Applications of Plant Anatomy

The applications are:

1. Enables to Identify Fragmentary Plant Materials
2. Enables to Detect Adulterants in Crude Drugs
3. Enables to Identify Wood
4. Enables to Identify Archaeological Plant Remains
5. Applied Aspects of Meristem Culture
6. Provides Evidences in Forensic Investigation
7. Provides Characters of Taxonomic Significance

1. Enables to Identify Fragmentary Plant Materials:

- Since the time of Linnaeus, flowers and fruits provided the characters of identification. Sometimes situation arises where fragments of herbarium specimens, leaf, dried and powdered medicinal plants etc.these characters are not available. The prerequisite of any botanical research is the proper identification of the specimen. Anyone dealing with plants for food, furniture, building materials, medicine etc. the plant breeders, geneticists and cytologists must have proper identifying characters of their source materials. These characters will identify parallel specimens, if required. They will be in a position to verify whether the parallel specimen is from the same species of the source material. The characters that differentiate a species from other species are considered as of taxonomic significance. Apart from vegetative and reproductive organs plant anatomy provides characters that are of taxonomic significance. Trichome anatomy, wood and leaf anatomy, leaf epidermis and cuticle etc. provide valuable characters in differentiation between species. As for example the different species of *Rhododendron* and *Ficus* can be differentiated by means of trichome characters.

2. Enables to Detect Adulterants in Crude Drugs:

- The medicinal plants provide the crude drug. Drug can be obtained from all parts of a plant (ex. *Swertia chirata*), leaves (ex. *Adhatoda vasica*, *Andrographis paniculata* etc.), roots (*Cephaelis ipecacuanha*), rhizome (ex. *Zingiber officinale, Rauwolfia serpentina* etc.), or bark (*Alstonia scholaris*). The crude drugs are imported in dry form and in some cases in dry powdered form.

- In this condition it becomes difficult to identify the materials by macroscopic appearance only. For this reason the microscopical along with morphological characters of drug materials are studied. They are described and published in pharmacopoeia. The pharmacopoeias may be of official publications.

Example:

- Their authenticity is established by comparing with the descriptions published in pharmacopoeias. A crude drug may also be identified from its chemistry. But the identification with the study of microscopical examination is much easier and quicker than that of chemical analysis.
- Mention may be made of a few drug plants with their uses and adulterants that can be detected microscopically. *Swertia chirata* (Family: Gentianaceae), commonly known as chirata is an indigenous drug of India. It is used as stomachic bitter tonic, anthelminthic and in skin diseases. The root is used as a substitute of *Centiana lutea*, which is used as gastrointestinal tonic, because the root of chirata does not constipate the bowels. The most common adulterant is *Swertia angustifolia* commonly known as pahari chirata. The distinguishing characters between the two species are given below according to Prasad et al., (1960).
- Apart from *Swertia angustifolia, Enicostema littorale*, roots of *Rubia cordifolia* and *Andrographis paniculata* are found to be mixed with *Swertia chirata. Andrographis paniculata* differs from *Swertia chirata* in having characteristic cystolith on leaves, diacytic type of stoma and phloem on the dorsal side of xylem only.

3. Enables to Identify Wood:

- The anatomy of a wood sample reveals many characters that help in the identification of plant from which the wood comes.
- In India the number of timbers available in large quantities is not more than sixty, among which the following three are most important-*Tectona grandis* (teak), *Shorea robusta* (sal) and *Cedrus deodara* (deodar).

4. Enables to Identify Archaeological Plant Remains:

- The wood-anatomy of present- day-plant provides characters to identify the fragmentary wood. These characters also enable to identify the wood and charcoal preserved in sites from antiquity.

- A burnt wood or charcoal sample is collected from the site of excavation. Microscopic slides are prepared and examined thoroughly. The observation shows that the very delicate features like perforation plate and lateral wall pitting are still retained. The wood anatomy of archaeological sample is compared with that of present-day-wood and thus their identity can be detected.
- After authentication it can be decided whether it was selected for burning purpose only. It may happen that the plants composed the vegetation of that area at that time. The plants, as they grew locally, were obtainable at ease and so were selected for burning purposes.
- *Dalbergia sissoo* (Sissoo) and *Holarrhena antidysenterica* (Kurchi) —these two timber-yielding plants were found in Hastinapura. These plants provide good fuel woods. It is not known whether these were used as firewood or charcoal. It is assumed that the Copper Age civilization was aware about the woods that have high calorific value.

