Introduction to Plant Morphology - Morphological Study of Leaf

Objectives

After going through this lesson, the learners will be able to understand the following:

- Morphological Study of Plant Leaves (Diversity In Form And Function)
- Morphological Study of Plant Leaves
- Phyllotaxy
- Leaf Modifications

Content Outline

- Introduction
- The Leaf
- Types of Leaf
- Parts of a Typical Foliage
- Types of Foliage Leaves
- Leaf Venation
- Some More Description About Leaf
- Phyllotaxy
- Modification of Leaves
- Summary

Introduction

The leaf is predominantly the site of photosynthesis within a plant. In order to do the function of photosynthesis leaves are morphologically and anatomically adapted and designed to facilitate gaseous exchange along with trapping sunlight. Not all plants have true leaves, non vascular plants such as bryophytes although have leaf like structure however due to missing vascular tissues the leaves are not considered to be true leaves. Vascularized leafs were first formed in Devonian period around 400-450 million years ago when the CO_2 decreased significantly this created to individual lineages the microphylls which had the lateral outgrowth of the stem as in *Lycopodium sp*., *Selaginella sp*. The other being the megaphylls that have been derived from a branch that got somewhat limited growth and took up leaf-like form as seen in ferns and seeded plants. Different angiosperms show a great diversity in form and structural design of leaves to adapt to the climate, topography, height and age of the plant

on which the leaves are borne. In the previous module we learned about the morphology of the root and the stem. In this module we would be learning about morphological study of a leaf in general along with the study of phyllotaxy and various leaf modifications exhibited by the plant world.

The Leaf

The activity of shoot apical meristem results in the formation of the **leaf primordium** which grows and matures into leaf. The leaf is a lateral, generally flattened structure borne on the stem. It develops at the node and bears a bud in its axil. The axillary bud later develops into a branch. Leaves originate from shoot apical meristems and are arranged in an acropetal order. They are the most important vegetative organs for photosynthesis. A typical leaf consists of three main parts: leaf base, petiole and lamina. The morphology of these regions within the leafs, shows a great extent of diversity in their growth and the relative dimensions from one species to the other.

Types of Leaf

- **Cotyledonary Leaves:** These are the embryonic leaves of seed.
- **Bract leaves or hypsophylls:** Bracts are the leaves which contain flower or inflorescence in their axil. These are usually small and green but in some plants such as Bougainvillea *and Euphorbia*; these are large and bright coloured.
- **Scale leaves or cataphylls:** These are usually present on underground stems (e.g. rhizome) and are usually brown or grey coloured membranous structures. Buds are present in their axil in onion and garlic (underground bulb), scale leaves store food and become fleshy.
- **Prophylls:** First few leaves on a stein, different from other leaves.
- **Foliage leaves:** Normal leaves attached on aerial stern and branches are called foliage leaves. These are usually green coloured.

Parts of a Typical Foliage Leaf

- **The Leaf Base:**

The leaf is attached to the stem by the leaf base and may bear two lateral small leaf-like structures called stipules. In monocotyledons, the leaf base expands into a sheath covering the

stem partially or wholly *Zea mays*, sugarcane, banana etc. In some leguminous plants the leaf base may become swollen, which is called the **pulvinus**. The petiole helps hold the blade to light. Long thin flexible petioles allow leaf blades to flutter in wind, thereby cooling the leaf and bringing fresh air to the leaf surface. The lamina or the leaf blade is the green expanded part of the leaf with veins and veinlets. There is, usually, a middle prominent vein, which is known as the midrib. Veins provide rigidity to the leaf blade and act as channels of transport for water, minerals and food materials. The shape, margin, apex, surface and extent of incision of lamina varies in different leaves.

Stipules: Leaves of some plants have lateral appendages on each side of leaf base, known as stipules. The leaves without stipules are known as exstipulate. The stipules also show a great diversity and can be classified into eight different types.

