

BOTANY IV-Semester Paper-IV Manual
Plant Anatomy, Morphology of Angiosperms, Plant Propagations



SREE SIDDAGANGA COLLEGE
OF ARTS, SCIENCE and COMMERCE
B.H. ROAD, TUMKUR
(AFFILIATED TO TUMKUR UNIVERSITY)



DEPARTMENT OF BOTANY
LABORATORY MANUAL
II B.Sc, IV SEM
PRACTICAL PAPER-IV
(Plant Anatomy, Morphology of Angiosperms,
Plant Propagations)

Theory SYLLABUS

4 Hrs per Week. 60 Hrs. 90 Marks

Unit-1: (14 Hrs).

Meristamatic tissues – structure, classification based on origin, position and function.

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Plant Anatomy, Morphology of Angiosperms, Plant Propagations

Theories of Apical meristems -Histogen theory, Tunica-Corpus theory.
Permanent tissues-Simple and Complex and Secretory tissues.

Unit-2: (8 Hrs).

Structure of Dicot & Monocot Root, Stem and Leaf.

Unit-3 :(10 Hrs).

Secondary growth in Dicot stem, Anamalous secondary growth in *Dracena* and *Boerhaavia*.
Wood anatomy-A brief account, types of wood (spring, Autumn ,Duramen, Alburnum, Porus wood and Non Porous wood).

Unit-4 :(20 Hrs)

Morphology of Angiosperms-Root System and its modifications,
Shoot system and Stem modifications, Leaf and its modifications, Inflorescence, Floral morphology and Fruits

Unit-5:(8 Hrs.)

Plant Propagation-Methods of Vegetative propagation-
Natural- Rhizome, Tuber, Corm, Bulb, Sucker, Stolon and offset,
Artificial-Stem Cutting, Grafting and Layering.

PRACTICAL SYLLABUS -IV

1. Anatomy of Dicot Root- Cicer, & Monocot Root- Grass/ Canna /Maize.
2. Anatomy of Dicot Stem - *Tridax*, & Monocot stem- Grass/ /Maize.
3. Anatomy of Dicot Leaf - *Tridax*, and Monocot Leaf- Grass/Maize.
4. Sectioning and staining -Slide preparation. Root, Stem (Dicot & Monocot)
5. Study of Root modification.
 - A. Underground Tap root Fusiform, Napiform & Conical.
 - B.Aerial Root –Prop root, Stilt Root
6. Study of Stem modifications.
 - A. Underground -Rhizome, Tuber, Corm, and Bulb.
 - B.Aerial- StemTendril,Stem Thorn, Phylloclade, Cladode, Bul-bil.
7. Study of Leaf –Stipules, Phyllotaxy, its types and its modification-Tendril, Phyllode (Australian Acacia).
8. Inflorescence-Racemose, Cymose,Special types.
Flower and it's Strcture . eg: Tribulus/ Hibiscus.
9. Fruits-Simple, Aggregate and Multiple.
8. Study of Vegetative propagation-Cutting, Grafting and Layering.

TUMKUR UNIVERSITY PRACTICAL QUESTION PAPER
BOTANY PAPER- IV

Time: 3 Hrs.

Max. Marks.50

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1. Identify the slides **A, B and C** with labelled diagrams and reasons. 3x4=12
 2. Prepare a temporary Saffronin stained T.S. of material '**D**', Sketch, and label and identify with reasons. Leave the preparation for evaluation. 1x8=8
 3. Identify the specimens **E, F, G, H and I** comment on their morphological/Biological features. 5x3=15
 4. Comment on '**J**'. 1x5=5
 5. Vivo-Voce +Submissions 3+2=5
 6. Class records 5
-

SCHEME OF VALUATION

1. Slides identification 'A, B, C'.

(Identification-1, Diagram-1, Reasons -2)

2. Slide Preparation 'D'.

(Identification-1, Diagram-1, Preparation-4, Characters-2)

3. Morphology: -'E, F, G, H, I'

1-Root, 1-Stem, 1-Leaf, 1-Inflorescence, 1-Fruits

(Identification-1, Reasons -2)

4. Vegetative Propagation- 'J'.One from Cutting / Grafting /Layering

(Identification-1, Diagram-1, Description-3)

5. Vivo-Voce (based on practical syllabus) - 3

Submissions- 2- slides (1- Root, 1- Stem) - 2

6. Class records - 5 marks

1. Anatomy of Dicot Root- Cicer, & Monocot Root

Anatomy of Dicot root. EX;-Cicer root

Transverse section of Cicer root shows following Anatomical features:-

1. **Epiblema:** Epiblema is the outermost layer of Root. It consists of single layer of compactly arranged, rectangular, thin walled cells. Some of the cells develop into unicellular, tubular cells called 'Root hair'. **It is meant for absorption.**

2. **Cortex:** Cortex is composed of many layers of Parenchyma cells with intercellular spaces. **Endodermis** is innermost layer of the cortex. It consists of single layer of barrel shaped cells with casparian strips on their radial walls. Few endodermal cells opposite to ProtoXylem are thin walled called 'Passage cells'.

3. **Stele:** Stele is composed of **Pericycle, Vascular bundle, Conjunctive tissue and Pith.**

a) **Pericycle:** Pericycle is the outermost layer of stele present next to endodermis. It is made up of single layer of parenchyma cells.

b) **Vascular bundle:** - **Vascular bundle is Radial, Tetrarch and Exarch.** (Radial-Xylem and Phloem are present alternately at different radii, **Tetrarch-** There are 4 patches of Xylem alternating with 4 patches of Phloem, **Exarch-** Protoxylem is present towards pericycle and Meta Xylem towards Pith.)

c) **Conjunctive tissue:** - Parenchyma tissue present between Vascular bundle is called 'Conjunctive tissue'.

d) **Pith:**-Central region of stele made up of parenchyma tissue constitutes 'Pith'. It is small.

Anatomy of Dicot Root- Cicer

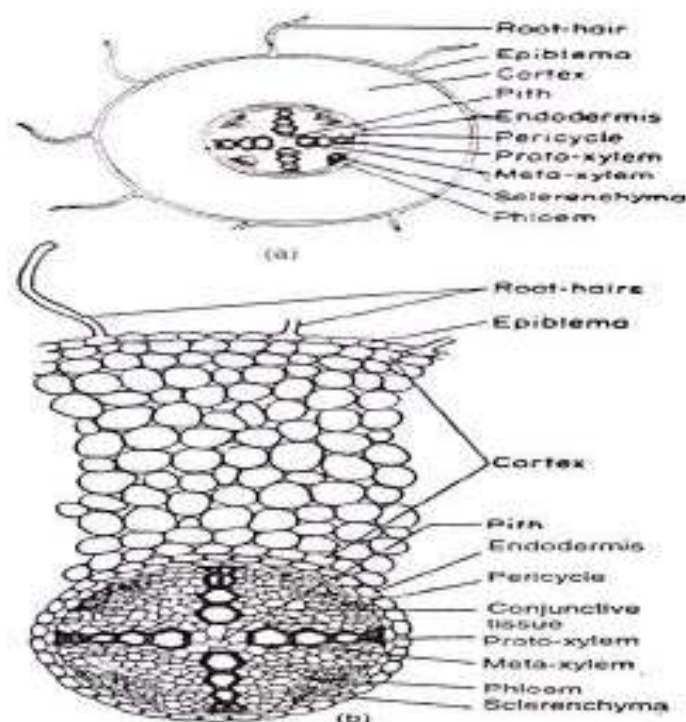


Fig. 6.7 : T.S. of root of gram : (a) Diagrammatic, (b) A portion of T.S. under magnification

Anatomy of Monocot root. EX:-Canna root

Transverse section of Canna root shows following Anatomical features:-

1. **Epiblema:** Epiblema is the outermost layer of Root. It consists of single layer of compactly arranged, rectangular, thin walled cells. Some of the cells develop into unicellular, tubular cells called '**Root hair**'. It is meant for absorption.

2. **Cortex:** Cortex is composed of many layers of Parenchyma cells with intercellular spaces. **Endodermis** is the innermost layer of the cortex. It consists of single layer of barrel shaped cells with casparian strips on their radial walls. Few endodermal cells opposite to Proto Xylem are thin walled called '**Passage cells**'.

3. **Stele:** Stele is composed of **Pericycle, Vascular bundle, Conjunctive tissue and Pith.**

a) **Pericycle:** Pericycle is the outermost layer of stele present below endodermis. It is made up of single layer of parenchyma cells.

b) **Vascular bundle:** - **Vascular bundle is Radial, Polyarch and Exarch.**(Radial-Xylem and Phloem are present alternately at different radii, **Polyarch-** There are many patches of Xylem alternating with equal number of Phloem Patches, **Exarch-** Protoxylem is present towards pericycle and Meta Xylem towards Pith.)

c) **Conjunctive tissue:** - Parenchyma tissue present between Vascular bundle is called '**Conjunctive tissue**'. d) **Pith:**-Central region of stele made up of parenchyma tissue constitutes '**Pith**'. It is very large.

Monocot Root- Maize

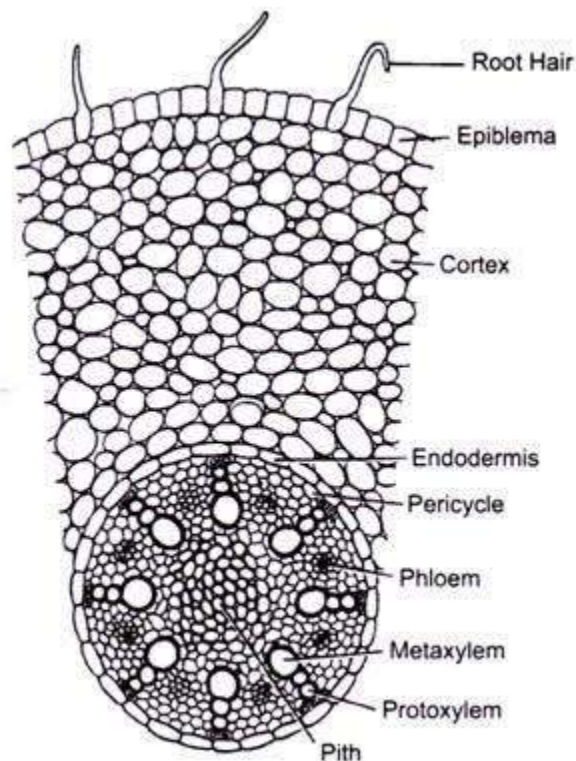


Fig. 4.5 ii Detailed structure of a portion of T.S. of Maize root (Monocot root)