5. Applied Aspects of Meristem Culture:

Meristems may be apical, intercalary and lateral. Each of the meristems is exploited in the improvement of plants.

i. Apical meristem:

- Apical meristems occur at the tips of root, leaf and shoot. The shoot apical meristems are particularly used in culture. In culture method the shoot apical meristem is excised out and placed in a glass container, containing nutrient. In a strict botanical sense the cells in the apical dome of shoot apex compose the meristem. In apical meristem culture the sub-millimetre shoot tip with 0.1 to 0.5 mm high apical dome is dissected out and placed in nutrient media.
- Sometimes circumstances arise when meristem culture becomes necessary for vegetative propagation. As for example the plant under study is infertile as in the case of triploid Musa sp., certain varieties of apple, tulips, iris, hyacinths etc. In breeding experiments the hybrid of first filial generation (F_1), when heterozygous, never breeds true, i.e. segregation of characters occur in the second filial generation (F_2).
- The meristem culture of F_1 plant keeps the progeny alike. In many experiments on plant breeding the hybrid plants fail to produce normal seeds. The seeds are either abortive or nonviable. These hybrids are propagated through meristem culture. The haploid plants

produced as a result of anther or pollen culture are always sterile. They become fertile when they are converted to homozygous diploid.

- The haploid plants are propagated through apical meristem culture. In apical meristems viruses are either absent or present in a very low concentration because the cells of this region have fast mitotic activity. By apical meristem culture a clone of virus-free plant can be obtained. It is to note that a virus-free plant is not virus resistant.
- The essential oil citronella is obtained from the leaves of *Eucalyptus citriodora* tree. These plants are micropropagated from where about 500 plants of teak and 1000 plants of *Eucalyptus* citriodora are raised from a single bud (Fig. 32.1) in a year. Apical meristem culture is widely used to raise virus-free plants.

Example:

Manihot esculentus, which is usually infected by Mosaic virus or Streak virus. A single meristem tip of *Manihot esculentus* provides a number of virus-free plants.

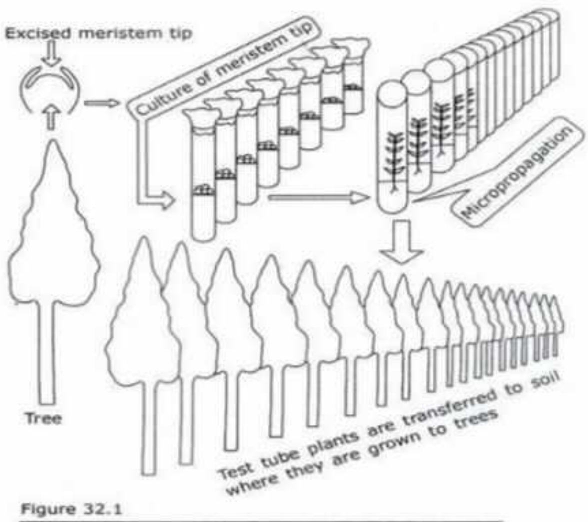

Diagram illustrating the meristem tip culture for rapid propagation of plants.

ii. Intercalary meristem:

- A large number of plants have meristem adjacent to and just above most nodes. This meristem is derived from apical meristem. During the course of development of apical meristem of a plant, a portion of meristem becomes separated from apical meristem by more or less mature tissues. This is intercalary meristem. In many plants adventitious roots are formed at nodes from this meristem.

iii. Lateral meristem:

Lateral meristem occurs on the lateral sides of a plant.

Example:

- Phellogen or cork cambium, fascicular cambium that is present between xylem and phloem of a vascular bundle of dicot stem and the inter-fascicular cambium that develops at the time of secondary growth from the tissues present between the two vascular bundles.

6. Provides Evidences in Forensic Investigation:

- The application of forensic science is indispensable in investigating a crime. Forensic science has many disciplines and forensic botany is one of them. Forensic botany encompasses many sub- disciplines, which include plant anatomy, plant systematic (taxonomy and species identification), palynology (the study of spores and pollen) etc. They refer the use of plant materials in solving crimes or resolving other legal problems.
- Plants remains are present everywhere. In a crime scene they may occur in the form of macroscopic pieces (ex. wood, twigs, leaves, flowers, fruits, seeds etc.) or microscopic forms (ex. pollen, spores, trichomes, cell walls in stomach contents etc.). Plant anatomy provides characters such as trichomes, stomata, cuticular pattern, leaf venation, wood anatomy, growth rings etc. to aid in species identification and in performing physical matches of evidence. The identified plant materials help the investigators of criminal cases to determine whether a suspect was present in a crime scene, in which season the crime occurred, how long the body has been buried, whether the body has been moved etc.

7. Provides Characters of Taxonomic Significance:

- It is the prime importance to know exactly to which species a plant specimen belongs. This is necessary for a natural and reliable classification. Most of the plants are classified according to their macro-morphological features. But an accurate classification results when the information from diverse sources are utilized.

