B.Sc. Semester-II

Paper-II : Morphology of Angiosperm

Topic: Leaf Morphology

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Definition of Leaf:

Leaf is a green, dissimilar exogenous lateral flattened outgrowth which is borne on the node of a stem or its branch and is specialised to perform photosynthesis. Typically it is a thin expanded green structure which bears a bud in its axil.

The green colour of the leaf is due to the presence of chlorophyll. Leaves are arranged in acropetal order. They develop as lateral outgrowth from shoot apical meristem. They are important vegetative organs which are specialised for photosynthesis. All the green leaves of a plant are collectively called foliage.

Characteristics of Leaf:

(i) It is dissimilar lateral flattened outgrowth of the stem,

(ii) The leaf is exogenous in origin,

(iii) It is borne on the stem in the region of a node,

(iv) An axillary bud is often present in the axil of the leaf,

(v) Leaf has limited growth,

(vi) An apical bud or a regular growing point is absent,

(vii) The leaf base may possess two lateral outgrowths called stipules,

(viii) A leaf is differentiated into three parts— leaf base, petiole and lamina,

(ix) The lamina possesses prominent vascular strands called veins,

(x) It is green and specialised to perform photosynthesis,

(xi) Leaf bears abundant stomata for exchange of gases,

(xii) It is the major seat of transpiration.

Parts of a Leaf:

A leaf consists of three parts— leaf base, petiole and lamina. Lamina (= epipodium) or leaf blade is the terminal thin, expanded, green and conspicuous part of the leaf which is specialized to perform photosynthesis. The flattened lamina or leaf blade is supported by veins and veinlet's which contain vascular tissues for conduction of water, mineral salts and prepared food.

There are two surfaces— adaxial (ventral, upper) towards the upper part of stem and abaxial (dorsal, lower) towards the lower part of stem. The two surfaces are quite distinct in dorsiventral leaves (most dicot leaves) but are quite similar in isobilateral leaves (most monocot leaves).

Petiole (= mesopodium) is a cylindrical or sub-cylindrical smooth or grooved stalk of the leaf which lifts the lamina above the level of stem so as to provide it with maximum exposure. Leaf having petiole is called petiolate. It is termed sessile if the petiole is absent.

Leaf Base: This is the part where a leaf attaches to the stem. Leaf base has two small leaf-like structure called stipules. In plants like paddy, wheat, and other monocotyledons, this leaf base is wide and masks the stem.

Petiole: Petiole is the long, thin, stalk that links the leaf blade to the stem.

Lamina: Also known as leaf blade. It is the green, flat surface of the leaves. It consists of small branched vein and veinlets. The vein that runs along the middle of the lamina is called midrib. Midrib divides the surface of the lamina into two. These veins and veinlets give rigidity to the leaf blade and help in transportation of water and other substances.

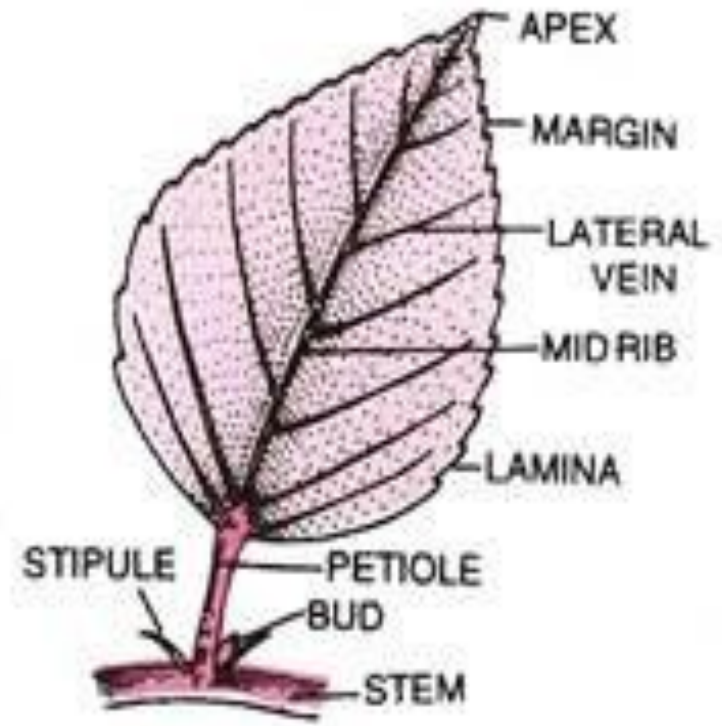


Fig. 5.51. Parts of a typical leaf.

Leaf base (= hypo podium) is the lowermost part of the leaf by which the leaf is joined to the node of the stem. It protects the young axillary bud. Leaf base is often indistinguishable from the petiole.

In many legumes it is swollen. The swollen leaf base is known as pulvinus. It is responsible for sleep and shock movements of certain leaves, e.g., Mimosa pudica. Leaf base may be broadened to enclose the stem. It is called sheathing leaf base.

The latter is of two types— amplexicaul (enclosing stem completely as in Grasses, Wheat) and semiamplexicaul (enclosing the stem partially, e.g., Buttercup).

Leaf base often contains two small lateral outgrowths called stipules. A leaf with stipules is called stipulate while the one without stipules is termed as exstipulate. In grasses an outgrowth is present between leaf base and lamina. It is called ligule. The leaf with ligule is called ligulate.

Differences between Petiole and Pulvinus

Petiole	*Pulvinus*
1. It is stalk of the leaf.	1. It is base of the leaf.
2. Petiole is nearly cylindrical.	2. Pulvinus is swollen.
3. It lifts the leaf blade above the stem.	3. It helps in sleep and other movements.

Parts of a Typical Leaf (Fig. 61):

A typical or an ideal leaf has usually three parts:

(i) Leaf base, by means of which the leaf remains attached to the stem or branch.

(ii) Leaf stalk or petiole, the cylindrical stalk which connects the leaf base with the flat blade.

(iii) Leaf blade or lamina, the green flat expanded part of the leaf. It goes without saying that the blade is the most important part.

The blade has usually a prominent rib running up to the tip. It is the midrib. The midrib has many branches and sub- branches distributed in the lamina. They are called veins. Veins really form the skeleton of the leaf on which softer materials remain inserted, and they are the channels for conduction of water and food. The outer edge of the leaf forms the margin, and the extreme tip, the apex.

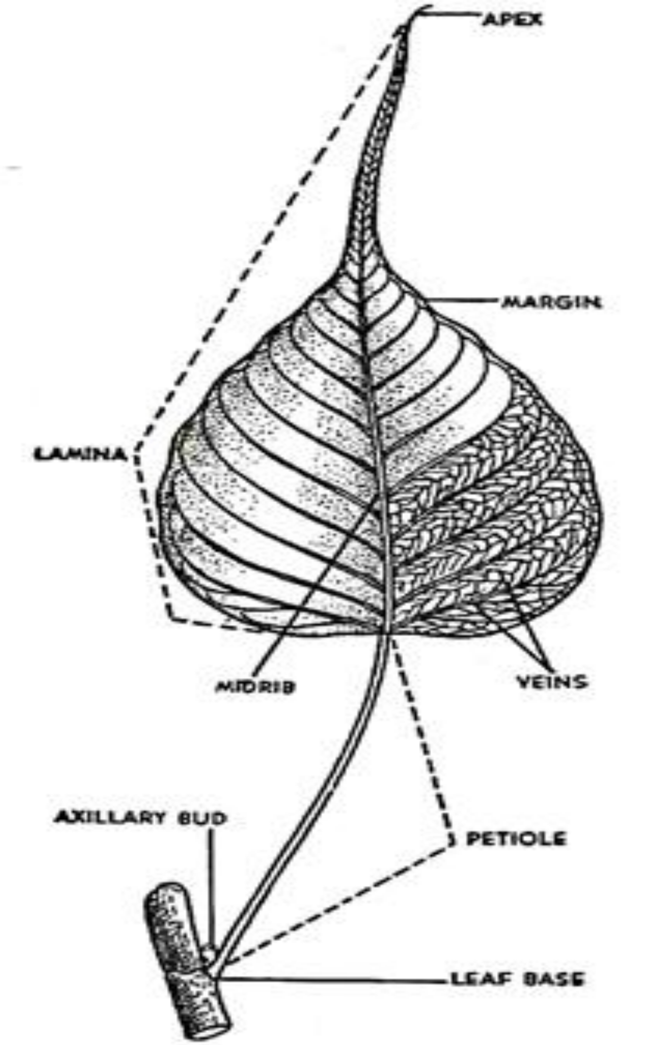


Fig. 61. Parts of a typical leaf.

