MORPHOLOGY OF LEAF

[F.Y.B.Sc. SEM – II PAPER – I UNIT – II]

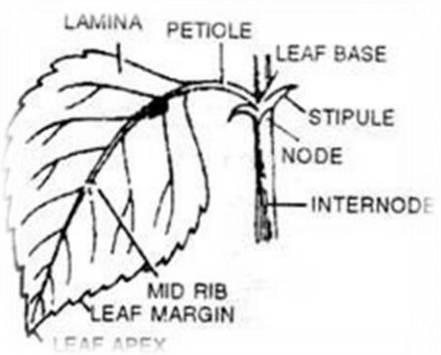
Definition of a Leaf: -

Leaf is defined as "A dorsiventrally compressed, lateral appendage of the stem, produced at the nodes and is specialized to perform photosynthesis". The leaves in plants develop from the leaf primordium.

Characteristics of a Leaf: -

1. Leaf is a thin, green, expanded structure. The green colour of the leaf is due to the presence of chlorophyll pigment.
2. It is exogenous in origin. It is borne on the stem at the node.
3. An axillary bud is often present in the axil of each leaf.
4. The leaf shows limited growth.
5. It does not possess apical bud or a regular growing point.

Parts of a typical leaf: -



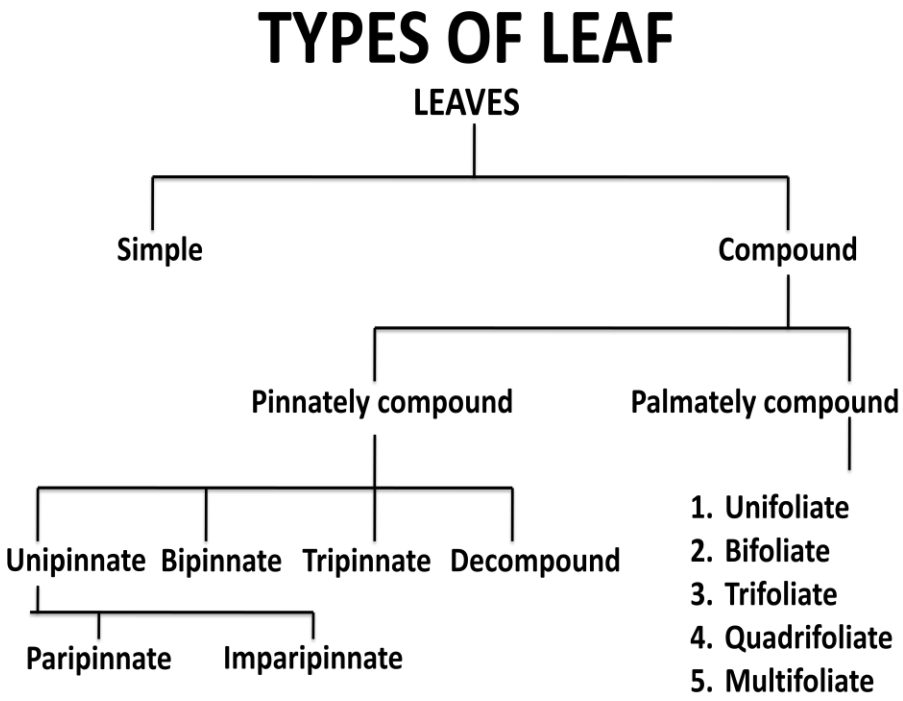
A typical foliage leaf has three main parts:

1. **Leaf base or the Hypopodium:** The part of the leaf attached to the stem or the branch is known as the leaf base. It can assume different shapes in different plants. Outgrowths called stipules may be present in some plants in the leaf base. The functions of the stipules are to protect the bud and carry out photosynthesis.

2. **Petiole or Mesopodium:** Petiole is the part of the leaf connecting the lamina with the branch or the stem. Leaves that possess petiole are called petiolate while those without petiole are called sessile. Petiole is usually cylindrical but it can also be hollow like in papaya. The function of the petiole is to raise the lamina to expose it to more light and air and to help in conduction.

3. **Lamina or Epipodium:** This is the largest, most important, green and flattened part of the leaf. It plays a vital role in photosynthesis, gaseous exchange and transpiration. The lamina is also called as the leaf blade, which shows considerable variations in many features in different plants. The structures like leaf apex, leaf margin, shape of the lamina, venation, etc varies from one species to another.

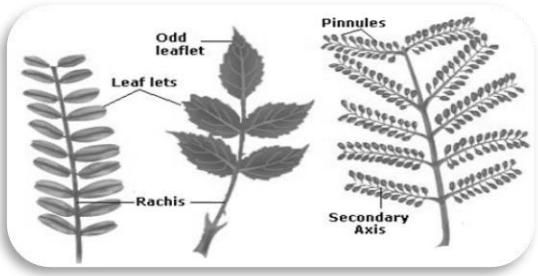
I. TYPES OF LEAVES: -



1. **Simple leaf:**

Simple leaf can be defined as the one in which there is a single lamina, and which is not divided into distinct leaflets. The lamina may be either entire or incised to any depth, but not down to the midrib or petiole, e.g., *Hibiscus rosa-sinensis, Mangifera indica , Ficus religiosa, Musa paradisiaca, Curcuma longa,* etc.

