Morphology in Relation to Plant Taxonomy

Morphological characters of the plants have provided the foundation and framework for taxonomy and they have been used extensively in the preparation of classification systems, diagnostic keys, etc.

Although, in recent years the synthetic approach has fast developed, yet the traditional method of plant taxonomy based upon comparative external morphological characters is still indispensable to systematics and this traditional method continues to predominate and has a bigger say over other sources of taxonomic characters in plant classification.

Reasons

- ***The morphological characters are easily observable. Since they have innumerable variants, they help in delimitation and identification.***
- ***To analyse morphological characters, one need not have sophisticated laboratory arrangements. A hand lens or dissecting microscope, or possibly a light microscope is enough to study these characters.***
- ***There is a well-knit terminology to describe variations as morphological characters have been in use for plant classification for several centuries.***
- ***The time and effort needed to obtain information from other sources such as photochemistry and molecular biology ensure the advantage of morphological characters over others in plant taxonomy.***

External Morphology of Plants

External morphological characters provide majority of the evidences used in the construction of classification system. It is often argued that exomorphic characters are less important than the endomorphic or other characters. But in case of plants this assumption may not always be true, as some exomorphic characters are stable in certain groups and show considerable variation in others.

It has been concluded by Bailey (1951), that endomorphic characters such as anatomy are neither more nor less reliable than exomorphic features.

Further, as evident from most of the classificatory systems, floral characters, in general, have been preferred over vegetative characters. There may be a wide variation in several superficial vegetative attributes, especially at higher levels.

As for example, structure, size and shape of leaves may be extremely variable within a genus or even within a species. Vegetative characters are often environmentally controlled, particularly plant pubescence.

For example, a particular member of a species may develop into an extremely hairy glabrous form, while a different member of the same species growing in a different place, in a different environment may not show such form.

On the other hand, reproductive features are concerned to be more constant and conservative against fluctuating environmental pressures than their vegetative counterparts particularly because, in flowering plants, reproductive characters are subjected to a much lesser degree of evolutionary pressure than the vegetative parts, as the sexual reproductive parts are produced only for a very brief period in most species.

However, reproductive characters are liable to strong selection pressures originating from various aspects of reproductive biology, e.g. the pollinator relationship. Thus, equal emphasis need to be given to both vegetative and reproductive characters as both are subject to different types of selection pressure, to which they react in different ways.

Some of the vegetative and reproductive characters, which are employed in plant taxonomy and in deducing phytogenic, include growth habit, phonological characters, underground organs, stem, leaves, petiole and stipules.

These vegetative features can be profitably used in identification of trees and shrubs, as they are less variable in such groups. Floral characters such as types of inflorescence and flower and associated structures, play a major role.

Types of fruit and seed also provide good diagnostic features useful at various levels of classification. In recent years, various biometric and graphic techniques are being used to interpret morphological features. Thus, many of the morphological features previously overlooked are being carefully studied now and their importance in taxonomic practices being assessed.

(a) Vegetative Features:

(i) Growth habit (herbs, shrubs, and trees):

It may be variable or constant within a genus or a family, e.g. all Brassicaceae members are herbaceous while members of Asteraceae are both herbaceous as well as woody.

(ii) Growth pattern:

It has been of particular interest in defining taxonomic groups and in interpreting interrelationships above generic level in

Zingiberaceae. A very, good example is the genus Zingiber. There has been a tot of controversy regarding its placement. Some authors have placed it under Alpineae, some under Hedychieae, while many have assigned it to Zingibereae.

However, study of growth patterns of leaves, which are arranged distichously to the rhizome, and based on the plane of distichy which may differ from parallel to transverse, it was suggested that Zingiber is more closely related to Hedychieae and Zingibereae (where the leaves are parallel to the rhizome), than to Alpineae (where the leaves are transverse to the rhizome).

(iii) Leaf characters:

This includes leaf structure, size and shape, arrangement, type, form, duration and venation. For example, leaflet size, shape and arrangement on the rachis has been successfully employed for distinguishing three species of Dalbergia (Papilionaceae), viz. D. latifolia, D. sissoo and D. sympathetica.

However leaf structure, size and shape is often variable in herbaceous species and thus cannot be used reliably for generic delimitation. For example species of Crotalaria exhibits continuous variation in this respect.