(I) Simple Leaf:

A leaf is said to be simple when it consists of a single blade which may be entire or incised (and, therefore, lobed) to any depth, but not down to the mid-rib or the petiole. Mango, Cucurbita, Guava etc., are the examples of simple entire leaves (Fig. 4.13).

Incised or lobed leaves again may be of two types:

(i) Simple pinnate leaf:

When the direction of incision is towards the mid-rib, e.g., Raphanus sativus (turnip).

(ii) Simple palmate leaf:

When the direction of incision is towards the petiole, e.g., Ricinus (Castor), Carica papaya (Papaya)

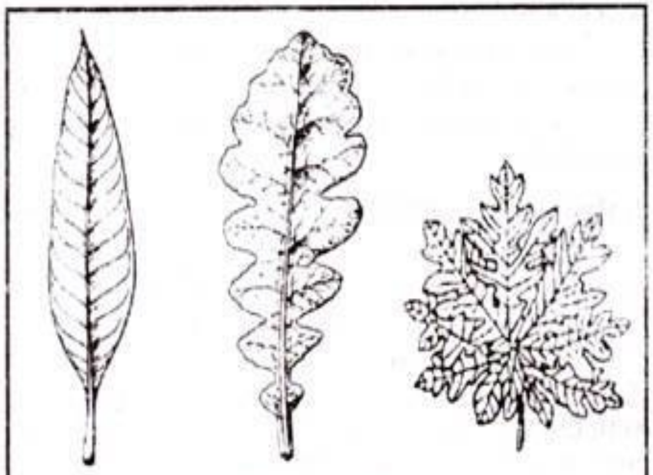


Figure 4.13 Simple leaf of Mango. **Figure 4.14** Lobed (simple pinnate) leaf of *Raphanus* (turnip). **Figure 4.15** Simple palmate leaf of papaya.

(II) Compound Leaf:

In a compound leaf, the incision of the leaf-blade goes down to the mid-rib (rachis) or to the petiole so that the leaf is broken up into a number of segments, called leaflets, these being free from one another, i.e., not connected by any lamina, and more or less distinctly jointed (articulated) at their base.

On the basis of incission, compound leaves are of two types:

(A) Pinnately Compound Leaf:

1. Pinnately Compound Leaf:

A pinnately compound leaf is defined as the one in which the mid-rib, known as the rachis bears laterally a number of leaflets, arranged alternately or in an opposite manner, as in tamarind, gram, gulmohur, rain tree, senstivie, plant, gum tree (Acacia), Cassia etc. (Fig. 4.16 A to E). It may be of the following types:

(i) Unipinnate:

When the mid-rib of the pinnately compound leaf directly bears the leaflets, it is said to be unipinnate. In it the leaflets may be even in number (paripinnate), as in Cassia, Saraca (B. Asok; H. Seeta-asok), Sesbania (B. Lak phul; H. Agast), etc., or odd in number (imparipinneate), as in rose, margosa (Neem) etc.

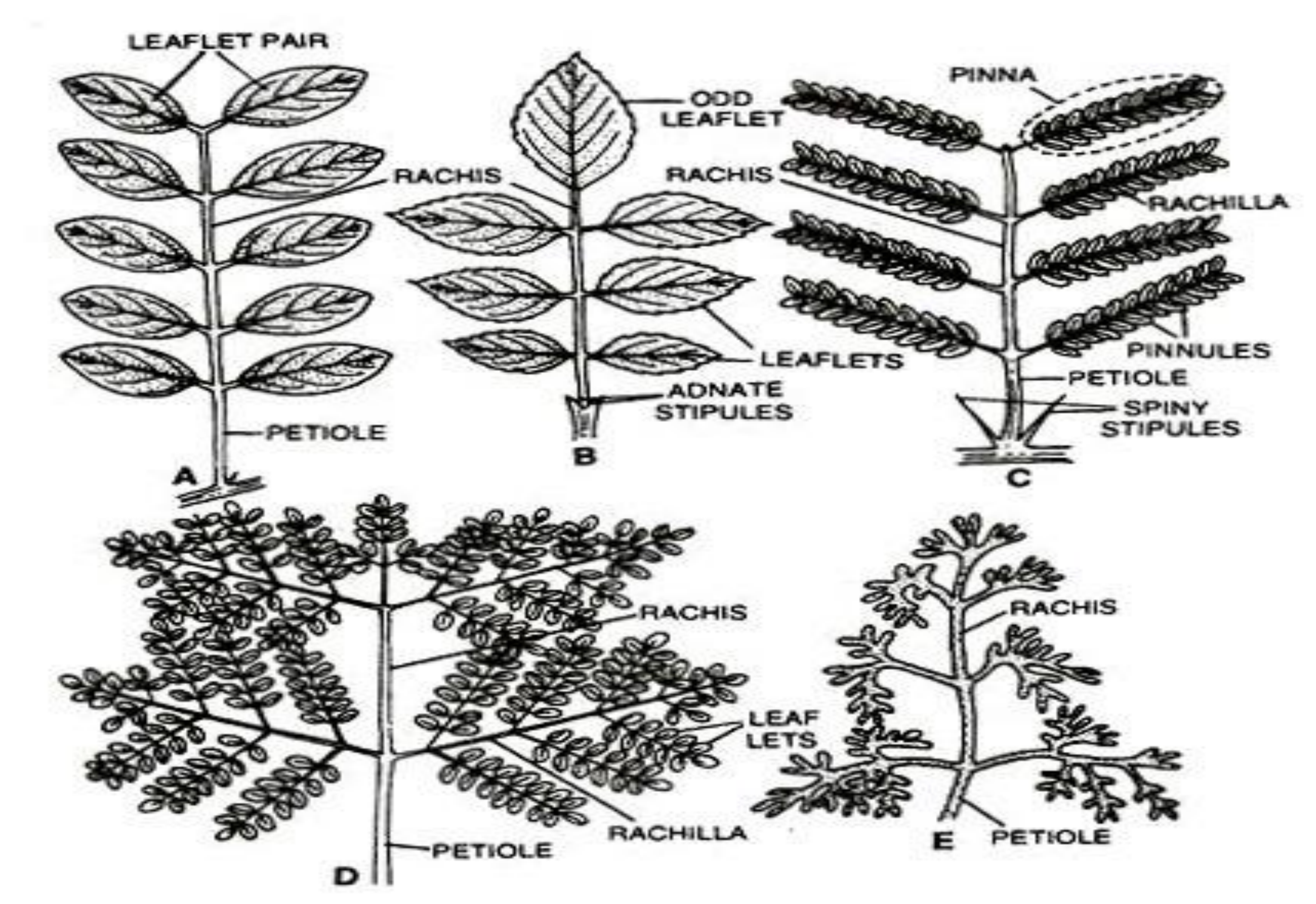


Fig. 5.58. Pinnate compound leaves. A, paripinnate; B, imparipinnate; C, bipinnate; D, tripinnate; E, decompound.