Anatomy of Dicot Stem. EX;-Tridax stem

Transverse section of Dicot stem shows following Anatomical features:-

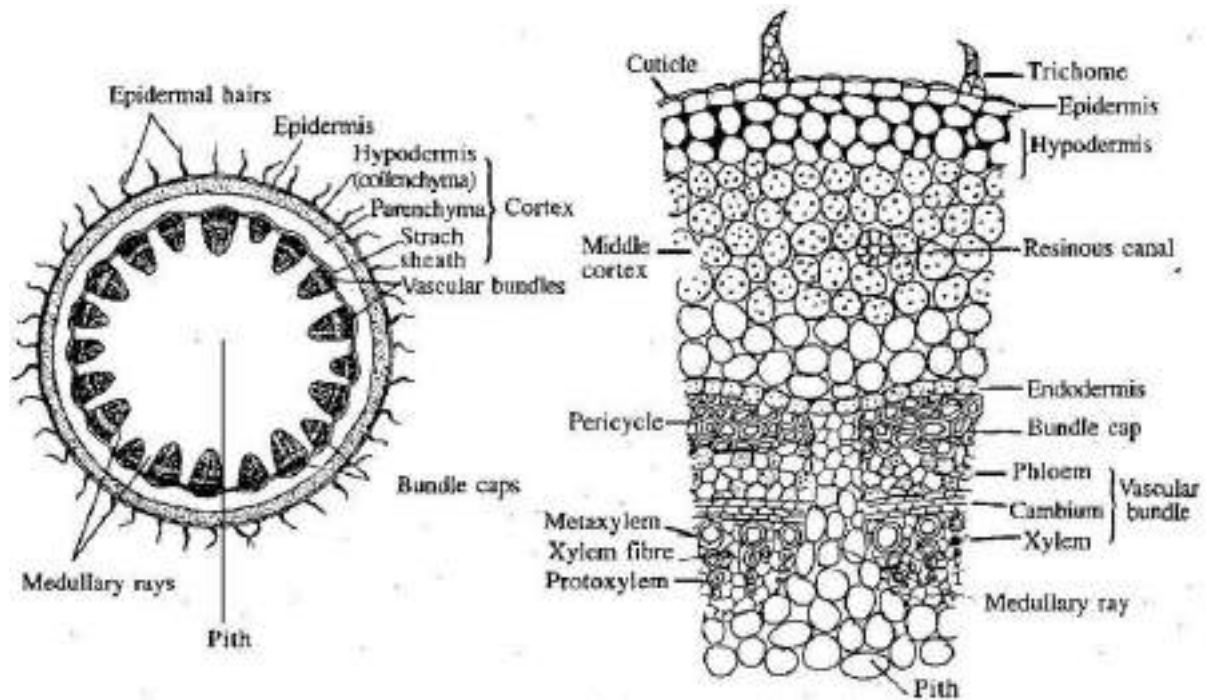


Fig. 3.5.1 : T.S. of young dicot stem (Sunflower) ground plan

Fig. 3.5.2 : T.S. of young dicot stem (Sunflower) - A sector enlarged

Anatomy of Dicot Stem - Tridax

1. Epidermis: -

Epidermis is the outermost, single layer of compactly arranged, tubular cells with cuticle on their outer walls. It bears multicellular epidermal hairs.

2. Cortex: -

Cortex is present internal to Epidermis. The outer zone of Cortex present below the epidermis consists of few layers of Collenchyma cells called "Hypodermis". Inner to Hypodermis is several layers of thin walled parenchyma cells. Its Outer cells contain chlorophyll. The innermost layer of the cortex is called Endodermis. It is made up of a single layer of barrel shaped cells with abundant starch and hence, called "Starch sheath".

3. Stele: - Stele is composed of Pericycle, Vascular bundle, Medullary rays and Pith.

a) Pericycle:-Pericycle is the outer layer of stele. It is sclerenchymatous in nature. There are more layers of Sclerenchyma opposite to Vascular bundles.

b) Vascular bundle:-Several Vascular bundles are arranged in a ring (Eustele). Each Vascular Bundle is Conjoint, Collateral, Open with Endarch xylem. (**Conjoint**-Xylem and Phloem are in a compact bundle, **Collateral**- xylem and Phloem lie in same radius, **open** – Strip of Cambium is present between Xylem and Phloem, **Endarch**- Protoxylem towards pith and Meta xylem towards Pericycle.,) Phloem is outer and Xylem is inner in position. (Xylem contains Vessels, Tracheids, Parenchyma and Fibers).

c) Pith (Medulla):- Centre of the stem is occupied by well developed parenchymatous Pith.

Anatomy of Monocot Stem. EX;-Canna stem

Transverse section of Monocot stem shows following Anatomical features:-

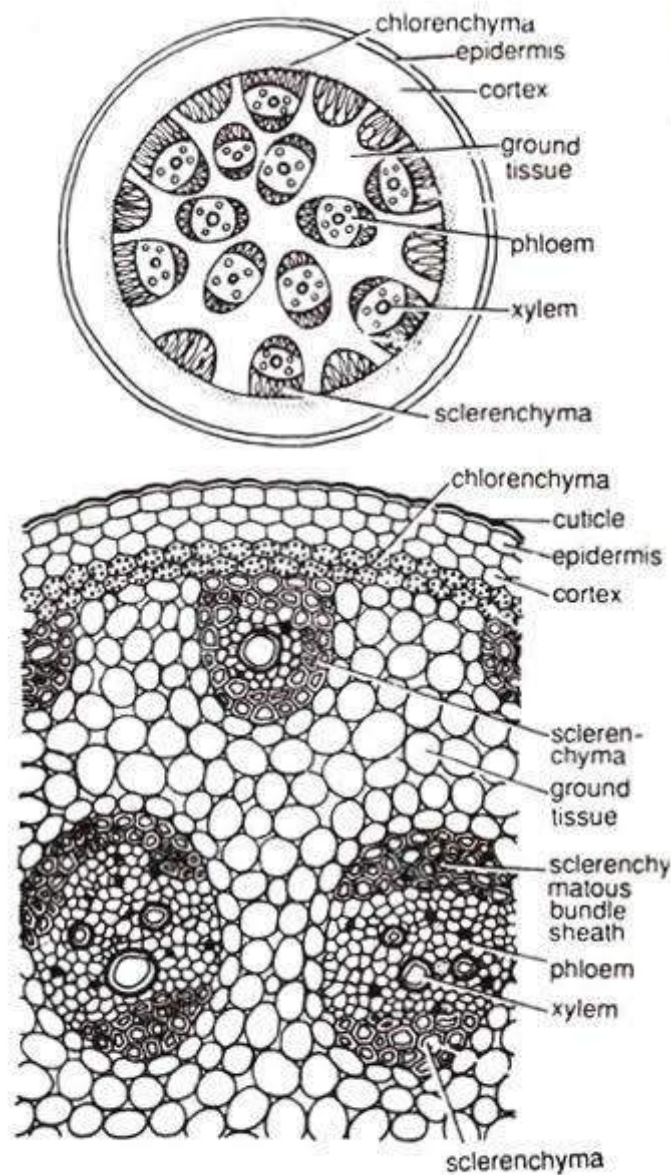


Fig. 109. *Canna*: Upper – T. S. stem (diagrammatic);
Lower – T. S. stem (A part cellular).

Monocot stem- *Canna*

1. Epidermis: -

Epidermis is the outermost, single layer of compactly arranged, tubular cells with cuticle on their outer walls. Epidermal hairs are absent, and Few Stomata are present.

2. Ground tissue: -

Ground tissue is present internal to Epidermis. Just below epidermis few layers of Sclerenchyma cells are called “**Hypodermis**”. Rest of the ground tissue is Parenchymatous in which vascular bundles are scattered (Atactostele). Endodermis; Pericycle, Medullary rays and Pith are absent.

b) Vascular bundle:-

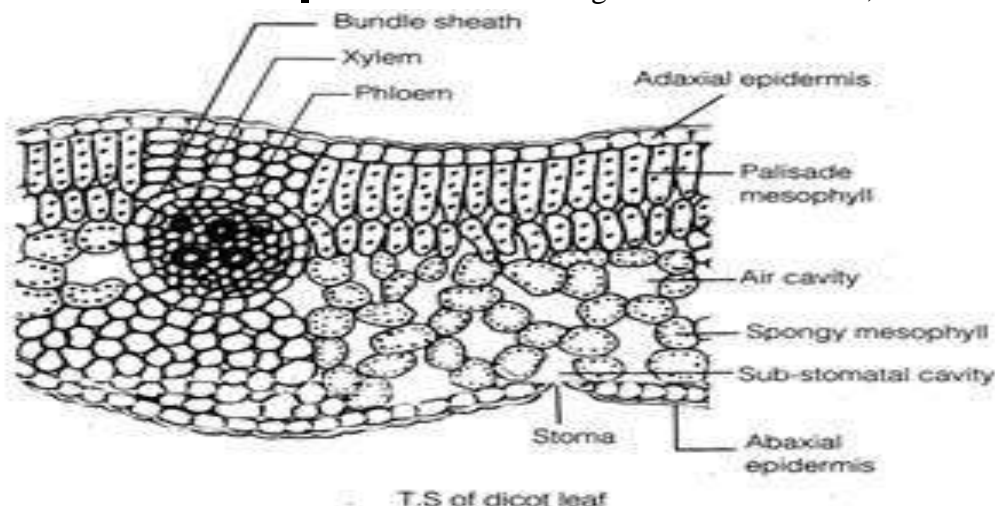
Vascular bundles are many scattered in the ground tissue. (Atactostele). Peripheral vascular bundles are small closely arranged; Central bundles are larger, less crowded.

Each Vascular Bundle is **Conjoint, Collateral, and Closed with endarch xylem.** (Conjoint-Xylem and Phloem are in a compact bundle, **Collateral**-Xylem and Phloem lie in same radius, **Closed** – Cambium is absent between Xylem and Phloem, **Endarch**- Protoxylem towards center and Meta xylem towards Periphery,) Phloem is outer and Xylem is inner in position. (Xylem contains irregularly arranged Tracheids, Four distinct Vessels arranged in the form of letter ‘Y’. 2 smaller vessels towards centre constitute Proto xylem and two bigger vessels present laterally constitute Meta xylem. Cavity formed due to breaking of proto xylem forms ‘**Water containing cavity**’. Phloem consists of Sieve tubes and companion cells. There is no Phloem parenchyma.

