Contribution of Anatomy to Taxonomy.

SANIA HAMID
ASSTT PROFESSOR IN BOTANY
GOVT COLLEGE FOR WOMEN GANDHINAGAR JAMMU

Anatomical evidence can be useful in systematics in several ways:

- When morphological characters prove to be of no help in the preliminary identification of a plant, anatomical study may prove helpful.
- Anatomy can well be exploited taxonomically in the identification of fragmentary material, say a piece of wood.
- Anatomical data has proved to be very useful in discerning evolutionary trends and interrelationships of taxa at and above the species level and at higher taxonomic categories.
- Anatomical characters are most useful in determining relationship between different genera, families, orders and other taxonomic categories.

IMPORTANT ANOTAMICAL CHARACTERS OF TAXONOMIC VALUE:

1. LEAF ANATOMY
2. STEM ANATOMY
3. PETIOLE ANATOMY
4. NODAL ANATOMY
5. WOOD ANATOMY
6. FLORAL ANATOMY
7. SCLEREIDS
8. STOMATA
9. SPECIALISED CELLS AND CELLULAR CONTENTS
10. TRICHOMES

LEAF ANATOMY

- Leaf anatomy has been used widely in several taxonomically different groups such as Euphorbiaceae, Cyperaceae and Gramineae of Angiosperms and Coniferae of Gymnosperms.
- It has been one of the most reliable characters in grass systematics. For example, the leaf anatomy of several species of Cyperaceae, was studied by Koyama and Govindrajalu and they formulated keys to identify various species of *Cyperus, Fuirena*, etc. Brown surveyed, 72 genera of grasses and on the bas of their tissue arrangement, six main types were recognized.
- Taxonomic implication of leaf anatomy of several genera of Musaceae, Zingiberaceae, Xanthorrhoeaceae and Ericaceae have also been established by several workers.

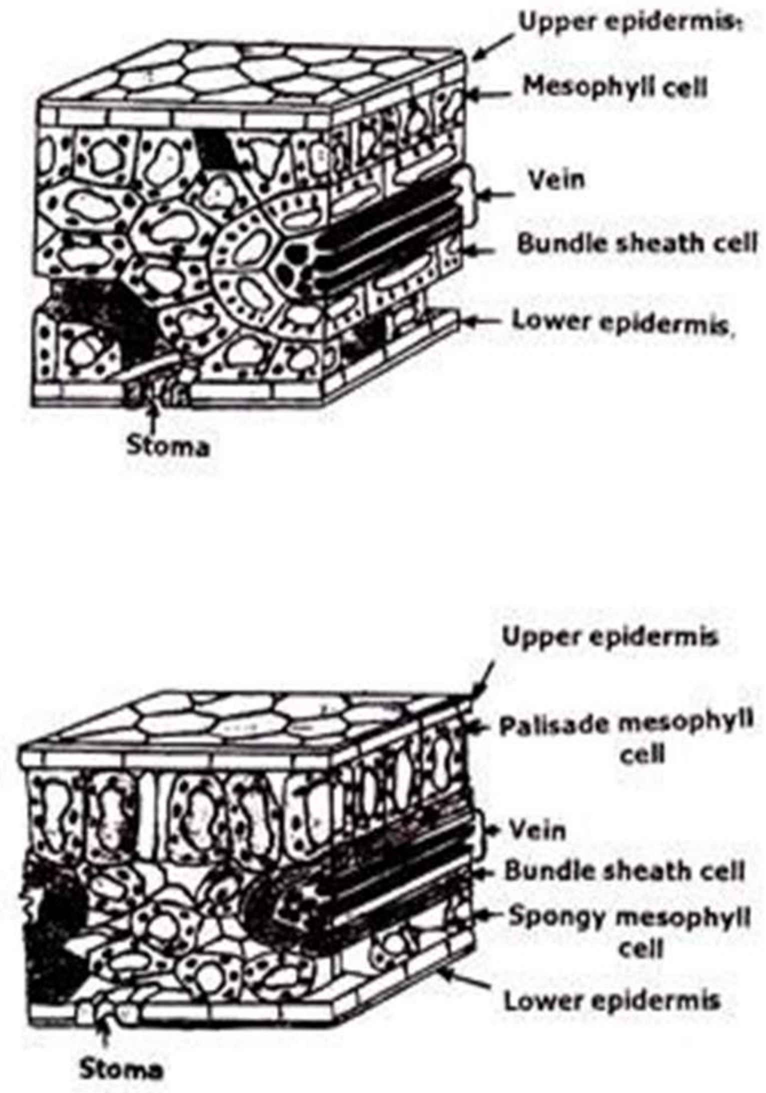


Fig. 8.2 : Cross-section of different types of leaves showing anatomical characters of taxonomic significance

Important characters of taxonomic significance in leaf anatomy include the following:

- **(i) Nature and thickness of epidermis :** Conde studied 5 species of the genus *Opuntia* with respect to cuticular thickness, epidermal papillosity, stomatal size and frequency, hypodermal thickness, vessel number, etc. and found that each species was distinct in respect of the degree of papillosity of epidermal cells, hypodermal thickness and vessel width.

- **(ii) Structure and types of mesophyll, storage parenchyma, mid vein structure, bundle sheath and secretory apparatus:** Anderson & Crech suggested precise groupings of *Solidago* and other species of Asteraceae based on their study of leaf anatomy, including qualitative and quantitative differences in mesophyll, storage parenchyma, secretory apparatus, bundle-sheath extension and midvein structure.

- **(iii) Distribution of Sclerenchyma :** Patterns of the distribution of sclerenchyma in *Carex* and *Festuca* have been used in distinguishing species.

- **(iv) Silica bodies :** Silica bodies in the epidermal cells of members of certain families like Zingiberaceae, Musaceae and Palmae among Monocotyledons and Rosaceae in the Dicotyledons have been used as diagnostic character in systematics at generic as well as specific levels

- **(v) Chloroplast structure:** This feature of leaf anatomy is also of taxonomic significance.