The pinnate leaf is said to be unifoliate, when it consists of only one leaflet, as in Desmodium gangeticunm: bifoliate or unijugate (one pair), when of two leaflets, as in Balanites (fig. 1.86) and sometimes in rose; trifoliate or ternate, when of three leaflets, as in bean, coral tree (Erythrina) and wild vine (Vitis trifolia). It may similarly be quadrifoliate, pentafoliate or multifoliate, according as the leaflets are four, five or more in number.

(2) Bipinnate:

When the compound leaf is twice pinnate, i.e. the midrib produces secondary axes which bear the leaflets, it is said to be bipinnate, as in dwarf gold mohur (Caesalpinia), gum tree (Acacia), sensitive plant (Mimosa), etc.

(3) Tripinnate:

When the leaf is thrice pinnate, i.e. the secondary axes produce the tertiary axes which bear the leaflets, the leaf is said to be tripinnate, as in drumstick (Moringa), and Oroxylurn

(4) Decompound:

When the leaf is more than thrice pinnate, it is said to be decompound, as in anise, carrot, coriander, Cosmos etc.

(B) Palmately Compound Leaf (fig. 4.18):

A palmately compound leaf is defined as the one in which the petiole bears terminally, articulated to it, a number of leaflets which seem to be radiating from a common point like fingers from the palm, as in silk cotton tree, lupin, Gynandropsis, etc.

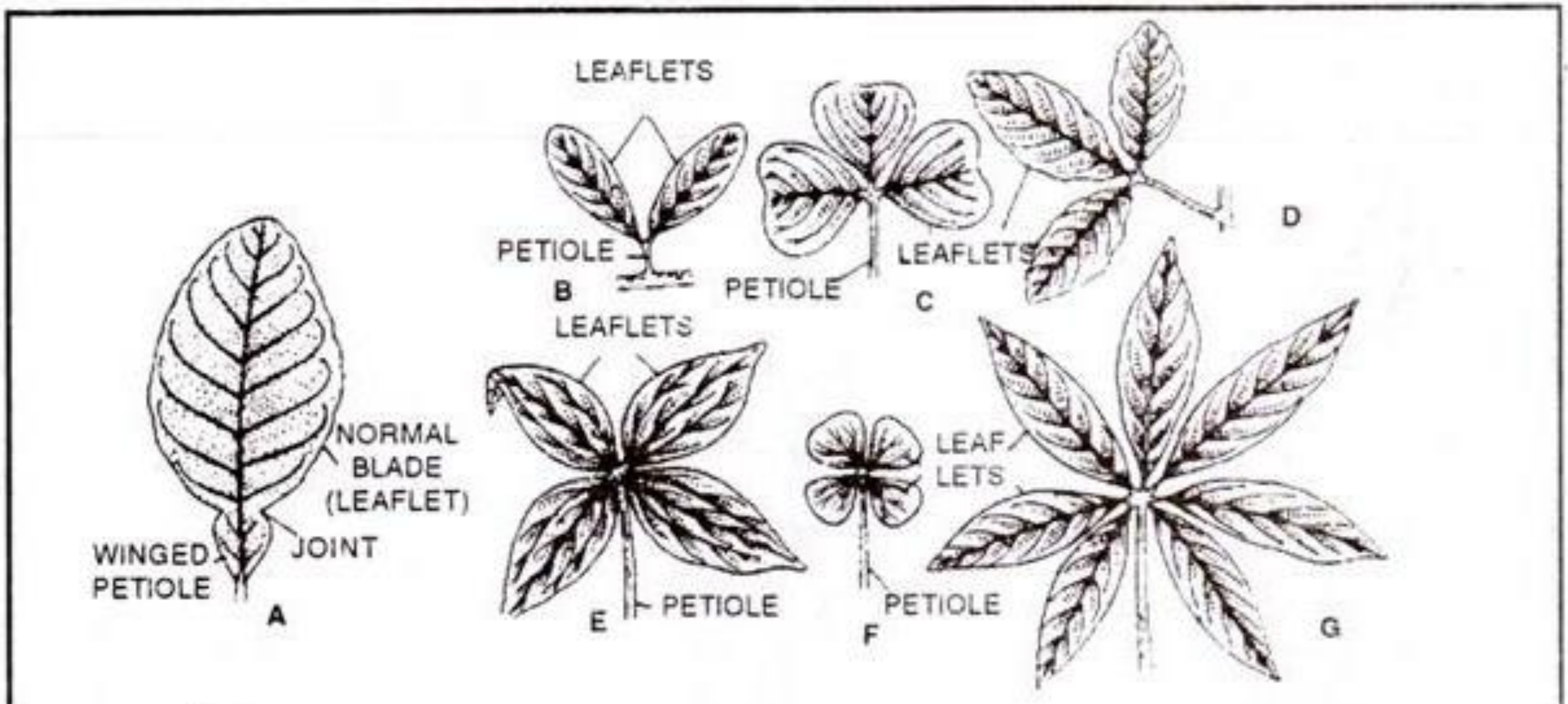
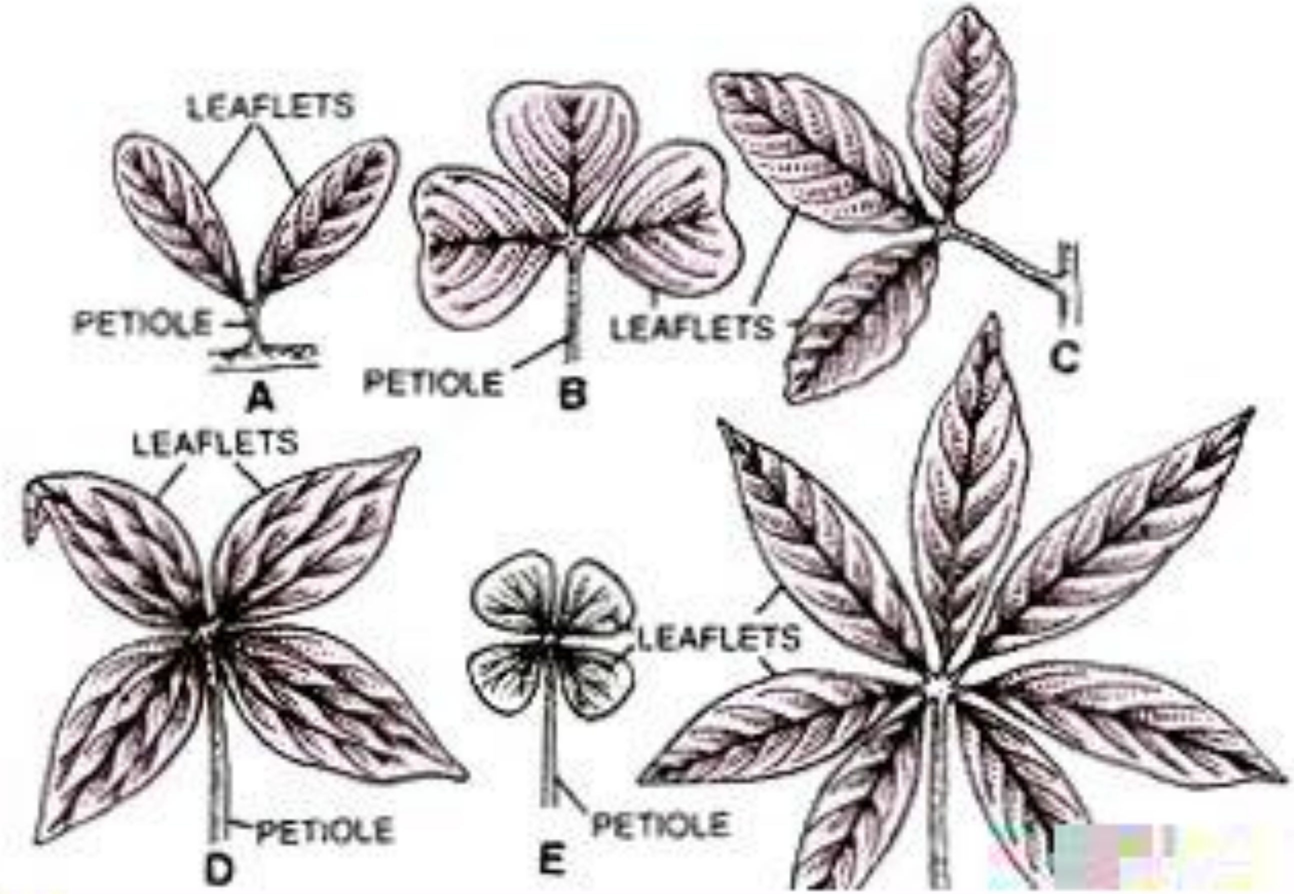


Figure 4.18 Palmately compound leaf. **A**. Unifoliate compound leaf of *Citrus*; **B**. Bifoliate leaf of *Balanites*; **C**. Trifoliate leaf of *Oxalis*; **D**. Trifoliate leaf of *Aegle* (Bael); **E**. Quadrifoliate leaf of *Paris quadrifolia*; **F**. Quadrifoliate leaf of *Marsilea*; **G**. Multifoliate leaf of *Bombax* (Simbal).