Anatomy of Dorsiventral leaf:-

Transverse section of Dicot leaf (Dorsi ventral leaf.) Ex: Dicot leaf. In Dicot plants grows leaf at right angle to stem, so tDorsal surface is more exposed to sunlight than ventral surface. Hence they show differences between upper and lower surfaces externally and internally Hence they are called

Dorsi ventral leaf. It shows following anatomical features:-



Anatomy of Dicot Leaf

1. Upper Epidermis:-It consists of single layer of continuous and compactly arranged rectangular cells with thick Cuticle. Multicellular hairs are present. It is protective in function.

2. Lower Epidermis: - It consists of single layer of discontinuous and compactly arranged rectangular cells with thick Cuticle. Few stomata are and multicellular hairs are present.

3:-Mesophyll:-Parenchyma tissue present in between Epidermal layers in leaf is called “Mesophyll”. It is differentiated into **a) Palisade Parenchyma:** - It consists of 2 to 3 layers of cylindrical, elongated compactly arranged Parenchyma cells with plenty of chloroplasts. It is placed at right angles to epidermis. **b) Spongy Parenchyma:** - It is composed of loosely arranged, isodiametric parenchyma cells with less number of chloroplasts. It is present between palisade parenchyma and Lower Epidermis.

4. Vascular bundles: - Mid and veins in Lamina are the regions of Vascular bundles. Phloem is present towards Lower epidermis and Xylem towards Upper Epidermis. Each Vascular bundle is surrounded by Sclerenchymatous Bundle sheath.

Anatomy of Iso bi lateral leaf:-

2) Isobilateral leaf. Ex: Monocot leaf. In Monocot plants grows parallel to stem, so they are equally illuminated on both the surfaces. Hence they do not show differences between upper and lower surfaces. Hence they are called “Iso bi lateral Leaves”.

Transverse section of Monocot leaf shows following anatomical features:-

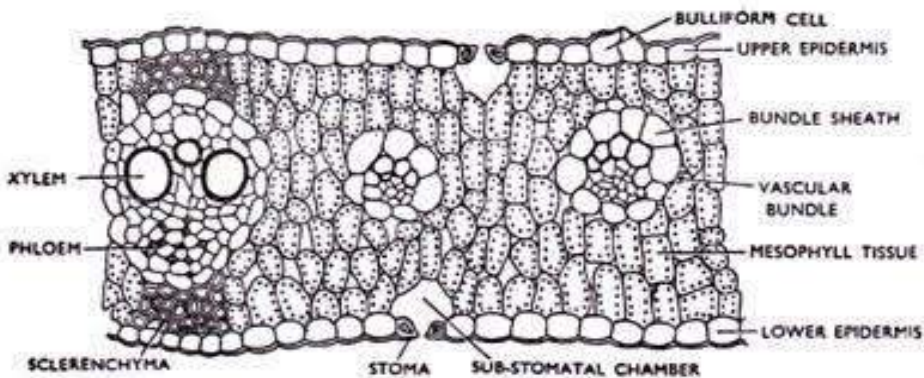


FIG. 619. A portion of leaf of *Zea* (maize) in transverse section.

Monocot Leaf- Grass/Maize.

1. Upper Epidermis:-It consists of single layer of compactly arranged, thick walled, rectangular cells with Cuticle. It contains Stomata and Bulliform cells. Each Stoma consists of 2 dumb-bell shaped guard cells and 2 triangular subsidiary cells. ‘**Bulliform cells**’ are also called as ‘**Motor cells**’. It consists of groups of thick walled cells which occur in longitudinal rows. In dry atmosphere, these loose water and bring about longitudinal rolling of lamina. Thus reduce rate of transpiration. It is protective in function.

2. Lower Epidermis: - It consists of single layer of discontinuous and compactly arranged rectangular cells with thick Cuticle. Few stomata are present.

3:-Mesophyll;-Parenchyma tissue present in between Epidermal layers in leaf is called “Mesophyll”. It is not differentiated into Palisade Parenchyma Spongy parenchyma. It consists of uniform, compactly arranged isodiametric cells containing chloroplasts.

4. Vascular bundles: - Lamina shows parallel venation; hence many larger smaller vascular bundles are seen in a section. In each vascular bundle Phloem is present towards Lower epidermis and Xylem towards Upper Epidermis. Each Vascular bundle is surrounded by parenchymatous Bundle sheath. Bundle sheath extension is Sclerenchymatous.

Study of Root modification.

Any change in normal form and structure of Root, in response to the need of the plant is called 'Root modification'. To perform special functions like food storage, to give mechanical support and to help in vegetative propagation both tap root and adventitious root are modified.

I.UNDERGROUND ROOT MODIFICATION.:In some plants both Tap root and Adventitious Root are modified for storage of food material.

A) TAP ROOT MODIFIED FOR FOOD STORAGE.

In many cultivated plants Primary root store food, become fleshy and enlarged. Based on its structure at maturity, it is classified as follows:-

1. CONICAL ROOT:-

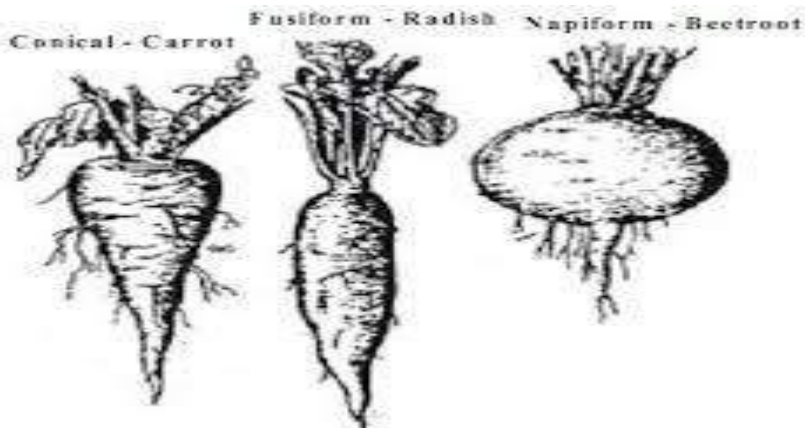
In Conical type primary root is broad at the base and gradually tapers towards the apex and become cone shaped to store the food material. Ex: Carrot (Dacus carota).

2. FUSIFORM ROOT :-

In Fusiform type primary root is broad in the middle, tapers at both the ends and become spindle shaped to store the food material. Ex: Radish (Raphanus sativa).

3. NAPIFORM ROOT:-

In Napiform type primary root is almost spherical shaped above and abruptly tapers towards apex to store the food material. Ex: Beet root (Beta vulgaris).



II.AERIAL MODIFICATION OF ROOT.

Adventitious roots growing from the aerial parts of the shoot system perform many functions like to give mechanical support, to help in breathing, sucking food material and absorption of water.

B) Adventitious root modified for giving mechanical support:-

Adventitious roots growing from the aerial parts of the shoot system are modified to perform functions like to give mechanical support. Based on the type of development it can be classified as follows:-

1. Prop root:-

Adventitious roots develops from horizontal branches of a tree, grows downwards, reaches the soil, become thick , woody, acts like pillars and gives additional mechanical support. Ex: Banyan (Ficus benghalensis).

2. Stilt root:-

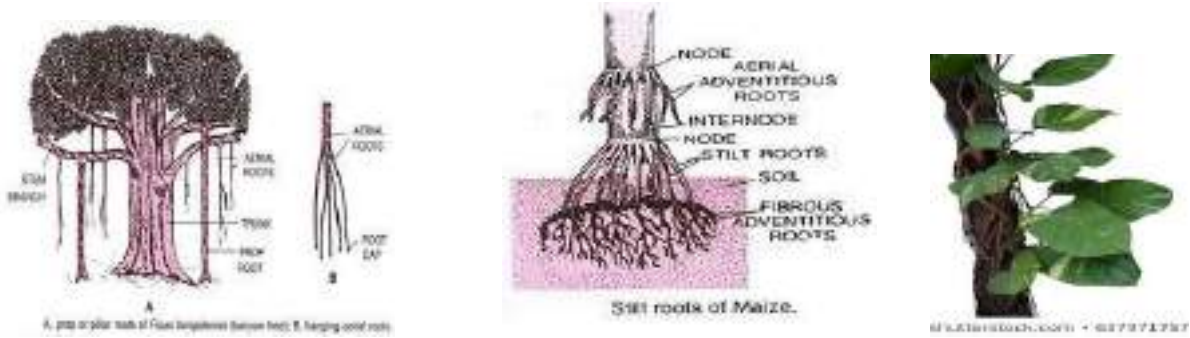
Stilt roots aerial adventitious roots developed from lower nodes of the stem. These grow obliquely downwards into the soil and give additional mechanical support.

Ex: Sugarcane. (Saccharum officinarum).

3Climbing root:-

Climbing roots aerial adventitious roots developed from nodes of the stem in climbers. (Weak stemmed plants). They clasp the supporting object and help to climb upon it.

Ex: Pepper (Piper nigrum), Betel (Piper betel), Pothos.



6. Study of Stem modifications.

Any change in normal form and structure of shoot or its parts, in response to the need of the plant is called 'stem modification'. It is classified into 3 types. They are 1) Underground stem 2) Sub-aerial stem and 3) Aerial stem modification.

1) Underground stem Modification

"Underground stems modifications". It includes 4 types. They are: -
A] Rhizome] Tuber C] Corm D] Bulb

A] Rhizome: -

Rhizome is a modified underground stem that grows horizontally below the soil surface. It consists of number of Nodes and Internodes. At nodes Scales are present. In the Axil of scale leaf Axillary bud and at the apex of Rhizome Terminal bud is present. Towards lower sides of the Nodes Adventitious roots are present.

The terminal bud develops into Leafy shoot and axillary bud develops into daughter Rhizome. These on separations from the mother plant, it develops into an independent plant.

Ex: Ginger, Turmeric

B] Tuber:-

Tuber is a bulged tip of lowermost branches of stem just below the soil surface. Tuber contains number of eyes that represent nodes. Each Eye consists of reduced scale leaf with axillary bud in its axil.