2. Compound leaf:

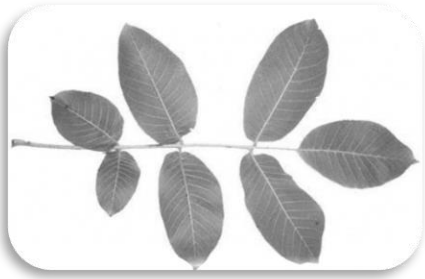


A leaf is called compound when incision of the leaf lamina goes down to the mid-rib (rachis) or to the petiole so the leaf is broken into a number of segments called leaflets. In compound leaves, the leaflets are distinct. Leaflets remain free from one another and jointed to the rachis or tip of the petiole.

2.1. Pinnately Compound leaf:

The incision is called pinnate type when incision takes place from margin towards the mid-rib in a unicostate lamina. In pinnately compound leaf, the mid-rib or rachis bears laterally a number of leaflets arranged alternately or in opposite manner. It is derived from simple pinnate leaf.

2.1.1. Unipinnately Compound leaf:

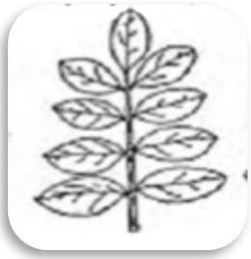


In such cases, leaf lamina divides only once. Leaflets or pinnae are attached to the central axis or rachis which is the continuation of the petiole.

2.1.1.1. Unipinnately Paripinnate Compound leaf:

Leaf lamina divides only once. Leaflets are borne on both sides of the primary rachis. The leaflets are even in number and without any terminal leaflet at the tip of the rachis, e.g., *Cassia tora*, *Abrus*, *Sesbania*, etc.

2.1.1.2. Unipinnately Imparipinnate Compound leaf:



The leaf lamina divides only once. Leaflets are borne on both sides of the primary rachis. The leaflets are odd in number and with a single terminal leaflet at the tip of the rachis, e.g., *Rosa gallica*, *Azadirachta indica*, *Murraya*, etc.

2.1.2. Bipinnately Compound leaf:

The leaf lamina divides twice. Leaflets are borne on both the sides of the secondary rachis called rachilla or rachule which is produced on rachis. e.g., *Caesalpinia pulcherrima, Acacia, Mimosa pudica, Albizzia,* etc.

2.1.3. Tripinnately Compound Leaf:

The leaf lamina divides thrice. Leaflets are borne on both sides of the tertiary rachis which is produced on secondary rachis. In other words, rachillae are further divided to form branches of third order and leaflets in this case are called pinnulules. e.g., *Moringa oleifera, Oroxylon,* etc.

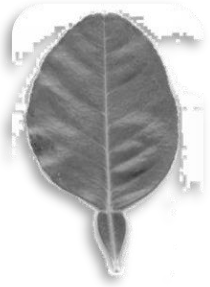
2.1.4. Decompound Leaf:

The leaf lamina divides more than three times to form pinnate structure, e.g., *Coriandrum sativum*.

2.2. Palmately Compound Leaf:

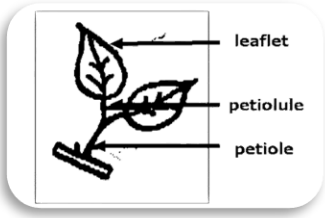
In palmately compound leaf, leaflets are borne at the tip of the petiole resembling the fingers of a palm.

2.2.1. Unifoliate Palmately Compound Leaf:



The rachis does not develop at all so that the leaflets are borne at the tip of the petiole to form palm like structure. Palmately compound leaf with single leaflet articulated to the tip of the petiole, e.g., *Citrus grandis*. The leaf of *Citrus* looks like a simple leaf but its compound nature can be confirmed due to presence of joint between lamina and petiole and by many abnormal leaves, where two leaflets along with central one make their presence. Two lateral leaflets are actually suppressed, hence unifoliate.

2.2.2. Bifoliate Palmately Compound Leaf:



Two leaflets are joined to the petiole. Eg. *Hardwickia*, *Prinsepia*, etc.

2.2.3. Trifoliate Palmately Compound Leaf:

Three leaflets are articulated to the petiole. Eg. *Aegle*, *Medicago*, *Oxalis*, *Trigonella*, etc.