LEAFLETS
PETIOLE
A
PETIOLE
B
LEAFLETS
C
LEAFLETS
PETIOLE
D
LEAFLETS
PETIOLE
E

On the basis of number to leaflet, a palmately compound leaf may be of the following types:

(1) Unifoliate:

In this type only one leaflet is attached on the apex of lamina, e.g., Citrus (lemon). In the leaves of these plants leaflets are present in primary stage, so palmate habit appears in these plants.

(2) Bifoliate (Fig. 4.17):

In this type, two leaflets are present on the apex of the petiole, e.g., Balanitis, Hardwickia, Bignonia grandiflora, Princepia etc.

Figure 4.17 Bifoliate leaf or *Balanites*

(3) Trifoliate or Ternate:

In this type three leaflets are arranged on the apex of petiole, e.g., Aegle marmelos, Medicago, Hydrocotyle, Trifolium and Desmodium.

(4) Quadrifoliate:

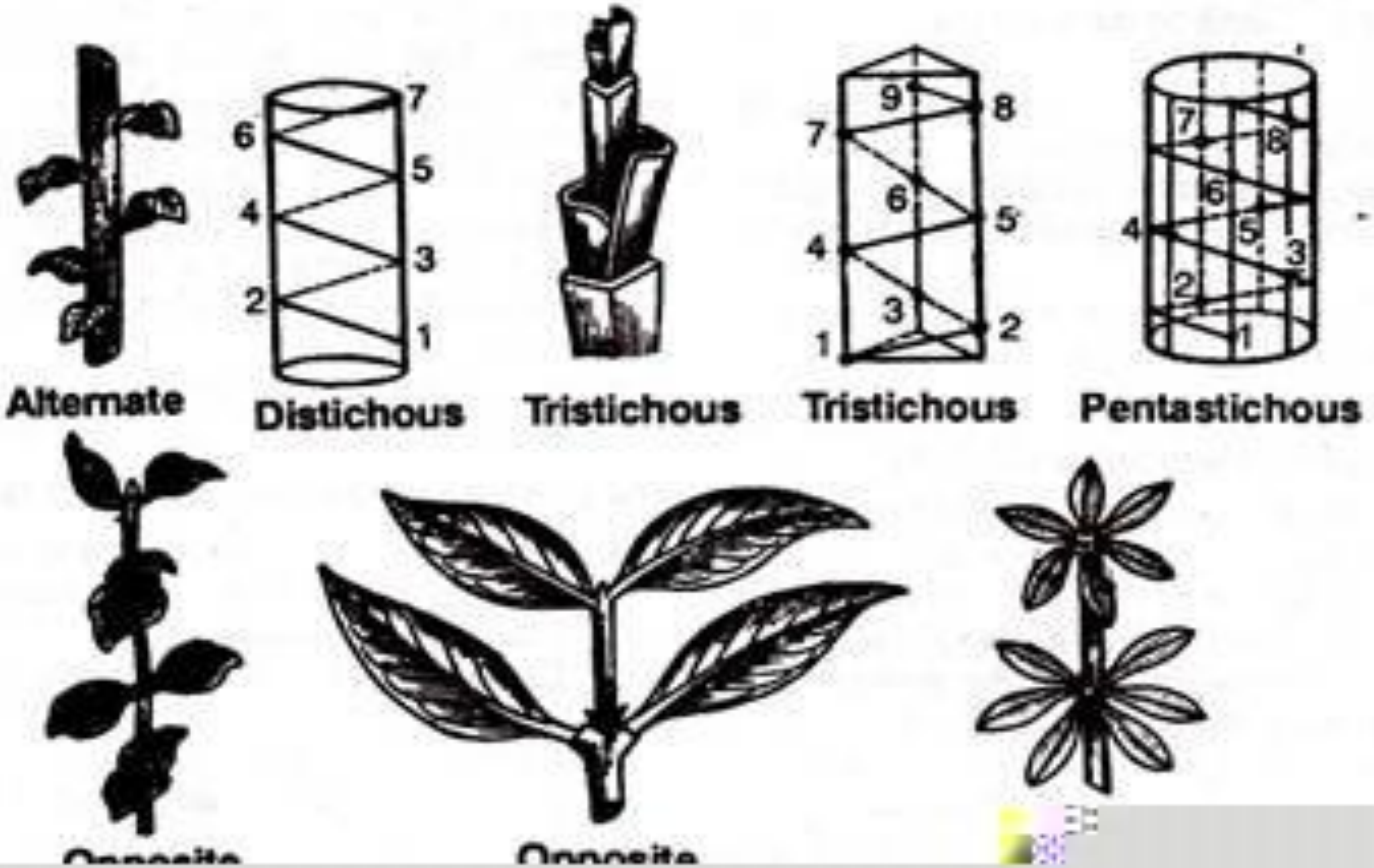
In this type, four leaflets are present on the apex of petiole, e.g, Paris quadrifoliata, Marsilea (a pteridophyte, not angiosperm).

(5) Multifoliate:

In this type, more than four leaflets are present on the apex of petiole, e.g., Bombax, Gynandropsis, Cleorne, Lupin etc.

Phyllotaxy:

The arrangement of leaves on the stem is called phyllotaxy.



It is following three different categories:

i. Alternate:

When only one leaf develops at each node, e.g., Brassica campestris, Nicotiana tabacum.

It is following types:

(a) Distichous or 1/2 or 2- ranked:

When 3rd leaf comes over the first one, e.g., grasses.

(b) Tristichous or 1/3 or 3-ranked:

When 4th leaf comes over the first one, e.g., Cyperus.

(c) Pentastichous or 2/5 or 5-ranked:

When 6th leaf comes over the first one after completing two revolutions of the spiral, e.g., apple.

(d) Octostichous or 3/8 or 8-ranked:

When 9th leaf comes over the first one after completing three revolutions of the spiral, e.g., Carica papaya.