Stem Anatomy

Stem anatomy has also been long relied on as a taxonomic tool. Important anatomical features of stem which are diagnostically useful include:

- Degree of elevation of stem ridges.
- The distribution and abundance of collenchyma.
- Pattern of collenchyma thickenings.
- Transformation of ground tissue cells of cortex into transfusion cells — e.g. *Casuarina*.
- Distribution of fibres — e.g. *Genista.*
- Variation in the structure of the cells of stem endodermis — e.g. in families like Piperaceae, Asteraceae and Lamiaceae.
- Features of the stem pith — e.g. species of *Dubantia* and *Fitchia* have been distinguished on the basis of anatomical differences in pith.
- Shape and size of sclerenchyma — e.g. used to distinguish species of the subgenus *Genuini* of *Juncus.*
- Arrangement and type of vascular bundles — e.g. two species of *Dioscorea*, viz. *D. cayenensis* and *D. rotundata* have been distinguished on the basis of arrangement of vascular bundles in the stem, which otherwise are difficult to distinguish on exomorphic grounds.

PETIOLE ANATOMY

Petiole anatomy of 64 species of *Baphia* of Leguminosae have been studied by Soladoye, and some species of Phlomis and Eremostachys of Labiatae by Azizian and Cutler, which provide clear support of its use in the taxonomy of these genera.

Some of the important diagnostic characters of petiole anatomy include:

I. Position of petiole on stem.

II. Distribution of collenchyma and sclerenchyma.

III. Petiole outline.

IV. Number of layers of parenchyma in the cortex.

V. Vascularization of petioles.

VI. Distribution of perivascular fibres.

VII. Number of traces.

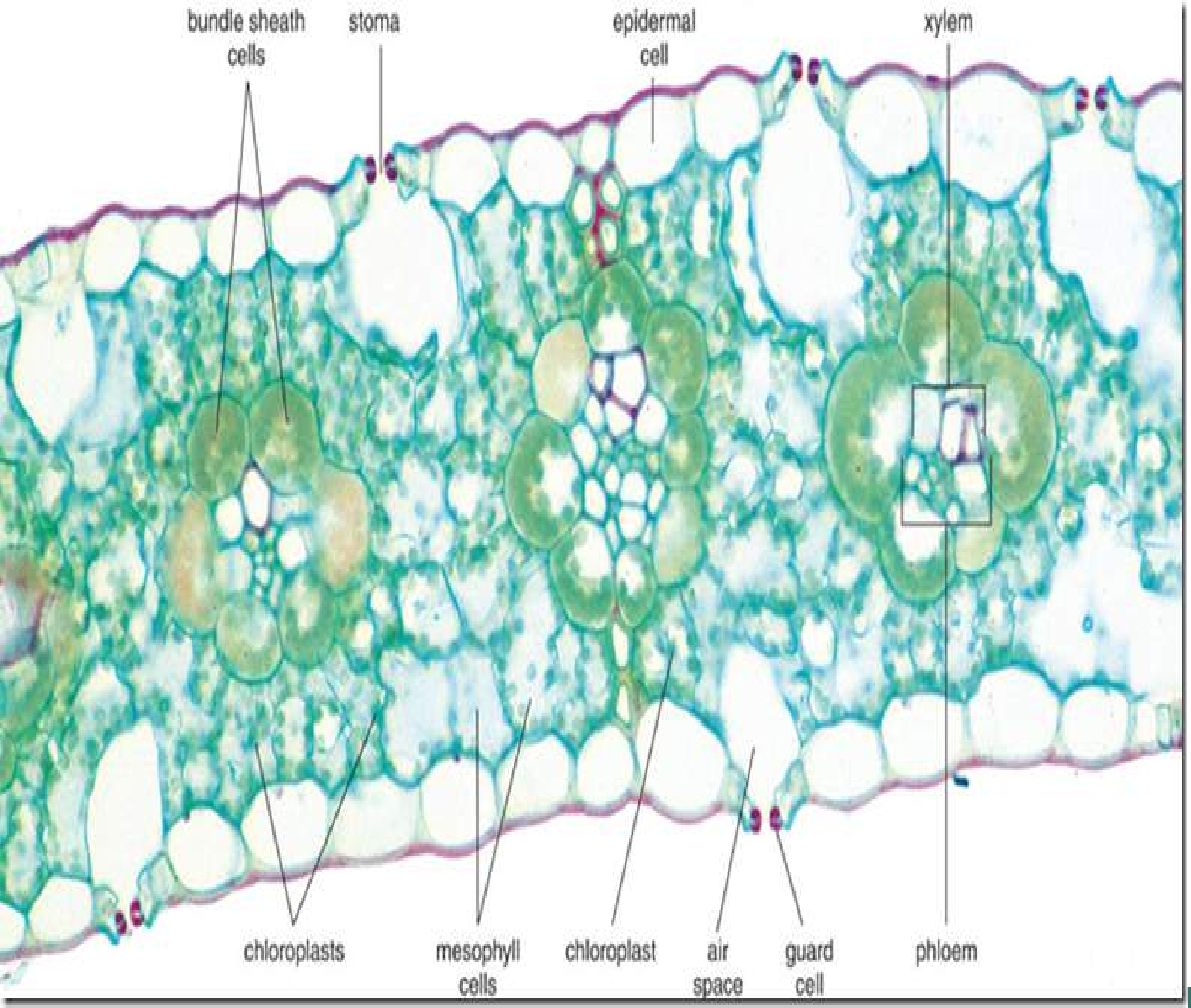


Fig: Leaf anatomy of C4 plant showing some taxonomically
important features.