2.2.4. Quadrifoliate Palmately Compound Leaf:

Four leaflets are attached to the tip of the petiole. Eg. *Marsilea.*

2.2.5. Multifoliate Palmately Compound Leaf:

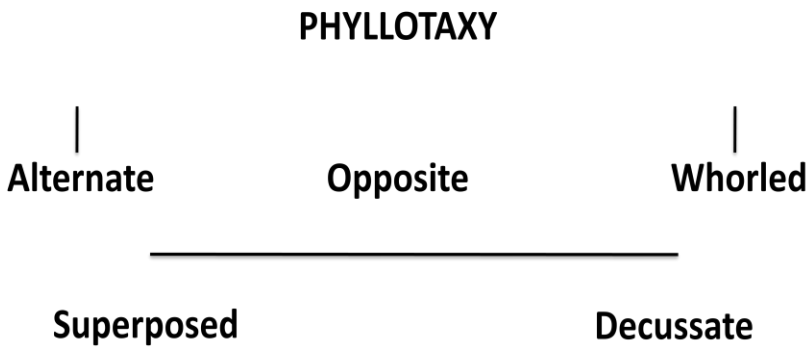
The rachis does not develop at all so that the leaflets are borne at the tip of the petiole to form palm like structure. Palmately compound leaf with five or more leaflets attached to the tip of the petiole, e.g., *Bombax ceiba, Alstonia,* etc.

Characters	Simple Leaf	Compound Leaf
Incision	The lamina is not divided into distinct lobes or leaflets i.e. it has a single lamina.	The lamina is incised into two or more distinct leaflets. The leaflets are borne either at the tip of the petiole or on sides of rachis.
Axillary Bud	An axillary bud is present in the axil of a simple leaf.	Individual leaflets do not bear any axillary bud. However, bud is present in the axil of whole leaf.
Arrangement	Simple leaves appear in acropetal succession on the stem.	Leaflets of a compound leaf do not appear in acropetal succession on the rachis.
Stipules	The base of the leaves may bear stipules.	Stipules may be present at the base of the compound leaf; however such structures are never present at the base of leaflets.
Plane	Simple leaves may appear in one or more planes.	Leaflets in a compound leaf appear in one plane only.

Characters	Pinnately compound Leaf	Palmately compound Leaf
Shape	Feather-like.	Like the palm of a hand.
Origin of leaflets	Leaflets arise on elongated axis.	Leaflets arise from a common point.
Appearance	Leaflets appear in two rows.	Leaflets are clustered together.
Joint	Joint absent between leaflet and its axis.	Joint usually present between leaflet and point of attachment.
Origin	Axis bearing leaflets is continuation of the branch of mid-rib.	Tip of petiole represents the leaflet bearing point.

II. LEAF PHYLLOTAXY: -

"The pattern of arrangement of leaves on the stem is called as phyllotaxy."



1. Alternate Phyllotaxy:

Only one leaf appear at each node, in such a way that the two successive leaves appear from two successive nodes appear alternate, e.g., *Hibiscus rosa-sinensis*.

2.1. Opposite Superposed phyllotaxy:

Two pairs of opposite leaves, come out from two successive nodes, lie one above the other in same plane which are parallel to each other, e.g., *Quisqualis*.

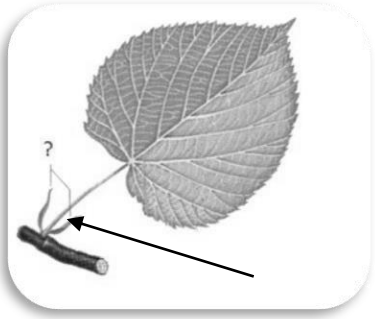
2.2. Opposite Decussate phyllotaxy:

Two pairs of opposite leaves, appear from two successive nodes, lie one above the other in two different planes, which are perpendicular to each other, e.g., *Calotropis.*

3. Whorled phyllotaxy:

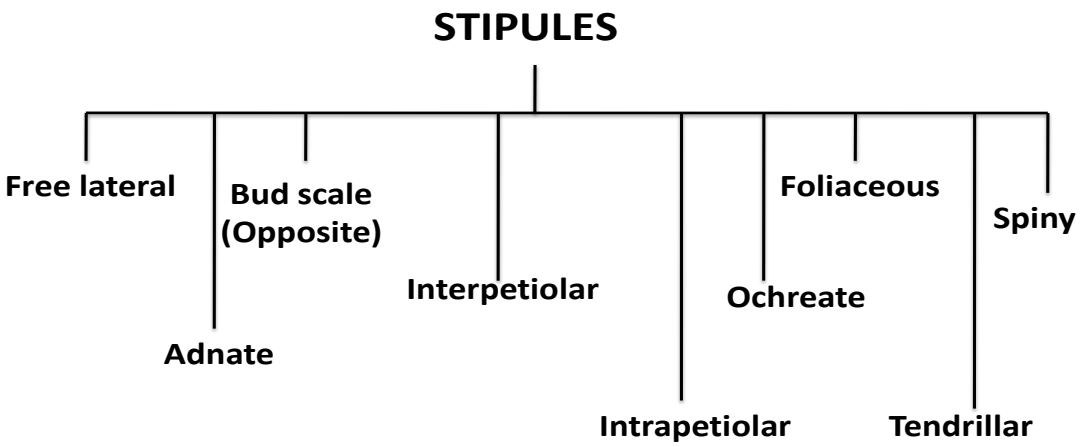
Two or more leaves are arranged in circular manner at each node of the axis, e.g., *Nerium.*