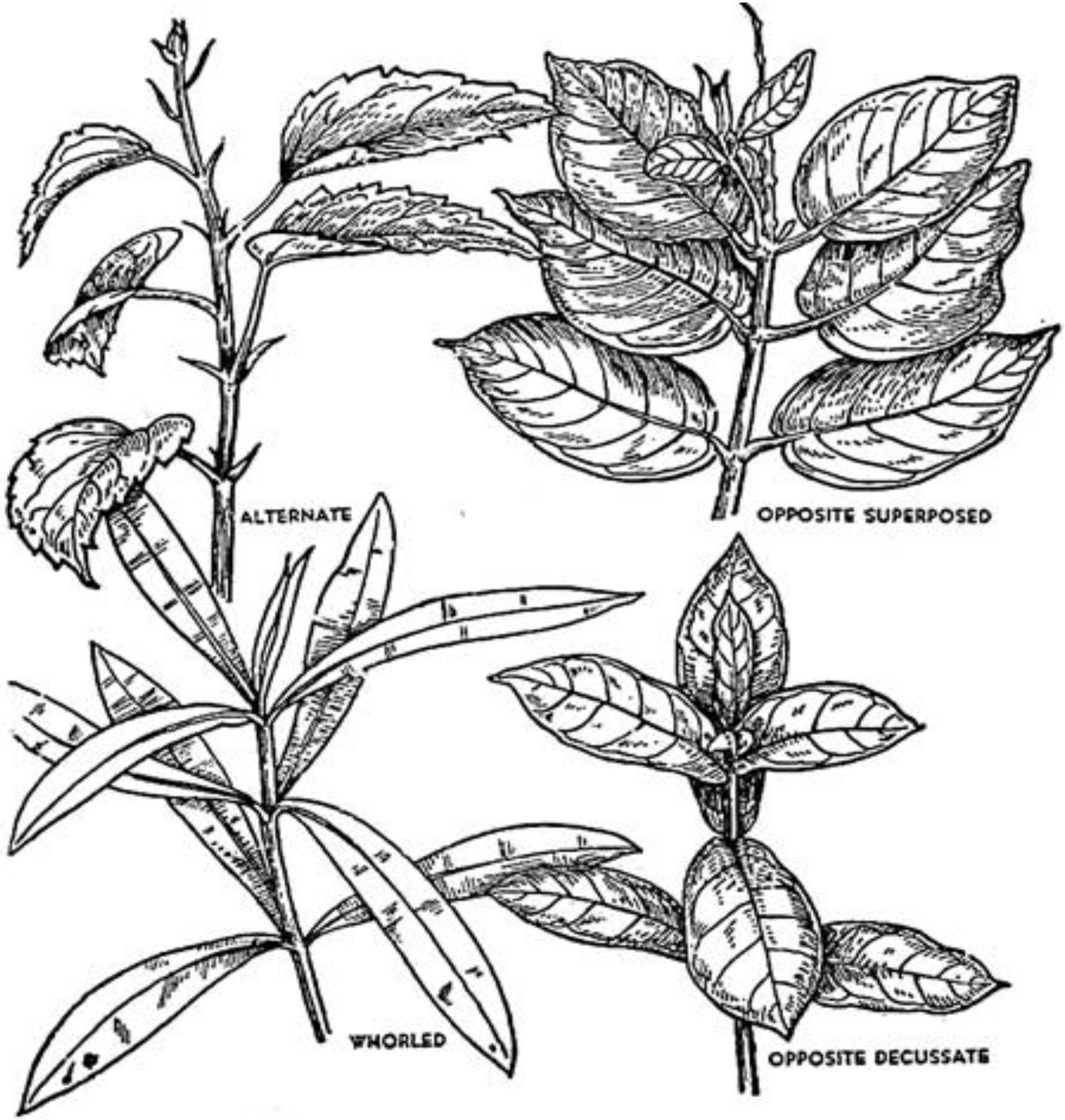


Fig. 73. Kinds of Phyllotaxy.

ii. Opposite:

When a pair of leaves are present just opposite to each other at each node, e.g., Calotropis.

It is of following types:

(a) Opposite and decussate:

When two successive pairs of leaves occur at right angle to each other, e.g., Psidium.

(b) Opposite and superposed:

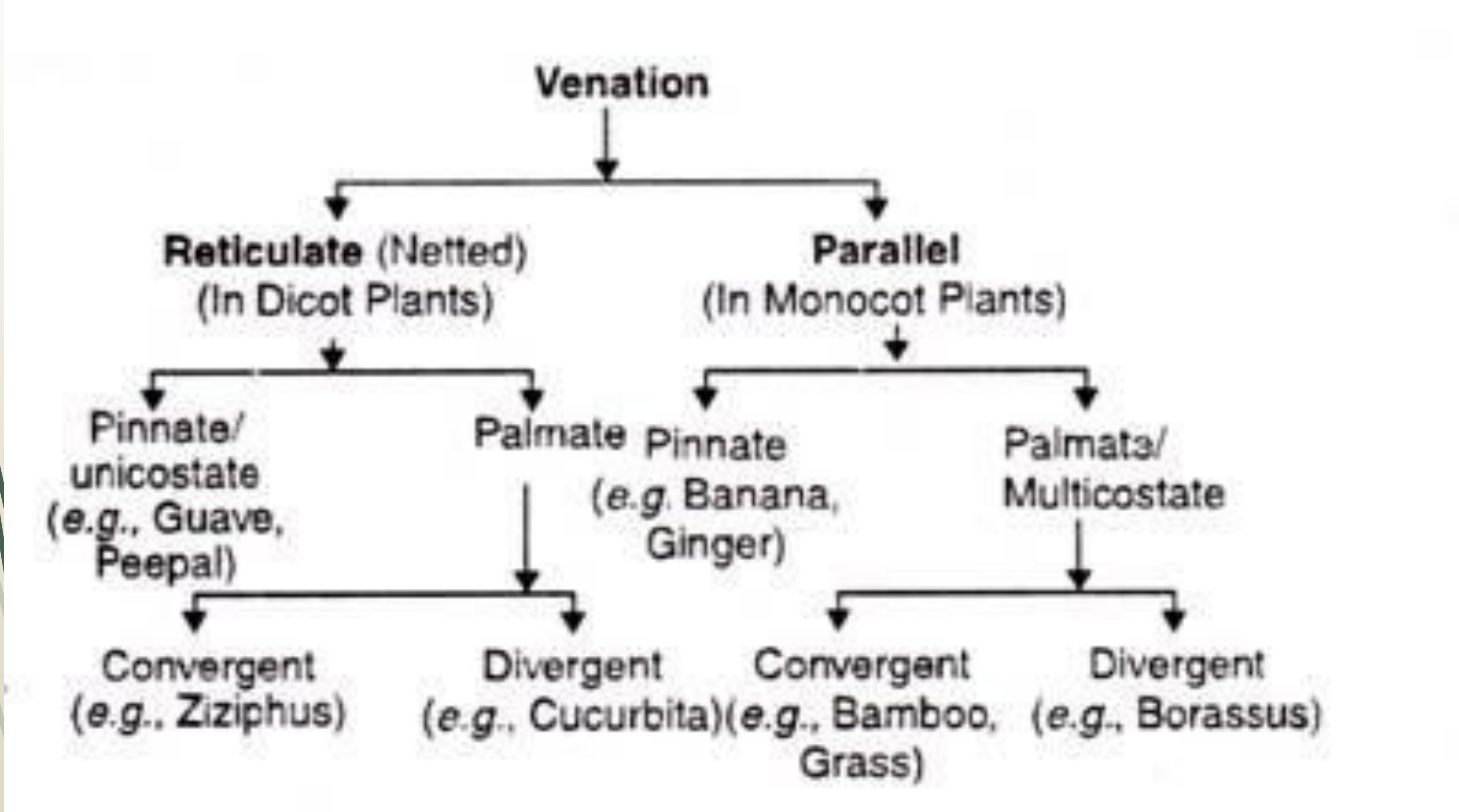
When all the pairs of leaves occur in the same plane, e.g., Combretum.

iii. Whorled:

When more than two leaves are arranged in the form of a whorl at each node the phyllotaxy is called whorled, e.g., Hydrilla verticillata, Nerium, etc.

Venation:

The arrangement of veins and veinlets in the leaf lamina is called venation. It is of two types – Reticulate and Parallel.



I. Reticulate venation:

In this type, the veinlets form a network in the lamina. It is the characteristic of most dicot leaves except Calophyllum. Some monocots like Colocasia, Dioscorea and Smilex show reticulate venation.

On the basis of number of mid-rib (main vein or costa), the reticulate venation is of two types:

(A) Pinnate or Unicostate Reticulate Venation:

In this type the lamina has a single prominent mid-rib running from the base to the apex. The lateral veins and veinlets arise on both sides of midrib forming a reticulum (mesh or network; e.g., China rose, mango, peppal etc.