- **Free lateral stipules:** stipules present on both lateral sides of the leaf base e.g. *Hibiscus sinensis*, *Gossypium*.
- **Adnate Stipules:** These are two lateral stipules attached to the petiole upto some distance e.g., *Hicksbeachiapinnatifolia*, *Lupin* etc.
- **Interpetiolar stipules:** The adjacent stipules of two opposite leaves are fused to form interpetiolar stipules. In this way these are alternate with leaves e.g., *Anthocephalus, Ixora*.
- **Intrapetiolar Stipules:** These stipules are also present on opposite leaves. In these, both stipules of each leaf join on the inner margin and look like a single stipule. Thus, these appear in the axil of leaf e.g., *Gardenia.*
- **Ochreate stipules:** When both stipules of the leaf join on outer and inner margin and make a hollow tube which encircles (surrounds) the stein upto the upper part of node, the structure is known as ochreate stipule e.g., *Polygonum, Rumex* etc.
- **Foliaceous Stipules:** These arc two leaf like, broad and green stipules. *Lathyrusaphaca*, *Pisumsativum.*
- **Tendrillar Stipules:** When stipules are thin and modified into wire like structure, these are known tendrillar. e.g., *Smilax*.
- **Spiny stipules:** When stipules are convened into sharp pointed structures in *Mimosa*, *Acacia* or in *Ziziphus*.

- **Petiole:**

  Leaf is called sessile when there is no petiole e.g., wheat, rice, Calorropis. Gloriosa, etc. Petiole bearing leaves are known as petiolate e.g., Peepal, Mango, Guava. Petioles are of the following types –

  1. **Winged petiole:** It is usually present in compound leaves. In this type the petiole becomes flattened leaf-like and carry out photosynthesis. E.g., *Citrus*.
  2. **Phyllode:** Lamina in some compound leaves falls off soon and petiole gets modified into leaf-like structure and synthesize food e.g. *Parkinsonia, Acacia melanoxylon.*
  3. **Tendrillar Petiole:** Petioles in some weak stemmed plants are modified into tendril and help in climbing the plants e.g., *Clematis, Nasturtium, Nepenthes* etc.
  4. **Floating or bulbous petiole:** In some plants viz. *Eichhornia, Trapa* etc. petiole becomes spongy. This petiole is full of air and helps in floating.

Types of Foliage Leaves

Foliage leaves can be classified into on the basis of incision of Lamina, leaves may be of two types: Simple and compound

- **Simple leaf:** In this type, there is a single lamina which is usually entire e.g., mango Guava, *Cucurbita*, Cucumber etc.
- **Compound leaf:** In this type, incision of lamina reaches upto the midrib or petiole due to which lamina is divided into several small parts known as leaflets.

Compounds leaves are of two types:

- Pinnate Compound Leaf
  - **Unipinnate:** In this type, leaflets are directly attached on the rachis.
  - **Bipinnate:** In this type rachis divided and gives rise to a secondary axis on both sides on which leaflets are arranged e.g. *Acacia*.
  - **Tripinnate:** In this type, the secondary axis too, divides and gives rise to the tertiary axis on which leaflets are attached e.g. *Moringa*.
- Palmate Compound Leaf
  - **Unifoliate:** In this type only one leaflet is attached on the apex of lamina e.g. *Citrus.*
  - **Bifoliate:** In this type, two leaflets are present on the apex of the petiole e.g. *Balanites* and *Hardwickia*.
  - **Trifoliate or Ternate:** In this type three leaflets are arranged on the apex of petiole e.g. *Aegle marmelos*.

- **Multifoliate:** In this type, more than leaflets are present on the apex of petiole e.g. *Bombax*.

Leaf Venation

The arrangement of veins and the veinlets in the lamina of leaf is termed as venation. When the veinlets form a network, the venation is termed as reticulate. When the veins run parallel to each other within alamina, the venation is termed as parallel. Leaves of dicotyledonous plants generally possess reticulate venation, while parallel venation is the characteristic of most monocotyledons.

- **Reticulate venation**: In this type, main veins divide into various branches and make a net-like structure in the lamina. On the basis of number of mid veins, it is of two types:
  - **Pinnate or unicostate**: In this type of venation there is one midrib or costa in the centre of lamina. e.g. Mango, Peepal.
  - **Palmate or multicostate**: In this type, many midribs, like the fingers of a hand, arise from the top of the petiole and spread on the tipper side. It has two kinds.
    - **(a) Convergent type**: All mid veins converged at the apex e.g. *Zizyphus jujuba* (Ber).
    - **(b) Divergent type**: In this type, all mid veins originate from the base and spread in different directions e.g. *Cucurbita*, Cucumber, Papaya etc.
- **Parallel or striate venation**: In this type, all veins run parallel to each other.
  - **Pinnate or unicostate**: In this type, lamina has a midrib in the centre. e.g., Banana.
  - **Palmate or multicostate**: In this type. many mid veins come out from the petiole. It may be convergent (grasses) or divergent (*Livistonia*).