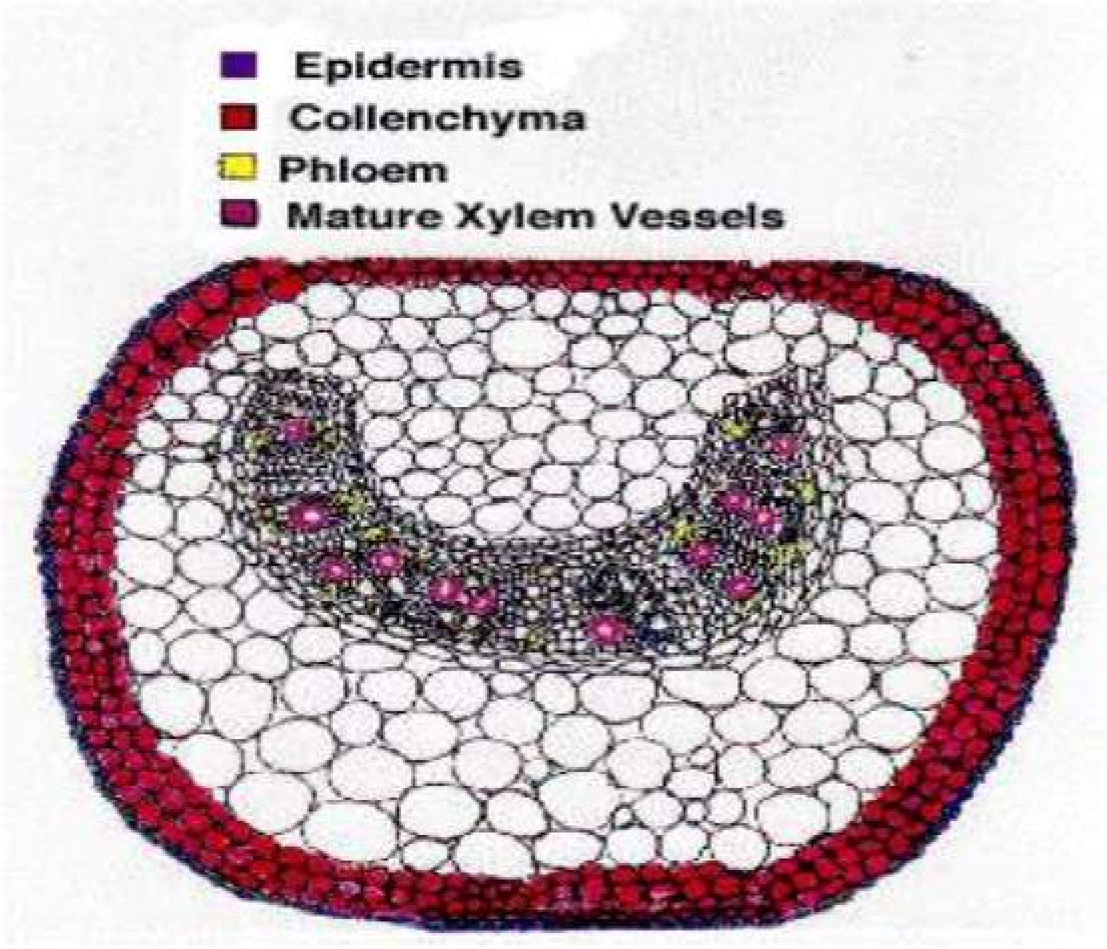


Fig: Petiole anatomy showing features of taxonomic value.

Nodal Anatomy

Correlations of nodal anatomy with some other features might help significantly in tracing the phylogeny of angiosperms. A comparative study of nodal anatomy may show important relationships or distinctness of genera or even species.

In general there are three major types of nodes:

- I. Unilacunar — occur in Laurales, Caryophyllales, Ericales, Ebenales, Primulales, Myrtales, some families of Tubiflorae and a majority of families of Asteridae.
- II. Trilacunar — occur in the majority of Dicotyledons.
- III. Multilacunar — occur in the primitive orders such as Magnoliales, Piperales, Trochodendrales and a few advanced orders such as Umbellule's and Asterales.

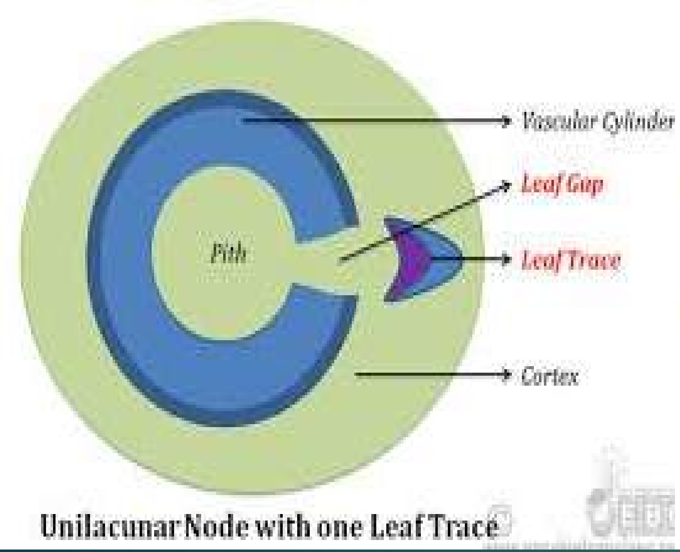
(Sinnott considered the tri-lacunar node as primitive, and unilacunar and multi-lacunar nodes as advanced. A fourth type of node was discovered by Marsden & Bailey)

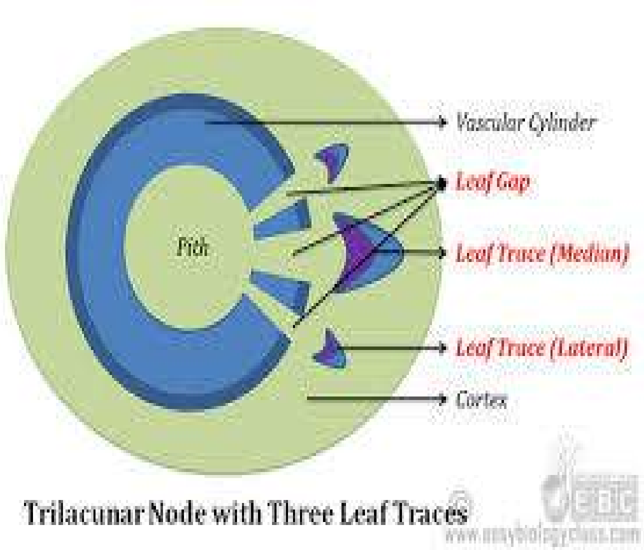
- IV. Unilacunar two-trace — It is now considered as the basic type of node found in angiosperms.