When Eyes of the Tuber separates from the mother Tuber and placed in moist soil, axillary develops into daughter plant. **Ex:Potato**

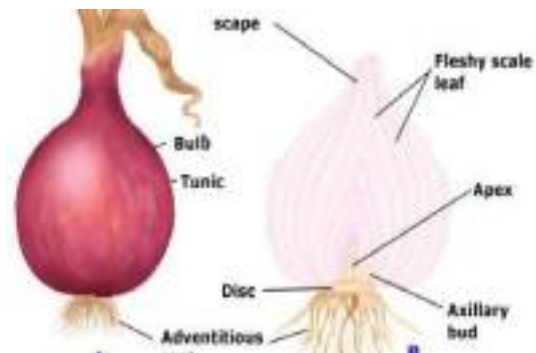
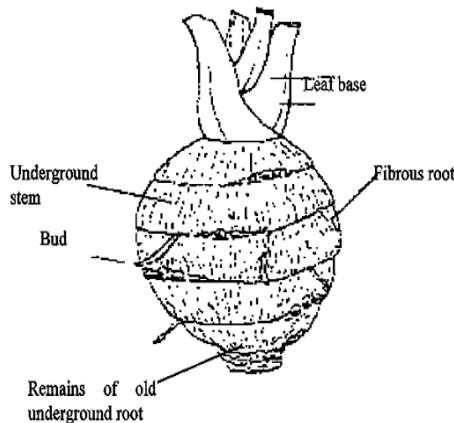
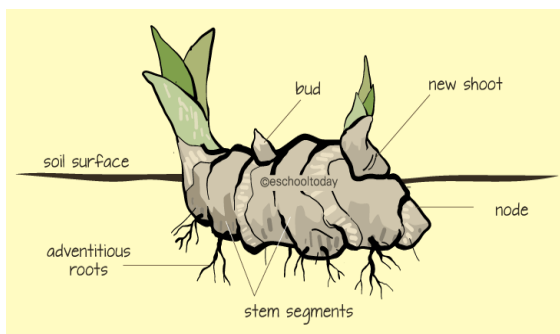
C] Corm: - Corm is an Underground stem. It is thick, Fleshy, Spherical shaped, grows vertically below the soil. It bears Scale leaves. In the axil of Scale leaves axillary buds are present. In its lower surface Adventitious roots are present. Single terminal bud develops into

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Leafy shoot. Axillary bud develops into daughter corm; this on separation from mother plant develops into independent plant. **Ex: Amorphophallus (Yam)**

D| Bulb: - Bulb is an underground modified stem meant for vegetative propagation and storage of food. In Bulb Stem is very much condensed into Disc like structure. From its lower surface number of adventitious roots develops and from its upper surface concentrically arranged fleshy scale leaves are present. In the axil of Scale leaf Axillary bud, at the central region terminal bud is present.

Terminal bud develops into flowering shoot and axillary bud develops into daughter buds. This on separation from mother Bulb develops into independent plant. **Ex: Allium cepa (Onion).**



Study of Aerial- StemTendrils, Stem Thorn, Phylloclade, Cladode, Bulbil.

B| Aerial Stem modifications:-

In Aerial stem modification the stem grows above the soil surface. The entire stem or different parts of the stem are modified to perform special functions like protection, Climbing, photosynthesis, vegetative propagation etc. It includes 5 types. they are as follows:- Stem tendril, Stem thorn, phylloclade, Cladode, Bulbil.

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1. Stem Tendril :-

Tendrils are long, slender, coiled modified structures which are sensitive to contact. They help the plants in climbing.

- In **Vitis quadrangularis** terminal bud is modified into Tendril.
- In **Passion flower (Passiflora)** axillary bud is modified into Tendril.

2. Stem Thorn:-

Thorns are hard pointed structures modified to provide protection.

- Ex: In **Canthium** axillary bud,
- In **Carrisa** Terminal bud is modified into thorn.

3. Phylloclade:-

Phylloclade is Green, Fleshy, Cylindrical or Flattened or Spherical structures meant for photosynthesis. Here Leaves at nodes are modified into spines or Scales to avoid Transpiration.Ex: - **Opuntia (Prickly pear)**.

4. Cladode:-

Cladode is a small, green, flat, leaf like modified lateral branch with only one or two internodes meant for photosynthesis. Leaves are reduced to small scales.Ex: **Asparagus**.

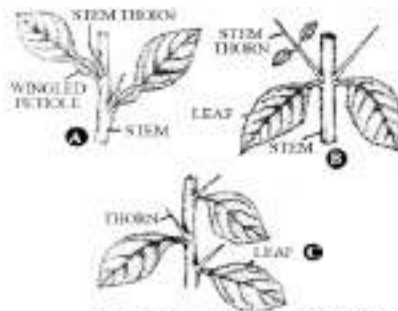
5. Bul-bil:-

Bul-bils are bulged vegetative or floral buds meant for Vegetative propagation.

- Ex: In **Agave** Florl buds.
- In **Dioscoria** Vegetative buds are modified.



TERMINAL BUD AS TENDRIL
(Ex: *Cissus quadrangularis*)



Stem thorns. A, *Citrus*; B, *Duranta*; C, *Bougainvillea*.

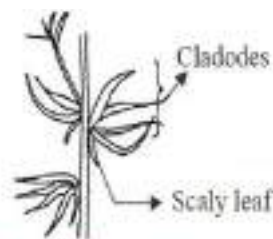
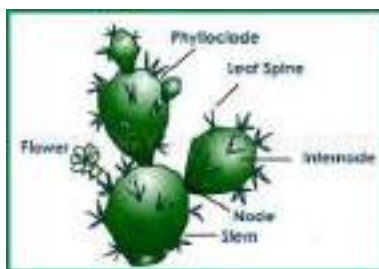


Fig. : Cladodes of *Asparagus*



7. Study of Leaf –Stipules, Phyllotaxy, its types and its modification-Tendril, Phylloclade (Australian Acacia).

Leaf is a Flat, green, lateral appendage developed at the nodal region on the stem.

Typical Dicot leaf posses 3 parts. They are Leaf base, Petiole, Lamina.

1. Leaf base:-The point of attachment of the Leaf to the stem is called “Leaf base”.

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2. **Petiole**—The narrow cylindrical, stalk of the leaf is called “**Petiole**”. The leaf with Petiole is called **Petiolate**; the leaf without Petiole is called ‘**Sessile**’.
3. **Stipule**—At the base of the Petiole arise a pair of lateral small, green outgrowths called ‘**Stipules**’. The Leaf with stipule is called:” **Stipulate**’. Leaf without stipule is called ” **Exstipulate**”.
4. **Lamina**—The flat, Green, expanded part of the Lamina is called “**Lamina** “or “**Leaf blade**”. The tip of the lamina is called “**Leaf apex**”, The Edge of the lamina is called “**Leaf margin**”. It may be smooth or entire or serrate or undulate or dentate or Spiny. The shape and size of Lamina shows variations.
5. **Mid-rib**— The main that extends from Petiole to apex in the middle of Lamina is called “**Mid rib**”, it is the main Vasculature. It gives rise to variously distributed “**Veins**”. These are secondary vasculature (Transport water, dissolved salts and Organic food).It gives rise to delicately branched “**Vein lets**”.



STIPULE

Stipule is a small leafy appendage present at the base of the leaf. It protects leaf in bud condition. The Leaf with stipule is called” **Stipulate**”. Leaf without stipule is called “**Ex stipulate**”.

KINDS OF STIPULES

1. **Free Lateral**: - Small greenish outgrowths one on either side of the leaf base is called” Free lateral”. It is the simplest type of stipule. **Ex: Hibiscus, Gossypium.**
2. **Adnate(Adherent)**:- Two lateral stipules fused with the petiole for some distance forming wing like structure . **Ex: Rose.**
3. **Interpetiolar**: In this type Stipules are present in between the petioles of opposite leaves. **Ex: Hamelia. Coffee.**
4. **Foliaceous(Foliaceous)**:-In this type Stipules are large, green and leaf likein structure.**Ex: Pea.**
5. **Ochreate**: In this type stipules fuse to form a tubular structure covering the stem above the node up to a certain height. **Ex: Polygonum.**

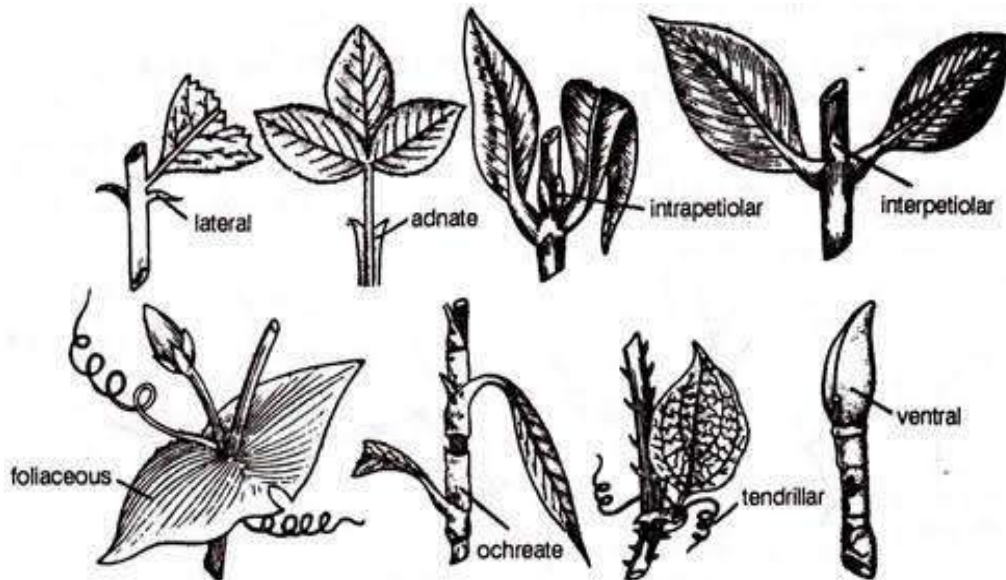


Fig. 74. Kinds of stipules.

TYPES OF LEAF

Based on the number of leaf blades per petiole Leaves are classified into 2 types. They are Simple leaves and Compound leaves.

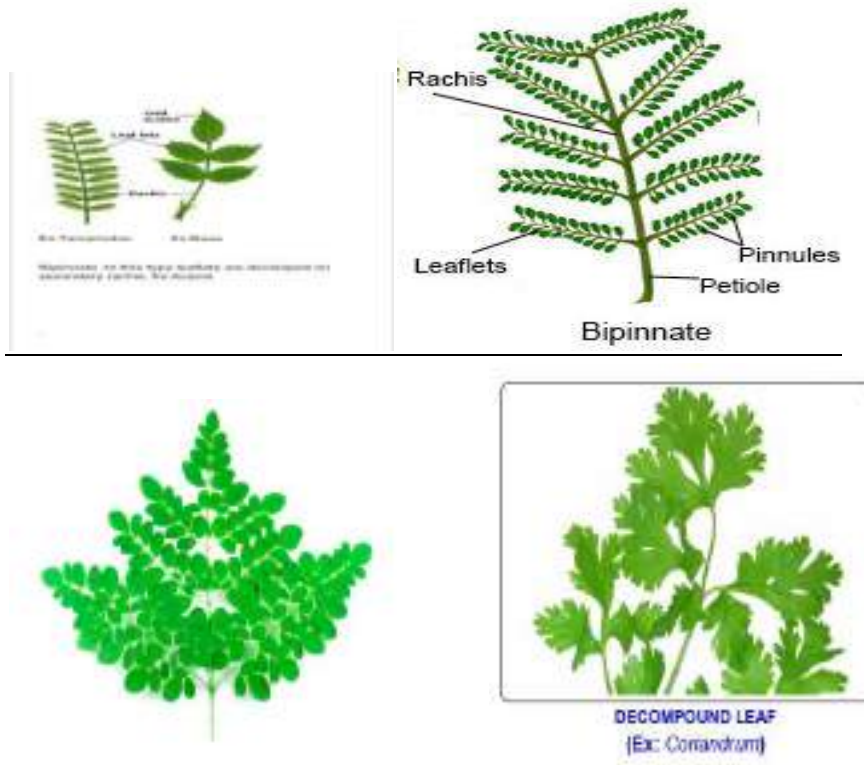
1. **Simple Leaf:** leaf with single Lamina is called “Simple leaf”.
2. **Compound:** Leaf with many leaflets arranged on Rachis is called “Compound leaf”. (Lamina is divided into many small separate units called ‘ Leaf lets’. Rachis is Petiole of the compound leaf).

