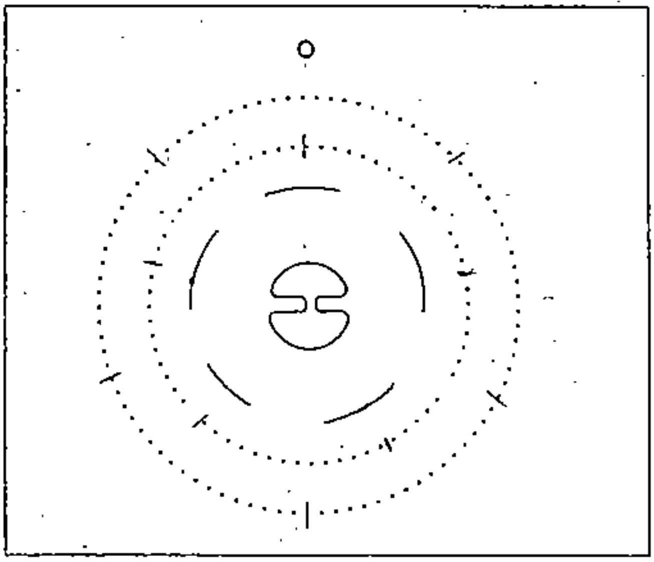
Q.6a: Make an outline diagram of a fruit (w.m.) of specimens A/B, whose name is .... Indicate its various parts.

Q.6b: Draw an outline diagram of the fruit depicted in 7a, after splitting it open. Also label its various parts.

Diagram space

Q.7: Make an outline sketch of the ovary cut in transverse plane of specimen A/B, whose name is .... Label the various parts of the ovary that can be seen in the figure.





Q.8a: Complete the floral diagram of .... *(name of specimen A)*

Q.8b: Complete the floral diagram of .... *(name of specimen B)*

Q.9a: Write the floral formula of specimen A.

Name of the Plant..

Floral Formula ....

Q.9b: Write the floral formula of specimen B.

Name of the Plant..

Floral Formula ....

23.5 FAMILY RUTACEAE

Theory Reference: LSE-13, Block-4, pp. 20-23.

Worksheet # 23.7: Study of specimen A.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Calyx:

Corolla:

Androecium:

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Worksheet # 23.8: Study of specimen B.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Calyx:

Corolla:

Androecium:

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Q.1: List the common diagnostic characters of specimens A and B.

(i) ....
(ii) ....
(iii) ....
(iv) ....
(v) ....
(vi) ....

Q.2: Classification and identification of the family of specimens A and B from the key (Block 2B), giving reasons.

Class: ....
Characters: i) ....
ii) ....

Subclass: ....
Characters: i) ....
ii) ....
iii) ....

Series: ....
Characters: i) ....
ii) ....

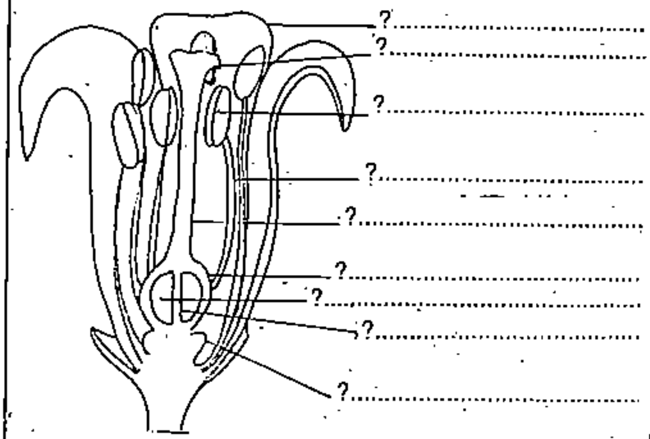
Order: ....
Characters: i) ....
ii) ....
iii) ....

Family: Rutaceae
Characters: i) ....
ii) ....
iii) ....
iv) ....

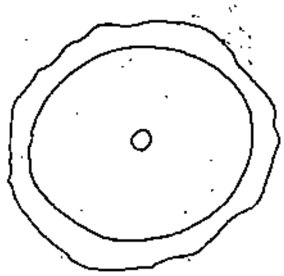
Q.3: List a few species of the family Rutaceae found in your area. Write their common name(s), and botanical name if possible.

....
....
....
....

Diagram space



Q.5: Complete and label the various parts of the schematic diagram of a flower of Rutaceae cut in the median longitudinal plane.



Q.4: Diagrammatically represent the habit of specimen A/B. The name of the specimen is ....

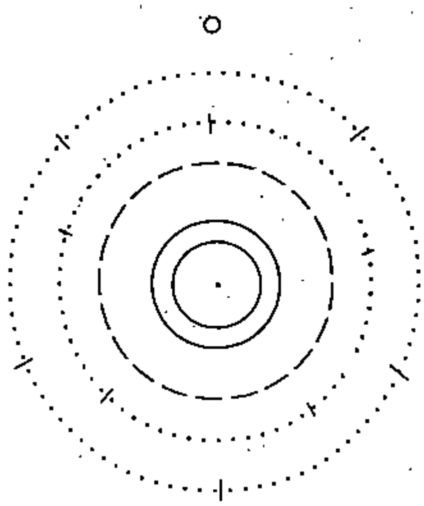
Q.6: Complete the above outline diagram of t.s. of the ovary of specimen A/B ....
....
(*Write the name of the specimen*)

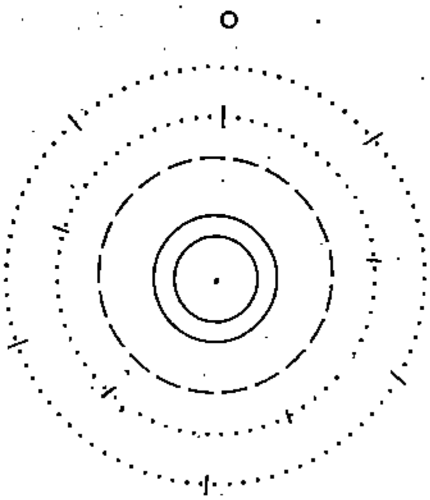
Diagram space

←

Q.7: Make an outline diagram of a stamen (w.m.) of specimen A/B. The name of the specimen is ....

(Cont.)





Q.8a: Complete the floral diagram of ....

....

(name of specimen A)

Q.8b: Complete the floral diagram of ....

....

(name of specimen B)

Q.9a: Write the floral formula of specimen A.

Name of the Plant..

Floral Formula ....

Q.9b: Write the floral formula of specimen B.

Name of the Plant..

Floral Formula ....

Your Notes

23.6 FAMILY APOCYNACEAE

Theory Reference: LSE-13, Block-4, pp. 79-82.

Worksheet # 23.10: Study of specimen A.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Calyx:

Corolla:

Androecium:

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Calyx:

Corolla:

Androecium:

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Worksheet # 23.12: Interpretation and Analysis.

Q.1: List the common diagnostic characters of specimens A and B.

(i) ....

(ii) ....

(iii) ....

(iv) ....

....

....

Q.2: Classification and identification of the family of specimens A and B from the key (Block 2B) giving reasons.

Class: ....

Characters: i) ....

ii) ....

Subclass: ....

Characters: i) ....

ii) ....

iii) ....

Series: ....

Characters: i) ....

ii) ....

iii) ....

Order: ....

Characters: i) ....

ii) ....

iii) ....

Family: Apocynaceae

Characters: i) ....

ii) ....

iii) ....

iv) ....

(Cont.)

Q.3: List a few species of the family Apocynaceae found in your area. Write their common name(s), and botanical names, if possible.

....

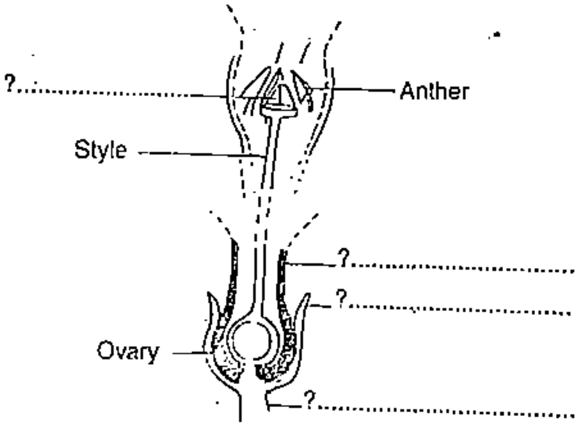
....

....

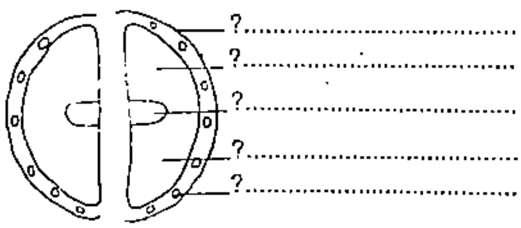
....

Diagram space

Q.4: Diagrammatically represent the habit of specimen A/B. The name of the specimen is ....

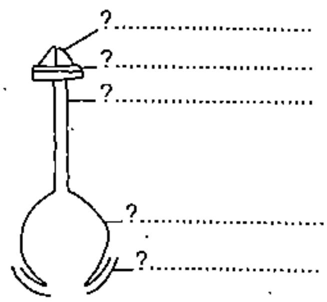


Q.5: Complete the schematic diagram of a flower of specimen A / B that is cut in median longitudinal plane. The name of the specimen is ....



Q.6: Complete the above outline diagram of the t.s. of ovary of specimen A/B. The name of the specimen is :......................................

Diagram space for Q 7a.

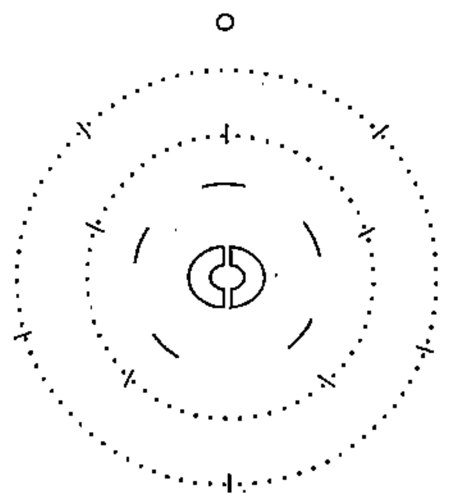


Q.7a: Make an outline diagram of a stamen of specimen ...., showing its different parts.

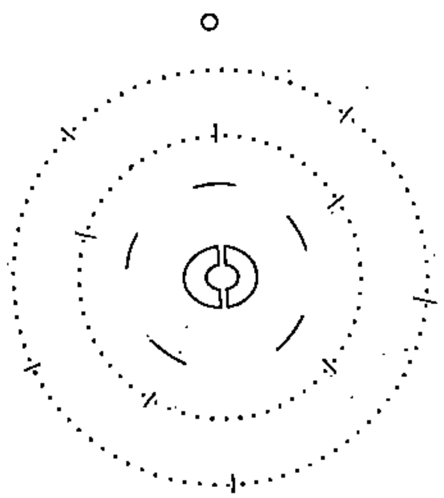
Q.7b: Label the various parts in the given outline diagram of w.m. of pistil.

←

(Cont.)



Q.8a: Complete the floral diagram of ....
....
(name of specimen A)



Q.8b: Complete the floral diagram of ....
....
(name of specimen B)

Q.9a: Write the floral formula of specimen A.

Name of the Plant ....

Floral Formula ....

Q.9b: Write the floral formula of specimen B.

Name of the Plant ....

Floral Formula ....

Your Notes

23.7 FAMILY AMARANTHACEAE

Theory Reference: LSE-13, Block-4, pp. 104-108.

Worksheet # 23.13: Study of specimen A.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Perianth:

Androecium:

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other features(s):

(Co...

Worksheet #23.14: Study of specimen B.

Botanical name ....
Common name(s)..................
....

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Perianth:

Androecium:

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Q.1: List the common diagnostic characters of specimens A and B.

(i) ....

(ii) ....

(iii) ....

(iv) ....

(v) ....

(vi) ....

Q.2: Classification and identification of the family based on your study of specimens A and B using key (Block 2B) giving reasons.

Class: ....

Characters: i) ....

ii) ....

....

....

Subclass: ....

Characters: i) ....

....

....

Series: ....

Characters: i) ....

iii) ....

....

....

Family: Amaranthaceae

Characters: i) ....

iv) ....

v) ....

vi) ....

vii) ....

viii) ....

ix) ....

....

Q.3: List a few species of the family Amaranthaceae found in your area. Write their common name(s), and botanical names if possible.

....

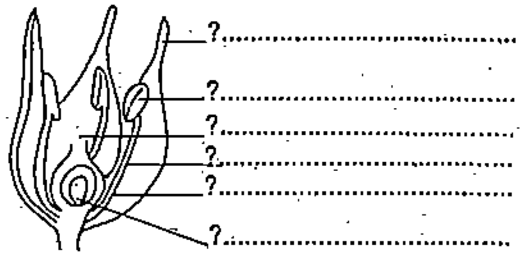
....

....

....

Diagram space

Q.4: Represent diagrammatically the habit of the specimen A/B. The name of the specimen is ....



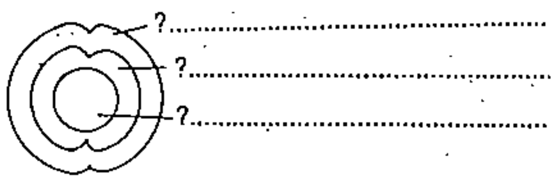
Q.5a: Label the various parts of the typical Amaranthaceae flower whose schematic diagram is given above. The flower is cut in median longitudinal plane.

Diagram space

Q.5b: Draw an outline diagram of a flower of specimen A/B that is cut in median longitudinal plane. The name of the specimen is ....

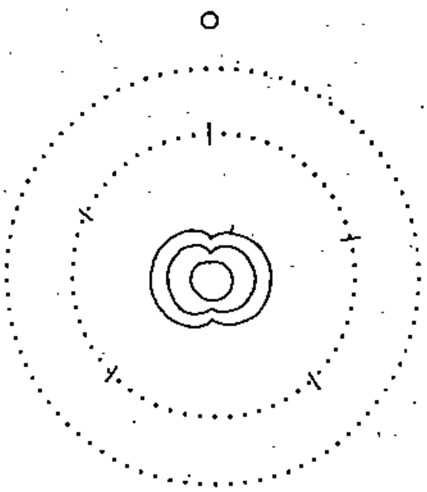
Diagram space

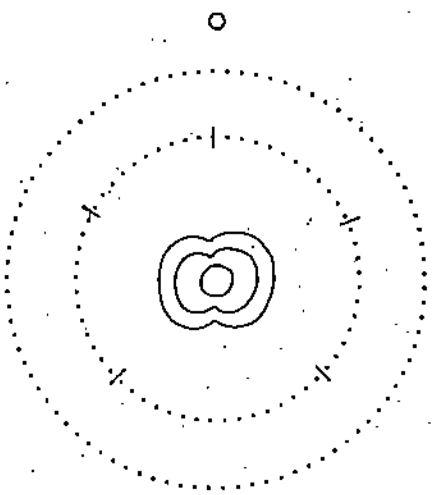
Q.6: Make an outline of androecium (w.m.) of specimen A/B. The name of the specimen is ....