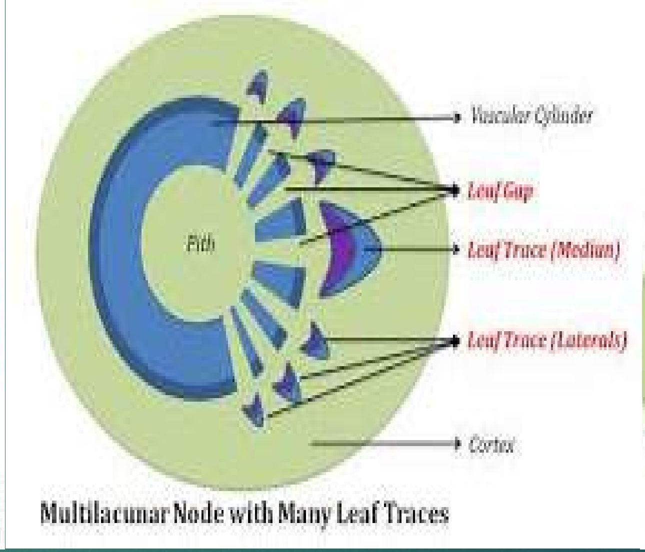
Usually, the mode of nodal vasculature is uniform in the family, but exceptions have also been reported, where different types of node occur even in the same individual plant.

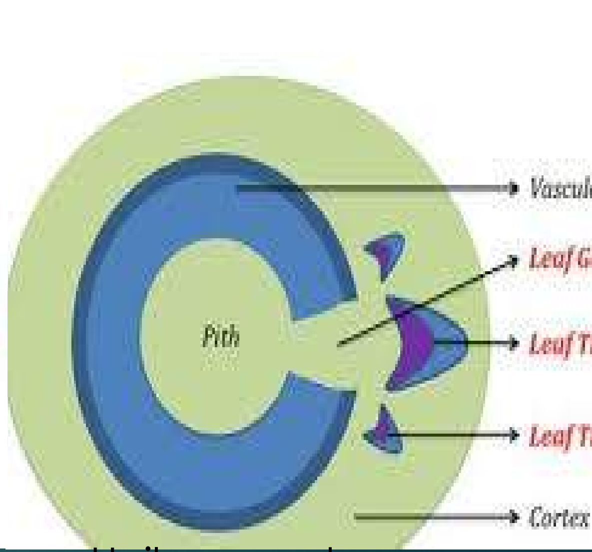
- **Example:**

On the basis of nodal structure, the subfamily Icacinoideae of the family Icacinaceae has been divided into two distinct groups i.e., one section, which is characterized by tri-lacunar nodes, while the other section, which is characterized by unilacunar nodes.



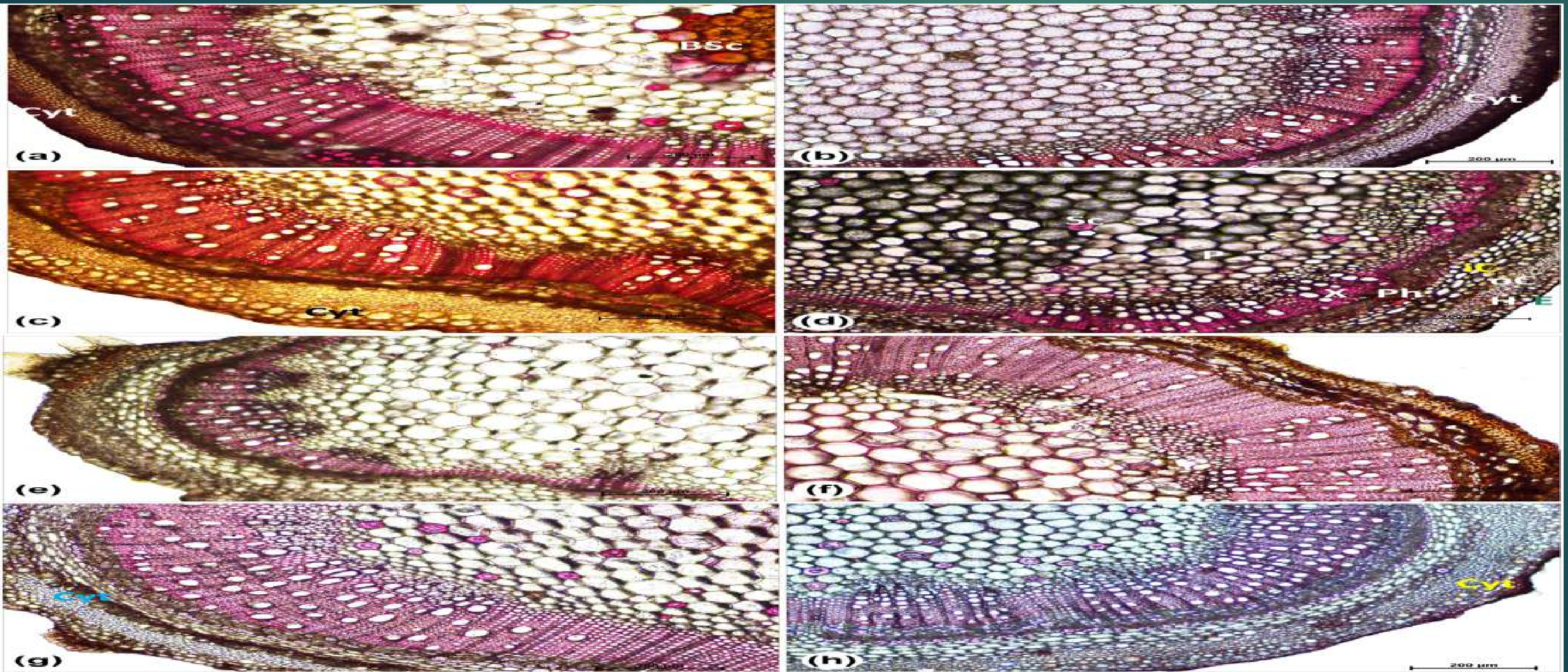






Unilacunar two -trace node

Types of nodes



Stem anatomy of various species of *Strobilanthes* (Family :Acanthaceae).

Wood Anatomy:

- Anatomical features of the wood (secondary xylem) have been very useful in taxonomic and phylogenetic studies.
- It has been successfully used in deciding the systematic position of primitive vessel less families such as Amborellaceae, Tetracentraceae, Trochodendraceae and Winteraceae, all included under the Magnoliales of angiosperms.
- Wood anatomy has been used to work out the phylogeny of families like the Salicaceae, Betulaceae, Fagaceae, Juglandaceae, etc.

The following features of wood anatomy have taxonomical significance:

1. **Vascular rays:**

- Rays with all the cells radially elongated i.e., homogeneous rays are considered advanced to the heterogeneous rays, i.e. rays with both vertically and radially elongated cells.
- The characteristics of vascular rays, which can prove useful as taxonomic criteria include: ray abundance. cellular composition of rays, dimensions of rays in tangential section, degree of wall thickness, etc.