(B) Palmate or multicostate reticulate venation:

In this type, the lamina has more than one equally prominent mid-rib. It is again of two types.

(i) Convergent types:

When all the mid-ribs diverge out from the leaf base but again converge towards the apex of the lamina e.g. Smilax, Ziziphus, and Cinnamomum etc.

(ii) Divergent type:

When all the mid-ribs diverge out from the leaf base and do not converge towards the apex, e.g., papaya, castor, cucumber etc.

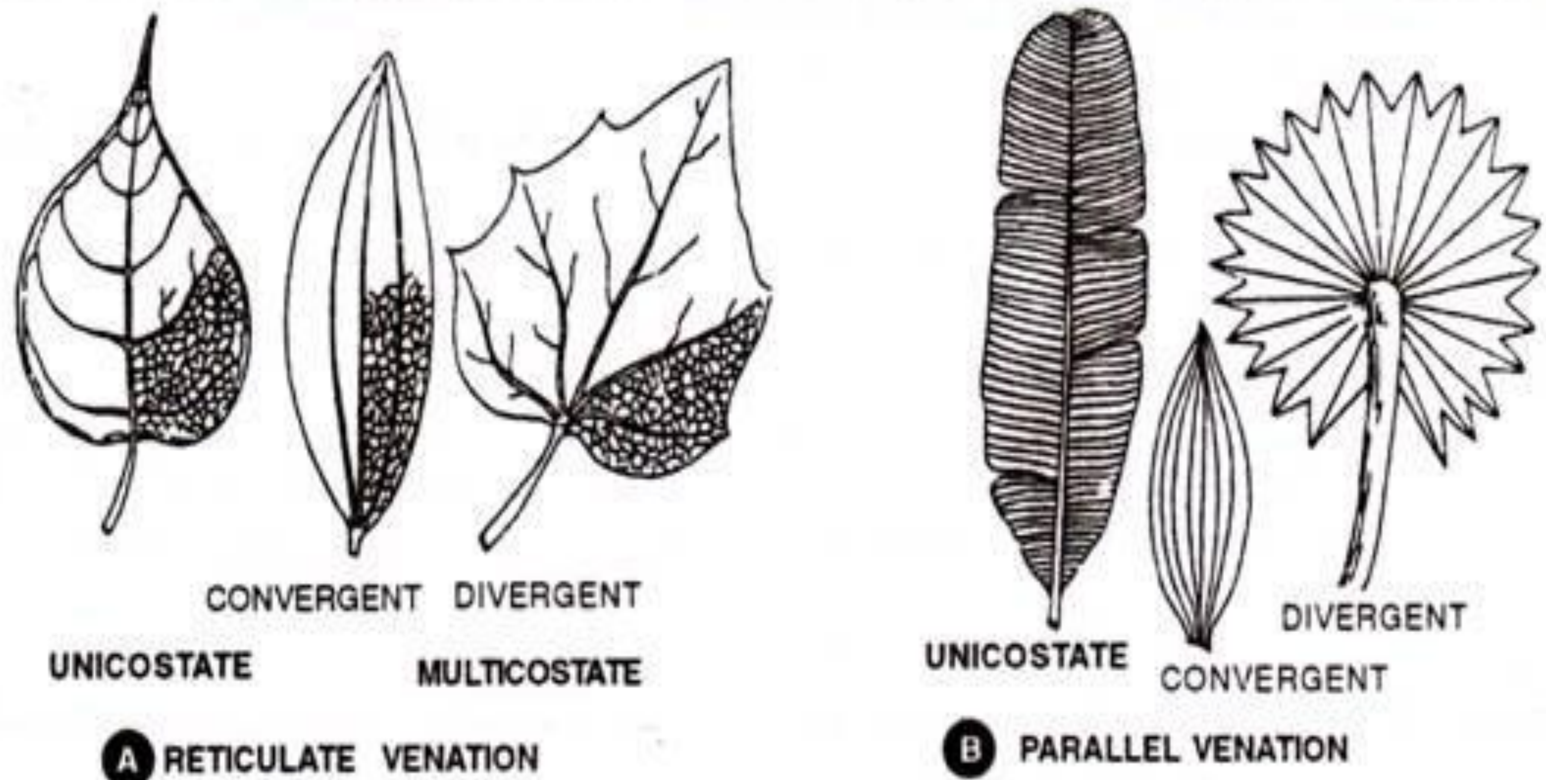


Figure 4.12. Kinds of Venation A–Reticulate Venation and B– Parallel Venation

II. Parallel Venation:

In this type, the veins arising from the mid-rib tend to run parallel to each other and do not form a network. It is the characteristic of monocot leaves except Smilax, Arisaema, and Dioscorea etc.

On the basis of number of mid-rib, the parallel venation is of following two types:

(A) Pinnate or Unicostate Parallel Venation:

In this type, lamina has a mid-rib in the centre. Lateral veins come out perpendicular to the mid-rib, which run parallel to each other towards margin or apex of lamina; the lateral veins do not anastamose, e.g., Carina, Musa (Banana).

(B) Palmate or Multicostate Parallel Venation:

Here, the lamina has numerous equally prominent veins arising from the tip of the petiole and running parallel towards the leaf apex or laminatnargin.

They do not branch. It is again of two types:

(i) Convergent type:

In this type, all mid-veins run parallel to each other from the base of lamina and unite (converge) at the apex, e.g., Bamboo Rice, grass, Eichornia etc.

(ii) Divergent type:

In this type the main veins arise from the tip ‘of the petiole and proceed (diverge) towards the margin of the leaf blade in a more or less parallel manner as in fan palms such as palmyra palm.

Modification of Leaves

Structures of the Leaves:

They are as follows:

1. Bladder:

In bladderwort (Utricularia) the leaves are very much segmented and they simulate roots excepting that they are green in colour. Some of these segments become modified into bladders. Each bladder is about 3 mm in diameter and is provided with a trapdoor entrance. The trap door acts as a short of valve which can be pushed open inwards from outside, but never from inside to outside.

This trap-door entrance allows aquatic animalcules to pass in, but never to come out. The inner surface of the bladder is dotted all over with numerous digestive glands. These glands secrete the digestive agent and absorb the digestive products.

2. Pitcher:

In the pitcher plant (Nepenthes) the leaf becomes modified into a pitcher. The morphology of the leaf of pitcher plant is that the pitcher itself is the modification of leaf blade, the tendrillar stalk supporting the pitcher is the modification of the petiole, and the laminated structure that of the leaf base.

The inner surface of the pitcher corresponds to the upper surface of the leaf and the lid of the pitcher arises as an outgrowth of leaf apex. The function of the pitcher is to capture and digest insect. When young the mouth of the pitcher remains closed by its lid which later on opens and stands erect.

The inner side of the pitcher remains covered with numerous, smooth and sharp hairs, all pointing downwards. Lower down the inner surface numerous digestive glands are found. The digestive agent, secreted by glands, is trypsin which helps in digesting the proteins. In the sundew (Drosera) the upper surface of the leaf is covered with glandular hairs which are sensitive to touch and capture insects.