Q.7: Complete the above outline diagram of the t.s. ovary of the specimen A/B. The name of the specimen is ....

(Cont.)





Q.8a: Complete the floral diagram of ....
....
(name of the specimen A)

Q.8b: Complete the floral diagram of ....
....
(name of the specimen B)

Q.9a: Write the floral formula of specimen A.

Name of the Plant ....

Floral Formula ....

Q.9b: Write the floral formula of specimen B.

Name of the Plant..

Floral Formula ....

Your Notes

23.7 FAMILY EUPHORBIACEAE

Theory Reference: LSE-13, Block-4, pp. 113-117.

Worksheet # 23.16: Study of specimen A.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Male Flower:

Perianth:

Androecium:

Gynoecium: *Absent*

Female flower:

Perianth: *The flower may not have any perianth whorl.*

Androecium: *Absent*

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Worksheet # 23.17: Study of specimen B.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Male Flower:

Perianth:

Androecium:

Gynoecium: *Absent*

(Cont.)

Female flower:

Perianth: *The flower may not have any perianth whorl.*

Androecium: *Absent*

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Worksheet # 23.18: Interpretation and Analysis.

Q.1: List the common diagnostic features of specimens A and B.

(i) ....

(ii) ....

(iii) ....

(iv) ....

....

....

Q.2: Classification and identification of the family based on your study of specimens A and B using key (Block 2B), and giving reasons.

Class: ....

Characters: i) ....

ii) ....

Subclass: ....

Characters: i) ....

ii) ....

Series: ....

Characters: i) ....

ii) ....

Family: Euphorbiaceae

Characters: i) ....

ii) ....

iii) ....

iv) ....

v) ....

vi) ....

vii) ....

viii) ....

....

....

....

....

Q.3: List a few species of the family Euphorbiaceae found in your area. Write their common name(s), and botanical names if possible.

....

....

....

....

Diagram space

Q.4: Diagrammatically represent the habit of the specimen A/B. The name of the specimen is ....

....

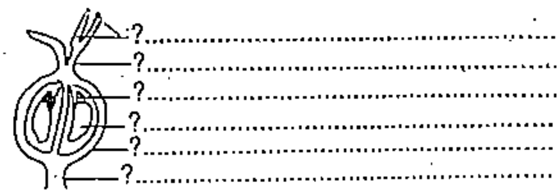
Diagram space

Specimen A

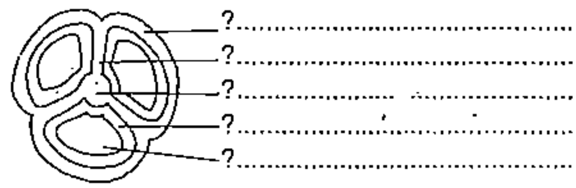
Specimen B

Q.6: Make outline diagrams of the stamens of both the specimens to show the variations.

Q.5a: A male flower of .... in median longitudinal plane. Draw an outline diagram and write the name of the plant.

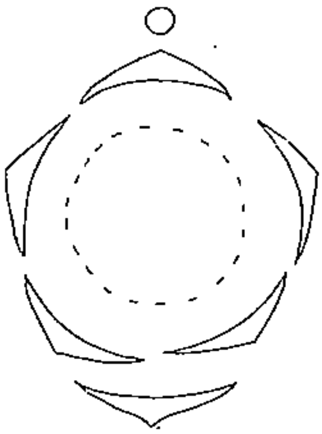


Q.5b: Label the various parts of a female Euphorbiaceous flower, in the above schematic diagram of the flower cut in median longitudinal plane.

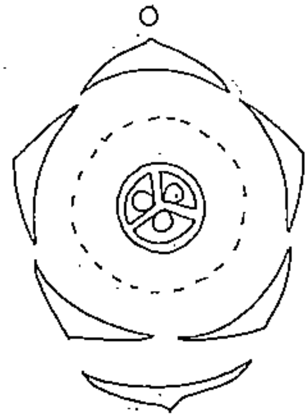


Q.7a: Identify and write the different parts of the ovary of an Euphorbiaceous plant, cut in transverse plane. **b:** Did you find this section resembling any of the specimens that you studied? If yes, write the name of that plant.

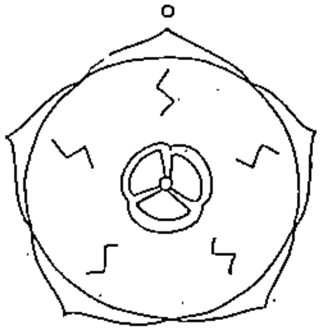
.... (Cont.)



Q.8a: Complete the floral diagram of the male flower. Indicate the name of the specimen.
....



Q.8b: Complete the floral diagram of the female flower. Indicate the name of the specimen.
....



Q.8c: Complete the floral diagram of the inflorescence (cyathium). Indicate the name of the specimen ....

Q.8b, 8b. 8c: Complete only those figures that are relevant to your specimen.

Q.9a: Write the floral formula of a male flower. Indicate the name of the plant.

Name of the Plant ....

Floral Formula ....

Q.9b: Write the floral formula of a female flower. Indicate the name of the plant.

Name of the Plant ....

Floral Formula ....

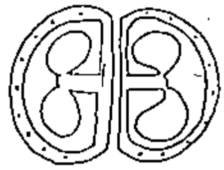
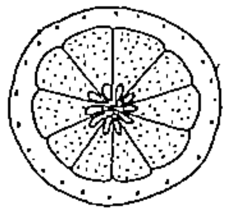
Your Notes

Q.1: Which one of the six families that you studied has a heterogeneous composition, and the one that is homogeneous? Mention their names. Give reasons in support of your answer.

Q.2: One of these six families contains aromatic herbs. Which is this family? Write the names of some of the commonly known plants of the family and their uses, if any .

Worksheet # 23.20: Test your knowledge of families.

Q.3: Match the items in Columns I, II and III, and record your answer in the space provided.

I	II	III
a) Cucurbitaceae (Male flower)	a) $\oplus$ ⚥ $K_5\, C_5\, A_{\infty\,(Polyadelphous)}\, \underline{G_\infty}$	
b) Euphorbiaceae (Cyathium)	b) $\oplus$ ⚥ $K_5\, \overset{\frown}{C_{(5)}\, A_5}\, \underline{G_2}$	
c) Rutaceae	c) $\oplus$ ♂ $K_{(5)}C_5A_{1,\,(2),\,(2)}\,G_0$	
d) Amaranthaceae	d) $\oplus$ ⚥ $K_5\, C_5\, A_5\, \overline{G}_{(2)}$	
e) Apocynaceae	e) $Br_5 \oplus$ ⚥ $K_0\, C_0 A_{5-\infty}\, \underline{G_{(3)}}$	
f) Apiaceae	f) $Br\ Brl \oplus$ ⚥ $P_5\, A_{(5+5)}\, \underline{G_{(2)}}$	

Answer

I	II	III
a		
b		
c		
d		
e		
f		

EXERCISE 24 MONOCOT FAMILIES

Date ....
Session # ....
Time allocated – 2 Hours

Structure **Page No.**

Have you read this exercise before coming for the lab. session? Please do read.

Hope you have not forgotten to put on your lab. coat while working in the lab.

24.1 INTRODUCTION

After having made a detailed study of some dicot families, you will study a few families of monocots in this exercise. The monocots are a much smaller group with very distinctive characters. You have studied two monocot families – Poaceae and Liliaceae in the LSE-08(L) Course. And in Exercise # 22, you also recalled the characters of these two families. In this exercise, you will study three more monocot families in the same way as you studied the dicot families in Exercise # 23. *You will describe at least two specimens belonging to different genera of each family, except Cannaceae which is monogeneric.* This will enable you to select the common features of the specimens, which may also be the diagnostic characters of the family.

The three families selected for this exercise are not covered in the corresponding theory course. This has been done deliberately. The reason for this is to give you an opportunity and some challenge to try out the families not studied earlier.

Having completed the Exercises # 22 and # 23 and with the Identification Key and Glossary (Block 2B), you may not find it difficult to handle these families. Nevertheless, the worksheets for the respective families would give you additional guidance of the study-route.

Objectives

After completing this exercise, you should be able to:

- distinguish the monocot families from the dicot families;
- list the common diagnostic characters of the given family members; and
- identify, with ease, the other members of these three monocot families.

Study Guide

See the details given in Exercise # 23 again before you begin your work for this exercise.

24.2 MATERIALS AND GUIDELINES

Given below is the list of requirements along with the additional guidelines for study.

Materials required

Items i) to viii) as given in Exercise # 23 are required for this exercise too. For item ix), the flowering and fruiting twigs belonging to two different genera of each of the following families are required: Commelinaceae and Amaryllidaceae; and one of family Cannaceae.

A list of suggested materials is given below. However, you are free to select any two materials for each family that are easily available in your locality.

1. **Family Commelinaceae**
   Commelina sp.
   Tradescantia virginiana
   Zebrina sp.
   Rhoeo sp.

2. **Family Amaryllidaceae**
   Crinum sp.
   Zephyranthes sp.
   Pancratium sp.

3. **Family Cannaceae**
   Canna indica

Procedure

Same as in Exercise # 23.

Observations and Interpretations

After describing the twigs given to you, select the common diagnostic characters and note them in their respective worksheets. Based on these characteristics, identify the families of the plants studied with the help of 'Identification Key' in the same manner as in the previous two exercises. Though the names of the families of the genera that you are going to study would be known to you, the whole idea of this exercise is to make you practise the identification method. What is important in this practice is that you may be able to reason out as to why the members of the family X belong to this very family, and not to the family Y or Z. Gaining confidence with the correct use of this method would enable you to handle any sort of material(s) or unfamiliar family(ies) with the same ease.

Your Notes

24.3 FAMILY COMMELINACEAE

Worksheet # 24.1: Study of specimen A.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Calyx:

Corolla:

Androecium:

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Worksheet # 24.2: Study of specimen B.

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Calyx:

Corolla:

Androecium:

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Q.1: List the common diagnostic characters of specimens A and B.

(i) ....
(ii) ....
(iii) ....
(iv) ....
....
....

Q.2: Classification and identification of the family of specimens A and B from the Identification Key (Block 2B) giving reasons.

Class: ....

Characters: i) ....

ii) ....
....
....

Subclass: ....

Characters: i) ....

ii) ....
....
....

Series: ....

Characters: i) ....

ii) ....

iii) ....

iv) ....
....
....

Family: Commelinaceae

Characters: i) ....

ii) ....

iii) ....

iv) ....
....
....
....
....

Q.3: List some species of family Commelinaceae growing in your area.

....

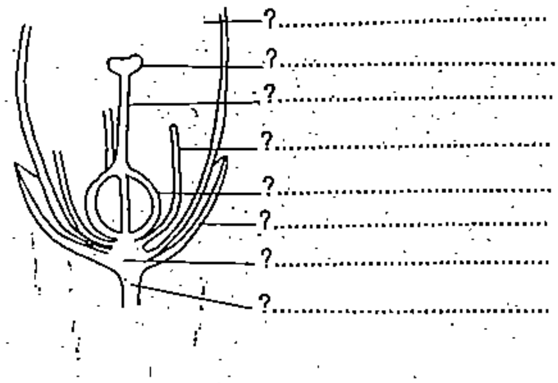
....

....

....

Diagram space

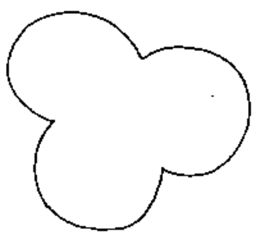
Q.4: Represent the habit of specimen A/B diagrammatically. The name of the specimen is ....



Q.5: Complete and label the above diagram of a flower (of Commelinaceae) cut in the median longitudinal plane.

Diagram space

Q.6: Make outline diagrams of fertile or sterile stamens of specimen A/B. The name of the specimen is ....

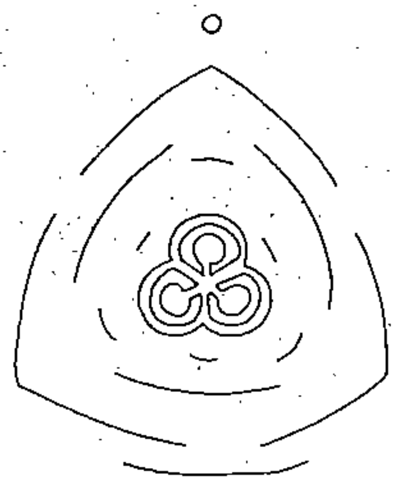


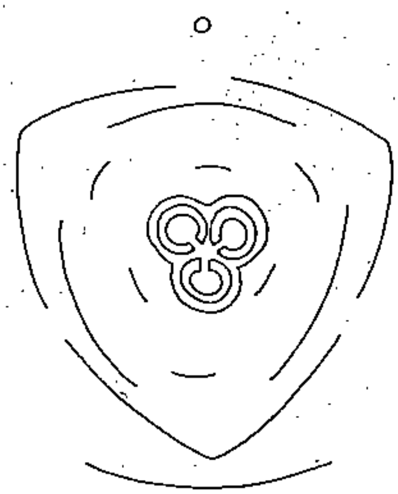
Q.7: Complete and label the adjacent diagram of t.s. ovary. The name of the plant is

....

....

(Cont.)





Q.8a: Complete the floral diagram of

....

(name of specimen A)

Q.8b: Complete the floral diagram of

....

(name of specimen B)

Q.9a: Write the floral formula of specimen A.

Name of the plant: ....

Floral formula: ....

9b) Write the floral formula of specimen B.

Name of the plant: ....

Floral formula: ....

Your Notes

24.4 FAMILY AMARYLLIDACEAE

Worksheet # 24.4: Study of specimen A.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Perianth:

Androecium:

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Worksheet # 24.5: Study of specimen B.

Botanical name ....
Common name(s) ....
....

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Perianth:

Androecium:

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Worksheet # 24.6: Interpretation and Analysis.

Q.1: List the common diagnostic characters of specimens A and B.

(i) ....
(ii) ....
(iii) ....
(iv) ....
(v) ....
(vi) ....

Q.2: Classification and identification of the family of specimens A and B from the Identification Key (Block 2B, of this course) giving reasons.

Class: ....

Characters: i) ....

ii) ....

....

....

....

Series: ....

Characters: i) ....

ii) ....

iii) ....

iv) ....

v) ....

....

....

....

....

Family: Amaryllidaceae

Characters: i) ....

ii) ....

iii) ....

....

....

....

....

....

(Cont.)

Q.3: List some species of family Amaryllidaceae growing in your area.

....

....

....