2. Vessel elements:

They are considered to have been derived from the tracheids and their evolution (advancement) is considered to have occurred along the following lines:

- (i) Decrease in the length of vessel element.
- (ii) Transition from vessels with angular outline to nearly circular outline.
- (iii) Loss of borders and decrease of bars on perforation plates.
- (iv) Alteration from oblique to nearly transverse angle of end wall.
- (v) Pitting of lateral walls of vessels showing evolutionary series from scalariform to transitional to opposite to alternate.

Apart from the structure, the abundance of vessels, distribution of vessels, and sculpturing on vessel walls have also proved to be of taxonomic significance. Thus, solitary vessels are considered to be primitive to aggregate groupings, such as pore clusters, pore multiples and pore chains. Similarly, diffuse-porous woods are considered primitive to ring-porous woods.

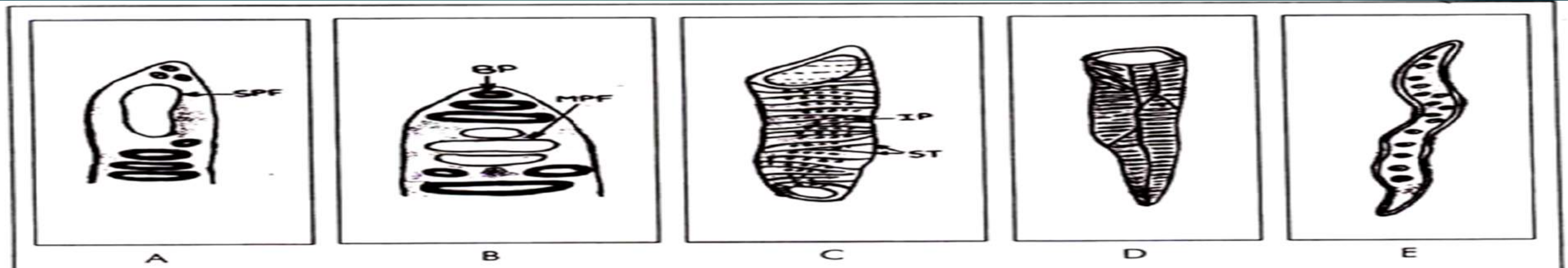


Fig. 8.5 : End walls of some tracheae (vessel members) – (A) With simple perforation plate (SPF); (B) with multiple (scalariform) perforation plates (MPF); (C) Complete tracheae with simple perforation plates, intervessel pitting (IP) and spiral thickening (ST); Tracheids - (D) with scalariform (E) with bordered pits (BP).

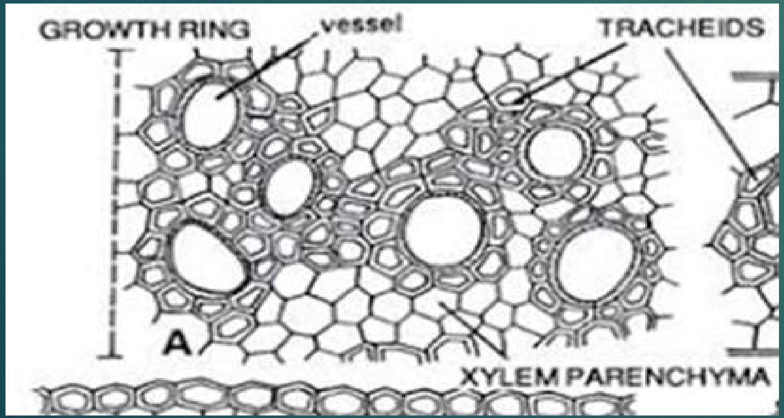
3.Axial parenchyma:

- The distribution and characteristics of the cells of axial parenchyma and the length and thickness and lignification of their walls, can be useful in taxonomic considerations.
- Based on the distribution of parenchyma cells, they can be of two types:

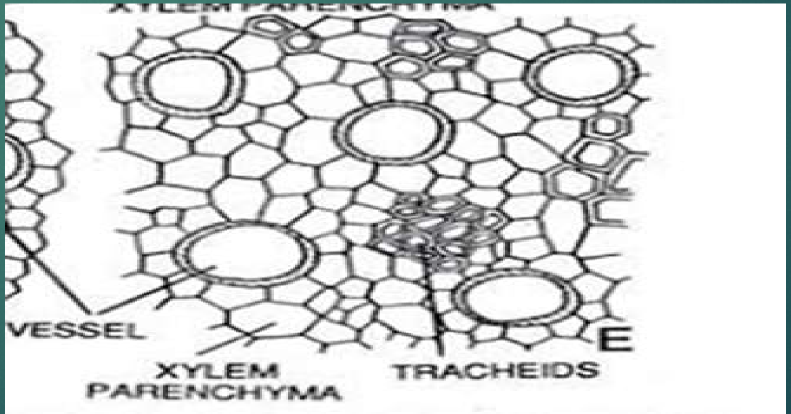
(i) Apotracheal — Parenchyma distributed without any specific relation to vessels.

(ii) Paratracheal — Parenchyma distributed in close association with vessels.

- Absence of parenchyma is considered to be feature of primitive families e.g., Winteraceae.
- Diffuse arrangement is primitive to apotracheal and paratracheal types.