Similarly, stipule character, which is fairly constant within a species except for Rosaceae, has also been used as a taxonomic character. Leaf venation, which also serves as an important taxonomical character, is of particular interest to palaeobotanists who carefully study leaf venation for describing fossils.

(iv) Underground parts:

Such as structure and morphology of roots, tubers, etc. are of some taxonomic significance in plants. For example, in Dioscorea (Dioscoreaceae), the structure and morphology of root-tubers has been used as a taxonomical character in the delineation of a large number of species.

Similarly, root morphology has been used as a character to distinguish two species of Chlorophytum (Liliaceae), viz. C. tuberosum and C. borivilianum.

(v) Seedling characters:

Juvenile characters, especially seedling characters, such as type of germination, cotyledonary characters, leaf dimorphism, etc. have been of systematic value and taxonomic significance in certain families like Brassicaceae, Convolvulaceae, etc.

(vi) Plant pubescence:

It is a character, which has been long neglected in morphotaxonomic studies. Although the degree of pubescence within the species is largely governed by ecology, the type of trichomes, stylar hairs, etc. Have been successfully used as taxonomic characters and in tracing phylogeny in certain groups of plants.

For example, Inamdar (1967) confirmed the systematic position of Nyctanthus in the family Oleaceae on the basis of the structure and ontogeny of its trichomes. Similarly, Raji (1971) used the stylar hair patterns of the tribe Viceae (Papilionaceae) to deduce phylogenetic pathways of its constituent genera.

(b) Reproductive Features:

(i) Inflorescence and flower:

Floral characters such as the type and position of inflorescence, flowers and associated structures such as structure of perianth, floral symmetry, the number, size, shape and union of floral leaves in each whorl, types of androecium and stamens, gynoecium and carpels, ovules, and also the characters of bracts, bracteoles and pedicels are very important from the taxonomic point of view.

For example, type of calyx has been used to distinguish species in Anthyllis. Similarly, nectaries and floral discs have proved to be of great diagnostic value in Brassicaceae. Other important floral characters are those associated with pollination i.e. different plant groups pollinated by different agents (wind and insects) have different floral adaptations.

Those plants, which are wind pollinated i.e., anemophilous, bear flowers which are small, inconspicuous, unisexual and mono- or achlamydous and are usually aggregated into inconspicuous spikes or catkins with a large output of pollen grains.

On the other hand, those plants, which are pollinated by insects, i.e. entomophilous, have flowers, which are large, conspicuous, brightly colour and are often nectariferous or scented. Adaptations for different kinds of pollen vector have also resulted in specialization in the calyx and/or corolla, in flower positioning, etc.

(ii) Fruit characters:

Characters of fruits have been used in the construction of diagnostic keys especially at and above the generic level, as fruit morphology appears to be fairly constant within the genus. Their adaptations for different types of dispersal or of opening has been of great help to taxonomists in analysing taxonomic problems. For example, fruit characters have been used to distinguish different families of Rhoeadales.

(iii) Seed characters:

Seeds have been successfully used particularly at the specific level. Seed characters such as number, colour, shape and sculpturing have proved helpful. For example, Anthericum and Chlorophytum (Uliaceae) have been distinguished on the basis of number and shape of the seeds.

Similarly, length and colour of hairy outgrowths on the testa of the seeds have helped in the distinction of genera and/or species in the Acanthaceae, Asclepiadaceae, Convolvulaceae and Malvaceae.

Microscopic Morphology (Epidermal Characters):

The development and use of Scanning Electron Microscopy in recent years, has opened a new chapter in the field of plant classification and systematics.

The ability of this technique to reveal details of the plant surface, has allowed morphologists and taxonomists consider epidermal features such as hairs, trichomes, cell-types, nectaries, etc., besides the gross morphological characters, which have so far been neglected in the construction of groups or identification of taxa.

These microscopic morphological features have proved to be very useful in plant taxonomy when gross features have proved inadequate.

Following are some of the epidermal features that are now being used frequently in taxonomic studies:

(i) Trichomes:

Trichomes are epidermal outgrowths, which exhibit great variation in structure and function and are thus of much taxonomic value. They may be glandular or non-glandular, simple or branched with the branches dendritic (arising like those of a tree) or star-like, terete, flattened, basally swollen, whip like or T-shaped, or of various other forms in different groups of plants (Fig. 8.1).