- The sources may be from anatomical features, palynology, biochemistry, embryology, cytogenetics, phytogeography, physiology etc. It is now realized that alpha taxonomy can form a natural, accurate and reliable classification.
- **The following important anatomical features those are often good indicators of the family, genera and sometimes species are discussed below:**
- **Trichomes:**
- Trichomes are the collective term of hairs and papillae. They occur on all organs of a plant. There exists much morphological diversity among them.
- There are two major categories of hairs-the glandular and non-glandular. Each of the categories is sub-divided according to their gross structure, cellular constitution, nature of branching etc. There exist much diversities and varied forms in non-glandular hairs than the glandular hair. A few types of hair are illustrated in Fig 32.4.

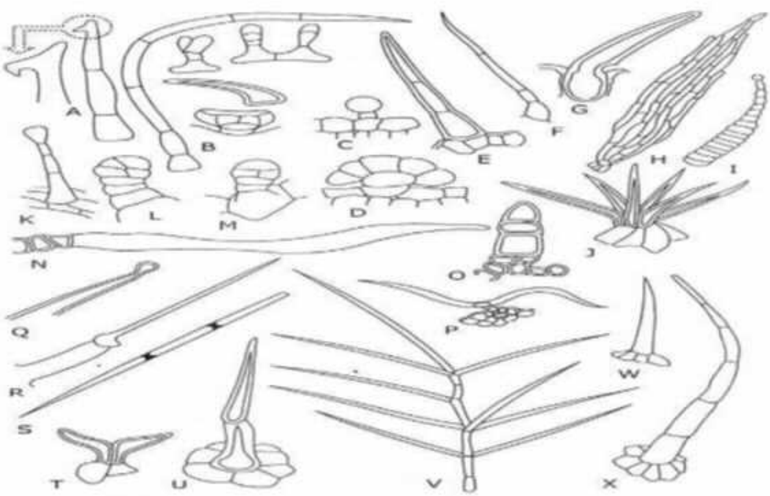

Figure 32.4

A. Hair of *Aphelia cyperoides*; B. Different hair types in *Mentha spicata*; C. Bicellular hair of *Salvia officinalis*; D. Multicellular hair of *Salvia officinalis*; E. Non-glandular hair of *Salvia officinalis*. F. Hair of *Centrolepis*; G. Hair of *Thamnochortus*; H. Surface view of hair of *Leptocarpus*; I. Glandular hair of *Cistus*; J. Dendritic hair of *Cistus*; K. Glandular trichome of *Pelargonium*; L. & M. Glandular trichome of *Cucurbita*; N. Hair of *Loxocarya*; O. & P. Hair of *Artemisia*; Q. & R. Glandular hair of *Urtica dioca*; S. Glandular hair of *Mucuna* containing irritant oil droplets; T. Hair of *Trigonobalanus*; U. Non-glandular hair of *Justicia*; V. Non-glandular hair of *Verbascum*; W. Non-glandular hair of *Coldenia*; X. Hair of *Origanum*.

A particular type of hair is constant in a species. This property is used as an aid to identify the different species of Oleaceae,

ii. Stomata:

- Stoma has been shown to have great value in the taxonomy of several taxa. The distribution, morphology and ontogeny of a stoma are of taxonomic significance. Stoma is absent in roots. In exceptional cases it is reported from *Ceratonia siliqua* and *Pisum arvense* seedling roots.

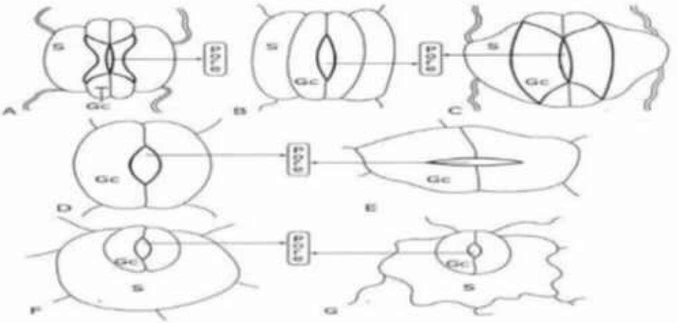

Figure 32.5

Diagram illustrating the types of guard cell and polocytic stoma. A. Dumb-bell type: The cell wall of guard cell is thinner at the polar ends than the other walls. Each guard cell is much narrowed in the middle and so it has dumb-bell like appearance in surface view. B. Rectangular type-A: The cell wall of guard cell is uniformly thick. Each guard cell is of uniform breadth in surface view. C. Rectangular type-B: The cell wall of guard cell is thinner at the polar ends than the rest of the walls. Each guard cell is of uniform breadth. D. Elliptic type: Each guard cell is as broad as long or longer than broad. The cell is reniform or more or less uniformly wide. Pore of stoma occurs parallel to guard cells. E. Right-angle type: Each guard cell is shaped like U or V. The contiguous wall of guard cells determines the stomatal axis, also referred to as polar axis of stoma. The pore of stoma occurs approximately at right angles to stomatal axis. The polar axis is frequently shorter than the equatorial diametre. F. Polocytic stoma (diagrammatic). G. Polocytic stoma of *Diplazium polypodioides*.