Some More Description About Leaf

- **Leaf bearing:**
  - **Cauline**: Leaves are borne on the main axis only. e.g., *Cycas circinalis*, palms
  - **Ramal**: Leaves are borne on the main axis and lateral branches. e.g., *Vinca rosea*

- **Radical**: Leaves are borne on a stem base forming a rosette. e.g., Primula or from an underground reduced stem. e.g., *Allium cepa* (Onion).

- **Leaf Duration:**
  - **Caducuous**: leaves fall off soon after formation. e.g., *Opuntia*
  - **Deciduous**: leaves fall at the end of the growing season. e.g., Gulmohar
  - **Evergreen (persistant)**: leaves persist throughout the year, fall regularly so that the tree is never leafless. e.g., *Mangifera indica.*

- **Leaf shape / outline of lamina**: the leaf lamina are variously shaped.
  - **Acicular**: needle shaped, long, narrow and cylindrical leaf. e.g., *Pinus*
  - **Subulate**: awl shaped; broad base tapers into a sharp point.
  - **Linear**: long narrow with almost parallel sides. e.g., Grasses.
  - **Lanceolate**: lance shaped; much longer than broader, a broad base tapers towards the apex. e.g., *Nerium, Polyalthea*.
  - **Oblong**: longer than broader; uniformly broad along the entire length. e.g., Banana
  - **Spathulate**: Spatula shaped; broad and round at the apex gradually narrow towards the base. e.g., *Calendula, Euphorbia hirta*.
  - **Cordate**: heart shaped; round lobes with a deep notch at the base. e.g., Beetle, *Tinospora*.
  - **Ovate**: egg shaped; broadest at the base than the apex. e.g., *Hibiscus rosa sinensis, Sida*.
  - **Obovate**: opposite of ovate; broadest at the apex than the base. e.g., *Cassia obtusifolia* leaflet.
  - **Oblanceolate**: opposite of lanceolate; broader at the apex than the middle and tapers towards the base. e.g., *Gnaphalium*.
  - **Rotund:** circular leaf lamina, petiole attached on the lower surface of the leaf. e.g., *Nelumbo, Nasturtium*.
  - **Reniform**: kidney shaped. e.g., *Centella asiatica*.
  - **Hastate**: arrow head shaped; the two basal lobes are directed outwards. e.g., *Typhonium, Ipomoea*.

- **Runcinate**: coarsely to sharply serrated and the serrations pointing towards the base. e.g., *Papaver, Taraxacum*.
- **Lunate**: half moon shaped. e.g., *Passiflora, Vallisneria*.
- **Sagittate**: arrow head shaped; the two basal lobes are directed downwards. e.g., Sagittaria, Arum.
- **Deltoid**: triangular shaped. e.g., *Abutilon*.
- **Lyrate**: lyre shaped; pinnatifid with bigger terminal lobe and smaller lobes. e.g., *Brassica compestris*.
- **Elliptic**: oval shaped; broadest in the middle and narrow to round at the ends. e.g., *Vinca rosea*, guava.
- **Cuneate**: wedge shaped; triangular shape with narrow end the the point of attachment. e.g., Oxalis.
- **Falcate**: sickle shaped. e.g., *Eucalyptus*.

- **Leaf margin**: the edge of the leaf blade called leaf margin may be variously shaped:
  - **Entire**: smooth, even, without any indentations. e.g., *Nerium, Vincarosea*
  - **Crenate**: shallow round indentations. e.g., *Bryophyllum*
  - **Dentate**: sharp coarse indentations. e.g., Melon
  - **Denticulate**: finely or very minutely dentate. e.g., *Coccinia*
  - **Serrate**: sharp pointed teeth cut like saw, pointing upwards. e.g., *Hibiscus*
  - **Serrulate**: finely or very minutely serrate. e.g., *Prunus*
  - **Undulate or simulate**: wavy up and down margin. e.g., *Polyalthia*
  - **Lobed**: margin divided into many lobes. e.g., *Ranunculus*
  - **Palmate:** divided into palm-like manners. e.g., *Ricinus*
  - **Spinous**: margins with spines. e.g. *Argemone*