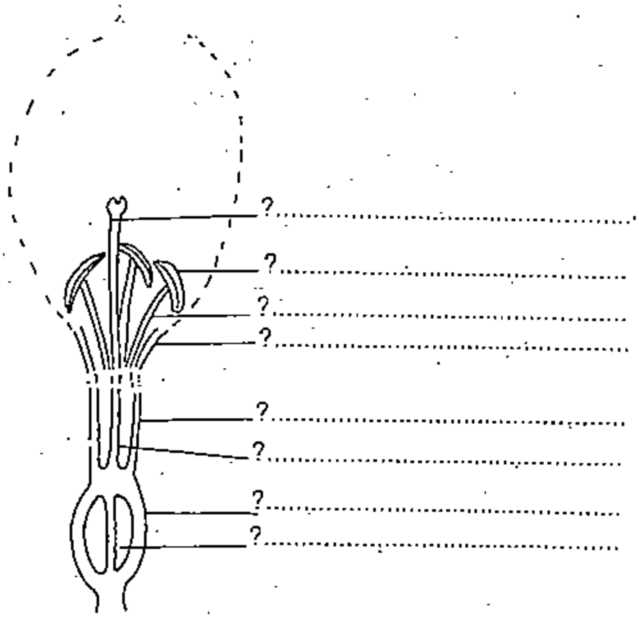
....

Diagram space

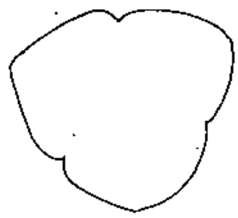
Q.4: Represent the habit of specimen A/B diagrammatically. The name of the given plant specimen is ....

Diagram space

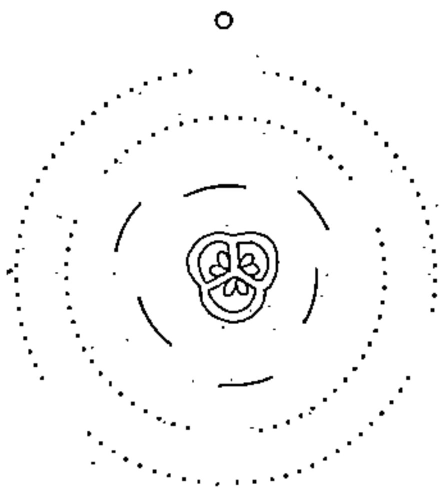
Q.6: Make outline diagrams of a stamen in different views. The name of the plant material is ....

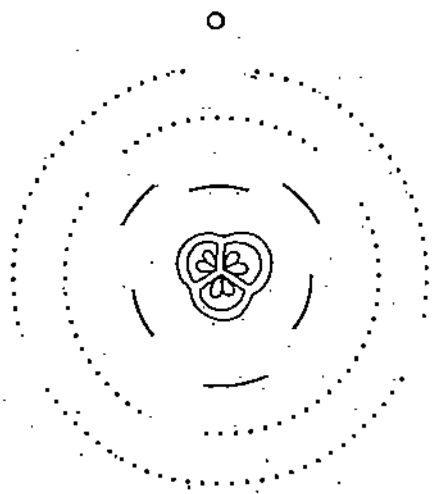


Q.5: Complete and label the above schematic diagram of a flower of Amaryllidaceae cut in the median longitudinal plane.



Q.7: Complete and label the above diagram of t.s. ovary. The name of the source plant is .... (Cont.)





Q.8a: Complete the floral diagram of

....

(name of specimen A)

Q.8b: Complete the floral diagram of

....

(name of specimen B)

Q.9a: Write the floral formula of specimen A.

Name of the plant ....

Floral formula ....

Q.9b: Write the floral formula of specimen B.

Name of the plant ....

Floral formula ....

Your Notes

24.5 FAMILY CANNACEAE

Worksheet # 24.7: Study of specimen A.

Botanical name: *Canna indica*
Common name(s) ……………
……………………………………

Habit:

Stem:

Leaf:

Inflorescence:

Flower:

Calyx:

Corolla:

Androecium:

Gynoecium:

Ovary:

Style:

Stigma:

Fruit:

Any other feature(s):

Q.1: Classification and identification of the family from the Identification Key (Block 2B) giving reasons.

Class: ....

Characters: i) ....

ii) ....

....

....

Series: ....

Characters: i) ....

ii) ....

iii) ....

iv) ....

....

....

Family: Cannaceae

Characters: i) ....

ii) ....

iii) ....

....

....

Q.2: List the species of the family Cannaceae from your local flora. Write their common names as well as the botanical names.

....

....

....

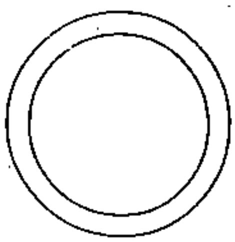
....

(Cont.)

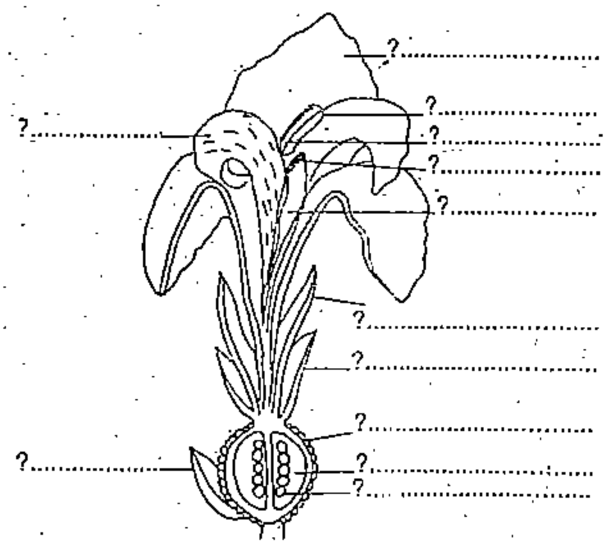
Your Notes

Diagram space

Q.4: Represent the habit of specimen A diagrammatically. The name of the plant specimen represented is ....



Q.7: Complete and label the above diagram of t.s. ovary.



Q.5: Complete and label the above schematic diagram of a flower of family Cannaceae cut in the median longitudinal plane.

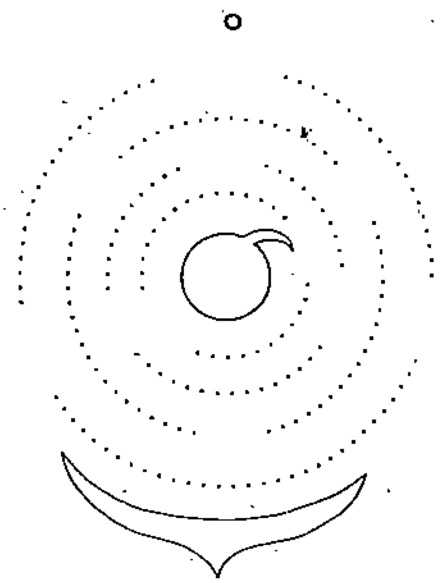
Diagram space

(a) Sterile stamen

(b) Fertile stamen

Q.6a,b: Make outline diagrams of a sterile (a) and a fertile stamen (b), and label their different parts.

(Cont.)



Q.8: Complete the floral diagram of the given specimen.

Q.9: Write the floral formula of specimen.

Name of the plant: ....

Floral formula: ....

Your Notes

EXERCISE 25 PLANT- PRODUCTS FROM FORESTS

Date ....
Session # ....
Time allocated – 2 Hours

Structure **Page No.**

Advance reading and planning about the exercise, would help you to complete your study in the stipulated time.

Always check that you are wearing a lab coat as you begin to work in the lab.

25.1 INTRODUCTION

Forests, also known as the green lungs of the earth, are important in a number of ways. If replenished properly, they are almost unlimited sources of a large number of valuable products. Apart from providing wood – one of the most versatile plant products they also provide us with a large number of useful products like cork, rubber, tannins, resins, dyes and many others. In this exercise, you would study about the plants that yield the above-mentioned commonly used products.

Objectives

After completing this exercise, you should be able to:

- identify a para-rubber plant, and describe its morphological features;
- describe the anatomical structure of the stem of para-rubber plant,
- explain the intricacies of the latex-tapping process;
- list the applications of rubber;
- identify a widely used tannin-yielding plant, and describe its morphological features;
- give the anatomical details of a resin-yielding structure in a common plant source;
- distinguish a piece of resin from that of gum;
- identify giving reasons the plane of cut of a wood sample;
- classify the given wood(s) based on their porous characters and weight; and
- explain in anatomical terms the various properties of cork.

25.2 RUBBER

1. Rubber is made from the latex of various woody plants found in the tropics and subtropics.

2. The latex occurs is special cells known as the laticifers that are found in the bark, leaves, and other soft tissues of some plants.

3. *Hevea brasiliensis* or the para-rubber tree is the most important rubber-yielding tree species.

4. The para-rubber tree is grown in Kerala, Tamil Nadu, Karnataka and Andamans on commercial scale.

5. - It is a tall tree, about 20m in height. The trunk is 2-3 m in girth.
   - It has a spreading or conical leaf canopy.
   - The leaves are trifoliate, compound, with long petioles.
   - The leaflets are short-stalked, elliptic to obovate, with acuminate apices.
   - The flowers are small, green, sweetly-scented, in pubescent panicles with female flowers at the top and the male flowers present in the lower portion.
   - The fruit is a tripartite capsule with one seed in each compartment.

6. The latex vessels do not run exactly vertically but in anti-clockwise spirals to the right hand side. This can be viewed in the stem cut in a longitudinal plane. They are arranged in concentric rings in the bark alternating with the rings of secondary phloem (see LSE-13, Block 3B, Fig. 20.12 on p. 104). The vessels are laterally interconnected with each ring, but the connections are disrupted as the trunk increases in circumference. Latex vessels are more numerous in the inner bark than the outer.

Refresh your memory

The study of rubber in this exercise involves the following **four activities**:

1. Morphological study of a twig of para-rubber tree.
2. Anatomical study of the stem.
3. Study about the tapping and latex collection process.
4. Listing of products made of rubber.

1. Morphological study of a twig of para-rubber tree.

The purpose of this exercise is to know about the morphological features of this plant.

Materials required

i) Fresh specimen/herbarium specimen/photograph of a para-rubber tree.

Procedure

Study the given specimen for a few minutes focussing on its various parts one by one.

Observations and Interpretations

Make an outline diagram of the given specimen in the Worksheet # 25.1, and note the salient morphological features. Also complete the tasks given in the worksheet.

Your Notes

Worksheet # 25.1: Morphological study of a para-rubber twig.

Diagram space

Q.1: Make an outline diagram of a twig of the para-rubber tree.

Q.2: After observing the given specimen/photograph of the para-rubber twig, write about the following aspects.

i) Phyllotaxy: ....

....

ii) Inflorescence: ....

....

iii) Fruit: ....

....

iv) Seed: ....

....

v) Any other aspect(s) that you found interesting: ....

....

....

....

....

2. Anatomical study of the stem.

The main feature of anatomical interest of this exercise is the presence of laticifers or the latex producing cells. It would be interesting to know about their structure, distribution, and relation with the other tissues of the stem. Knowing about these aspects will answer some of the questions such as how deep is the source (the cells) of latex in the stem? How abundant are these cells? How is the latex tapped from a rubber plant? And many other questions.

Materials required

1. Fresh/preserved soft blocks of para-rubber stem for sectioning
2. A sharp razor blade
3. Watch-glasses – 2
4. Tap water
5. Slides
6. Coverslips
7. Safranin
8. Glycerine
9. Camel hair brush
10. Forceps
11. Permanent slide of t.s. of para-rubber stem (in case material is not available for sectioning/because of time constraint)
12. Compound microscope

Procedure

1. Make a temporary preparation of t.s. stem.
2. Observe the above preparation/permanent slide under the compound microscope.

The rubber stem is a relatively hard material for section cutting. So, apply just the right force while section-cutting, *always taking care of your fingers.*

Observations and Interpretations

1. Study the structure of stem in general, and laticifers in particular.

2. Observe the structure of laticifers and note:
   - whether single-celled/multicelled;
   - branched/unbranched;
   - thin-walled/thick-walled;
   - cell contents – do they fill the cell completely, or, are they localized? whether structurally they appear homogeneous or heterogeneous?

3. Complete the Worksheet # 25.2.

Worksheet # 25.2: Anatomical study of para-rubber stem.

Diagram spaces	Description space
Q.1: Make an outline diagram of the t.s. stem, showing its various zones. Highlight the distribution of laticifers with respect to various tissues in the stem.	**Q.2:** Write the salient features of the figure drawn in Q.1.
Diagram space	Description space
Q.3: Illustrate a couple of laticifers in enlarged view.	**Q.4:** Write the peculiar features of the laticifers based on your observations.

3. Study about the tapping and latex collection process.

Study the given photograph and fill the required information in the worksheet.

Worksheet # 25.3: Tapping of latex from a para-rubber tree.

Q.1: Study the above photograph and answer the following questions:

a) Is it a mechanical or manual process?

....

....

b) Name the part being tapped.

....

....

c) What is(are) the instrument(s) used?

....

....

d) Describe the type of plane of cut.

....

....

e) Which area of the plant (tree) surface is cut?

....

....

f) Comment on the height of the plant being tapped.

....

....

4. **Listing of products made of rubber.**

Worksheet # 25.4: Prepare a list of as many uses of rubber as you can.

You may use a separate sheet, if necessary.

25.3 TANNINS

1. Myrobalan is one of the widely used sources of vegetable tannins. It is in fact the trade name given to the fruits of several species of the genus *Terminalia*. Some of these are: *T. chebula* (chebulic myrobalan) and *T. bellirica* (belleric myrobalan). The chebulic myrobalan trees occur throughout India, from the Ravi eastwards to West Bengal and Assam. These are abundant in Madhya Pradesh, Orissa and Maharashtra. The Myrobalans from the Salem District in Tamil Nadu are considered the best because of their high tannin content.
2. *Terminalia chebula* is a medium-sized tree attaining a height of about 12 to 18 m.
3. It has a cylindrical bole and a somewhat rounded crown.
4. The leaves are ovate or elliptic and have a pair of glands at the top of the petioles.
5. The flowers are arranged in terminal spikes. They are yellowish white, unpleasant scented and brown. The fruits are drupes. The fruits that are hard, firm, about 2.5 cm in length are considered valuable from the commercial angle. They resemble dried plum, and are ellipsoidal, obovoid or ovoid, yellow or orange-brown, sometimes tinged with red or black. The fruits become irregular and wrinkled on drying.
6. The dried flesh of the fruit surrounding the kernel is rich in tannins (30-32%) and is an important tanning material.
7. Roots, bark and wood also contain tannin.

Materials required

1. Fresh specimen/herbarium specimen/photograph of *Terminalia chebula* twig with fruits.

Procedure

Observe the morphological features of the specimen provided very carefully and learn to identify this plant.

Observations and Interpretations

Record your observations in the Worksheet # 25.5. Note the peculiar features in such a way that these could help anyone to identify the plant.

Your Notes

Worksheet # 25.5: Morphological study of a myrobalan twig.

Diagram spaces **Q.1:** Make an outline diagram of a chebulic myrobalan twig.	**Description space** **Q.2:** Write the morphological features of a chebulic myobalan twig.
Diagram space **Q.3:** Draw an outline diagram of a fruit of chebulic myrobalan.	**Description space** **Q.4:** Write the salient morphological features of the fruit depicted in the adjacent column.