III. STIPULES: -

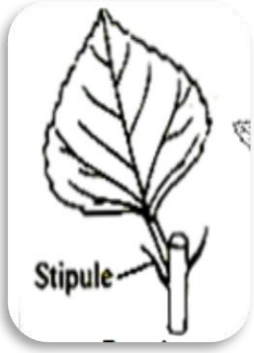


- Leaf base is provided with two lateral appendages called **stipules.**

- They are responsible for **protection of axillary buds**.
- They may be modified to perform various other functions.
- In case stipules are present, then leaves are called **stipulate**.
- In their absence, leaves are called **ex-stipulate**.



1. Free lateral stipules:



These are simplest type of stipules. They are two soft filiform stipules hanging freely on the two sides of the leaf base, e.g., *Hibiscus rosa-sinensis.*

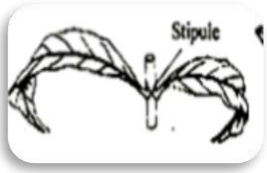
2. Adnate stipules:

Here, the two stipules are adherent to the sides of the petiole to certain distance so that the base of the petiole appears to be winged, e.g., *Rosa indica*.

3. Bud scale (Opposite) stipules:

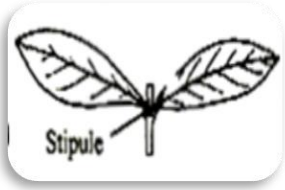
These are scaly stipules which unite by their outer margins to cover and protect the vegetative buds. They are seen in banyan tree (*Ficus benghalensis*).

4. Interpetiolar stipules:



Cohesion occurs between the stipules of two opposite leaves by their outer margins, which lie on 2 sides of stem between the petioles of 2 opposite leaves, e.g., *Ixora*.

5. Intrapetiolar stipules:



When two stipules of the same leaf are coherent by their inner margins so that only one stipule appears to be present in the axil of a leaf, e.g., *Gardenia*.

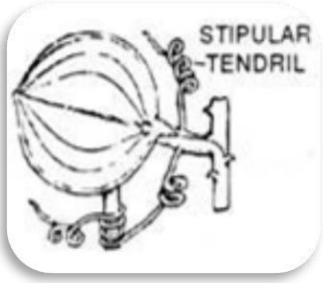
6. Ochreate stipules:

In plants like *Polygonum*, the two stipules of the same leaf unite by their inner and outer margin. They fuse to form a tubular sheath around the internode up to a certain height. This tubular sheath of covering is called ochrea and the stipule called ochreate.

7. Foliaceous stipules:

In this stipules are modified into large leaf-like green structures which take up all the functions of foliage leaf, e.g., *Lathyrus aphaca* (wild pea).

8. Tendrillar stipules:



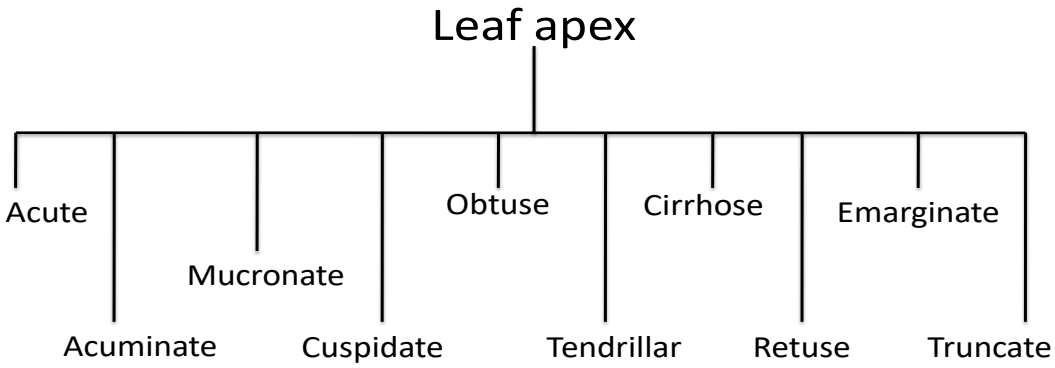
Here the stipules are modified into tendrils. These help the plant in climbing. Eg., *Smilax*.

9. Spiny stipules:

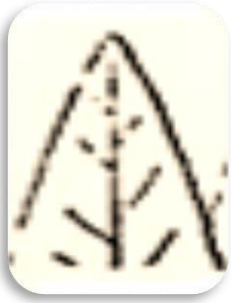
The stipules are modified into two spines to give protection to the plant, e.g., *Acacia*

IV. LEAF APEX: -

"The tip of the leaf blade is called as the leaf apex".

