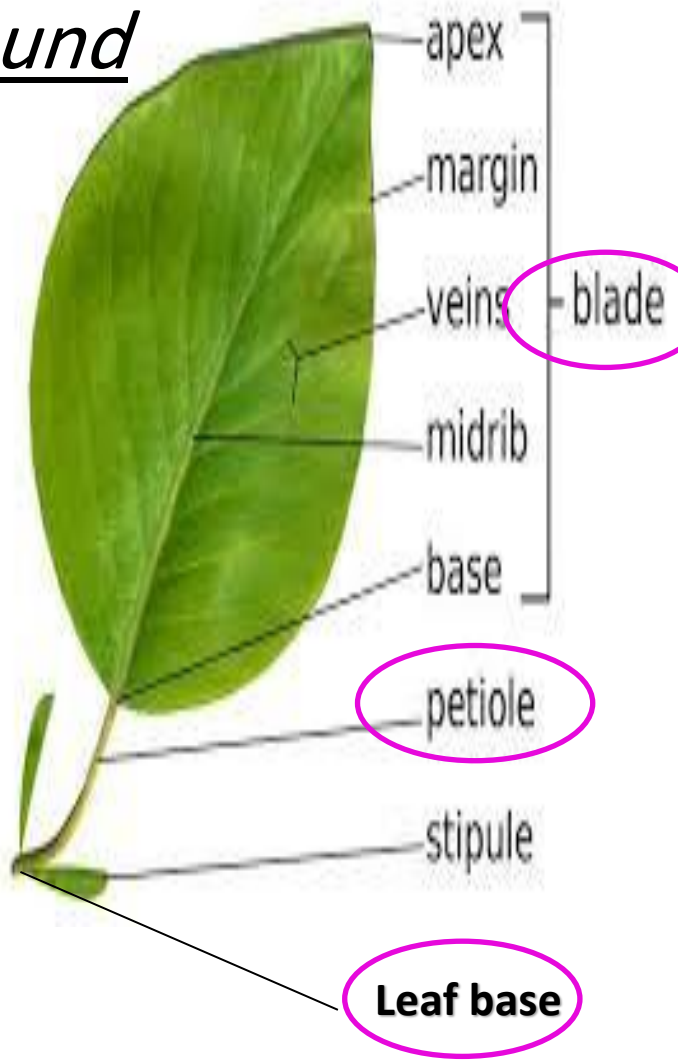
THE LEAF:

MORPHOLOGY

Position, external structure and function

- Leaves are green flattened appendages of the stem.
- They arise from the nodes and *found on no other part of the plant*.



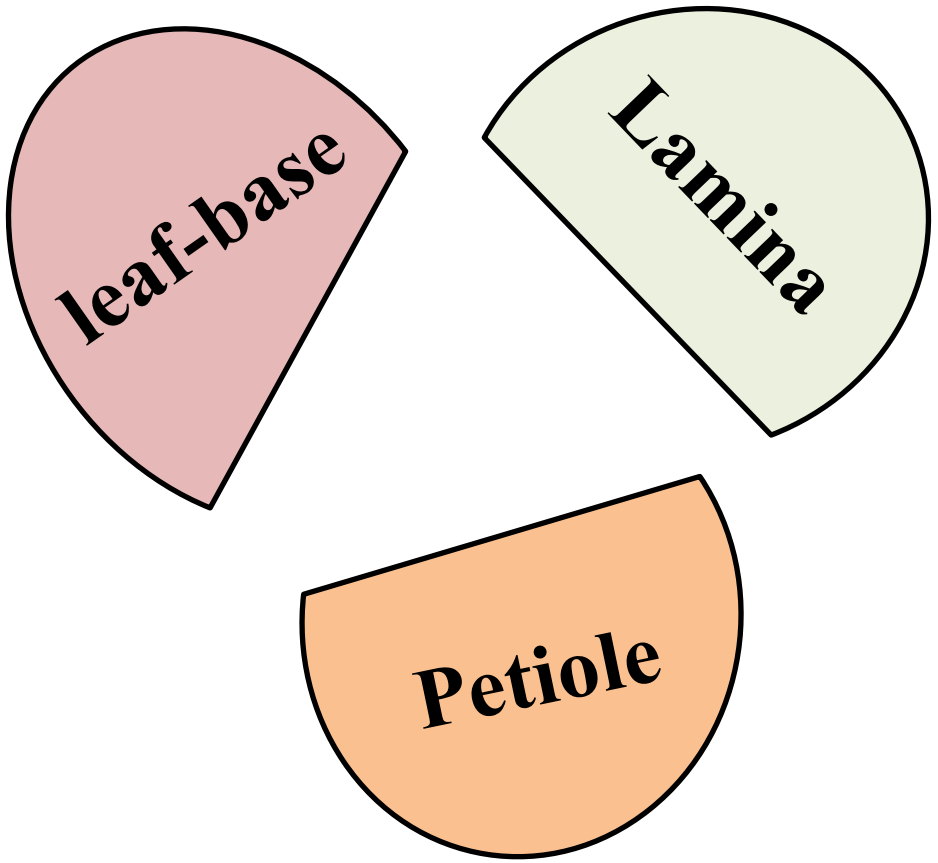
- **They are concerned with:**

➢ Photosynthesis .