Types of Compound leaf

Based on the arrangement of leaf lets compound leaf is classified into 2 following types: - I] Pinnately compound leaf, II] Palmately compound leaf

I] Pinnately compound leaf:- In Pinnately compound leaves leaflets arise along the sides of rachis. It is of following types:-

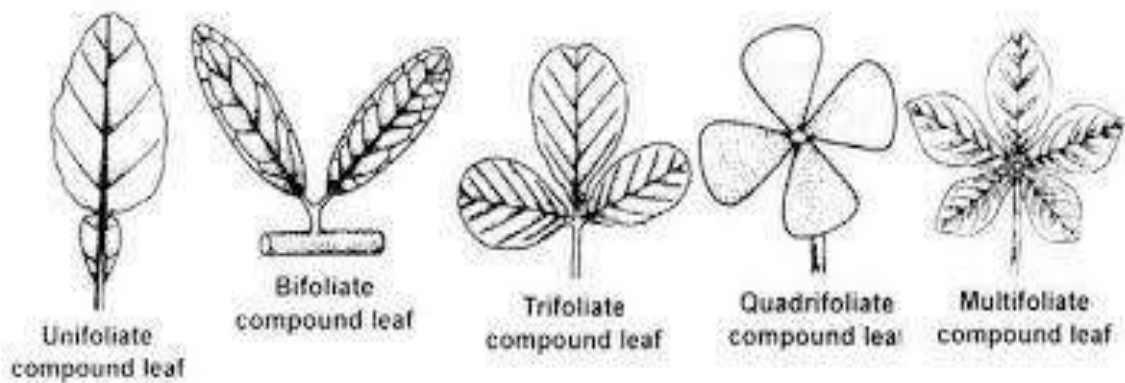
- **Unipinnate:** In this type, leaflets are developed on Primary rachis. If Rachis terminates in a pair of Leaflets it is called “**Paripinnate leaf**” .Ex: Tamarind. If Rachis terminates in single Leaflet, it is called as “**Immiparipinnate leaf**”. Ex: Rose.
- **Bipinnate:** -In this type, Leaf lets are developed on secondary rachis. Ex: Mimosa pudica.
- **Tripinnate:-**In this type Leaf lets developed on tertiary rachis. Ex: Moringa (Drum stick).
- **Decompound:** Rachis branched many times, with leaf lets on ultimate branches.



II] Palmately compound leaf:-

In Palmately compound leaves leaflets arise from single point at the tip of the petiole. Based on the number of leaf lets present It is of following types:-

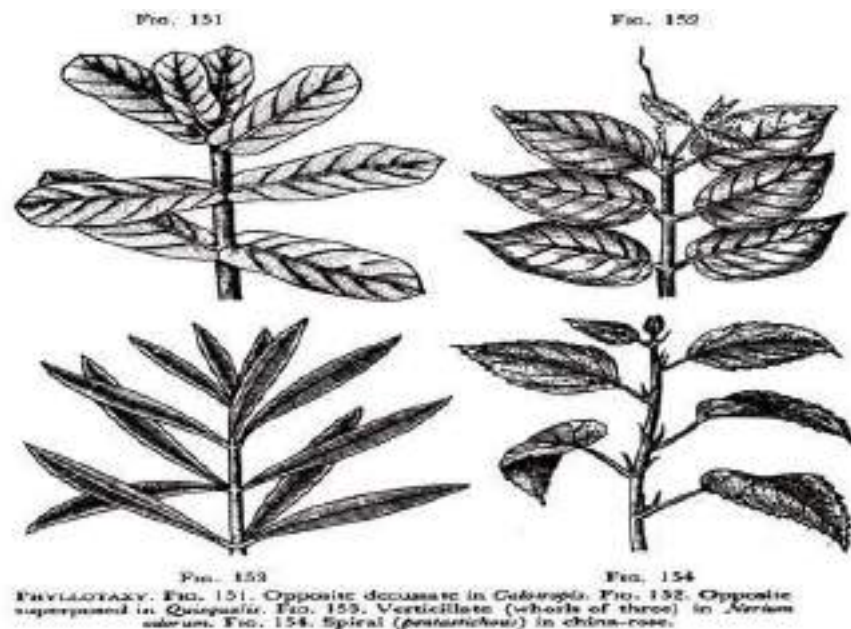
- **Unifoliolate:** - In this type single leaf let is attached to the winged petiole. Ex: Citrus.
- **Bifoliolate:** - In this type two leaf lets are developed from tip of petiole. Ex: Hardwickia.
- **Trifoliolate:** - In this type three leaf let's are developed from tip of the petiole.
Ex: Aegle marmelosus(Bilva patrae).
- **Quadrioliolate:** - In this type Four leaf let's are developed from tip of the petiole.
Ex: Marselia.
- **Multifoliolate:** - In this type more than Four leaf lets are developed from tip of petiole. Ex: Silk cotton.



PHYLLOTAXY

The pattern of arrangement of leaves on Nodes of the stem at its branches is called “Phyllotaxy”. It is derived from Greek term where ‘**phyllon**’ means leaf and ‘**taxis**’ means arrangement. Phyllotaxy can be classified into following types:-

1. **Alternate (Spiral):**-In Alternate type Single leaf at each node alternately. Or in a spiral manner around the stem. Ex: Hibiscus.
2. **Opposite:** -In Opposite type two leaves at each node opposite to each other.
In Opposite Decussate, a pair of leaves arise alternating planes at each node, at right angles to each other. Ex: Calotropis, Ixora.
In Opposite Superposed, A pair of leaves arise in same plane at successive nodes are on the same plane. Ex: Guava.
3. **Whorled:** - In Whorls Phyllotaxy three or more leaves arise in whorls at every node. Ex: Nerium.



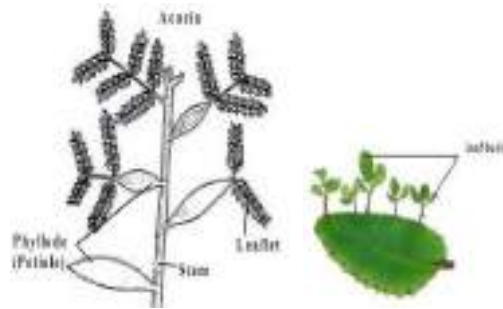
Modification of Leaves

Any change in normal form and structure of leaf or its parts, in response to the need of the plant is called ‘**Leaf modification**’. According to the nature of Special functions, the following leaf modifications are recognised:-

1. **Leaf tendrils:** - Tendrils are long, slender, coiled structures which are sensitive to contact and may develop from any part of the plant, meant for climbing. Such plants are called ‘Tendril climbers’. Ex: In Garden Pea terminal leaf let is modified into Tendril, In Gloriosa Leaf tip, In Smilax Stipules are modified into Tendril.
2. **Leaf Spines:**-Hard, pointed structure developed from leaf is called ‘**Leaf spine**’. It is meant for protection and to check transpiration. Ex: In Acacia stipules are modified into spines. In Date palm, Agave Tip of the leaf is spiny.

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3. **Phyllode:-** Green , flattened leaf like modified petiole or Rachis meant for photosynthesis is called ‘ **Phyllode**’. **Ex:** In *Acacia melanoxylon* secondary Rachis and leaf lets are shed during early growth and Petiole is modified into Phyllode.
4. **Leaf Buds:-** Leaf buds are adventitious Buds produced from the surface of the leaf , meant for Vegetative reproduction . They are also known as Epiphyllous buds. Ex: In *Bryophyllum*, Leaf buds ar developed along the margin. They develop roots below and leaves above. This can be developed into an independent plant.

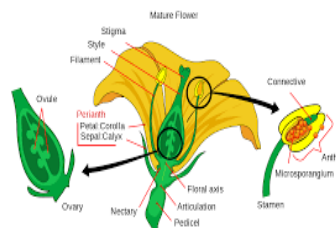


Garden Pea terminal leaf

Flower and it's Strcture . eg: Hibiscus.

Flower is a modified shoot meant for Sexual reproduction. A Typical Flower consists of following parts:-

1. **Pedicel** :- Stalk of the Flower is called “ Pedicel”. Flower with stalk is called ‘Pedicillate’ and flower without Stalk is called ‘Sessile’.
2. **Thalamus:-** Thalamus is the bulged tip of the Pedicel on which flower whorls like Calyx, Corolla, Androecium and Gynoecium are present.
3. **Calyx(K):-** Calyx is the outermost and protective whorl . It consists of small green Sepals.
4. **Corolla(C):-** Corolla is the second whorl of the Flower. It consists of coloured, attractive petals.
5. **Androecium(A) :-** Androecium is the third and Male reproductive whorl of a Flower. It consists of 10 Stamens. Each Stamen has long Filaments with 2 Anther lobes attached by connective.
6. **Gynoecium(G):** - Gynoecium is the innermost and female reproductive whorl. It consists of Basal Bulbous Ovary, Middle Style and terminal Stigma.



Study of Inflorescence-Racemose, Cymose, Special types.

INFLORESCENCE

“Cluster of Flowers produced by a plant, borne on a special reproductive axis is termed as an “Inflorescence”.

The main axis of the inflorescence is called “**Peduncle**”. Stalk of the Flower is called ‘**Pedicel**’. Stalked flowers are called “**Pedicillate**” and stalk less flowers are called “**Sessile**”. Bract is a leaf like structure which bear flower or an Inflorescence. Flower with bract is called ‘**Bracteate**’ and Flower without bract is called ‘**ebracteate**’. Pair of small, scale like structures developed on either sides of the pedicel between the flower and the Bract is called “**Bracteoles**”. Flower with Bracteoles is called ‘**Bracteolate**’ and Flower without Bracteole is called ‘**ebracteolate**’.