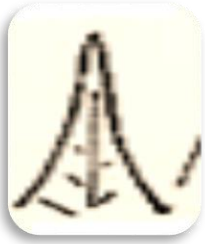


1. Acute Apex:



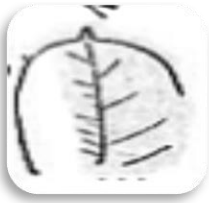
Tip ends into a sharp point forming an acute angle. Eg. *Mangifera indica* leaf.

2. Acuminate Apex:



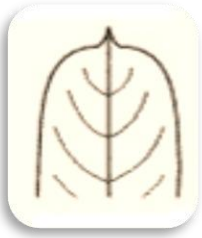
Tip ends into a sharp, long, tapering point. Eg. *Ficus religiosa* leaf.

3. Mucronate Apex:



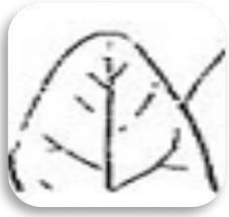
Tip end abruptly into a sharp point. Eg. *Vinca rosea* leaf.

4. Cuspidate Apex:



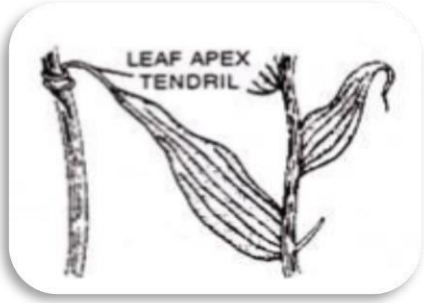
The apex ends into a hard and pointed structure. Eg. *Pandanus*.

5. Obtuse Apex:



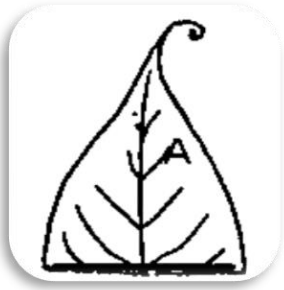
Tip ends into blunt, rounded structure. Eg. *Ficus benghalensis* leaf.

6. Tendrillar Apex:



The tip of the leaf is modified to form a tendril. Eg. *Gloriosa superba*.

7. Cirrhose Apex:



The rounded apex ends into a fine thread like apex. Eg. Banana (*Musa* sp.)

8. Retuse Apex:

The rounded apex has a slight notch in the centre. Eg. *Pistia*.

9. Emarginate Apex:

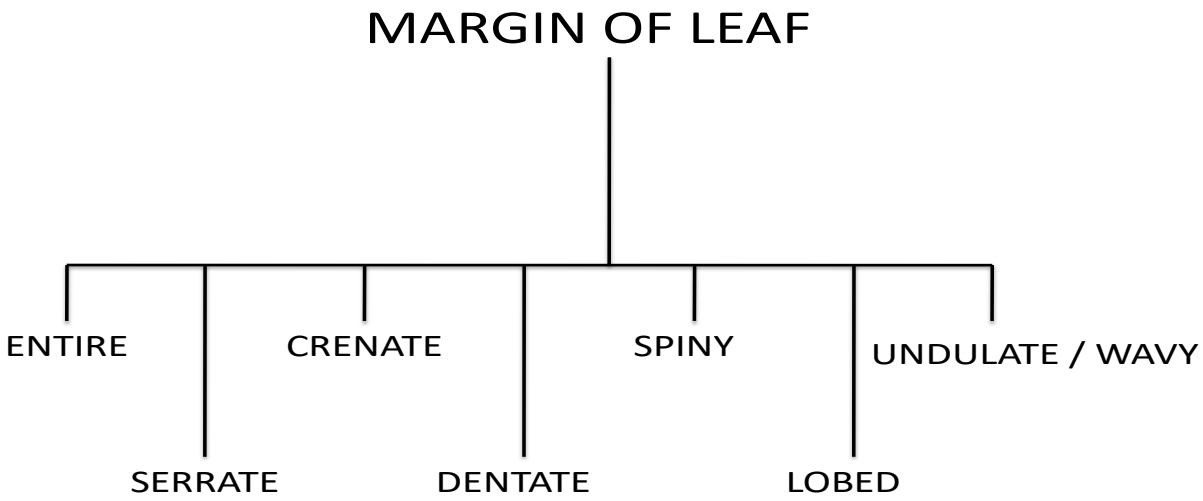
Tip shows deeper notch at the apex. Eg. *Bauhinia* leaf.

10. Truncate Apex:

The apex is abruptly cut across. Eg. *Quercus*.

V. LEAF MARGIN: -

Leaves of all plant species show marked variation in the pattern of their leaf margin. These patterns can be seen on both the edges of the leaf blade or lamina.