Hence, plant-hair types have been successfully used in the classification of genera and species and in the recognition of hybrids within certain groups. A very good example of the use of trichomes in plant classification is that of Parthenium (Asteraceae).

In a series of observations (1944, 1945, 1946, and 1949) on the trichomes of two species of Parthenium and their natural hybrids] Rollins (1941) found that P. argentatum had T-shaped trichomes while in P. incanum they were whip-like with a long thread. Intermediate types of trichomes were observed in the hybrids between these species.

Another good example is the generic key for the Indian members of Asteraceae proposed by Ramayya (1969) on the basis of his critical studies of trichomes in the family. Besides the distribution and anatomy of the actual trichomes, the degree of modification of the adjacent epidermal cells and the scars left by lost trichomes are important aspects of variation.

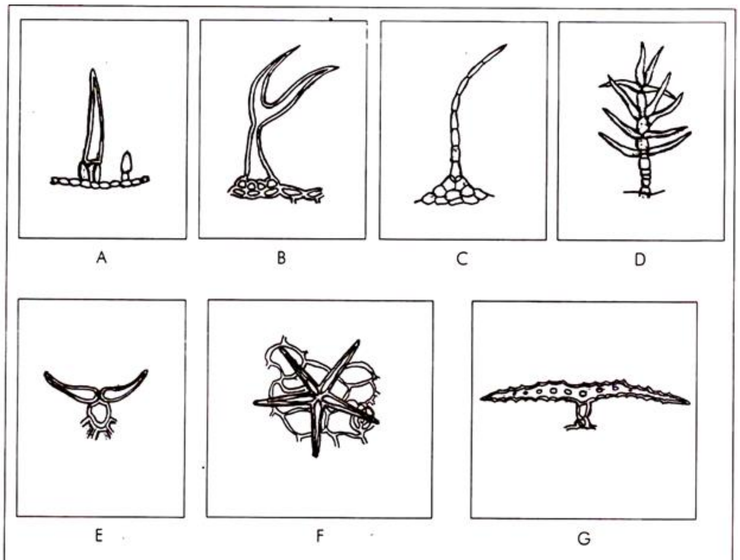


Fig. 8.1 : Types of trichomes (A) Sharp hairs of *Lantana* sp. (B) Lobed hairs of *Amaranthus* sp. (C) Wooly hairs of *Helianthus* sp. (D) Dendroid hairs of *Mimosa* sp. (E) Peltate hairs of *Olea* sp. in side view (F) Stellate hair of *Althaea* sp. (G) T-shaped hair of *Dicrasus* sp.

(ii) Epidermal Cells:

The structure of epidermal cells, other than those associated with special structures like stomata, trichomes, venation system, etc., has been found to vary in certain groups of plants and has been used as a taxonomic character in recent years. This variation in structure, include, variation in size, shape, orientation, undulation of anticlinal wall, curvature of periclinal wall, etc.

The expression of the distribution of cell types in a systematized way is termed as dermogratn, and the dermograms may be indicated for each species as a dermotype. Dermotype studies have been employed with success in taxonomy e.g., in the taxonomy of species of Puccinellia (Poaceae), Agrostis (Poaceae) and related genera, etc.

Recently, Ramayya & Rajgopal have even proposed a generic key for the Indian members of Alzoaceae and Portulacaceae based on the dermotype studies of these families.

Often the epidermal cells have been found to be modified along leaf margins and also may be calcified, silicified, suberized, gelatinized or contain various types of crystals, which may be of significant taxonomic importance. For example, silicified and suberized epidermal cells are of taxonomic value in the family Poaceae.

(iii) Seed Surface Patterns:

Recently SEM is being extensively used in the study of seed coat characters, which have yielded very useful taxonomic information. Cellular arrangement or cellular patterns and the distribution of idioblastic elements such as trichomes and multicellular appendages, can be of considerable diagnostic and systematic value.

An excellent example of the use of seed surface pattern in taxonomy is the species separation of

Glinus Linn., which has appendaged seeds. The seeds of two species of Glinus, growing in India viz. G. oppositifolius and G. lotoides, appear very similar and tubercled under the light microscope. SEM studies have however revealed that the shape of the tubercles is quite different in the two species.