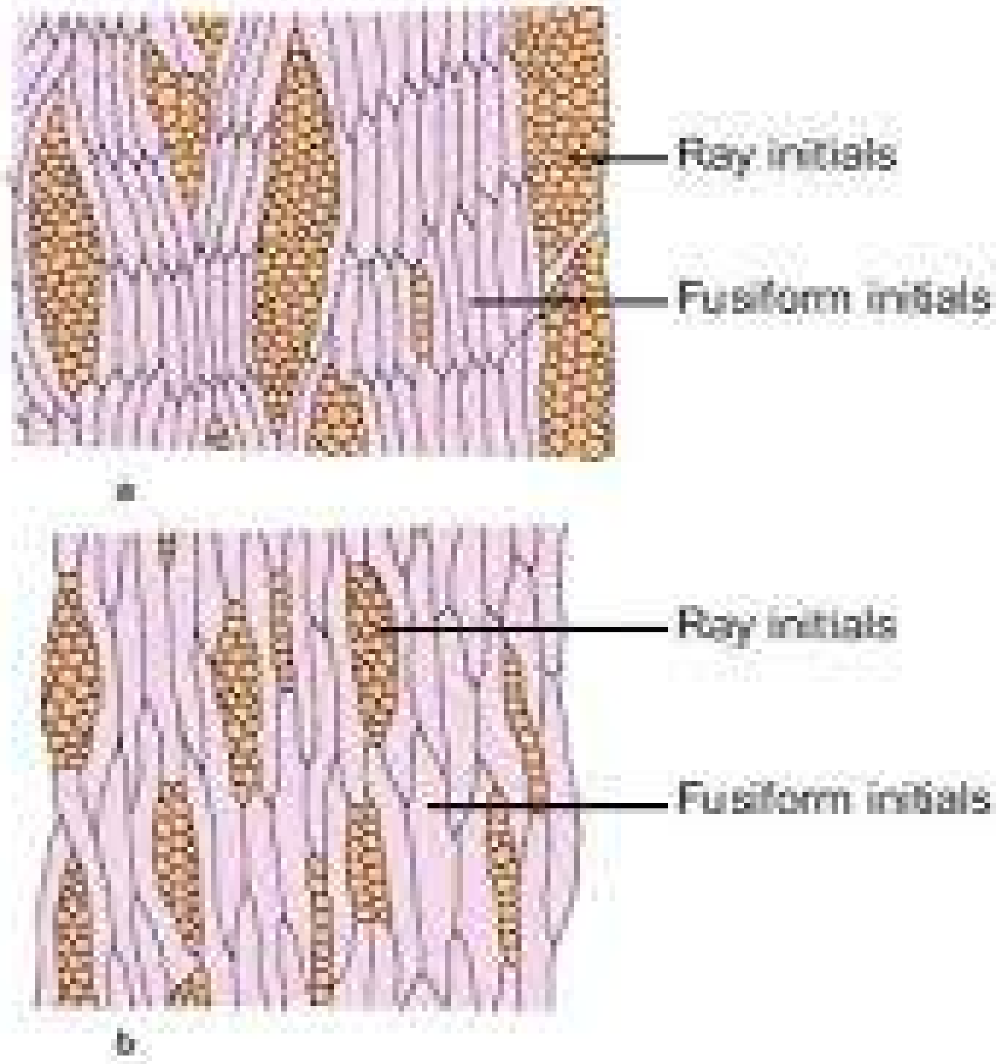
Apotracheal



Paratracheal

4.Storied wood:

- Storied structure of wood refers to the planes of divisions of cambial initials.
- Woods with non-stratified cells are considered primitive to storied structures.



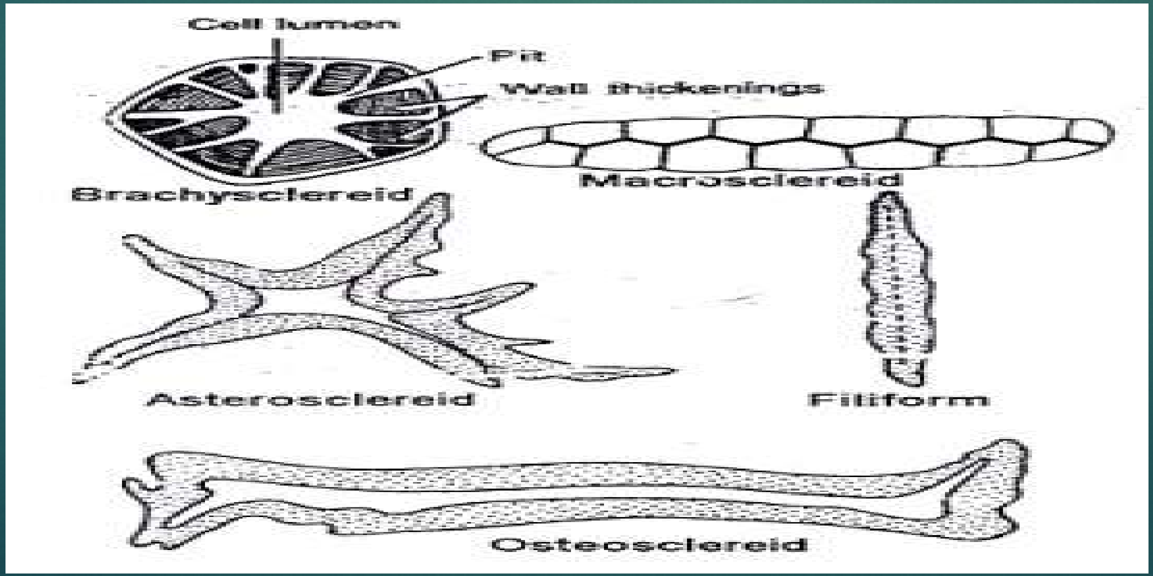
(a) Storied: with overlapping fusiform initials

(b) Non- storied: non overlapping fusiform initials.

Sclereids:

Sclereids, i.e. cells with very thick lignified walls, which are widely distributed in the plant body, have been used as diagnostic tools in several taxa like Connaraceae, Nymphaeaceae, Oleaceae, Theaceae, Umoniaceae, and a few genera of Araceae, Acanthaceae, Ericaceae and Melastomaceae.

- In dicots, they are more common in woody forms than in herbaceous ones, but they are extremely rare in monocots, except in certain genera of Araceae, Agavaceae, Arecaceae and a few other families. As they exhibit various shapes, sizes and characteristics of their walls, they have been of some taxonomic significance.
- Two main types of sclereids have been recognized, viz. isomorphic and polymorphic types. The sclereid forms may be characteristic of a particular species and thus of taxonomic value.



Floral Anatomy:

- As the reproductive organs show a high degree of conservation, they have been widely used in the classifications.
- The floral anatomical characters of families and genera are generally well marked and have been useful in solving some fundamental questions, like the nature of flower, carpel, inferior ovary and also several problems related with homologies, phylogeny and taxonomy.
- The vascular supply to these floral organs is also conservative and thus more reliable in taxonomic and phylogenetic interpretations (see fig)
- The distribution and course of vascular bundles within the receptacle and floral parts have proved to be of systematic significance, particularly in ranking taxa of higher order such as genera and families. Even specific characters may be quite clear in some cases.