1. Entire margin:

The margin is smooth without any indentations. Eg. *Mangifera indica* leaf.

2. Serrate margin:

Presence of series of fine pointed teeth like projections turned towards apex. Eg. *Hibiscus* leaf.

3. Crenate margin:

Margin is toothed which are rounded. Eg. *Bryophyllum* and *Begonia*.

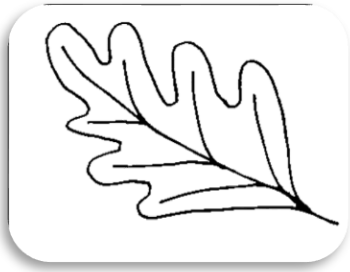
4. Dentate margin:

The teeth in the margin do not point upwards but outwards. Eg. Water lily (*Nymphaea*).

5. Spiny margin:

The teeth form a hard spine as in *Aloe* and *Argemone*.

6. Lobed margin:



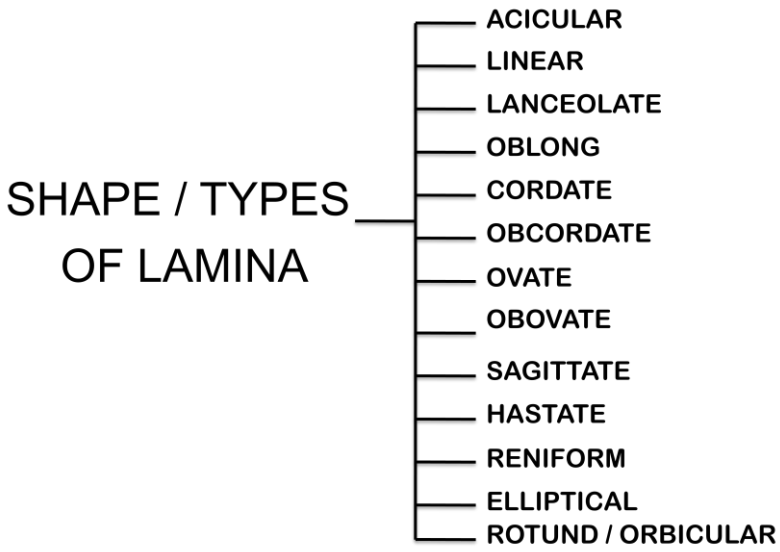
The margins are deeply divided forming lobes. Eg. *Liriodendron* (tulips).

7. Undulate / Wavy margin:

The margin is wavy in appearance. Eg., *Polyalthia longifolia.*

VI. LEAF LAMINA SHAPE: -

The shape of the leaf depends on the shape of its lamina or the leaf blade.



1. **Acicular:** Needle like leaf with long, narrow, cylindrical lamina. Eg. *Pinus* needle

2. **Linear:** Long, narrow leaf. The margins run more or less parallel. Eg. Grass (*Cynodon dactylon*) leaf

3. **Lanceolate:** It means the shape of a lens. In this case, the lamina is longer than broad and tapers towards both the ends. Eg. *Nerium* leaf.

4. **Oblong:** Leaf with wide long lamina margin of which are parallel to each other. It has obtuse or rounded base and apex. Eg. Banana (*Musa*) leaf.

5. **Cordate:** Heart shaped lamina. There is a deep notch at the base of the lamina forming two basal lobes. Eg. *Ficus religiosa* leaf, betel leaves, *Pothos*, *Dioscorea*, etc.

6. **Obcordate:** It is the reverse of cordate. The notch is at the apex. Eg. *Bauhinia*.

7. **Ovate:** Egg shaped leaf. The lamina is narrow towards the upper end and broadest at the base. Eg. *Ficus benghalensis* leaf.

8. **Obovate:** Opposite of ovate. The apex is rounded. The lamina tapers towards the base. Eg. *Terminalia catappa* leaf, *Artocarpus* leaf.