TYPES OF INFLORESCENCE

The Inflorescence are classified into 2 main types .They are 1) **Racemose or Indefinite type** 2) **Cymose or Definite**

I. Racemose Inflorescence or Indefinite:-

Racemose inflorescence is further classified into following types. They are as follows:-

a. Simple Raceme:-

In this type **elongated Peduncle bears Pedicillate flowers in acropetal manner**. Ex Cassia.

b. Spike:- In this type **elongated peduncle bears sessile flowers in Acropetal manner**. Ex: Acyranthus



c. Spadix:- In this type **Peduncle is thick, fleshy, bears sessile unisexual flowers. Entire inflorescence is enclosed by single, large, coloured bract called” Spathe’**. Ex: Colocasia. If Axis of Spadix is branched , each branch bears unisexual flowers & entire florescence is covered by large woody, boat shaped bract, it is called “**Compound Spadix**”. Ex: Musa, Coconut.

d. Corymb:-In this type **Peduncle is short and Pedicels of the lower flowers are much longer than upper flowers**, so that all flowers are more or less placed at the same level. Ex; Gold mohur.

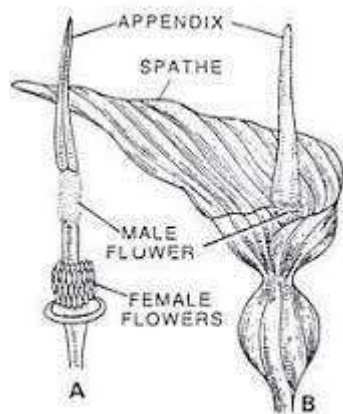


Fig. 34.50. Inflorescence-spadix-A, spadix of an aroid without spathe; B, same with spathe.



e. Umbel:-

In this type Peduncle is highly condensed, flowers have equal length pedicels arising from same point. Flowers are bracteate and bracts are arranged in a whorl at the base to form Involucre. Ex: Onion. If the main axis is branched and branches are of equal size, which bear flowers with pedicels like Umbel, it is called “**Compound Umbel**”. Ex: Carrot, Coriander.



f. Head or Capitulum:-

In this type Peduncle is flattened to form a circular disc called “Receptacle”. On its lower surface it bears large number of green bracts forming an Involucre. The Flowers are arranged on the receptacle in a centripetal manner. I.e. The central flowers are younger and peripheral ones are older, and the sequence of blooming is from periphery towards the centre.

The sessile small flowers are called ‘Florets’. There are 2 types of Florets, the peripheral Zygomorphic Ray florets and central, actinomorphic ‘Disc florets’. Based on type of florets in an Inflorescence it can be grouped into 2 types, namely 1) **Homogamous head** – Head inflorescence with only one type of Floret. 2) **Heterogamous head**- Head inflorescence with both Ray floret and Disc floret.

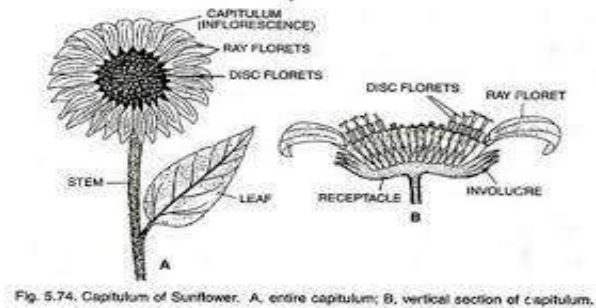


Fig. 5.74. Capitulum of Sunflower. A. entire capitulum; B. vertical section of capitulum.

II. Cymose Inflorescence or Definite type:-

Cymose Inflorescence shows following characters:-

- Peduncle shows **limited growth**; hence it is also called “**Definite Type**”.
- Peduncle **terminates in a Flower**.
- Flowers are arranged in **Basipetal manner** i.e., The Older flower is present in terminal region and Younger flowers are towards the base.
- The order of opening of Flowers is ‘**Centrifugal**’ i.e., the central older flowers in the inflorescence open first and the younger peripheral ones open later, while the central flowers are younger and open later.

TYPES OF CYMOSE INFLORESCENCE

1. **Solitary cyme:** Inflorescence axis end up in a single flower. Ex: Hibiscus



2. **Monochasial or Uniparous cyme:** -

In this type the main axis terminates in a flower. It then produces lateral branch in the axil of a bract, which also ends in a flower. On the basis of development of flowers two main forms are recognized. They are:- Helicoid cyme and Scorpid cyme.

- a) **Helicoid cyme:** - In this type successive branches are developed on the same side forming helix. Ex: Hamelia.
- b) **Scorpid cyme:**-In this type successive lateral branches are developed from bracts alternately on the opposite sides of the axes resulting in the Zigzag manner. Ex: Heliotropium.



Figure 4.6: (b) diagrammatic,
(c) Monochasial Helicoid

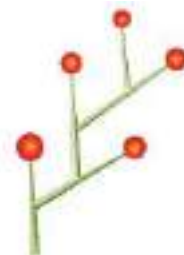


Figure 4.6: (d) diagrammatic,
(e) Monochasial Scorpioid



3. **Dichasial Cyme:** - In this type main axis terminates in a flower, and then 2 flowers develop from axils of oppositely placed bracts behind it. Ex; Jasmine. From this various compound Dichasium are developed as in Clerodendron, Ixora.

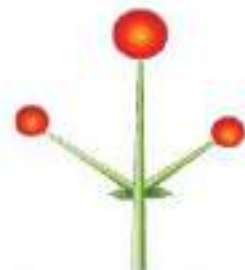


Figure 4.6: (f) diagrammatic,
(g) Simple dichasium



4. **Polychasial Cyme:**-In this type main axis terminates in a flower, then more than 2 lateral branches are developed simultaneously, each of which behaves in a similar manner. Ex: Calotropis.



Figure 4.6: (j) diagrammatic,
(k) Polychasial cyme



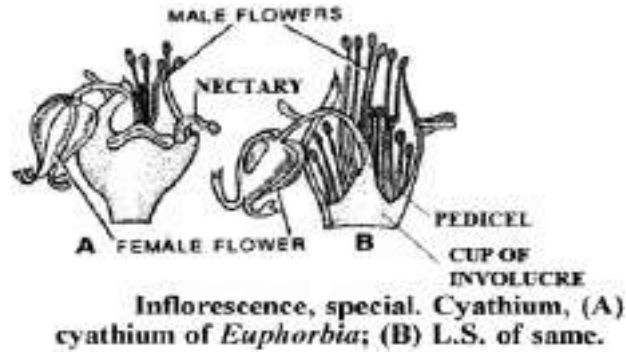
IV.SPECIAL INFLORESCENCE

Special Inflorescence may show characters of racemose or Cymose along with its own special characters. It includes 3 types, they are as follows:-

1. CYATHIUM, 2.HYPANTHODIUM, 3.VERTICILLASTER

1. CYATHIUM: -

Cyathium is a specialized cymose inflorescence. It has cup like structure formed by fusion of bracts. It encloses disc like axis with Single centrally placed pistillate flower (Female flower) with long pedicel which brings out of the cup. It is surrounded by many staminate flowers (Male flowers) arranged in Zig-Zag manner. Honey secreting disc called Nector gland is present towards one side of the cup. Ex: Euphorbia.



5. HYPANTHODIUM:-

In Hypanthodium Peduncle condenses to form fleshy, cup shaped receptacle with an opening called ‘Ostiole’. Receptacle encloses hollow cavity which bears unisexual flowers. Male flowers are present towards ostiole and female flowers towards base. Between these two are sterile Goll flowers. Ex: Figs.

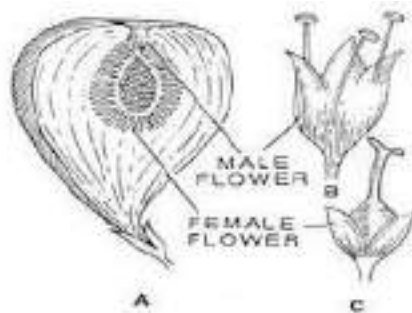


Fig. 34.57. Inflorescence. A. Hypanthodium of Fig; B. male flower; C. female flower.

6. VERTICILLASTER: -

Verticillaster is the characteristic inflorescence of the Family ‘Lamiaceae’. In this type in the axil of opposite leaves Biparous cyme develops, Lateral branches of it produces Uniparous Scorpioid cyme. The flowers are sessile and form a false whorl (Verticel) around the stem.



Figure 4.8: (c) diagrammatic,
 (d) Verticillaster

Study of Fruits-Simple, Aggregate and Multiple.

FRUITS

The Fertilized, ripened Ovary is called "Fruit". The fruit wall is called "Pericarp". The fruit developed from Ovary is called 'True fruit'. Fruit developed from other floral parts in addition to ovary is called 'False fruit'. Or 'Pseudo carp'.

CLASSIFICATION OF FRUITS

Fruits are classified into 3 main types. They are:-

- 1) **Simple fruits:** - Fruit developed from syncarpus ovary of a single flower.
- 2) **Aggregate fruits:** - Fruit developed from Apocarpus ovary of a single flower.
- 3) **Multiple fruits:** - Fruit developed from entire Inflorescence.

1) Simple fruits: -

Fruit developed from Monocarpellory or Polycarpellory syncarpus, ovary of a single flower is called "Simple Fruit".

TYPES OF SIMPLE FRUIT

Base don nature of Pericarp at maturity, simple fruits is classified into 2 types. Namely

I) FLESHY FRUITS II) DRY FRUITS

I) FLESHY FRUITS

Fleshy fruits are simple fruits in which Pericarp is thick, Fleshy and juicy at maturity. Pericarp is differentiated into outer Epicarp, Middle Mesocarp and Inner Endocarp. It includes 5 types. They are: - Drupe, Berry, Hesperidium, Pome and Pepo.