25.4 RESINS

1. Resins resemble gums in their external appearance, but differ in their origin and chemical composition. Unlike gums, they are insoluble in water, but dissolve readily in alcohol and other organic solvents to form 'varnishes'.
2. Resins are of various forms; some are sticky viscous liquids while others are hard, brittle solids. Generally, they are transparent, but some forms are opaque.
3. They are believed to be the oxidative products of essential oils, occurring as secretions in special ducts. These are often mixed with other substances such as latex, essential oils or gums.
4. Resins for commercial purposes are tapped from families such as the Fabaceae, Dipterocarpaceae and Pinaceae. Out of these three, you are familiar with the last one (Reference: LSE-13, Block-1, pp. 50-51; and 108-109). The resins obtained from the family Fabaceae are known by the following names: Congo copal, Copaiba balsam, and balsam of Peru. Those obtained from Dipterocarpaceae are known as Damars, and from Pinaceae are known by the name Canada balsam.
5. The famous resin Amber is a fossil resin occurring chiefly along the Baltic Sea. It is an exudate from the extinct pine, *Pinus succinifera*.

Refresh your memory

Resins are used in a variety of ways. In this section, we have kept this small exercise for you to get a first hand feel of this so very special plant product!

Materials required

1. A piece of Amber/museum specimen of the same.
2. A few pieces of gum crystals of any of the following types: gum arabic, gum tragacanth, gum karaya, or cherry gum.

Procedure

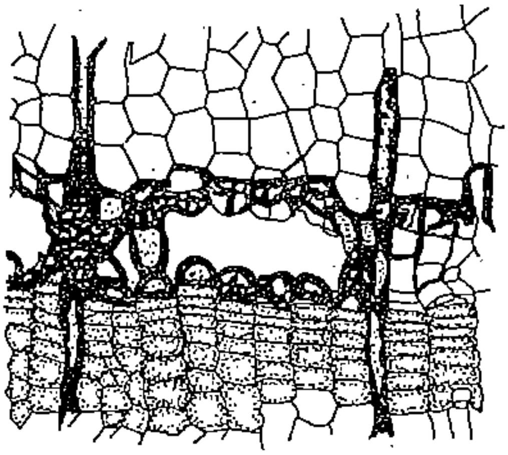
Two tasks are outlined for this exercise: **First** is recapitulation of the location and structure of resin ducts in the t.s. of *Pinus* stem, and, **second** involves study of a sample of Amber.

Observations and Interpretations

Complete the tasks as outlined in the Worksheet # 25.6. While observing Amber, compare it with the sample of gum provided to you and note the unique features of each, and also learn to make a clear distinction between the two.

Your Notes

Worksheet # 25.6: Study of Resins.

Diagram space	Description space
	

Q.1: Observe the diagram of a portion of *Pinus* stem in t.s. as given above. Use this illustration to study the permanent slide of the same material provided to you. Label the resin ducts in the diagram. Make a note of the features of a resin duct in the right hand column.

Q.2: Study the given piece of Amber and note its details about the following aspects:

i) Colour ....

ii) Texture ....

iii) Inclusions, if any: ....

....

....

iv) Solubility in water – *This would be demonstrated by your Counsellor. Observe whether gum and Amber show any reaction with water.*

....

....

....

....

25.5 WOODS

Since early human civilization, wood has been an important natural resource that is used in innumerable ways. In Unit # 20 of LSE-13 Course, you have studied about some commercially important sources of wood, and you may recall that speoific kinds of woods, cut in particular planes, are used for specific purposes. In this section, you will study some features of the wood that are important from the utilitarian point of view. Some of these are: *the anatomical structure of wood in different planes; the ring- and diffuse-porous condition of wood; and the light and heavy woods. Accordingly, you have three tasks in this section:*

Reference: Commercial sources of wood

1. Study of wood cut in three different planes, viz., transverse, tangential and radial.
2. Study of the ring-porous and diffuse-porous conditions in woods.
3. Grouping of woods as light and heavy woods.

1. Study of wood cut in three different planes, viz., transverse, tangential, and radial.

The woods cut in different planes exhibit certain anatomical characteristics. Our aim is to draw your attention to these anatomical characteristics, so that after knowing and understanding these, you should be able to identify the kind of plane of wood, and judge which kind of plane of wood would be suitable for specific purpose(s).

Materials required

1. Blocks of wood, **particularly of one plant source,** cut in transverse, tangential, and radial planes.
2. Permanent slides of sections of wood cut in the above-mentioned three planes.
3. A hand lens
4. A dissecting microscope
5. A compound microscope

Procedure

You have three categories of materials for studying the anatomical characteristics of wood in each of the three planes. These are:

i) the blocks of wood – to be observed by the hand lens:
ii) the permanent slides – to be observed first under the dissecting microscope, and then under the compound microscope; and
iii) the illustration given for reference in the Worksheet # 25.7 – work as per the instructions given therein.

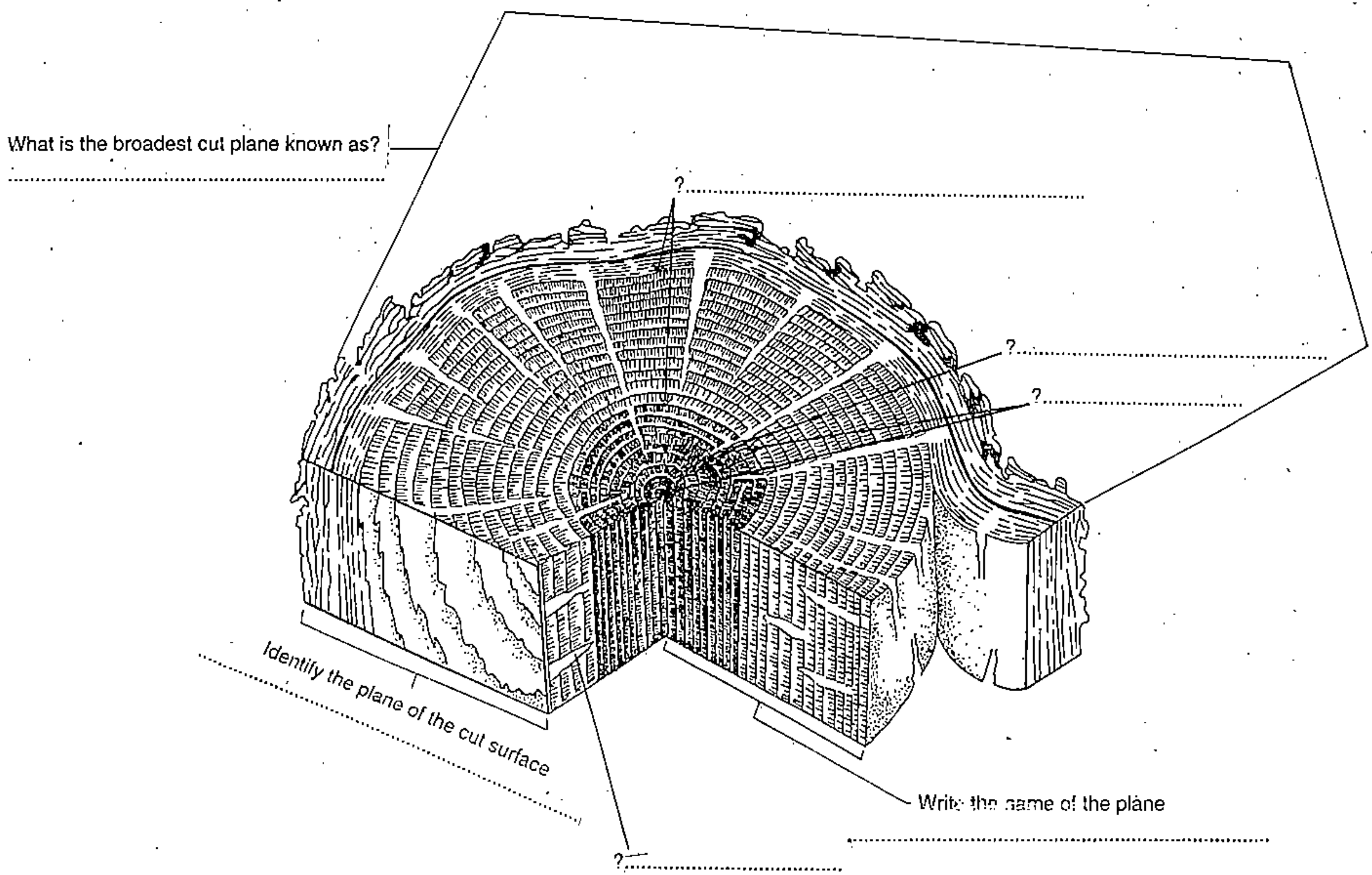
Observations and Interpretations

Study Guide

1. A logical way of observation would be to first observe the wood in a particular plane say – the transverse plane, with an unaided eye, then with a hand lens, followed by a dissecting, and then a compound microscope. While the first two observations are to be made on the wood blocks, the last two are to be made on the permanent slides. *A recapitulation of Appendix 20.1, pp. 122-126, of Block 3B, LSE-13 Course would be very helpful for your study.*
2. Similarly, study the anatomical characteristics of the remaining two planes, one by one.
3. In each of the plane, try to identify as many tissues of the stem (with secondary growth) as you can, while moving from the outer surface inwards. To put it in another way, note the outermost covering, i.e., the bark – is it complete, sloughed-off completely/ in bits and pieces, and the kind of tissue(s) composing it. Similarly, note the features of the cortical region, vascular region, and the pith.
4. It may have occurred to you that in wood – that is largely the product of secondary growth, the bulk is made up of xylem – the secondary xylem to be precise. So, while the other tissues of stem, i.e., bark, cortex, and phloem reflect their anatomical peculiarities, but the major chunk of information for identification purposes can be constructed from its xylem elements, and the xylem rays are the most important in this regard. You could focus on the type, the proportion, of and the arrangement of the constituent xylem elements, as seen in different planes.
5. Complete the tasks given in the Worksheets # 25.7 and 25.8 as per the given instructions.

Your Notes

orksheet # 25.7: Illustration-based identification of different parts of wood.



Q.1: Label the various parts marked (in dotted lines) in the above three-dimensional diagram of a wood block of a dicot stem.

Worksheet # 25.8: Study of wood specimens cut in three different planes.

Diagram space	Description space
(a) Transverse plane	

Diagram space	Description space
(b) Tangential plane	

Diagram space	Description space
(c) Radial plane	

Q.1: Based on your observation with unaided eye and hand lens of the blocks of wood cut in the transverse, tangential, and radial planes, draw their outline diagrams. Observe their respective sections (permanent slides) under the microscope, and depict a few cells of each to represent the anatomical highlights of a particular plane. For a transverse section, show how the xylem elements, viz., the vessels, tracheids, parenchyma, etc. appear in this plane. Note the diagnostic features of the wood cut in each of three planes.

2. Study of the ring-porous and diffuse-porous conditions in woods.

Plant-Products from Forests

Refresh your memory

Theory reference: LSE-13 Course, Block-3B, pp. 122-123.

Materials required

1. Wood pieces cut in transverse planes, representing the above-mentioned conditions; and/or permanent slides of t.s. wood of the above two conditions.
2. Hand lens
3. Dissecting microscope
4. Compound microscope

Procedure

It is the same as for Task-1.

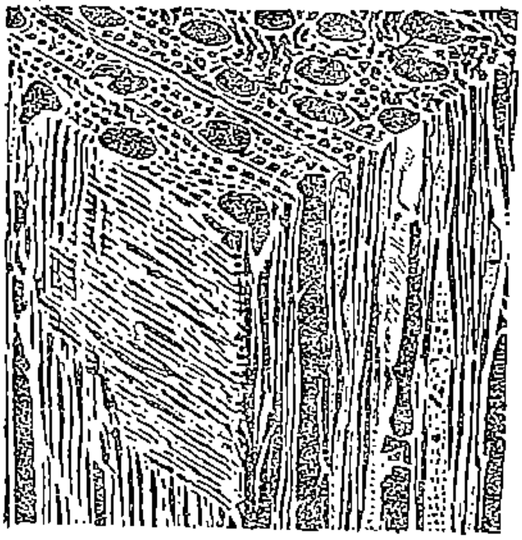
Observations and Interpretations

1. Complete the Worksheets # 25.9 and # 25.10 as per instructions.
2. In Worksheet # 25.9, you have to record your observations from your study of wood blocks and/or the permanent slides.
3. The Worksheet # 25.10 has a diagrams-based identification quiz for you.

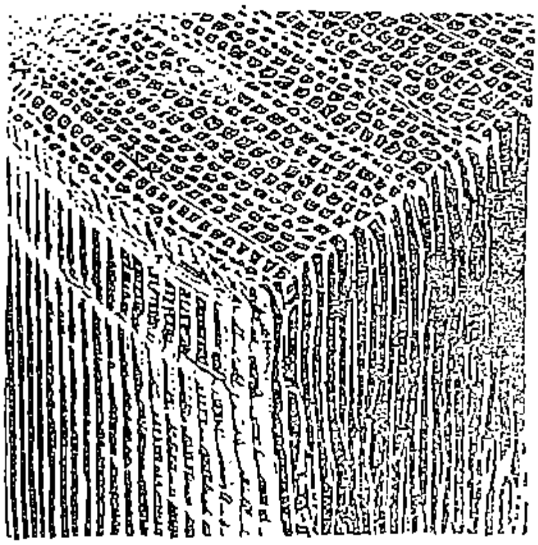
Your Notes

Worksheet # 25.9: Study of the ring-porous, and diffuse porous condition in wood.

Diagram space	Description space
Q.1: Make an outline diagram of wood showing diffuse-porous condition.	**Q.2:** Write the salient features of diffuse-porous wood observed by you.
Diagram space	Description space
Q.3: Make an outline diagram of wood showing the ring-porous condition.	**Q.4:** Write the salient features of a ring-porous wood studied by you



a)

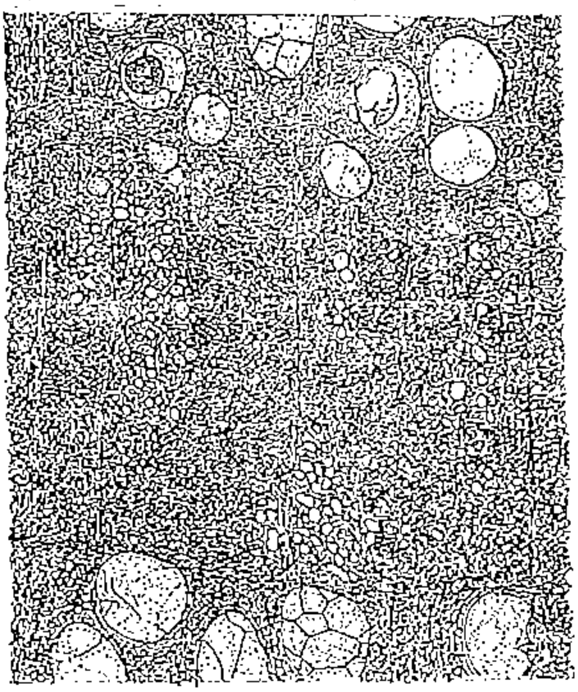


b)

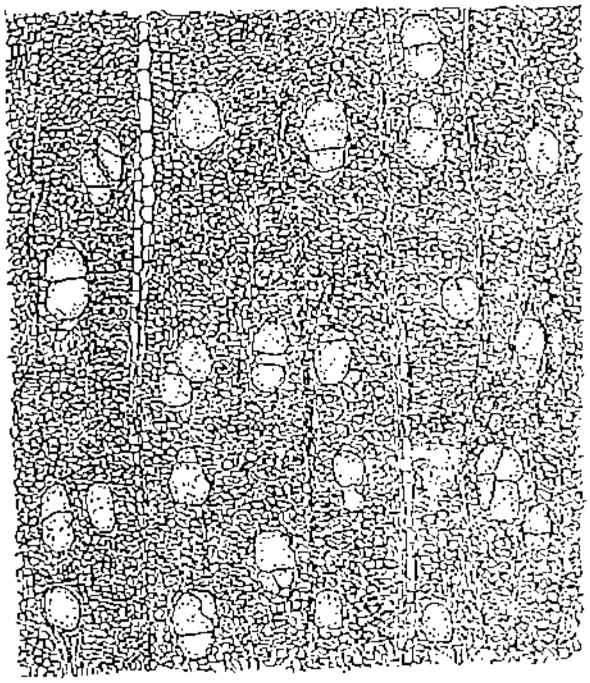
Q.1: Which of the above denotes *porous condition* and which one the *non-porous condition*?