(a) Shape of cells (Primary sculpture):

The most prominent feature of sculpturing of the seed surface is the cell shape, particularly the curvature of the outer periclinal wall. Following are the micro characters that influence the primary sculpture i.e., the superficially visible shape of the cell.

Anticlinal walls:

The superficially visible cell boundaries may be straight, irregularly curved or more or less regularly undulated. The undulations may be further of S-, U-, V-, and Omega-types, which are of high taxonomic significance.

Relief of cell boundary:

The anticlinal boundary may be channelled or raised. In some groups, the cell boundary may exhibit several additional micro- characteristics. For example, the anticlinal boundaries and cell junctions of the seed coat of Browningia (Cactaceae) are deeply depressed.

Curvature of outer periclinal walls:

This is responsible for the roughness of the seed surface that is macroscopically visible. The curvature of the outer periclinal wall may be flat, convex or concave. Often the surface cells may show a transition to unicellular trichomes, which are of immense diagnostic value.

Specialties in the curvature may also be of high taxonomic interest. For example, only one small excentric portion of the outer wall.of the seed coat of Blossfeldia (Cactaceae), is curved out into a trichome-like structure.

(b) Fine relief of the cell wall (Secondary sculpture):

The outer cell wall surface (if the testa consists of intact cells, it means the surface of the cuticle) may be smooth, or exhibit micro-ornamentation, which may be striate, reticulate or micropapillate (verrucose), resulting from very different portions of the cell wall.

The major structural categories are as follows:

Cuticular sculptures:

This may occur as regular or irregular striations. In angiosperms, the cuticular folds show high micro morphological diversity, which may serve as good diagnostic characters, but their systematic significance is limited.

Secondary wall thickenings:

This may occur as helical to reticulate patterns on the inner side of the outer periclinal and on the anticlinal walls. Usually they occur in the form of reticulations or striations and are of high taxonomic significance. For example, dense reticulate pattern is seen on the seed coat of Chondrorhyncha (Orchidaceae).

(c) Epicuticalar secretions (Tertiary sculpture):

Seed coat exudes of different chemical nature, particularly mucilaginous adhesive substances are very common and their nature and origin may be of taxonomic and systematic significance and used in the delimitation of genera, families, and even orders.

The micromorphology of epicuticular waxes and related solid lipophilic substances can be easily viewed with the help of SEM. For example, only certain epidendroid and vandoid tribes and subtribes under Orchidadeae, possess epicuticular waxes on their seed coats (e.g. Bulbophyllinae).

(iv) Pollen Wall Ornamentation:

SEM has had an enormous impact on palynology and has proved very useful to palynologists primarily concerned with taxonomy. Like seed surface patterns, the different types of surface ornamentation of the pollen wall i.e. exine have also yielded very useful taxonomic information.

Variation in exine structure and sculpture, together with variation in the number, position and complexity of apertures in the pollen grain wall gives morphological diversity of the pollen grains.

(v) Stomata:

Systematic studies on the development and morphology of stomata and associated epidermal cells are proving to be increasingly important from the taxonomic point of view, as they may be expected to give clues to the various evolutionary trends and help assign taxa of uncertain affinity to their true position.

Though certain types of stomata are characteristic of some families and subfamilies, some authors are of the view that the taxonomic value of types of stomata is lowered when exploited at lower taxonomic levels, as one may find different types of stomata on the same leaf.

The distribution of stomata, frequency and structure differs in different taxonomic groups. There are different types of classification of stomata based on different criteria.

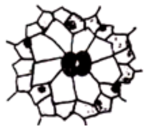
Following are some of the types of stomata based on the arrangement of subsidiary cells in the mature stomatal complex of vascular plants:

1. **Anomocytic (Ranunculaceous type) :** Stomata and guard cells surrounded by a limited number of cells that are indistinguishable in shape, size or form from those of normal epidermal cells.

2. **Cyclocytic :** Stomata and guard cells surrounded by a ring of four or more small subsidiary cells.

3. **Amphicyclocytic :** Stomata and guard cells surrounded by a double ring of small cells.

4. **Actinocytic :** Stomata and guard cells surrounded by a single ring of enlarged and radially elongated subsidiary cells.



5. **Anisocytic (Cruciferous type) :** Stomata and guard cells surrounded by 3 cells of which 2 are larger and 1 is smaller.