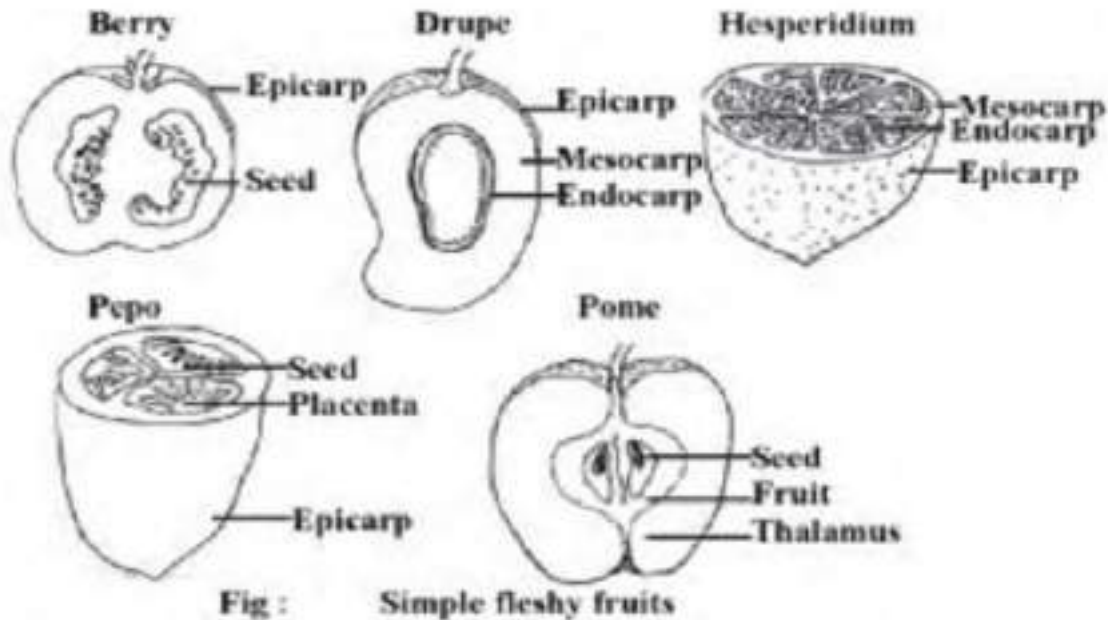
1. **Berry:-** Berry is a simple fleshy fruit developing from Bi or multicarpellory, syncarpous ovary. Entire pericarp is fleshy, juicy and edible. Ex: Tomato, guava, Sapota.
2. **Drupe: -** Drupe is a simple fleshy fruit developing from monocarpellary, syncarpous, superior or inferior ovary. Endocarp is hard enclosing seeds. Ex: Mango, Coconut.

In Mango- Epicarp forms the skin, mesocarp is fleshy, juicy and edible, and Endocarp is hard.

Coconut-Epcarp forms the skin, Mesocarp is fibrous, Endocarp is hard and Endosperm is edible.

3. **Hesperidium:-**Hesdperidium is a simple fleshy fruit developing from multicarpellory, syncarpus ovary with ovules on axile placenta. It is a characteristic fruit of the family Rutaceae.Epicarp and mesocarp unite to form thick rind, Endocarp is membranous, project inwards, form flakes, edible part is juicy ingrowths of endocarp.Ex: Lemon, Orange.
4. **Pepo:-**Pepo is a simple, fleshy flase fruit developing from inferior, Tricarpellory, syncarpous ovary with Parietal placentation. It is characteristic fruit of Family Cucurbitaceae. Placental tissue is fleshy, and edible. Ex: Cucumis, Pumpkin.

5. **Pome:-** Pome is a simple, fleshy fruit developing from inferior, syncarpous ovary. Thalamus is fleshy, Juicy, edible part. It encloses Pericarp and seeds. Ex: Apple, Pear.



Dry fruit

Dry fruits are **Simple fruits in which Pericarp is thin, dry at maturity** without distinction into EPicarp, Mesocarp and Endocarp. Based on the mode of dehiscence of fruit at maturity it is classified into 3 types. They are as follows:-

- 1. Dry dehiscent fruits: -**Pericarp split open to release seeds.
- 2. Dry indehiscent fruits: -** Pericarp never split open to release seeds.
- 3. Dry schizocarpic fruits: -** Pericarp splits into individual units which never break open.

1. Dry dehiscent fruits: - (Pericarp split open to release seeds).

In Simple Dry dehiscent fruits, at maturity Pericarp split open to release seeds. It includes following types:-

a) Legume (Pod):-

Legume is a dry dehiscent fruit that develops from superior, monocarpellory ovary with marginal placenta. It is a characteristic of Family Leguminosae.

At maturity Pericarp dehisce along both the margins to release seeds. Ex; Pea, Bean.

b) Follicle: - Follicle is a simple dry dehiscent fruit developing from superior, monocarpellory ovary.

At maturity pericarp dehisce along only on ventral suture to release seeds. Ex: Calotropis.

c) Siliqua:-

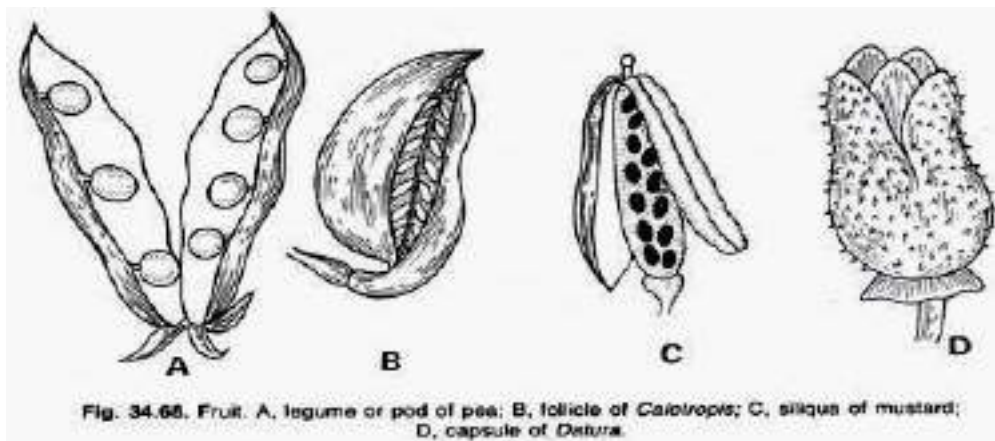
Siliquea is a dry dehiscent fruit that develops from superior, Bicarpellory, syncarpous ovary with parietal placentation. It is a characteristic fruit of the family Brassicaceae(cruciferae). At maturity pericarp splits along both the margins from base upwards. Seeds are attached to false septum called “Replum”. Ex: Mustard.

d)Capsule:-

Capsule is a Simple, dry dehiscent fruit developing from superior or inferior, multicarpellory , syncarpous ovary with ovules on axile placentation.

At maturity Pericarp may split along the middle of the locule called “Loculicidal capsule”.

Ex: Cotton, Lady’s finger. OR Split along the septa called “Septicidal capsule”Ex: Datura.



2. Dry Indehiscent fruits (Pericarp never split open to release seeds).

In Simple Dry indehiscent fruits at maturity pericarp never split open to release the seeds. The seeds are released only after the decay of the Pericarp. It includes following types.

a) Caryopsis:-

Caryopsis is a Simple Dry indehiscent fruit developing from superior, monocarpelory , unilocular ovary. It is a characteristic fruit of the Family ‘Poaceae’.

It is one seeded fruit in which Pericarp is united with the seed coat of seed. At maturity Pericarp never split open to release seed. Ex: paddy, Maize, Wheat.

b) Cypsella:-

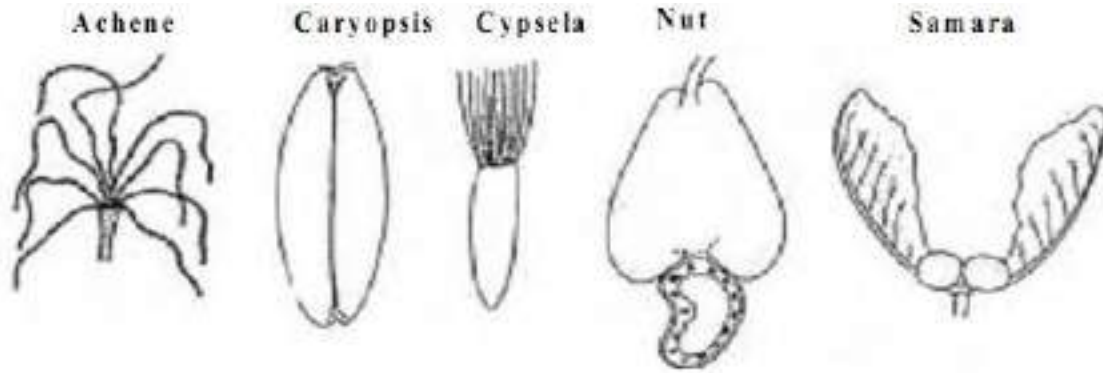
Cysella is a Simple Dry indehiscent fruit developing from inferior, Bicarpelory , syncarpous, unilocular ovary with basal placenta. It is a characteristic fruit of the Family ‘Asteraceae’.

It is one seeded fruit in which Pericarp is free from the seed coat of seed. Ex: Sun flower.

c) Nut:-

Nut is a Simple Dry indehiscent fruit developing from superior, monocarpelory , unilocular or polycarpellory ovary.

Here Pericarp is stony in nature. Ex: Cashew nut.



3. Dry schizocarpic fruits(Pericarp splits into individual units which never break open).

In Simple dry schizocarpic fruit, at maturity fruit breaks into individual, indehiscent units called 'Mericarps'. It includes following types:-

a) Lomentum:-

Lomentum is a simple dry schizocarpic fruit developing from monocarpellory, unilocular, superior ovary with marginal placentation.

At maturity fruit splits transversly into single seeded units called 'Mericarp'. Ex: Acacia.

b) Cremocarp:-

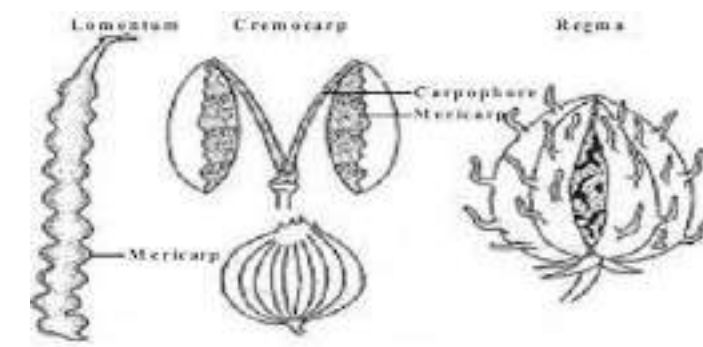
Cremocarp is a simple dry schizocarpic fruit developing from inferior, bicarpellory, syncarpous, inferior ovary. It is the characteristic fruit of family 'Umbelliferae'.

At maturity fruit splits vertically into 2 mericarps held together by central stalk called 'Carpophore'. Ex: Coriander.

c) Regma:-

Regma is a simple dry schizocarpic fruit developing from tricarpellory or multicarpellory, syncarpous, trilocular or multilocular, superior ovary.