....

....



c)



d)

Q.2: Of the four terms given below, select which one(s) describe the conditions in Fig. c and d. The terms are: porous, non-porous, diffuse-porous, ring-porous. Write your answers below:

....

....

Refresh your memory

3. Grouping of woods as light and heavy woods.

Theory references: LSE-13 Course, Block 3B, pp. 122-126.

Materials required

1. Wood blocks of the **same size** of the following plants:
   i) Balsa
   ii) Teak
   iii) Oak
   iv) Pine

Procedure

1. Take the blocks of wood provided to you one by one in your hand, judge their weight and classify them as light/heavy woods.

Observations and Interpretations

Read your observations in the mini-Worksheet # 25.11.

Worksheet # 25.11: **Classification of wood as light and heavy woods. Which ones of the given samples have heavy wood and which ones have light wood? Record your observations (the names of the plants) in the columns given below.**

Light wood	Heavy wood

25.6 CORK

1. The chief source of cork for commercial purposes is *Quercus suber*, commonly known as the cork oak.
2. The commercial value of cork is determined by its following properties:
   i) buoyancy and lightness;
   ii) resilience and compressibility;
   iii) insulating properties and low thermal conductivity;
   iv) chemical inertness;
   v) high resistance to deterioration;
   vi) imperviousness to water and other liquids;
   vii) lack of odour;
   viii) ability to absorb sound and vibrations;
   ix) high coefficient of friction; and
   x) slow to catch fire.
3. For more details and figure, see LSE-13 Course, Block 3B, pp. 101-102.

Materials required

1. Permanent slide of a t.s. of cork/temporary preparation of the same.
2. Compound microscope.

Procedure

Focus and observe the above slide under the microscope.

Observations and Interpretations

1. If the section is of a portion of stem with cork on the outer surface, study the various layers in the 'cork region', particularly the cork cambium, and the cork.

   Note the tissue composition, and specific features of the cells composing the 'cork region'.

2. Draw a few cork cells in the Worksheet # 25.12, and complete the other tasks given therein.

Your Notes

Worksheet # 25.12: Study of cork.

Diagram space	Description space
Q.1: Draw a few cells from the section of cork that you have observed.	**Q.2** Write the salient features of cork cells.

Q.3: Which anatomical characteristic(s), is(are) associated with the properties of cork mentioned below. For any information / guidance, discuss with your Counsellor.

i) Buoyancy and lightness: ....

ii) Resilience and compressibility: ....

iii) Insulating properties, low thermal conductivity: ....

iv) Chemical inertness: ....

v) High resistance to deterioration: ....

vi) Imperviousness to water and other liquids: ....

vii) Lack of odour: ....

viii) Ability to absorb sound and vibrations: ....

ix) High coefficient of friction: ....

x) Slow to catch fire: ....

Q.1: What is the difference between wood and timber?

....

....

....

....

....

....

....

....

Q.2: Which part of the plant cell forms the bulk of the wood?

....

Q.3: In a transverse section of wood, which cell(s) actually get longitudinally cut?

....

Q.4: Mention the most widespread use of rubber.

....

....

Q.5: Why is *Hevea* rubber the most important source amongst all the rubber-yielding plants?

....

....

Q.6: Which of the following is used widely in leather industry?

Resin / gum / tannins

(Tick on one)

Q.7: Which of the following is used in sizing paper and cloth?

Gum / resin / tannins

(Tick on one)

Q.8: Write the name of a cork substitute of plant origin.

....

Your Notes

EXERCISE 26 NON-ALCOHOLIC BEVERAGES

Date ....

Session # ....

Time allocated – 1 Hour

Structure **Page No.**

We believe you have got into the habit of reading in advance the text, and planning your work before coming for the lab session.

We also trust that you wear lab coat while working in the lab.

26.1 INTRODUCTION

Non-alcoholic beverages are stimulants to the central nervous system owing to the presence of certain alkaloids in them. In addition, they also contain tannins and essential oils which give the distinct colours and the unique flavours. Tea, coffee and cocoa are the three most important beverages of the world. These beverages have become an integral part of our daily life and are a part of social etiquette for people across the continents. With so many positive points of these beverages, their habit forming nature could perhaps be their only minus point.

Objectives

After completing this exercise, you should be able to:

- identify a tea plant/twig;
- describe the morphological characteristics, and anatomical details of tea leaves;
- ascertain the genuineness of a given sample of tea leaves;
- list, highlighting the features of different grades/kinds of tea leaves;
- identify a coffee plant/twig;
- describe the characteristic features of coffee fruit and beans;
- point out the peculiarities of different kinds of coffee available in the market;
- differentiate between pure and mixed/adulterated coffee;
- list the common adulterants and flavour enhancers of coffee;
- explain the fruiting habit of cocoa plant;
- point out the structural peculiarities of a cocoa fruit; and
- list the products made with cocoa.

Study Guide

1. Management of time is the key to making maximum learning out of this exercise. Prior reading for familiarization, and planning the work schedule is essential. Some activities in this exercise can be done in your free time, that is, these do not require you to necessarily work in the lab. You may take on these activities before or after this lab session. Thus making more time available for the rest of the activities.
2. The salient points for the plant specimens to be studied are given in this manual just before the beginning of the related activity/task. However, for further guidance, you may refer to Unit-18 of the LSE-13 Course.

26.2 TEA

1. Tea is an evergreen or semi-evergreen woody shrub.
2. The leaves are arranged in alternate manner. The mature ones are tough and coriaceous. These are generally elliptic to lanceolate and have acute tips and toothed (serrate) margins. The characteristic fragrance and aroma of the leaves is due the presence of numerous oil glands.
3. It has rose-like flowers that are white or pinkish with yellow center and are borne in leaf axils (axillary), either solitary or in groups.

In this section, you will study tea by the following **five activities:**

1. Morphological study of a tea plant/twig.
2. Study of v.s. leaf.
3. Study of a peel mount of the leaf.
4. Tests for identifying the adulterants of tea.
5. Study of different grades of tea.

1. Morphological study of a tea plant/twig

Materials required

1. Fresh/herbarium specimen of a tea plant/twig.
2. Hand lens/dissecting microscope.

Procedure

Observe the given specimen, making a mental note of its salient morphological characters.

Observations and Interpretations

- Illustrate the given specimen of tea and jot down its diagnostic features in the Worksheet # 26.1. The description given above and the points for observation given in the worksheet would help you in your study. For further information, you may refer to the related theory Unit # 20, LSE-13 Course, Block-3B, pp. 31-40.

Your Notes

Diagram space

Q.1: Make an outline diagram of the specimen of tea provided, highlighting its diagnostic characters.

Q.2: Comment on the following aspects of the tea plant:

Leaves : phyllotaxy- ....

texture - ....

shape (base, tip, overall shape) - ....

....

margin - ....

surface (upper and lower as seen with a hand lens/dissecting microscope) - ....

....

Flower: position - ....

colour - ....

single/many - ....

description - ....

Other features: ....

....

....

2. Study of v.s. leaf

This involves either cutting a section of tea leaf and observing it. If time is a constraint, then a permanent slide of the same may be observed.

Materials required

1. Fresh/fixed (preferably unprocessed) leaves of tea
2. A sharp razor/blade
3. Microslides
4. Coverslips
5. Safranin
6. Watch-glass
7. Water
8. Camel hair brush
9. Pith for sectioning
10. Glycerine
11. Compound microscope

Procedure

Be careful about your fingers while using the razor/blade.

1. Cut vertical section (v.s.) of leaf, i.e., at right angles to the leaf surface. The section should include the midrib and the lamina
2. You may look back at Exercise # 1 if you need any guidance for cutting v.s. of leaf.
3. It would be easier for you if you use pith for section cutting.
4. Select the best sections, stain with safranin, and mount in glycerine.
5. Fix the above temporary preparation under the compound microscope and observe.
6. If using a permanent slide, observe it also under the compound microscope.

Observations and Interpretations

1. Study the v.s. of this dorsiventral leaf of tea. Recall and compare the anatomical features of a typical dorsiventral leaf with the preparation you have made, or the permanent slide provided to you.
2. Focus particularly on:
   - epidermis;
   - palisade and spongy parenchyma;
   - vascular bundle in the mid-rib, note whether it is surrounded by tissues, if yes, which kind of tissues, is it sclerenchyma or some other cells?
   - astrosclereids or the idioblasts in the palisade and in the mid rib region are very prominent, don't miss out on them! These are the characteristic features of the leaves and are sometimes as long as the leaf.
3. Make an outline diagram of the section in the Worksheet # 26.2. Also, enlarge an astrosclereid and jot down the anatomical details of the leaf.

Diagram space

Q.1: Make an outline diagram of v.s. leaf and enlarge an astrosclereid.

Description space

Q.2: Write the main anatomical features of the leaf, commenting particularly on the astrosclereids.

3. Study of a peel mount of the leaf

This exercise is meant for observing the trichomes or the hairs present on the leaf surface.

Materials required

1. Fresh/preserved (preferably unprocessed) young leaves of tea
2. Watch-glass
3. Water
4. Forceps (fine)
5. Microslides
6. Coverslips
7. Glycerine
8. Compound microscope
9. A sharp blade
10. Needles
11. Safranin

Procedure

Prepare a peel mount of the leaf. The method of taking out a peel is given in Exercise # 1. You may stain the peel with safranin; it makes the structure clear. Mount the peel in glycerine and observe under the compound microscope.

Observations and Interpretations

The young leaves have trichomes or hairs on their surface. These hairs are unicellular with a swollen base, short shaft and a lumen, which runs a little way into the shaft. Study and describe the hairs as seen in the peel-mount that you have prepared. Illustrate a couple of hairs in the Worksheet # 26.3 and write their characteristic features.

Your Notes

Mini Worksheet # 26.3: Study of a peel of a tea leaf.

Diagram space	Description space
Q.1: Make one or two hairs in enlarged view along with the epidermal cells surrounding them.	**Q.2:** Describe the characteristic features of the leaf-hairs.

Your Notes

4. Tests for identifying the adulterants of tea.

How can one determine whether the tea we consume is genuine tea? This may not be the problem with the reputed brands, but the tea that is sold 'loose', is many a times mixed with non-tea substitutes. How do we find out whether a given sample is pure tea or has some other ingredients? This is precisely what you would learn to do now.

Materials required

1. Tea leaves (processed tea that we use for making the beverage)
2. Rose, *Cassia*, strawberry leaves
3. Spent leaves
4. Saw dust/husks of grains, beans, and other seeds.
5. Filter paper
6. Water
7. Test tubes
8. Test tube holder
9. Bunsen burner/spirit lamp
10. Compound microscope
11. Microslides
12. Coverslips
13. Safranin
14. A sharp blade/razor

Procedure

The following **five** things are to be done in this regard:

i) Study the anatomy of leaves of the given sample.
ii) Prepare peel mounts from (previously soaked) leaves from the given samples.
iii) Boil the tea leaves (genuine) in a test tube. Similarly, boil the rose, *Cassia*, and strawberry leaves in separate tubes that are well labelled (with the name of the source plant written on them). The texture of these leaves is to be felt by hand.
iv) Put the sample of tea – fresh and spent, separately on wet filter papers. See, what happens. Mark the papers as 'fresh' and 'spent'.
v) Take saw dust, husks of various seeds that have been coated brown like that of tea. Take a bit of these and put them on a wet filter paper and note what happens. The second thing you could do is soak these materials in water, and try to cut their sections and observe them under the microscope. If sectioning is difficult, you may tease the materials on different slides, put a small drop of glycerine and place a coverslip on each and observe under the compound microscope.

Observations and Interpretations

1. You are well-versed with the diagnostic features of tea leaf, i.e., its anatomical features and trichomes on the surface. With these in mind, you can easily identify the adulterant materials that will exhibit variant anatomy. This is what you have to do for points # **i** and # **ii** mentioned in the procedure; and note your observations in Worksheet # 26.4.

2. For point # **iii**, with little concentration you can feel the difference of texture of the boiled tea leaves from the adulterant rose and *Cassia* leaves. Describe how you felt regarding the texture of the different leaves in the Worksheet # 26.4.
3. Point # **iv** is simple. No hints being given. Observe and record your findings in the Worksheet # 26.4.
4. Some hints for point # **v**. Saw dust is mainly wood, so what do we get in wood – the xylem elements. If the section/teased material shows elements like vessels, tracheids, and xylem parenchyma. So it conclusively shows that the material is fine wood shavings or saw dust. Also note down your finding regarding this test in the Worksheet # 26.4.

If husks of various seeds are used as adulterants, their structure too would be very different from the tea leaf. Like sawdust make their preparations and observe them under the compound microscope.

Your Notes

Working 26.4: Tests for the identification of genuine tea sample and the adulterated ones.

Diagram space	Description space
Q.1: Make outline diagrams of v.s. leaves (tea and adulterants)	**Q.2:** Write the salient anatomical differences of the materials depicted in the adjaced column.
Diagram space	Description space
Q.3: Draw a few cells of the leaf peel from the tea leaf and those of its adulterants.	**Q.4:** Jot down the important features of the different peels prepared.

Q.5: Describe how do the tea leaves and other leaves feel on touching?
Tea leaves - ....
Rose leaves - ....
Cassia leaves - ....
Strawberry leaves – *(put a cross mark on the samples not available/studied)*..........................
....

Q.6: Write about the outcome of placing tea leaves (fresh and spent) on wet filter papers.
Fresh leaves - ....
Spent leaves - ....

Q.7: Study the saw-dust mixed/pure tea sample, and comment on the following aspects:
i) Reaction on wet filter paper - ....
ii) Observation under the compound microscope - ....
....
....

5. Study of different grades of tea.

This small activity is to test your familiarity with different grades of tea. Some brand names are very commonly heard/seen in advertisements, and some we know from our use and experience. A few names would have been added to your list from your study of Unit-20 of LSE-13 Course. How about doing a hands-on with as many samples/grades/types of tea as we can? It's going to be interesting!

Materials required

1. Different kinds of tea – green, black, oolong, scented, brick, CTC, tea-bags, and whatever other types could be arranged.
2. Dissecting microscope/hand lens

Procedure

1. Take a little tea sample on a small white sheet. This will give a contrasting background, and help focus on the constituents of the tea.
2. Observe the sample with a hand lens/dissecting microscope.
3. Similarly, observe each type of the tea provided.
4. The previously soaked samples could also be observed for their constituents.