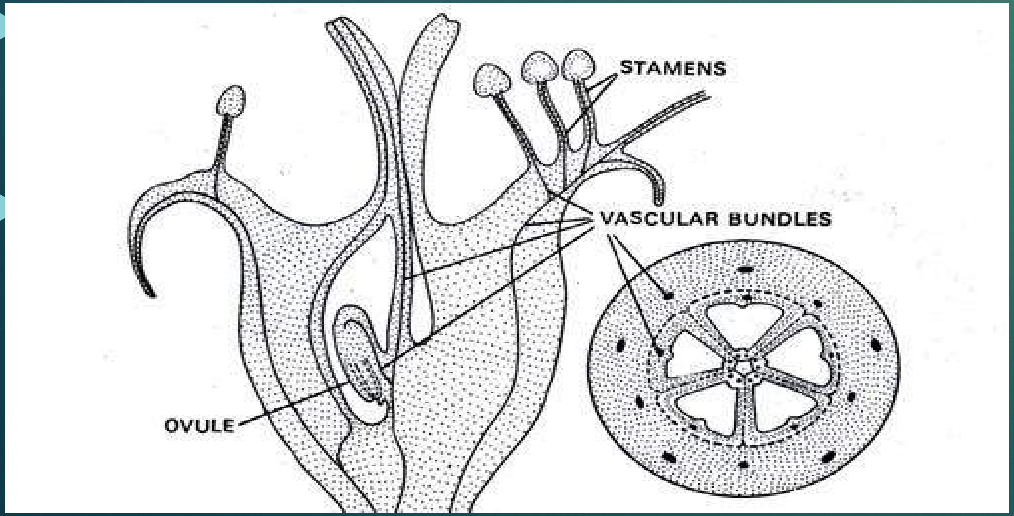


Fig. showing floral vascular supply.

Following are some of the examples of the contribution of floral anatomy in resolving the taxonomic position of some disputed taxa:

- I. Confirmation of the origin of the families of Annonaceae, Calycanthaceae and Menispermaceae from Ranunculaceae.
- II. Separation of *Paeonia* from Ranunculaceae and its inclusion under a separate family Paeoniaceae.
- III. Separation of Polemoniaceae and Caryophyllaceae.
- IV. Cyperaceae and Poaceae were formerly treated together in one single order. Later Hutchinson separated them and placed them in Cyperales and Poales respectively, which has been confirmed by floral anatomical studies of both the families.
- V. Inclusion of Solanaceae and Scrophulariaceae under one single order, Scrophulariales due to uniformity in floral vasculature.
- VI. Confirmation of the close relationship between Cyrtandromoea and members of Scrophulariaceae based on the presence of several lateral traces in carpels, a bilocular ovary, and absence of a disc in both.
- VII. Confirmation of the transfer of *Hydrocotyle asiatica* L. to the genus *Centella* in the form of *Centella asiatica* L.

Specialised cells and Cellular contents

- Crystals and crystalliferous cells have been found to be of systematic importance in several families of angiosperms such as Euphorbiaceae, Leguminosae, Verbenaceae, etc.
- Presence or absence of Laticifers, which are cells or a series of fused cells containing latex, and their structure, has also been of some taxonomic value. They are common features of many succulent plants and other plants of arid regions, and vary widely in their structure and the latex in their composition.For example, certain species in Aroideae lack laticifers or any related structures, while others have longitudinal rows of elo
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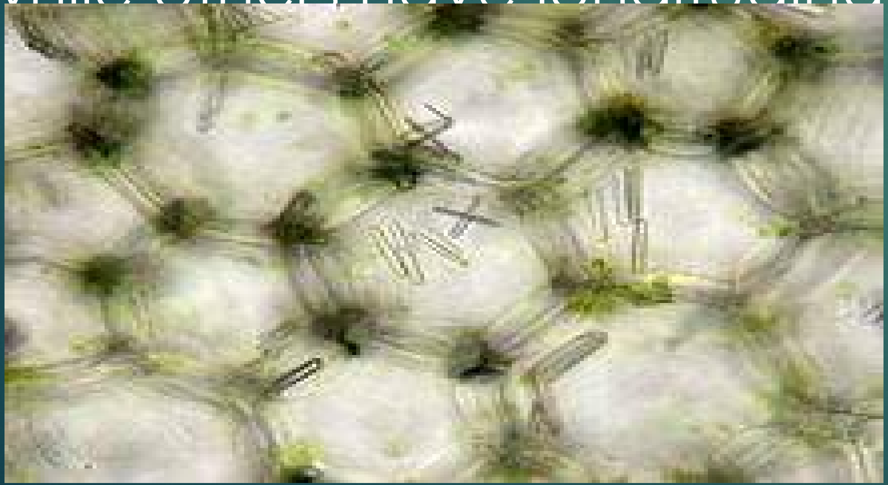