At maturity fruit splits into many units as number of carpels. Each unit is called 'Coccus'. Ex: Castor, Geranium.



2) Aggregate fruits (Fruit developed from Apocarpus ovary of a single flower).

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An aggregate fruit develops from Multicarpellory, apocarpus ovary of flower. Each carpel develops into small fruitlet. Bunch of fruitlets are together called as 'Etaerio '.

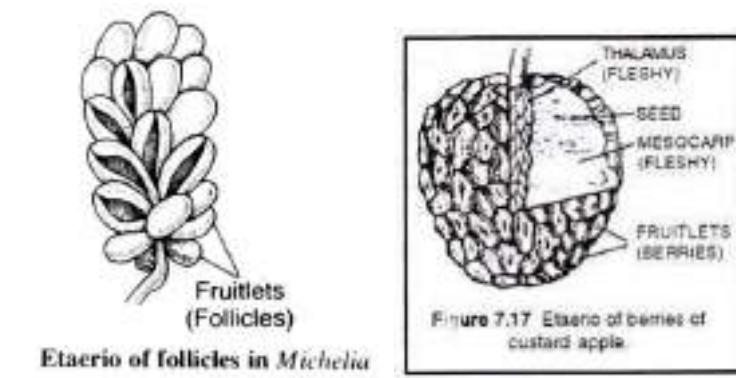
Based on the nature of fruitlets Aggregate fruits are classified into many types as follows:-

a) Etaerio of Follicle:-

This Fruit develops from Multicarpellory, apocarpus ovary of flower. Each carpel develops into small fruitlet of Follicle ie, it opens along only ventral suture to release seeds, thus all fruitlets together gives rise to Bunch of Follicle. Ex: Michelia.

c) Etaerio of Berry:-

This fruit develops from Multicarpellory, apocarpus ovary of flower. Each carpel develops into small fruitlet of Berry. ie, Entire pericarp is fleshy, juicy and edible. Thus all fruitlets together give rise to Bunch of Berry. Ex: Custard apple.



Ex: Michelia.

Ex: Raspberry.

Ex: Custard

apple.

3) Multiple fruits (Fruit developed from entire Inflorescence).

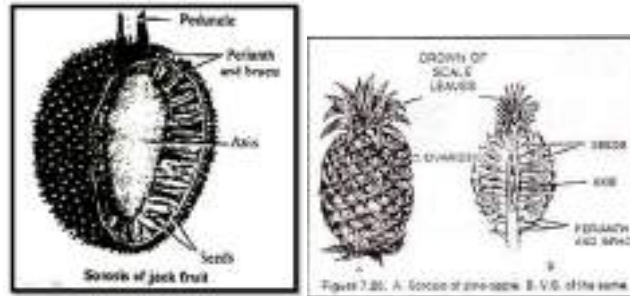
Multiple fruit develops from entire Inflorescence. It is a False fruit. It includes 2 types. They are: - **a) Sorosis and b) Synconus:-**

a) Sorosis:-

Sorosis is a Multiple fruit that develops from Spadix or spike or Cat kin inflorescence. Ex: Jack fruit (*Artocarpus heterophyllus*-Moraceae), Pineapple (*Annanus cosmosus* - Bromeliaceae) Mulberry(*Morus*- Moraceae).

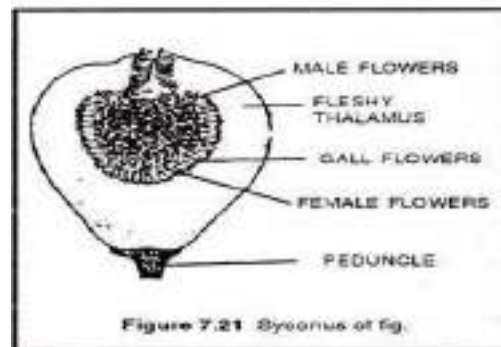
Jack fruit develops from Spadix inflorescence, central axis is peduncle. Fleshy; juicy, yellow and edible part is the perianth of flowers; inside the flake membranous bag containing seed represent pericarp. White, thin, less juicy chaffs are bracts. Spines on the rind are stigmas of the carpels.

Pine apple develops from Spike inflorescence, Fleshy; juicy, edible portion is Peduncle, bract and Perianth. Polygonal marks on the outer surface of the fruit correspond to each flower.



b) Synconus:-

Synconus is a Multiple fruit that develops from Hypanthodium inflorescence. Fleshy edible portion is the Receptacle. Ex: Figs.



Study of Vegetative propagation-Cutting, Grafting and Layering

ARTIFICIAL METHODS OF VEGETATIVE PROPAGATION.

Multiplication of plants by vegetative organs with the involvement of man is referred as **“ Artificial method of vegetative propagation”**. **This method is practiced to propagate valuable ornamental and Horticultural plants for Commercial purpose.**

Advantages of artificial propagation:-

1. New plants developed are exactly identical to the parent plant without alteration in genotype.
2. Many plants can be produced from a single plant in a short period.
3. Growth habit of the plant can be modified to environment.
4. Useful characters of 2 different individuals can be made to combine to obtain new variety.
5. It helps to produce more plants where seed output is less or plants do not produce seeds.

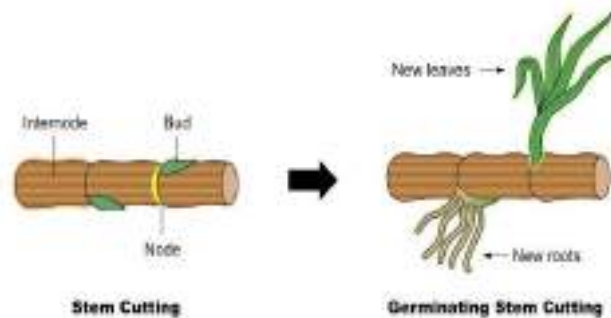
TYPES OF VEGETATIVE PROPAGATION

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Artificial method of vegetative propagation can be basically classified into 3 types. They are as follows:-Cutting ,Layering, Grafting

1.Cutting

Multiplication of plants by vegetative organs with the involvement of man is referred as “Artificial method of vegetative propagation”. **cutting** is a method of artificial method of vegetative propagation. In this method healthy branch of a plant is selected, cut into several pieces of 8 to 10 inches length. They are placed into fertile moist soil. From the portion of cutting below the soil surface roots develops and portion above the soil surface buds develops that grow into leafy shoot. Thus each stem cutting develops into an independent plant.Ex: Hibiscus, Rose, Sugar cane, Grapes.



2.Layering

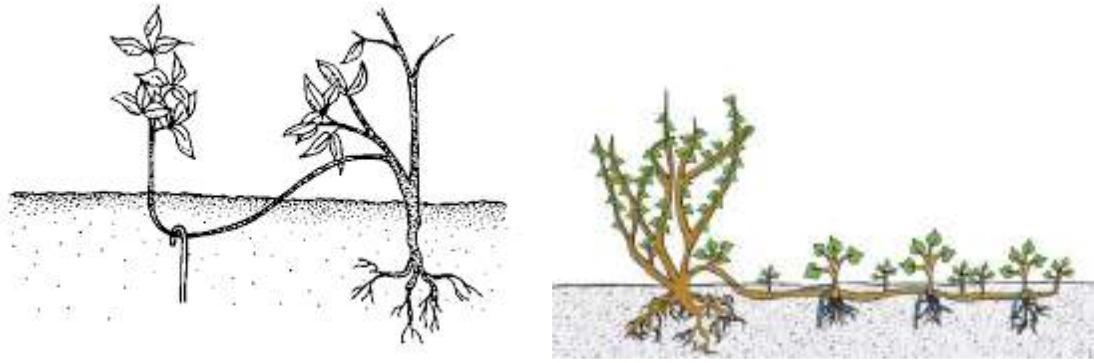
It is a method of artificial method of vegetative propagation. The development of roots from a branch when it is intact with the stem is called as “Layering”. The branch which develops roots is called “Layer”. The process of Layering involves following steps:-

- Select healthy branch of desired plant.
- Remove a ring of bark about 1 to 2 inches.
- Push this portion into moist soil keeping terminal portion of the branch free.
- Roots develop from the bark removed portion after 30 days.
- Cut off this from the main plant and it can be grown as an independent plant.

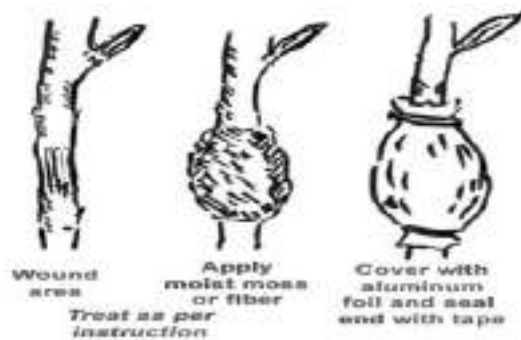
TYPES OF LAYERING: - Layering includes following types:-

A) Simple layering:- In this method any healthy branch of a plant is selected, 1 to 2 inches bark is removed, pushed into the moist soil, weight is placed to keep branch in position. After 30 days roots develops in the layered portion. This is separated from mother plant and grown as an independent plant.

B) Compound layering: - in this method long, flexible branch is selected, ring of bark is removed at several points, covered with the soil and watered regularly. After several days’ roots develops layered portion below and shoots in exposed region. Then branch is cut into pieces and grown into independent plants.



Air layering (Gootee):- It is an ancient method of Layering practiced in woody fruit plants. In this method woody branch of desired plant is selected, ring of bark of 2 to 5 cms is removed, this portion is sprayed with growth promoting hormones, thick plaster of grafting clay is applied, wrapped with soil and tied using polythene cover and regularly wetted. After 30 days roots develop in layered portion. Then separate it from mother plant by cutting it below the bandage and grown as an independent plant.



3.GRAFTING- It is a method of artificial method of vegetative propagation. In this method 2 different plants named as **Stock and Scion** are made to unite covered with grafting clay and grown as a single plant.

The branch selected as **Scion is allowed to grow on the branch of rooted plant which serves as Stock**. It is physically strong, supplies water and nutrition for scion.

Approach grafting:

1. The approach grafting is used if the base of the root stock plant is thicker than that of the scion plant.
2. A narrow cut of 7 to 10 cm long is made in the bark of the rootstock plant by making two parallel cuts and removing the strip of bark between, the cut should be exactly as wide as the scion to be inserted.
3. The stem of the scion plant should be cut long shallow along one side, of the same length as the cut in the rootstock plant and deep enough to go through the bark into the wood. This cut surface of the scion branch should be laid into the slot cut in the rootstock plant and held

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thoroughly and covered with grafting wax. After the union has healed, the rootstock can be cut off above the graft and the scion below the graft.