- **Leaf apex**: the leaf apex may be variously shaped.
  - **Acute**: pointed apex forming an acute angle. e.g., *Mangifera.*
  - **Acuminate or caudate**: apex elongated and drawn out into a long thin tail. e.g., *Ficus religiosa* (peepal).
  - **Cuspidate**: apex ending in a long, sharp spiny point. e.g., Pineapple.
  - **Retuse**: shallow notch from an obtuse apex. e.g., *Oxali*s.
  - **Emarginated**: apex with a shallow broad notch. e.g., *Bauhinia*

- **Mucronate**: round apex terminates abruptly with a short point. e.g., *Vincarosea*
- **Cirrhose**: slender coiled apex. e.g., *Gloriosa.*
- **Apiculate**: sharp short flexible tip. e.g., *Dalbergia.*
- **Obtuse**: blunt or broad apex. e.g., Banyan.

- **Leaf surface**: the leaf surface may show variations such as:
  - **Glabrous**: smooth surface without hairs or outgrowths. e.g., *Crinum.*
  - **Glaucous**: green and shining. e.g., *Citrus.*
  - **Spiny**: covered with spines. e.g., *Argemone.*
  - **Hairy**: covered with hairs of different shapes, sizes. e.g., *Calotropis.*
  - **Glutinous**: covered with sticky exudates. e.g., *Nicotiana.*

Phyllotaxy

Arrangement of leaves on main stem or branches is known as Phyllotaxy.

- **Opposite:** In this type only two leaves are attached on each node which are opposite to each other.
  - **Opposite decussate:** Usually both leaves of a node arise at right angle in relation to the leaves of upper or lower nodes e.g., eel:num, Calotropis.
  - **Opposite superposed:** In many plants leaves arising from a node are in the same direction as of the upper or lower node e.g., Quisqualis.
- **Whorled or Verticillate:** In this type more than two leaves arise from each node e.g., Three in Nerium and five or more in Alstonia.
- **Spiral or Alternate:** In this type, one leaf arises from each node. e.g., Mango, China-rose.

Modifications of Leaves

Leaves may show diverse modification which are as following:

- **Leaf tendril**: The whole leaf is modified into a thin thread like coiled structure called leaf tendril. As they come into contact with any object, they coil around it and help the plant in climbing for e.g., *Lathyrus phaca* (wild pea). Tendril may be formed by modification of the whole leaflet or part of it. Tendril formed by terminal leaflet (*Pisumsativum*), Leaf apex (*Gloriosa*), Petiole (*Clemantis*) and stipule (*Smilex*).

- **Leaf spine**: Leaves or any part of the leaflet gets modified into a pointed spine called as leaf spine for e.g., *Asparagus, Opuntia, Aloe and Argemone*. These are used as defense weapons by plants.
- **Leaf scale**: When the leaves become thin, dry and form a membrane or paper like structure which helps in protecting axillary buds as *in Ficus, Tamarix, Ruscus*and *Casurina* is called as leaf scale.
- **Leaf pitcher**: Leaves of some plants are modified to pitcher shape e.g., *Nepenthes* and *Dischidia* and used in capture, killing and digestion of insects in insectivorous plants.
- **Leaf bladder**: Leaves are modified into bladder like structures (*Utricularia*).
- **Leaf Hooks**: Terminal leaflets are modified into curved hooks which helps the plant in climbing e.g., Argemone, Opuntia, Aloe and Cat's nail (Bignonia unguis – cati).
- **Phyllode**: Petiole may be modified into flat structure, functioning as a normal leaf e.g., Australian acacia (*Acacia auriculiformis*).
- **Fleshy leaves:** These leaves store food material for e.g., Onion and Garlic.

Summary

Leaf is a lateral outgrowth of a stem developed exogenously at the node. These are green in colour to perform the function of photosynthesis. Leaves exhibit marked variations in their shape, size, margin, apex and extent of incisions of leaf blade (lamina). Like other parts of plants, the leaves also get modified into other structures such as tendrils, spines for climbing and protection respectively.