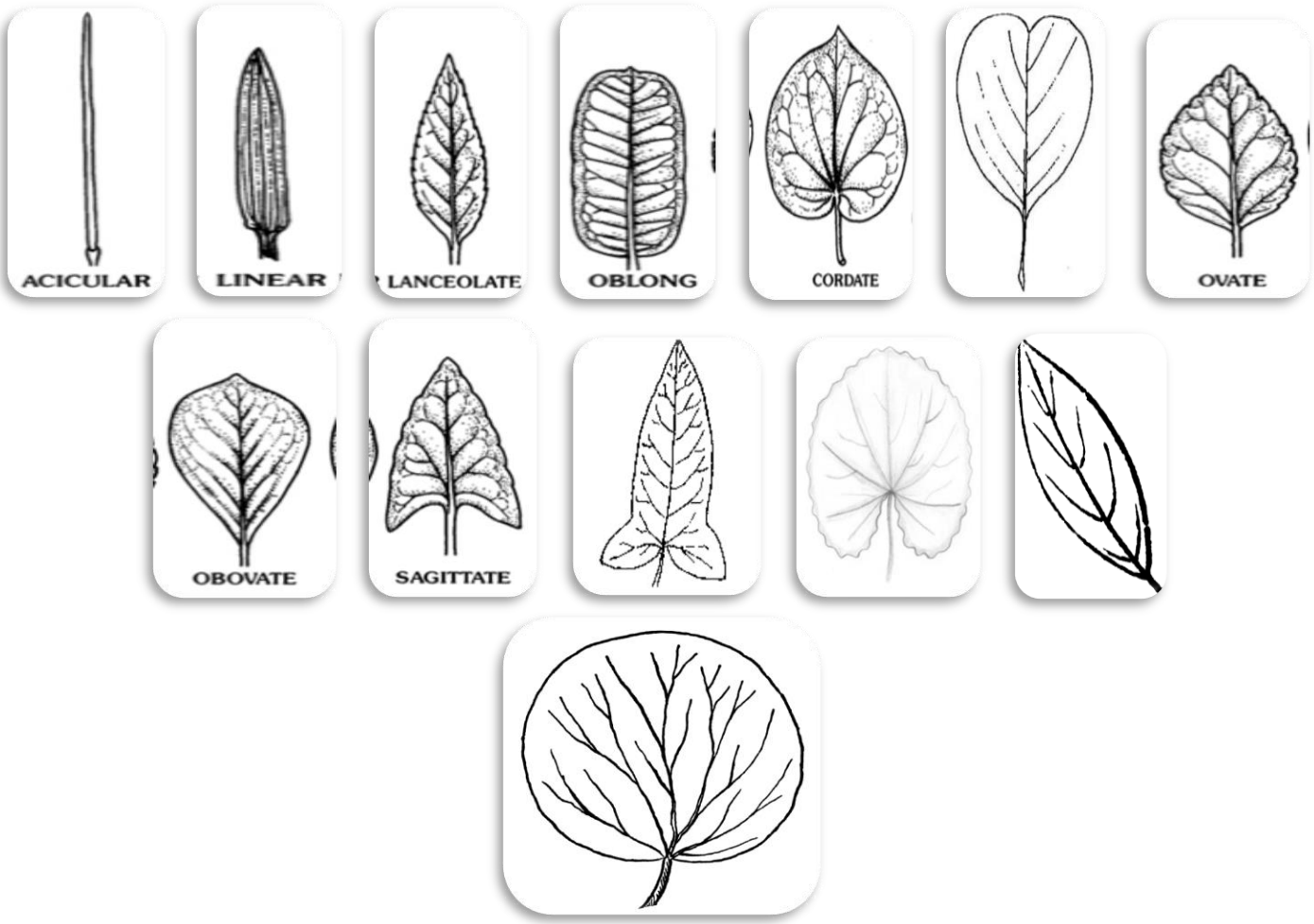
9. **Sagittate:** Arrow shaped lamina. The two basal lobes point downwards while the apex is pointed. Eg. *Arum*, *Sagittaria*.

10. **Hastate:** This is like sagittate leaf except that the two basal lobes instead of pointing downwards are directed outwards as in *Ipomoea*.

11. **Reniform:** The lamina is kidney shaped. It has a deep notch on inner side towards the petiole while the outer or upper side is rounded as in *Centella*.

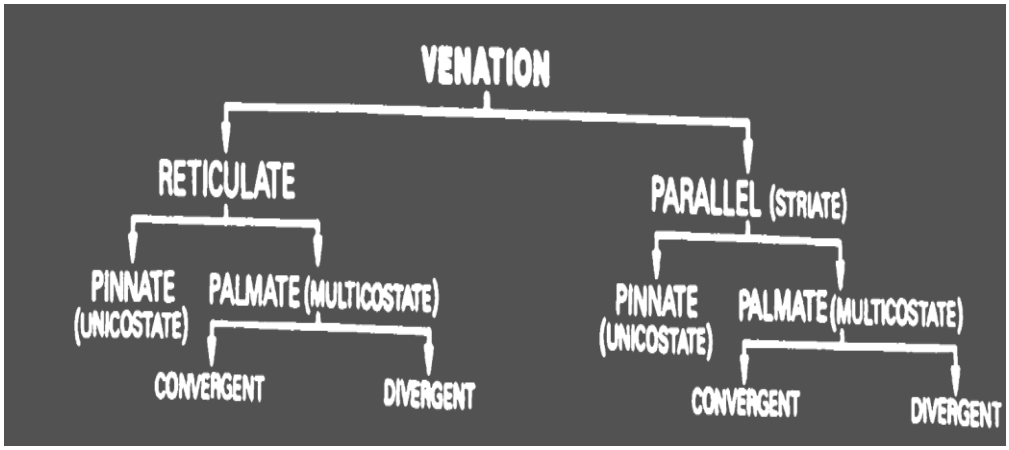
12. **Elliptical:** In this case, the lamina is broad in the centre but tapers towards the base and apex like an ellipse. Leaves of *Vinca* or guava are of this type.