- The surface view of guard cells of a stoma can be of taxonomic significance. Rajagopal and Ramayya classified five types of guard cells on the basis of their appearance in surface view under light microscope (Fig. 32.5). The types are (a) dumb-bell type (ex. Cyanodon), (b) rectangular type-A (ex. Eriocaulon), (c) rectangular type-B (ex. Cyperus), (d) elliptic type (ex. Scilla, Mollugo) and (e) right-angle type (ex. Azolla).

iii. Veins:

- The veins and their innumerable variations in leaf venation pattern provide various characters of taxonomic importance. The anatomical division of Angiosperm into dicotyledon and monocotyledon is based on venation pattern.

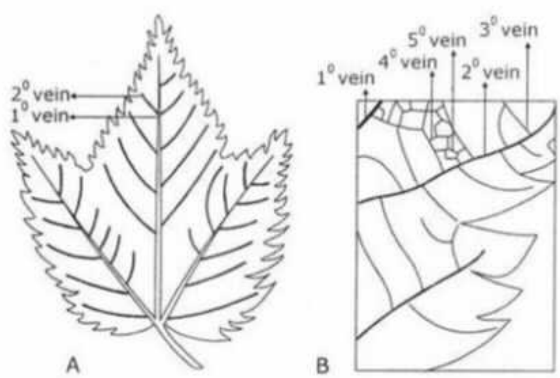

Figure 32.6

A. Diagram of a leaf of *Acer argutum* showing 1^0 and 2^0 veins. B. A portion of A enlarged showing 1^0, 2^0, 3^0, 4^0 and 5^0 vein.

- The different categories of vein provide many characters that are very useful in leaf identification. The 1° veins may be single, three or more. The 2° veins form an angle with 1°. The angles are constant in a species. The angles may be uniform, abruptly increasing towards the base, smoothly decreasing towards base etc.
- The spacing between 2° veins is also of taxonomic significance. It may be uniform, irregular and increasing or decreasing towards the base. The 3° veins show different angles to 1° (Fig. 32.7A, B, C, & D). The course of 3° veins may be straight, convex and sinuous (Fig. 32.7E, F, and G). The number of vein-islets in a unit area is species-specific.
- Usually four square millimetre area of a leaf is considered as a unit in counting the vein-islet numbers. The ultimate free endings of vein-lets have diagnostic value. They may be unbranched, linear or curved 1-branched, 2 or more branched etc. The following features of veins provide taxonomic information.

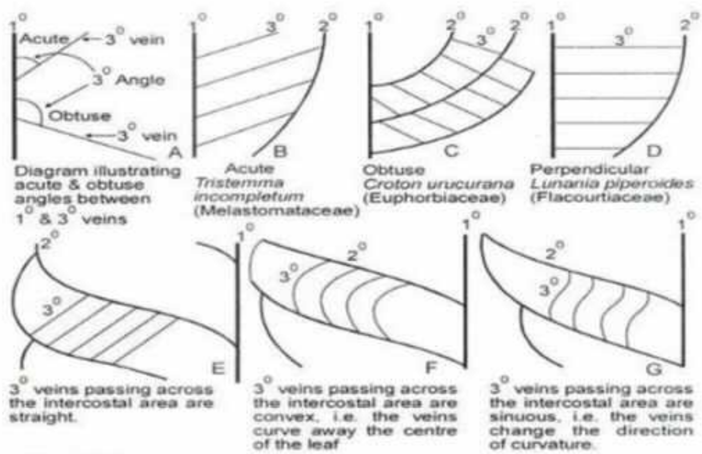

Figure 32.7

Diagram illustrating the angles formed between 1° and 3° veins (A, B, C, D) with terminology and the course of 3° veins in the intercostal areas (E, F, G).

Examples where anatomical features solved taxonomic problems:

- There are numerous examples where the anatomical features were used in solving taxonomic disputes, a few of which are mentioned below.
- The ultra-structure of sieve tube plastids was used in circumscribing taxa. Sieve tube plastids are broadly of two types-starch accumulating (S-type) and protein accumulating (P-type). The S-type occurs in Polygonaceae, Plumbaginaceae, Batqceae, Theligoniaceae etc. whereas the P-type is found in Phytolaccaceae, Molluginaceae etc.
- There are certain families like Rafflesiaceae, Crassulaceae, and some species of Moraceae etc. where the sieve tube plastids accumulate neither starch nor protein. The

ultra-structural details of sieve tube plastids are taxon-specific and hence taxonomically useful. It was best used in elucidating the inter-relationships in the order Caryophyllales.