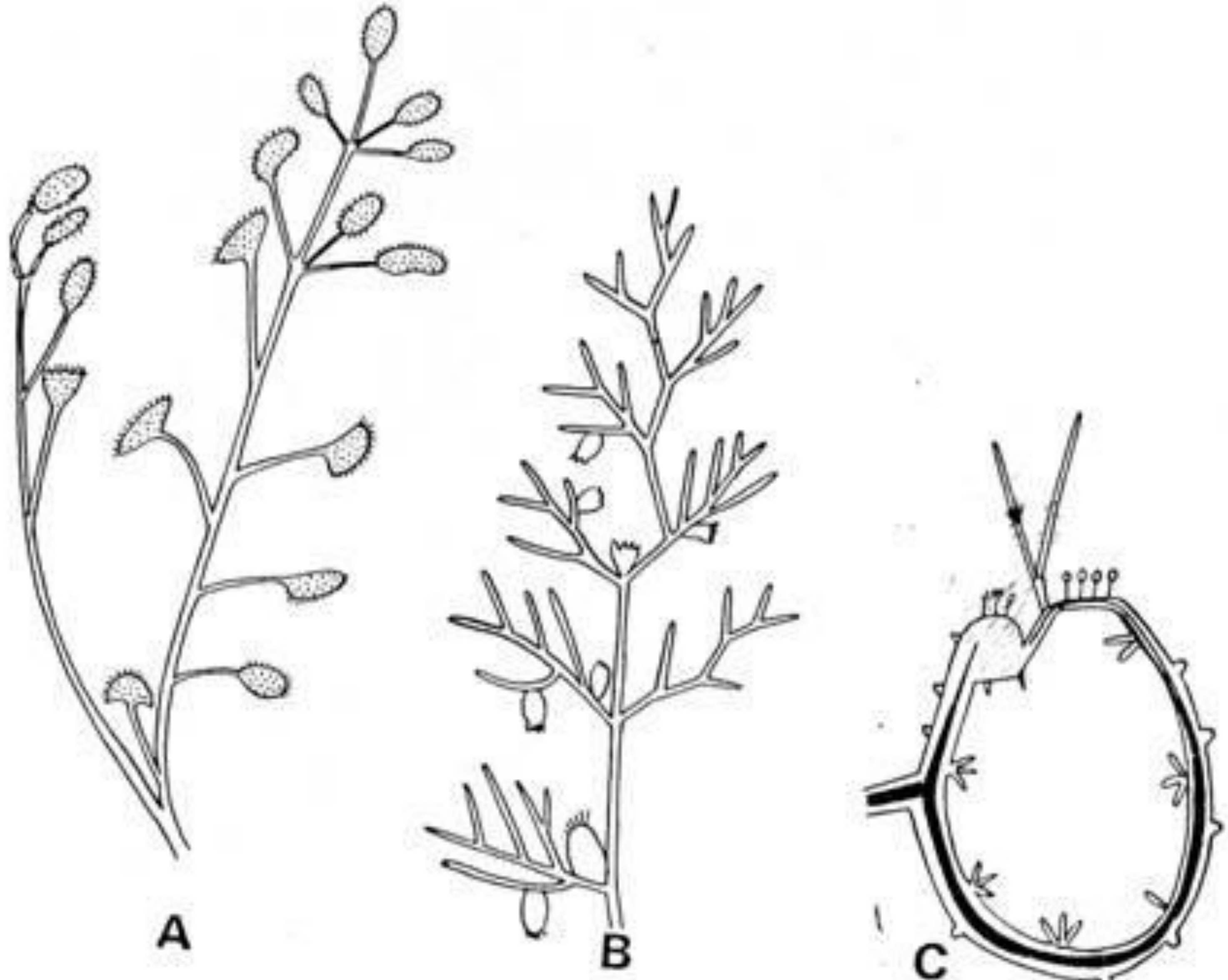


Fig. 34.46. Leaf modification to catch insects. A, *Drosera;* B,—C, *Utricularia.* In this case the leaf segments become modified into bladders that catch insects. In C a bladder is shown in L.S. to illustrate its internal structure.

3. Phyllode:

In some species of Australian Acacia the lamina of the leaf is absent but the petiole is so flattened as to appear leaf-like. These flattened petioles are known as phyllodes and they are so developed as to place their surfaces in the vertical plane. The normal leaf is pinnately compound and only develops in the seedling stage. The phyllode then carries all the functions of the leaf.

4. Leaf-Tendrils:

In certain plants the leaves become modified into slender, wire-like-coiled structures known as tendrils. The leaf may be partially or wholly modified into tendrils.

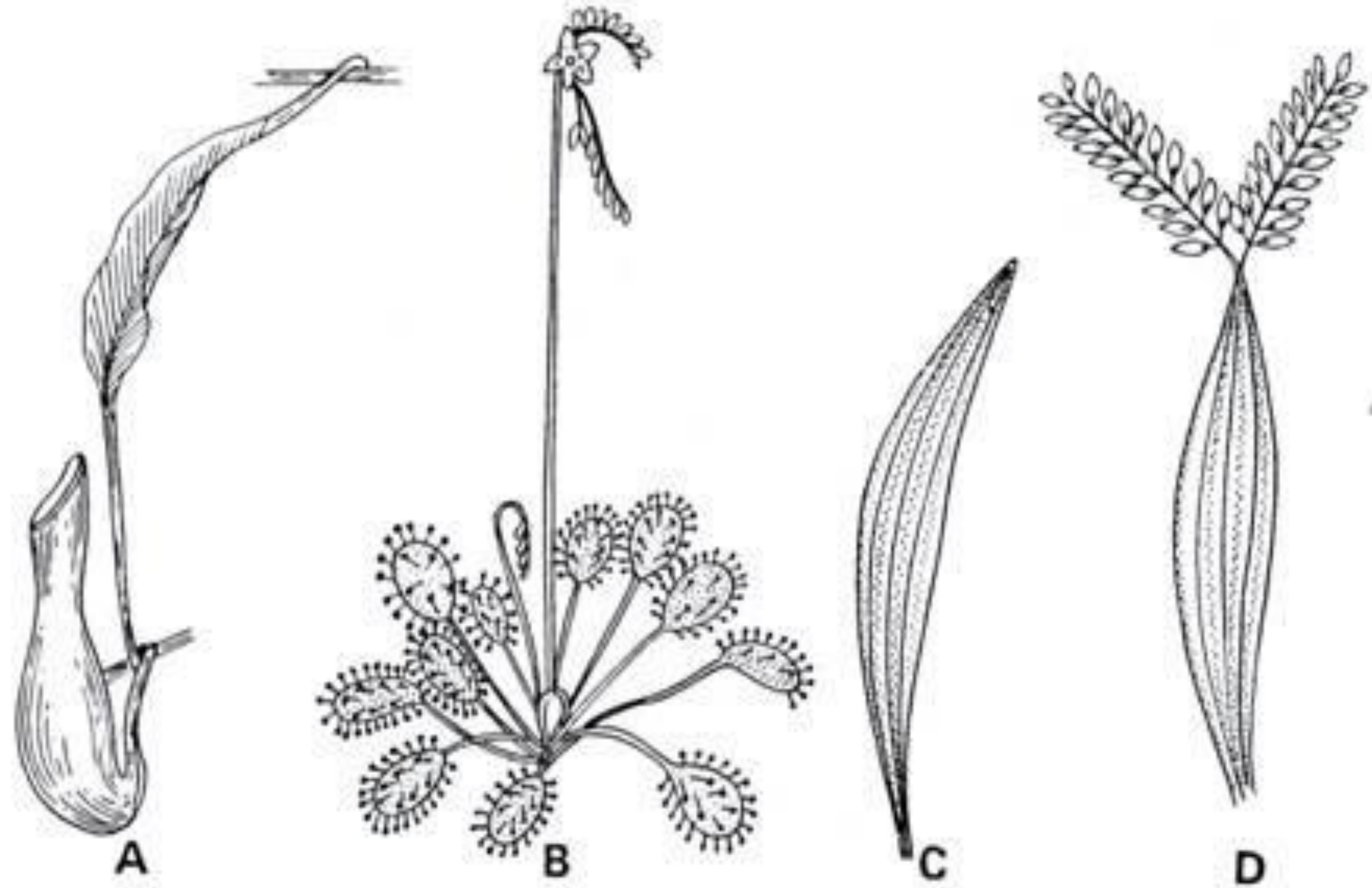


Fig. 34.47. Modification of leaves to conserve matter and to catch insects. A, *Nepenthes khasiana* or the pitcher plant. It catches insects in the pitcher; B, *Drosera* sp. leaves modified to catch insects; C—D, Australian *Acacia*. The petiole becomes flattened, green and leaf like. It is called phyllode.