13. **Rotund / Orbicular**: The lamina is rounded or circular as in *Nelumbo.*



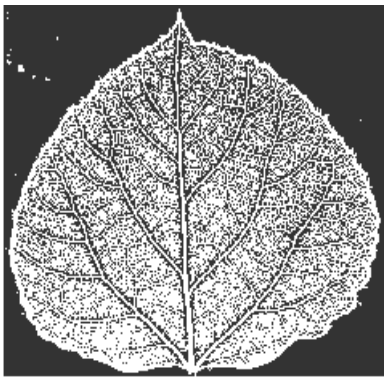
VII. LEAF VENATION: -

"When lamina is traversed by conspicuous system of one or more mid-rib and many veins, it is called venation."



Reticulate - In reticulate type, the veins or branches arising from the main vein or veins form a network or reticulum.

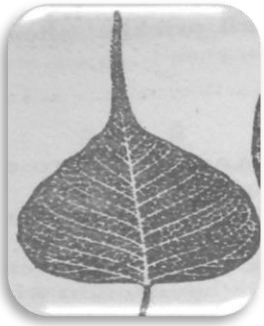
Parallel - In parallel type, the veins run more or less parallel to one another.



Reticulate

Parallel

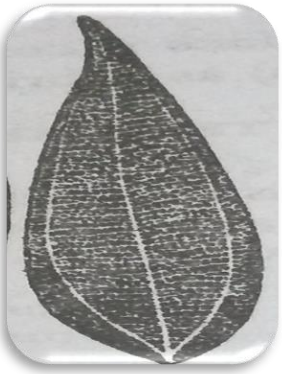
1. Pinnate (Unicostate) Reticulate:



A leaf venation having single mid vein (costa) is called unicostate reticulate venation,

e.g., *Ficus religiosa, Mangifera indica.*

2. Multicostate Reticulate Convergent:

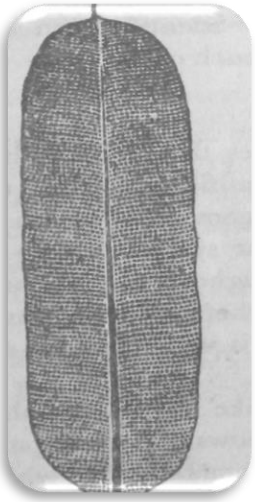


A leaf venation having two or more mid veins (costae) is called multicostate reticulate venation. Many principal veins appear from lamina base and converge towards the apex of the lamina, e.g., *Zizyphus*.

3. Multicostate Reticulate Divergent:

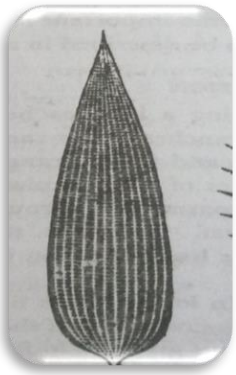
Many principal veins arise from single point at the base and then diverge from one another, towards the margin of lamina, e.g., *Carica papaya*.

4. Unicostate Parallel:



When the veins run parallel to each other without forming a complex network, it is known as parallel venation. The lamina has single prominent mid vein from which many lateral parallel veins arise at regular intervals, e.g., *Musa*.

5. Multicostate Parallel Convergent:



Two or more mid veins or costae run parallel to each other. Many principal veins appear from base of the lamina and converge at apex, e.g., *Bambusa*.

6. Multicostate Parallel Divergent:

Many principal veins appear from base of the lamina and diverge towards margin,

e.g., *Borassus flabellifer*.

VIII. LEAF MODIFICATIONS: -

The leaves or its parts may be modified in some plants to carry out various functions like defence, food storage, adaptation to harsh climates, etc. Some of the interesting modifications are mentioned as follows:

1. **Leaf Spines:** The leaves or their parts are modified into spines to give protection. In *Opuntia*, the entire leaf is reduced to form sharp spines which give protection to the plant.

2. **Leaf Tendrils:** The whole leaf or it's part gets modified into thin, long, wire-like structure called tendril which coil around the support and help the plant to climb, e.g., *Lathyrus aphaca* (wild pea) in which entire leaf is modified into tendril. In *Gloriosa*, on the other hand, the tip of the leaf becomes tendrillar.

3. **Leaf Hooks:** In *Bignonia*, the terminal three leaflets are modified to form spines which are hook-like and around the support and help in climbing.

4. **Phyllode:** In *Acacia auriculiformis*, the plants at seedling stage bear normal pinnately compound leaves. As these leaves become mature, the leaflets drop off and the petiole gets modified into flat, green, leaf-like structure called phyllode which helps in photosynthesis.