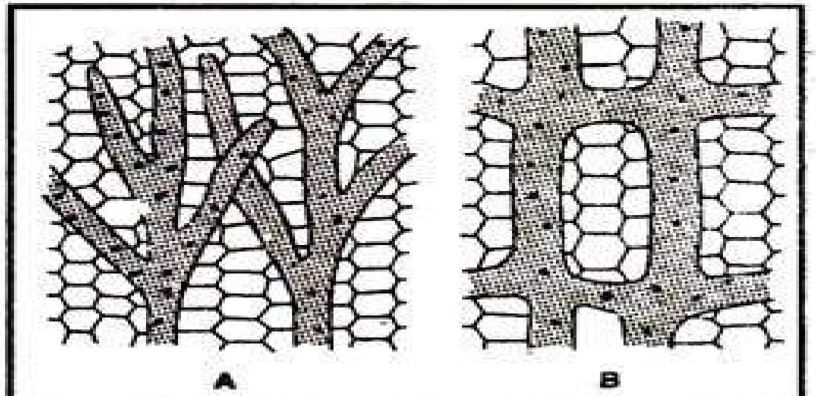


Figure 9.9 Laticiferous Tissue. A. Latex cells ; B. Latex vessels

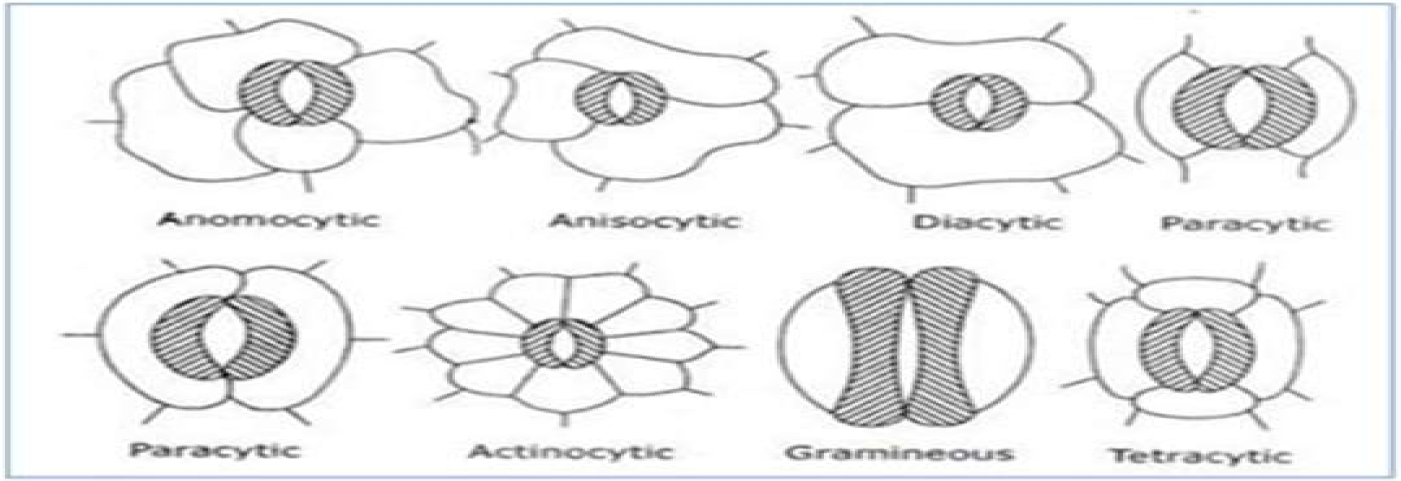
- Crystalliferous cells

Cell contents such as chemical deposits, can serve as important diagnostic tools, and prove extremely helpful in delineating species, genera and families.

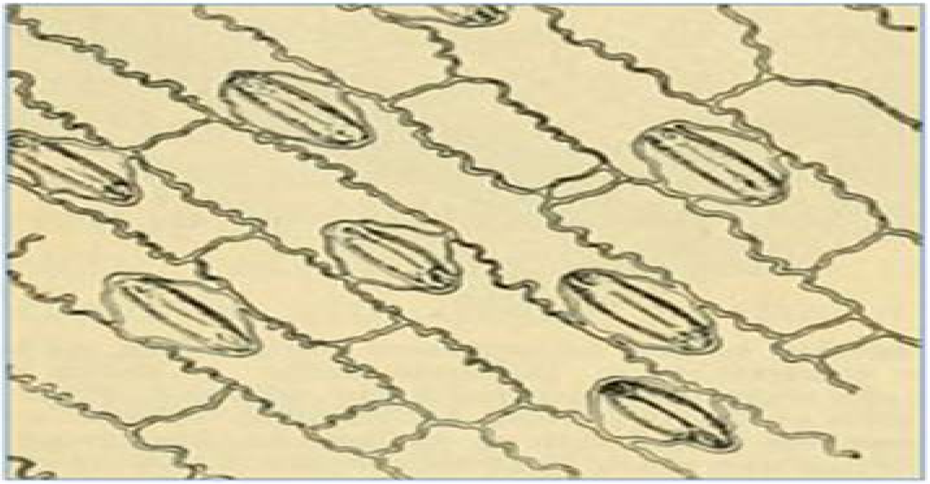
- **Some of the important chemical deposits of systematic significance are as follows:**
- **I. Albuminoids** —These are insoluble proteins present in plant cells. e.g. *Laportea*.
- **II. Starch grains** — The immense diversity in the types of starch grains is a good taxonomic character for the angiosperms in general, e.g. Solanaceae family.
- **III. Protein bodies** — Solid protein depositions have systematic use, e.g. in some members of family Cactaceae.
- **IV. Large silica bodies** — Silica bodies in the epidermal cells of various families like Arecaceae, Musaceae and Zingiberaceae can be used at generic as well as specific levels.
- **V. Calcium oxalate crystals** — They are widely distributed in plants and are of different types, like prismatic, styloid and idioblasts. Their distribution is very specific for a particular taxon and hence of taxonomic importance, e.g. *Eichhornia*, *Allium*.
- **VI. Cystoliths** (calcium carbonate crystals) (Fig. 8.9) — e.g. Cannabinaceae, Moraceae and Urticaceae.
- VII. **Tanniniferous cells** — The presence and absence of tanniniferous cells in the root cortex of related families of Rapateaceae and Xyridaceae can be used as systematic criterion.

Stomata

- Stomatal types and distribution are also used in the study of taxonomy.
- Some families have specific stomata types:
- Anomocytic stomata: Ranunculaceae,Malvaceae, Capparidaceae
- Anisocytic stomata: Brassicaceae, many members of Solanaceae.
- Paracytic: Rubiaceae
- Diacytic: Caryophyllaceae
- Graminaceous: Poaceae, Cyperaceae.



Classification of Stomata



Stomata of Grasses

Stomatal index is also used as criterion for taxonomic studies.

- Syndetochelic stomata (in which guard cells and subsidiary cells are derived from a single mother cell)usually found in Gymnosperms are considered primitive.
- Haplocheilic stomata (in which guard cells and subsidiary cells develop from different initials) mostly found in Angiosperms are considered advanced(vi) Silica hair. e.g.Poaceae

Trichomes

Trichomes are mostly used to compare closely related taxa.

- Types of trichomes used for taxonomic studies are:
- (i) Glandular. e.g. species of genera belonging to Lamiaceae.
- (ii) Non-glandular. e.g.Lauraceae, Moraceae.
- (iii)Stellate hairs.e.g.Malvaceae.
- (iv) Mucilage hairs.e.g. *Rumex*.
- (v) Stinging hair. e.g.Urticaceae
- (vi) Silica hair. e.g.Poaceae

Glandular trichomes