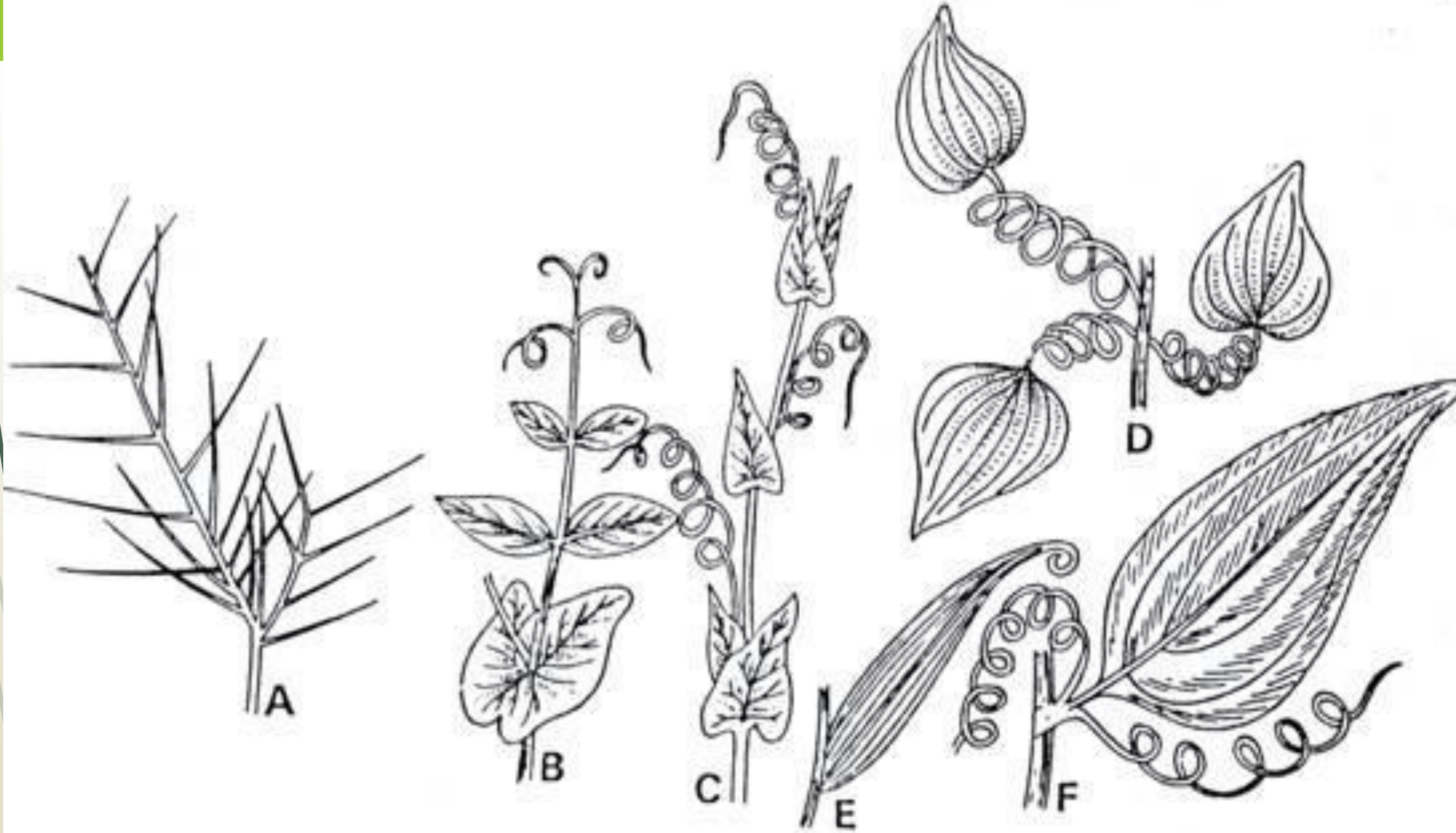


Fig. 34.48. Leaf tendrils and spines. A, leaf spines of *Hakea* ; B, leaflet tendril of *Pisum sativum;* C, leaf tendril or *Lathyrus aphaca*. Note the leaf like stipules; D, petiolar tendrils of *Clematis;* E,tendrillar leaf tip of *Gloriosa superba* ; F, stipular tendrils of *Smilax*.

For example, in pea only the upper leaflets are modified into tendrils. In Naravelia and Bignonia the terminal leaflet converts into a tendril. In Gloriosa the leaf apex becomes modified into a tendril. In Nepenthes the petiole acts as a tendrillar structure.

In Lathyrus aphaca the whole leaf is being converted into a single tendril while the two foliaceous stipules act like the leaves. Tendrils are always climbing organs and are sensitive to contact with any solid body. Whenever a tendril comes in contact with a neighbouring object it coils around it and helps the plant to climb.

5. Leaf-Spines:

In Hakea and Opuntia the whole leaves are modified into spines. The morphological nature of such spines can be pointed out by the presence of a bud in their axis. In such cases the stems become green and carry on photosynthesis. In Acacia nilotica and Zizyphus the stipules are modified into spines.

The position of such spines on either side of the leaf base shows their morphological nature. In Solatium xanthocarpum, Argemone Mexicana, Aloe, Acanthus, etc., the surface and margins of leaf are covered with spines. Morphologically, they are the modified parts of the leaves.

6. Scale-Leaves:

They are thin, dry, papery, stalk-less membranous structures usually brown in colour. Sometimes scale-leaves are thick and fleshy as found in onion. In Casuarina, Tamarix, Asparagus, Ruscus, etc., the leaves are reduced to scales. In such cases the stem becomes green, flattened and leaf like to perform functions of leaf.

Scale leaves are common on underground stems where they cover and protect the axillary buds under unfavourable conditions. The scale- leaves are also common on angiospermic parasites where they replace the green vegetative leaves.

Functions of the Leaves:

1. Manufacture of Carbohydrates:

The main function of the leaf is to manufacture food particularly carbohydrates. Chloroplasts found in the leaf cells, trap the solar energy which is then utilized in the synthesis of carbohydrates from carbon dioxide and water by the process of photosynthesis.

The upper side of the leaf contains abundance of the chloroplasts and the sun rays fall directly on the upper surface and normally the manufacture of food takes place in this region of the leaf.

2. Exchange of Gases:

To facilitate the exchange of gases between the atmosphere and the plant body numerous minute openings called stomata, develop, usually on the under-surface of the leaf. The stomata remain open during day light.

In the process of respiration of all the living cells the oxygen is taken in and carbon dioxide is given out while in photosynthesis the green cells absorb carbon dioxide and give out oxygen. The respiration of the living cells goes on round the clock, while the photosynthesis takes place only in daytime.

3. Transpiration:

Although large quantities of water are absorbed by plants from the soil but only a small amount of it is utilized. The excess of water is lost from the aerial parts of plants in the form of water vapours. This is called transpiration. It occurs mostly through stomata, but sometimes it also takes place through cuticle and lenticels.

The transpiration is necessary as it helps in the transport of water within the plant body and also regulates its temperature.

4. Storage of Food:

Fleshy leaves of succulents, such as Indian aloe, purslane and fleshy scale leaves of onion store up water and food material for the future use of the plants. Fleshy leaves of many desert plants store a large quantity of water, mucilage and food material.

5. Vegetative Propagation:

The leaves of Bryophyllum, Begonia and Kalanchoe produce buds on their margins. Bach such bud develops into a new plant.

6. Protection:

The leaves also give necessary protection to the axillary bud. The leaves modified into thorns and spines (e.g., in Berberis, Aegle), give protection to the plants from animals.

Thank You….!