Observations and Interpretations

Size of tea leaves, and the processing mechanism mainly are the basis of different grades and kinds of teas. Study and observe the samples provided and record your observations in the Worksheet # 26.5.

Your Notes

Worksheet # 26.5: Study of different grades/kinds of tea.

Q.1: List the various grades/kinds of tea you know of, including the ones that are provided to you.

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....
....
....
....
....
....
....

Q.2: Compare CTC tea and the green tea. Presenting your findings in a tabular form would make your comparison effective.

Q.3: Take tea bags of two or three kinds, open them and observe which kind of tea these contain? Comment on their constituents.

....
....
....
....
....
....
....
....

26.3 COFFEE

1. It is an evergreen shrub or a small tree, often kept short by pruning.
2. The leaves are ovate-elliptic, opposite, glabrous and glossy. Its margins are undulate, and tips are acuminate. Interpetiolar stipules are present.
3. Flowers are star-like, snow-white, and smell delicately like jasmine flowers. These occur in dense axillary clusters and are produced in flushes 3 or 4 times in a year.
4. The fruit is a drupe, about 1.5 cm long. It is green when young and turns crimson-red at maturity. It takes about 6-9 months after flowering for the fruits to develop to maturity.

   The drupe has 3 distinct regions:

   i) exocarp or epicarp, it is the outer, thin, deep crimson skin;
   ii) mesocarp is the yellowish mucilaginous or fleshy layer; and
   iii) endocarp is hard, cartilaginous and parchment-like, enclosing two and sometimes one ellipsoidal or oval seeds called coffee beans.
5. The coffee seeds or beans have an outer delicate seed coat called the silver skin. The bulk of the seed is composed of a curiously folded corneous endosperm enclosing a very small embryo.
6. The three species of coffee consumed world-over are:
   Coffea arabica – Arabic coffee
   C. canephora – Robusta or Congo coffee
   C. liberica – Liberian coffee

This section requires you to perform the following **four studies**.
1. Morphological study of a reproductive twig.
2. Morphological study of coffee fruit and bean.
3. Study of the different kinds of coffee available in the market.
4. Study of pure and mixed/adulterated coffee in whole / powdered forms.

1. Morphological study of a reproductive twig.

Materials required

1. Fresh/herbarium specimen of a coffee twig bearing fruits, or a photograph of the same
2. Hand lens/dissecting mircroscope

Procedure

Study and observe the given specimen minutely.

Observations and Interpretations

Illustrate the given specimen of a reproductive twig of coffee. Make an outline diagram only. Depict the details of one node, and draw one leaf. Use the diagram space in the Worksheet # 26.6 for this purpose. The description given above and the points of observation given in the worksheet would help you in your study. For further information, you may refer to the related theory unit, # 20, LSE-13 Course, Block-3B, pp. 40-46.

Reference for more information

Worksheet # 26.6: Morphological study of a twig of coffee.

Diagram space

Q.1: Illustrate the given specimen of coffee. Highlight the details of one node and a leaf.

Q.2: Based on your observations, comment on the following aspects of a coffee plant:

Leaves : phyllotaxy - ....
texture - ....
shape (base, tip, overall shape) - ....
....
margin - ....
surface (upper and lower as seen with a hand lens/dissecting microscope) - ....
....

Flower: position - ....
colour - ....
single/many - ....
description - ....

Fruit: to be studied in Worksheet # 26.7.

Other feature(s): ....
....
....
....

2. Morphological study of coffee fruit and bean.

Materials required

1. Fresh/preserved coffee fruits (mature) or photographs of the same
2. Unroasted coffee beans
3. Needles
4. Water
5. Microslides
6. Coverslips
7. Safranin
8. Compound microscope

Procedure

1. First observe the intact coffee fruit, then cut it open and study it.
2. Similarly, study the coffee bean, and make note of its characteristic features.
3. Scrape the inside of the groove of the coffee bean with your mounted needle. Place the scraping onto a slide. Stain it with safranin. Mount in glycerine and observe under the compound microscope.

Observations and Interpretations

1. Study the fruit, focus mainly on:
   - the distinctive features of raw vs. mature fruit,
   - the intact fruit,
   - type of fruit, and
   - split-open fruit to see the number and arrangement of seeds.
   - Details of the fruit are given above, see whether they match with the specimen that you have for study. Complete the related tasks in the Worksheet # 26.7.
2. Similarly, pay attention to the coffee seeds, also known as beans.
   - Note how many they are per fruit.
   - How does each bean look like.
   - Do you find it resembling to the grain of wheat?

   Write your observations in the Worksheet # 26.7.
3. Observe which kind of cells compose the scrapings (parchment plus sliver skin) taken from the groove. Illustrate the parchment (endocarp) cells and the silver skin (seed coat) below. Some hint for these: the parchment cells are macrosclereids, and the silver skin is membranous. Draw a few cells of each in the Worksheet # 26.7.

Your Notes

Worksheet # 26.7: Fruit and beans of coffee – morphological study.

<table>
<tr><th>Diagram spaces</th><th>Description spaces</th></tr>
<tr><td>Q.1: Draw a fruit (raw/mature) intact, and as seen on opening it up.</td><td>Q.2: What kind of fruit is it? ……………………
……………………………………
Q.3: How many seeds does it contain? …………
……………………………………
Q.4: Other aspects that you choose to elaborate on: ……………………………………
……………………………………
……………………………………
……………………………………
……………………………………
……………………………………
……………………………………
……………………………………
……………………………………
……………………………………
……………………………………</td></tr>
<tr><td>Q.5: Illustrate a coffee bean and label its various parts.</td><td>Q.6: How would you describe a coffee bean?
……………………………………
……………………………………
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……………………………………
……………………………………
Q.7: Do you find it resembling wheat grain? Give reasons.
……………………………………
……………………………………
……………………………………
……………………………………
……………………………………</td></tr>
<tr><td>Q.8: Draw a few parchment cells along with the cells of the silver skin.</td><td>Q.9: Describe the characteristic features of :
a) parchment cells: ……………………………
……………………………………
……………………………………
……………………………………
……………………………………
……………………………………
……………………………………
b) silver skin cells: ……………………………
……………………………………
……………………………………
……………………………………
……………………………………
……………………………………</td></tr>
</table>

3. Study of different kinds of coffee available in the market.

Coffee is available as beans – both in roasted and in unroasted forms, also in ground, i.e., powdered form. And there is one very popular form – instant coffee. What are the differences between these? Let us have a detailed look at them.

Materials required

1. Roasted beans
2. Unroasted beans
3. Coffee powder – (filter coffee)
4. Instant powder
5. Water
6. Beaker
7. Burner
8. Test tubes
9. Test tube stand

Procedure

1. First, study the roasted and unroasted beans one by one. Focus mainly on the differences between the two.
2. Next, study the ground coffee. For this, make comparative observations on the pure coffee powder and the instant coffee. Observe them first in powdered form. And then see their solubility in boiling water. Surely, you know how to make coffee. For this exercise, boil some water in a beaker. Take equal amount of pure coffee powder and instant coffee powder in separate test tubes. Pour equal amount of water in both of them and observe.

Observations and Interpretations

1. For interpreting the differences between the roasted and unroasted coffee beans, you can make note of their following features:
   - their relative size,
   - size of one bean,
   - colour,
   - shape,
   - aroma, and
   - other features

   Note these observations in the Worksheet # 26.8.
2. Following the above line you can observe the differences in the two kinds in their dry (powdered) form, and in solution.

   For powder form you could make the following observations:
   - colour,
   - aroma,
   - texture and feeling to touch.

And in solution, you could observe the following aspects:

- how much time each takes to dissolve;
- see whether they dissolve completely;
- the colour of the solution – you can describe them as different shades of brown colour, e.g., chocolate brown, golden brown and so on; and
- any other features you may notice.

Your Notes

Worksheet # 26.8: Study of different kinds of coffee available in the market

Q.1: How would you distinguish the roasted coffee beans from the unroasted ones?

S.No.	Characteristics	Unroasted beans	Roasted beans
1.	Size		
2.	Colour		
3.	Shape		
4.	Aroma		
5.	Other features		

Q.2: What differences did you observe in the powdered coffee and the instant coffee?

S.No.	Characteristics	Indicate the state (dry/liquid)	Powdered coffee	Instant coffee
1.	Colour	Dry		
2.	Texture and feeling on touch	Dry		
3.	Dissolution time	Liquid		
4.	Colour	Liquid		
5.	Other features			

4. Study of pure and mixed/adulterated coffee in whole/powdered forms.

You may recall from your study of Unit # 20 of LSE-13 Course (p. 45) that roasted peas, beans, cereal grains and roasted tamarind seeds are commonly mixed with coffee beans. Therefore, such a coffee is known as adulterated coffee.

On the other hand, consumers demand coffee with additives like chicory, flavour enhancers like chocolate, liqueurs, orange or almond extract, and Vanilla. Such types of coffee may be referred to as mixed coffee. So, you must catch the meaning of the mixed and adulterated powdered coffee.

You may now take on the activity given in the Worksheet # 26.9.

Your Notes

Worksheet # 26.9: Pure and mixed/adulterated coffee in whole/powdered forms.

Q.1: List the adulterants of unroasted and roasted beans and the coffee powder.

Before you proceed further, here are some guidelines for this activity.

i) You could fill in the information asked for from the explanation given above and from the related theory unit.
ii) However, you must explore and find out more about adulterants/additives used, from other sources/literature related to coffee, coffee drinkers, your friends, shopkeepers, and surely your Counsellor.
iii) This activity would, therefore require your additional free time for exploration and not solely the practical session time.

Form of coffee → / Adulterant ↓	Characteristics	Unroasted beans	Roasted beans
1.			
2.			
3.			
4.			
5.			
6.			

26.4 COCOA

Read more about – branching pattern

1. Cocoa tree grows to a height of about 8-10 m, but is kept low by pruning when it is under cultivation.
2. It has a characteristic branching pattern (see p. 47, Unit # 18, LSE-13 Course).
3. The leaves are spirally arranged on the main stem and subsequent chupons, but are alternately arranged on jorquette branches. The mature leaves are dark greenish, oblong-oval or elliptic-oblong with prominent veins and veinlets.
4. The inflorescence occurs in a peculiar manner on the old, leafless trunk or the main stem and fan branches. The flowers are tiny, white, yellowish or pinkish, pentamerous, pedicellate, and bisexual. The petals are five in number, smaller than sepals, are expanded into concave, cup-shaped pouches; end of the petal is spatulate, yellowish, bending outwards and backwards and attached to pouch by narrow connective. Androecium has five outer staminodes, and five inner fertile stamens that bend outwards and the anthers are concealed in the pouches of corresponding petals. Gynoecium has 5 carpels, ovary is superior, and has numerous ovules.
5. The fruit is a drupe, commonly called a pod. It is borne directly on the stem. In botanical terms, this condition is known as cauliflory. The fruit is indehiscent, white, greenish or reddish, variable in size and shade. Pericarp is fleshy and mesocarp is thick. The pods mature in 4-6 months after fertilization including a month for ripening. The seeds are usually called beans. Each fruit has 20-60 seeds, that are arranged in rows. The seeds are variable in size and shape.

For more details you can look at Unit # 18, LSE-13 Course, pp. 46-50.

In this section, the following **three tasks** have been outlined for your lab work.

1. Study of fruiting habit of a cocoa plant.
2. Morphological study of a pod.
3. Study of various products made with cocoa.

1. Study of fruiting habit of a cocoa plant.

Materials required

1. A photograph of cocoa plant bearing fruits.

Procedure

Observe the morphological details of the plant, particularly the bearing of fruit.

Observations and Interpretations

Illustrate the fruiting habit of cocoa. Pay attention to the details such as how many fruits are present at a given point. Are all of same sizes, and so on. Note your observations in the Worksheet # 26.10.

2. Morphological study of a pod.

Materials required

1. A fresh or fixed museum specimen of a longitudinally cut cocoa pod.

Procedure

Observe the given specimen minutely.

Observations and Interpretations

Complete the outline diagram of the fruit depicting the fruit wall, the number, relative size, and arrangement of seeds in the Worksheet # 26.10.

Your Notes

Worksheet # 26.10: Study of Cocoa.

Diagram spaces | **Description spaces**

Q.1: Make an outline diagram of the cocoa tree bearing fruits.

Q.2: The peculiar fruit bearing habit of cocoa is called.

....

....

....

(Write the technical term)

Q.3: Write the salient features of a cocoa tree bearing fruits.

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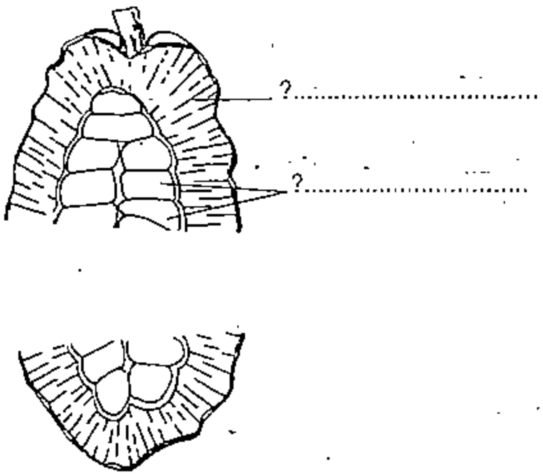

Q.4: Complete the outline diagram of a longitudinally cut cocoa pod.

Q.5: Describe the salient features of a longitudinally cut pod.

3. Study of various products made with cocoa.

This is basically a recapitulation and awareness building activity. How about trying it out!

Worksheet # 26.11: The products of cocoa.

Q.1: Fill in the blank spaces given below:

a) .... chocolate is made by grinding nibs (cotyledons) into an oily paste.

b) Cocoa powder is bitter chocolate with .... removed. *(Write the name of the constituent)*

c) Milk chocolate contains mainly .... and ....

d) Sweet chocolate is made by adding .... and .... to cacao mass or bitter chocolate.

e) Name some additives used in various cocoa products:

....

....

....

....

....

....

Q.2: Name the food drinks available in the market that contain cocoa as an ingredient.

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Worksheet # 26.12: The beverage quiz. Test your knowledge and understanding of the non-alcoholic beverages by the following quiz.

Q.1: Why do the tea leaves not get reduced to paste-like form on boiling?

....

....

Q.2: Why is tea plantation (originally of tree habit) maintained as bush, under cultivation?

....

....

Q.3: Why does tea become dark brown on prolonged boiling? Is it more refreshing?

....

....

Q.4: Which of the three beverages (you have studied) is more addictive?

....

Q.5: Why does the instant coffee dissolve completely?

....

....

Q.6: Mention any two effects of excessive consumption of coffee on human body.

....

....

....

....

....

....

Q.7: Of the three beverages, which one has the maximum food value?

....

....

Q.8: Which beverage is used in making the 'cola' drinks?

....

....

....

(Hint: you can refer to Unit 19, of LSE-13 Course)

EXERCISE 27 FIBRE-YIELDING PLANTS

Date ....
Session # ....
Time allocated – 1 Hour

Structure **Page No.**

Prior reading and planning is a strategy you can adopt to complete your study in the given time frame.