6. **Amphianisocytic :** Stomata and guard cells enclosed by 2 rings of cells with the inner ring consisting of 3 cells of which 2 are larger and 1 is smaller and the outer ring comprising of 2-3 or even 4 cells.

7. **Diacytic (Caryophyllaceous type) :** Stomata and guard cells enclosed by a pair of subsidiary cells whose common wall is at right angles to the guard cells.

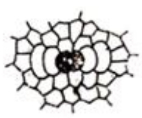
8. **Amphidiacytic :** Stomata and guard cells surrounded by a double ring of 4 cells which are at right angles to the long axis of the guard cells.

9. **Paracytic (Rubiaceous type) :** Stomata and guard cells surrounded by 2 cells which completely enclose the guard cells with their long axis parallel to long axis of the guard cells.

10. **Amphiparacytic :** Stomata and guard cells surrounded by double ring of 4 cells which completely enclose the guard cells with their long axis parallel to long axis of the guard cells.

11. **Brachyparacytic :** Stomata and guard cells flanked by 2 cells which do not completely enclose the guard cells, may or may not elongate, with their long axis parallel to long axis of the guard cells.

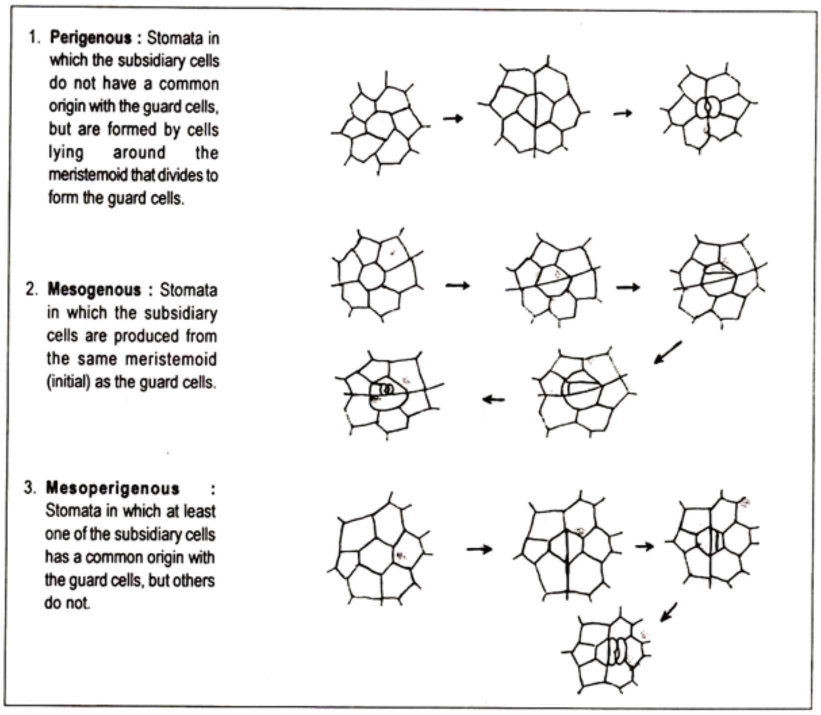
12. **Amphibrachyparacytic :** Stomata and guard cells flanked by 4 cells which do not completely enclose the guard cells, may or may not elongate, with their long axis parallel to long axis of the guard cells.



Examples:

In the family Acanthaceae the stomata are diacytic, whereas in the closely related Scrophulariaceae the stomata are anomocytic. In the family Combretaceae, the stomata are paracy tic in the subfamily Strephonematoideae and anomocytic in the subfamily Combretoideae except the tribe Laguncularieae where they are cyclocytic.

Further, depending on the development of stomata, Pant (1965) has classified stomata into following three types:



Besides the above, following types are also used in taxonomy, depending on the presence of the stomata on the surface of the leaf:

Epistomatic *Presence of stomata on the upper side of the leaf*

Hypostomatic *Presence of stomata on the lower side of the leaf*

Amphistomatic *Presence of stomata on both sides of the leaf*

For example, the presence or absence of stomata on the upper surface of a leaf has been used as a very good diagnostic feature in the separation of Ainus subcordata C.A. Mey and A. orientalis Decne. (Betulaceae), which are otherwise very difficult to distinguish.