Protect your self and your clothing while working in the lab. Wear a lab coat.

27.1 INTRODUCTION

Botanically speaking, a fibre is a very long, narrow cell, many times longer than broad. Also, it is a thick-walled cell with a small lumen, with simple, often oblique pits on its walls. The mature fibre cells are non-living and these give mechanical strength to the plant body. A large number of fibres are composed of cellulose – a polymer of glucose.

Classification of plant fibres is based either on their use or on their location in the plant (see Unit # 20 of LSE-13 Course). Since the fibre cells are dead and empty, their cell wall characters generally determine their strength, lustre, colour, and the ability to be spun.

In this exercise, you will make a detailed study of three fibre-yielding plants in the context of our country. These are: cotton, jute,and coir. In addition, you would also learn to differentiate fibres based on their microscopic details, and the microchemical constituents.

Objectives

After completing this exercise, you should be able to:

- identify a cotton plant/ twig, pointing out its characteristic features;
- describe the peculiar features – both of surface and inside structure of a cotton boll;
- explain the structural changes undergone by the cotton boll during the course of its development;
- locate and differentiate between the two types of fibres on the surface of cotton seed;
- differentiate between the various species of cotton;
- identify a jute plant/twig, highlighting its characteristic features;
- describe the anatomical structure of the jute stem, with particular reference to the origin and structure of bast fibres;

- differentiate between the two widely cultivated species of jute;
- identify the different regions of a coconut fruit, describing the structural peculiarities of each;
- explain the anatomical detail of a coir fibre;
- give reasons for the wide commercial utility of the coir fibre based on its anatomical structure;
- point out the origin and structure of flax and hemp fibres;
- identify various kinds of fibres on the basis of their microscopic details; and
- analyse the chemical nature of fibres employing microchemical tests.

Your Notes

27.2 COTTON

1. Cotton is one of the commercially important surface fibres, that is cultivated widely in our country.
2. The main stem bears spirally arranged leaves and branches, but not the flowers directly.
3. Leaves are large, palmately-lobed, and are covered with multicellular stellate hairs. The leaves bear two kinds of buds – axillary and extra-axillary.
4. Cotton exhibits dimorphic branching; it is monopodial in vegetative condition, and sympodial in fruiting condition. The former develop from the axillary buds, and the latter from the extra-axillary buds of the upper nodes.
5. The flowers are large and showy, each is surrounded by an involucre of large, leafy bracts – the epicalyx – that are generally persistent.
6. The fruit, known as boll, is a spherical or ovoid leathery capsule consisting of 3 to 5 locules. The contents of each division or loculus are called lock within which six to nine seeds are present. The capsule cracks at maturity and the contents in the form of a white fluffy mass ooze out of the capsule wall.
7. The source of the commercial fibre is the seed whose surface is covered with hairs. These are of two types:
   i) the long hairs, also known as lint floss or staple; and
   ii) the short hairs, or the fuzz or linter.

   For more details, you may refer to Unit # 20, pp. 108-114, of the LSE-13 Course.

The following **four aspects** have been selected for the study of cotton:

1. Morphological study of plant/twig;
2. Morphological study of unripe and mature boll;
3. Morphological study of cotton seed; and
4. Comparative study of different species of cotton.

1. Morphological study of plant/twig

Materials required

Herbarium/ fresh specimen/photograph of a cotton plant/twig, with flowers and fruits (bolls).

Procedure

Study the given specimen minutely, and complete the related work in Worksheet # 27.1.

Observations and Interpretations

Observe and illustrate the given specimen, and write its salient features. Focus on the branching pattern, number of lobes of leaves, colour and the other features of the flower. Note the details in Worksheet # 27.1.

Worksheet # 27.1: Study of cotton plant/twig.

Diagram space

Q.1: Make an outline diagram of the specimen of cotton provided, highlighting its diagnostic characteristics.

Q.2: Write about the following aspects of the cotton plant:

Botanical name - ....

Common name(s) - ....

Branching pattern - ....

....

....

....

Leaf - ....

....

....

Flower - ....

....

....

Fruit - ....

....

....

Other features - ....

....

....

2. Morphological study of unripe and mature boll.

This study involves two activities, explained as a and b below.

a) Materials required

1. Fixed/fresh specimens of cotton bolls – unripe, ripe and dehisced

Procedure

Study the different development stages of cotton boll. After studying them, complete the related tasks in the Worksheet # 27.2.

Observations and Interpretations

Observe the structural changes undergone by the bolls at various stages of development. Label the parts of and identify the developmental stage of boll, in **Q.# 1** in Worksheet # 27.2.

b) Materials required

1. Fixed/fresh specimens of well-developed, unopened cotton bolls
2. A sharp blade/razor
3. Microslides
4. A dissecting microscope/stereomicroscope.

Procedure

Cut one of the cotton bolls in transverse plane and the other one in longitudinal plane. Place them on slides, or fix for observation with unaided eye and the dissecting/stereomicroscope.

Observations and Interpretations

Study the bolls cut in both the planes carefully and note the number of locules, type of placentation, number of seeds per locule, and presence of surface hairs on seed. Record your observations in diagrammatic and descriptive forms in the Worksheet # 27.2. See **Q.# 2 (a-c)**.

3. Morphological study of cotton seed

Materials required

1. Mature cotton seeds
2. Watch-glass/petri-dish
3. Water
4. A dissecting/stereo-microscope

Your Notes

Procedure

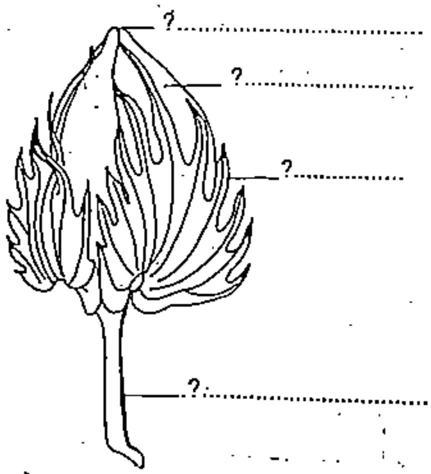
1. Soak a mature cotton seed in water in a watch-glass/petri-dish.
2. Observe under a dissection/stereomicroscope.

Observations and Interpretations

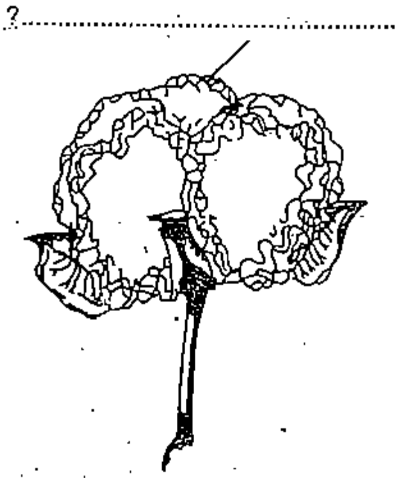
Observe and study the location of fuzz (the short fibres) and lint (the long fibres) on the seed surface. Record your observations both in diagrammatic and descriptive forms in the Worksheet # 27.2.

Your Notes

Worksheet # 27.2: Study of boll and seed of cotton.



a)



b)

c)

Q.1: Label and identify the structure, and the developmental stage of each (a, b, and c).

a) .... b) .... c) ....

Diagram space	**Diagram space**	**Diagram space**
Description space	**Description space**	**Description space**
Q.2a: Illustrate a boll cut in transverse plane, label its parts and note its salient features.	Q.2b: Illustrate a boll cut in longitudinal plane, label the various structures, and note their salient features.	Q.2c: Make an outline diagram of a cotton seed in w.m., and write its main features.

4. Comparative study of different species of cotton.

Materials required

Herbarium/fresh *specimens of at least three species of cotton,* including one diploid and one tetraploid species. One of these three specimens could be from the first activity (of this section).

Procedure

Study the specimens of the three species of cotton provided. You may use the information you gathered in your study of the cotton species in the first activity. On the same lines, study the remaining two species also.

Observations and Interpretations

Focus mainly on the differences pertaining to their leaves, flowers, and bolls – unripe and mature. Describe these differences in the Worksheet # 27.3.

Your Notes

Worksheet # 27.3: Comparative study of different species of cotton.

Species → / Characters ↓	*Gossypium*	*Gossypium*	*Gossypium* ....
1.			
2.			
3.			
4.			

27.3 JUTE

1. Jute is a commercially important bast fibre cultivated mainly along the eastern coast of the country.
2. The plant is a woody, branched annual.
3. Leaves are simple, ovate, with serrate margin and have peculiarly curved bristles known as auricles near the leaf base.
4. Flowers are solitary or arranged in cymes.
5. Two species – *Corchorus capsularis,*, and *C. olitorius* are cultivated for the commercial production of fibres. *C. capsularis* has small yellow flowers; globular capsules that are much wrinkled and are flattened at the top, enclosing brown seeds.*C. olitorius* is a much taller species. Its leaves have shiny upper surface and rough under surface. Its flowers are yellowish and are larger than the flowers of *C. capsularis*. The fruit is long, cylindrical, ridged and has an elongated beak. The seeds are small, bluish-green to steel-grey or black.

   For more details, you can look at the Unit # 20 of LSE-13 Course; pp. 115-116.

The following **three aspects** have been outlined for study of jute in this exercise:

1. Morphological study of a jute plant/twig.
2. Anatomical study of jute stem.
3. Comparative study of two species of jute.

1. Morphological study of a jute plant/twig.

Materials required

Herbarium/fresh specimen/photograph of a jute plant/twig, with flowers and fruits (capsules) of any of the above-mentioned two species.

Procedure

Study the given specimen and complete the related work in Worksheet # 27.4.

Observations and Interpretations

Observe and illustrate the given specimen and write the salient features. Note the phyllotaxy, the serrated leaf margin, the auricles, and of course the type of fruit.

Your Notes

Diagram space

Q.1: Make an outline diagram of the specimen of jute provided highlighting its diagnostic characters.

Q.2: Fill in the details about the following aspects of the jute plant.

Botanical name - ....

Common name(s) - ....

Phyllotaxy - ....

....

....

....

Leaf - ....

....

....

Flower - ....

....

....

Fruit - ....

....

....

Other features - ....

....

....

....

2. Anatomical study of jute stem.

You can make a temporary preparation of t.s. stem or use a permanent slide for your study. Choice is yours!

Materials required

1. Fixed/fresh pieces of jute stem
2. A sharp blade
3. Microslides
4. Coverslips
5. Water
6. Watch-glass
7. Glycerine
8. Safranin
9. A compound microscope
10. Permanent slide of t.s. stem of jute

Procedure

Handle the razor/ blade carefully while cutting the sections.

1. Cut a transverse section of the stem provided. Stain lightly with safranin, mount in a drop of glycerine on a microslide. Observe under a compound microscope.
2. If time is a constraint, you may straight away use the permanent slide for observation.

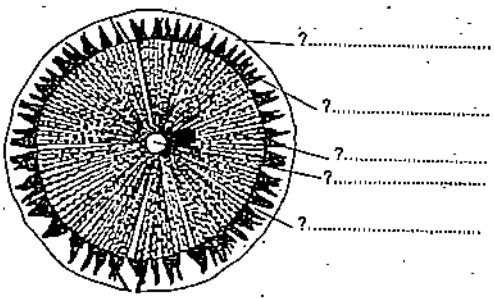
Observations and Interpretations

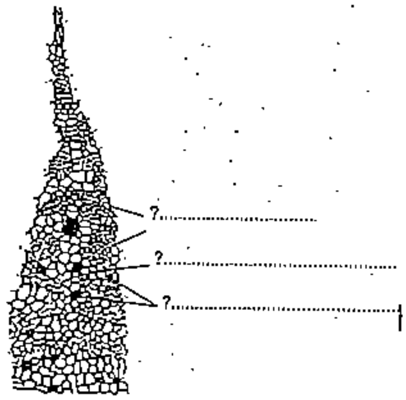
1. Observe and study the section of stem focussed under the compound microscope. Note particularly the periderm, cortex, secondary phloem, the phloem wedges with fibres, secondary xylem, and pith.
2. Label the various parts of the given outline diagram of t.s. stem, and a cellular portion of phloem wedge in the Worksheet # 27.5.
3. Draw two or three bast fibres as they appear in the t.s. of stem.

Your Notes

Worksheet # 27.5: Study of anatomical details of jute stem.

Diagram space





Q.1: Label the various regions in the above diagram of t.s. of stem.

Q.2: Label the various tissues composing the phloem wedge in the above figure.

Q.3: Illustrate two or three bast fibre cells.

Description space

Q.4: Describe the salient features of the structures depicted in the above figures. (in Q.# 1 – 3.)

3. Comparative study of two species of jute.

Materials required

Herbarium/fresh specimens of the two species of jute plants/twigs – one species you have already studied in the first activity of this section.

Procedure

Having studied one of the species for the first activity, study the other species too on the same lines.

Observations and Interpretations

Focus mainly on the differences pertaining to their leaves – size, shape, texture on both the surfaces;
fruit – type, structure, surface;
seeds – number of seeds per fruit, seed colour; and
fibres – colour, length of fibres.

Note your observations in Worksheet # 27.6.

Your Notes

Worksheet # 27.6: Comparative study of two species of jute.

Species → / Characters ↓	*Corchorus olitorius*	*Corchorus capsularis*
1.		
2.		
3.		
4.		

27.4 COIR

1. Coir is an important structural fibre with immense commercial value.
2. Coconut plant is a tall tree with an inclined trunk and has prominent ring-like leaf scars.
3. The stem is swollen at the base and at the tip are present 20 to 30 large paripinnate leaves.
4. The inflorescence is axillary and consists of a central axis with up to 40 lateral branches. The whole inflorescence is enclosed by a spathe. The male flowers are numerous, about 200 to 300 in number, and are borne singly or in 2's or 3's in the upper part of the floral axis. The female flowers are few and are located singly at the base of the inflorescence branches.
5. The mature fruit is a fibrous drupe, somewhat ovoid, 1.2 to 2 kg in weight. The fruit wall is differentiated into 'exocarp' which is tough, smooth, hard and green when young and is shed off at maturity. 'Mesocarp' is the middle, thick region constituting the coir of commercial importance. The inner, hard, dark brown layer known as the 'endocarp' encloses the single seed with a thin brown testa, solid endosperm or meat that too is commercially important, and a cavity partially filled with liquid which is commonly known as the coconut milk. In botanical terms, the latter is actually the liquid endosperm. It takes about 9-12 months for a fruit to ripen.

For further details on coir, you may consult Unit # 20, pp. 117-118 of the LSE-13 Course.

The following **two activities** have been designed for the study of coir in this section:

1. Morphological study of coconut fruit; and
2. Study of the anatomical details of a coir fibre.

1. Morphological study of coconut fruit.

Materials required

A fresh/museum specimen of a coconut fruit cut in either the longitudinal/or transverse manner.

Procedure

Study the given specimen with your full attention and complete the associated task in the Worksheet # 27.7.

Observations and Interpretations

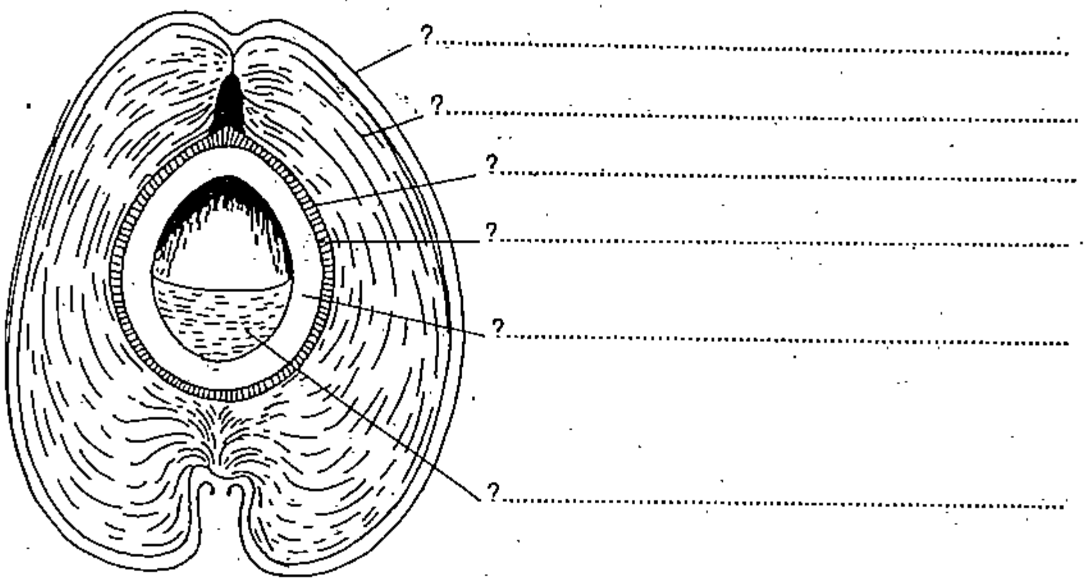
1. The structure of the fruit has been explained in point # 5 above. Focus on the characteristic features of various regions of the fruit, i.e., the exocarp, mesocarp, endocarp, seed coat, endosperm, and embryo. The related task in the Worksheet # 27.7 requires you to study the above regions, and point them out in the illustration provided therein. Write down your observations pertaining to these regions.

2. In the Worksheet # 22.7, an illustration of a longitudinally cut fruit is provided. In case the specimen provided to you is cut in a transverse plane, we take it that by now you can handle it with ease. You can make a mental visualization of the different regions as they appear in the longitudinal cut, and their relative positioning in a transverse view.

Your Notes

Worksheet # 27.7: Study of coconut fruit.

Diagram space



Q.1: Label the different regions in this outline diagram of the fruit cut in a longitudinal plane.

Description space

Q.2: Write the salient features of different regions seen in the above figure.

2. Study of the anatomical details of a coir fibre

Coir fibre strands are up to 0.3m in length, the surface of the fibre bundle is occasionally covered with small lens-shaped silicified stegmata. Each fibre consists of a thick-walled sclerenchymatous sheath surrounding a collateral vascular bundle. The collateral vascular bundle will show xylem and phloem cavity, if the phloem is retted; and intact phloem, if the fibre is not retted.

Materials required

1. Permanent slide of a coir fibre cut in transection
2. Compound microscope

Procedure

Focus the slide under the microscope and observe the anatomical structure of the fibre. Its unlabelled outline diagram is given in the Worksheet # 27.8, for your reference, as well as an exercise.

Observations and Interpretations

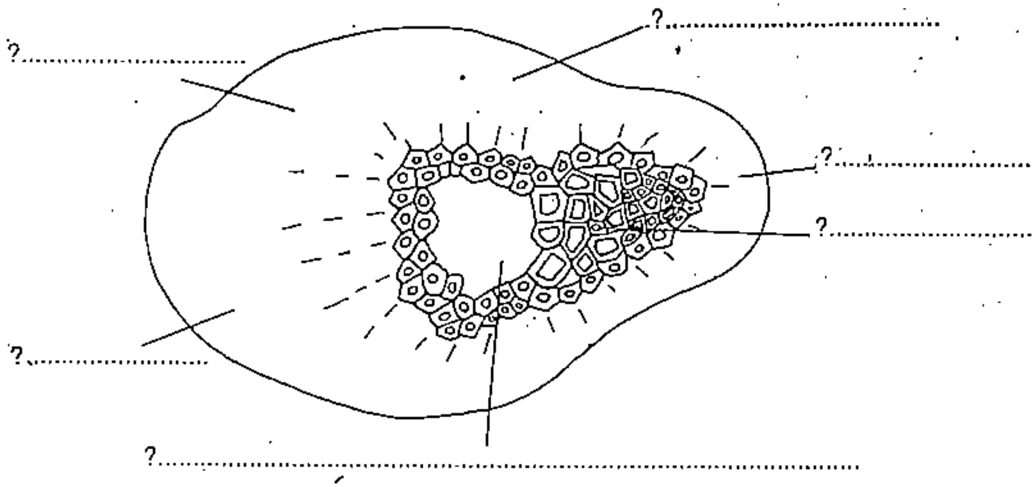
The brief description of the fibre is given above for your guidance.

Think about and complete the following aspects:

i) Does the structure in the slide match with the given diagram?
ii) Identify the different regions of the fibre and indicate them in the given diagram in the Worksheet # 27.8.
iii) Make a portion of the fibre cellular in the Worksheet # 27.8.
iv) Write the salient anatomical details of the fibre.
v) Is this fibre retted or unretted?

Your Notes

Worksheet # 27.8: Study of a coir fibre.



Q.1: Identify the different regions of the fibre and indicate them in the diagram.

Diagram space

Q.2: Make a portion of the fibre cellular.

Description space

Q.3: Does the structure of fibre as seen in the permanent slide match with the one depicted in the diagram? Comment.

....

....

....

....

....

....

....

....

Q.4: Write the salient anatomical features of the coir fibre, based on your study.

....

....

....

....

....

....

....

....

....

....

Q.5: Is the fibre (in the permanent slide) retted or unretted?

....

....

27.5 OTHER FIBRE SOURCES

In this section, you would be familiarized with two more common fibre sources of our country, namely, flax and hemp. Can you recall their botanical names? These two plants, however have not been dealt with in the fibre-related unit in this course. Nevertheless, spend two minutes on observing permanent slides of each to apprise yourself about these two types of fibres.

Materials required

1. Permanent slide of t.s. stem of hemp
2. Permanent slide of t.s. stem of flax
3. Compound microscope.

Procedure

Focus the slides one by one, and observe..

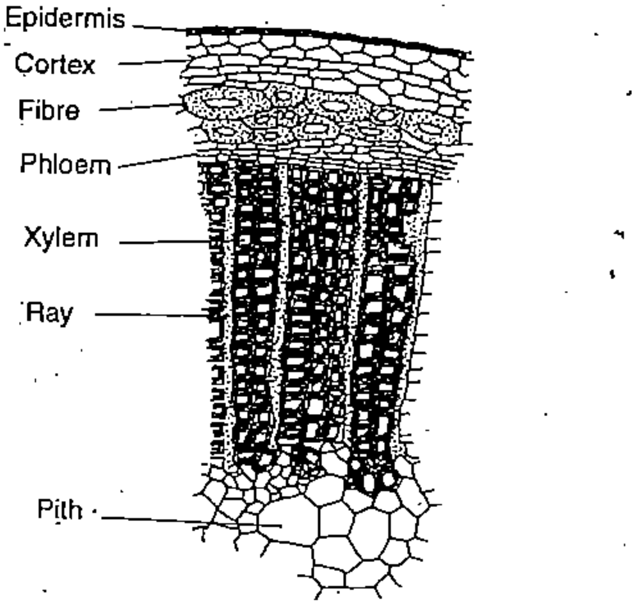
Observations and Interpretations

i) After observing the structure of stem in the permanent slide, try to identify its various regions, and mark them in the cellular diagrams of both the stems in the Worksheet # 27.9.
ii) Draw a fibre cell each in the same worksheet.

Your Notes

Worksheet # 27.9: Study of flax and hemp fibres.

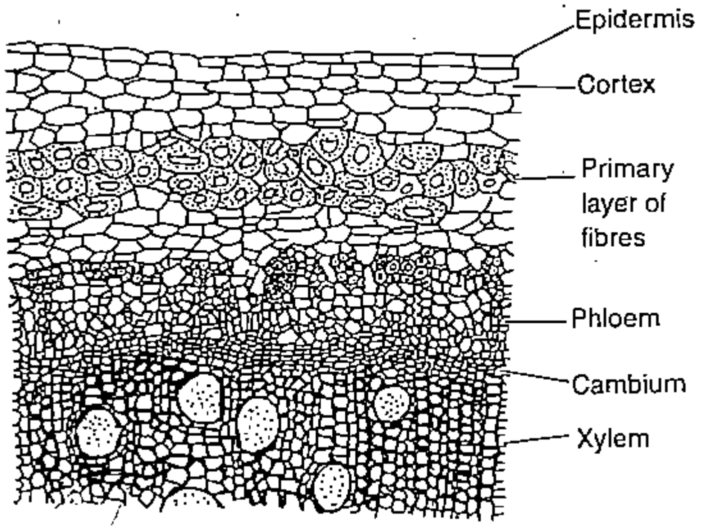
Botanical name: ....
....



Q.1: Study the above diagram of a cellular portion of a t.s. of flax stem.

Q.2: Draw a flax fibre as seen in transection.

Botanical name: ....
....



Q.3: Observe the above diagram of the cellular sector of the t.s. stem of hemp

Q.4: Draw a hemp fibre as seen in transection.

27.6 MICROSCOPIC STUDY OF FIBRES

The above title might have given you some indication about what you have to do in this section of the exercise. You would study the micro structure of some fibres - most of them being of plant origin, and a couple of them of animal origin. This is going to be very interesting as we use these fibres in our day-to-day life.

Materials required

1. Cotton fibres
2. Jute-fibres
3. Silk cotton fibres
4. Hemp fibres
5. Flax fibres
6. Coir fibres
7. Silk fibres
8. Wool
9. Any other easily available fibres
10. Compound microscope
11. Slides
12. Coverslips
13. Glycerine
14. Water

Procedure

1. Mount a few fibres of a particular type on a microslide, in a drop of water or glycerine. Carefully place a coverslip from one side, avoiding the air bubbles.
2. Focus the slide under the microscope and observe it minutely.
3. Similarly, make preparations of the other types of fibres. Don't forget to label the slides with the name of the fibre source.

Study Guide

Since time is a constraint, you can mount plant fibre say cotton, your friend can mount silk-cotton, and so on. You can exchange slides, but make sure you study all the given materials.

Time management

Observations and Interpretations

Study the micro-details of fibres in a comparative manner. Some of the features you can focus on are given below:

i) outer surface of fibre – smooth or some pattern can be seen;
ii) the thickness of wall;
iii) width of the lumen;
iv) outline of the lumen – smooth or irregular; and
v) any other peculiarity of the wall or the lumen.

Draw a portion of each fibre and write the salient points in the Worksheet # 27.10.

Worksheet # 27.10: Microscopic study of fibres.

Q.1: Make outline diagrams of fibres in the left-hand boxes mentioning the names of the source plants in each of the boxes. Describe their salient points in the adjacent description boxes.

Diagram boxes	**Description boxes**
a) .... *(Write the name of the fibre)*	a)
b) .... *(Write the name of the fibre)*	b)
c) .... *(Write the name of the fibre)*	c)
d) .... *(Write the name of the fibre)*	d) (Cont.)

Worksheet # 27.10: Microscopic study of fibres (Cont).

e) .... *(Write the name of the fibre)*	e)
f) .... *(Write the name of the fibre)*	f)
g) .... *(Write the name of the fibre)*	g)
h) .... *(Write the name of the fibre)*	h)

27.7 MICROCHEMICAL TESTS ON FIBRES

After microscopically studying various kinds of fibres, how about performing some simple microchemical tests to get an idea about their chemical nature? The requirements and reactions for the various tests are being given below for your ready reference.

Materials required

1. The following kinds of fibres:
   i) cotton
   ii) jute
   iii) silk-cotton
   iv) hemp
   v) flax
   vi) silk
   vii) wool
   viii) coir
   ix) any local source
2. Conc. H_2SO_4
3. IKI solution
4. Conc. HCl
5. Phloroglucinol solution (saturated)
6. Aniline chloride or Aniline sulphate
7. KOH (saturated solution)
8. Million's reagent
9. Bunsen burner/spirit lamp
10. Microslides
11. Coverslips
12. Water

Handle the chemicals carefully. Also see Exercise # 1

Procedure

1. Take a few fibres of each material on separate and labelled (with the name of the fibre) slides.
2. Test these fibres for cellulose, lignin, cutin, and proteins. The guidelines for these tests are given below.

Your Notes

Constituent to be tested	Test	Result
Cellulose	1) Fibres + conc. H_2SO_4 (1-2 drops).	Complete dissolution of fibre
	2) Fibres mounted on slide under a coverslip. Add 1 or 2 drops of IKI. Add conc. H_2SO_4 (1 or 2 drops) from the side of the coverslip.	Blue colour
	3) Fibres + Iodine solution (3 or 4 drops)	Yellow colour
Lignin	1) Fibres + saturated solution of Phloroglucinol (3-4 drops) + conc. HCl (1-2 drops)	Magenta colour
	2) Fibres + Aniline chloride (2-4 drops) or Fibres + Aniline sulphate (2-4 drops)	Yellow colour
Cutin	Fibres + saturated KOH solution (2-4 drops)	Yellow colour
Protein	Fibres + Millon's Reagent. Heat briefly on the flame.	Buff colour

Study Guide

We suggest you adopt the same strategy as the one used for the microstructure study, that is, you may test one kind of fibre and share your slides with your friend(s) and use his/her/their slides to complete your study in the limited time available to you.

Overcome time constraint by team-work

Observations and Interpretations

1. Note whether your results match with the expected results given in the above table (in Procedure).
2. Record your findings in the Worksheet # 27.11.
3. You may use + (plus) and – (minus) signs to indicate the presence and absence of the constituents being tested.
4. And you may use one or more + signs, (+, ++, +++ and so on) to express the relative intensity of expression (various colours) of the various tests.

Your Notes

Worksheet # 27.11: Microchemical tests on fibres.

↓Name of the fibre	Cellulose	Lignin	Cutin	Proteins

From your museum specimens, the displayed products in the markets and your household, list as many fibre-products as you can. Try to identify their fibre sources also.

S.No.	Name of the product	Fibre source

Worksheet # 27.13: The Fibre Quiz.

1. Name the most widely used product made of fibre.

2. Cotton and silk-cotton are pure cellulosic fibres (True or False)?

3. Silk-cotton is glossier than cotton. Is the cloth made from it also glossier?

4. Where does the silk-cotton originate from in the fruit?

5. Why is jute used to make gunny bags and not fine textiles?

6. Which fibre would you recommend for making ropes whose use requires submergence in water?

7. In which region of the stem did you observe the fibres of jute, flax and hemp?

8. Name a fibre made from plant proteins.

9. Which of the fibres, amongst the ones mentioned in this exercise, is fire-resistant?

Your Notes

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