➢ transpiration and gas exchange.

➢ sometimes they are modified to perform special functions.

A typical foliage leaf consists of the following three parts :



1. Leaf insertion

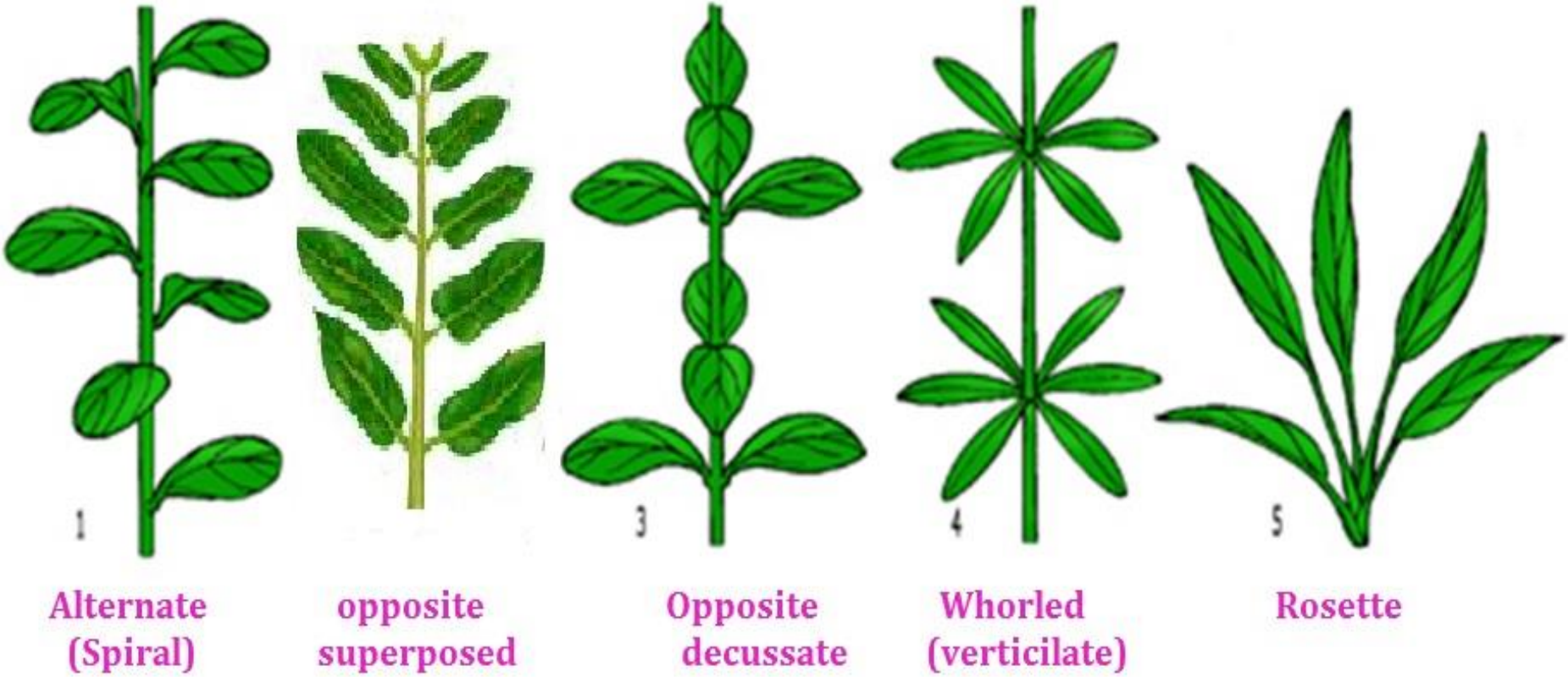
1. **Cauline**: borne on a long stem e.g. *Duranta*.

Cauline

2. **Radical**: borne on a dwarf stem e.g. onion, carrot, turnip, beet and radish.

Radical

2. Leaves arrangement (phyllotaxy)



1- Alternate or Spiral: When the stem is upright and ***a single leaf arises on a node***, the leaves are said to be alternate and the arrangement is described as spiral because a line which collects the base of the several leaves is spiral.

2- Opposite: In this, two leaves arise on a node opposite to each other. This is of two types :

(a) Opposite superposed: the line of insertion of a pair of leaves at one node is ***parallel*** to the lines of the leaves of the next lower or upper node.

(b) Opposite decussate: When the pairs of leaves at two successive nodes are placed at right angled to each other (e.g. mint).

3- Whorled or Verticillate: more than two leaves arise at a node and form whorl round it, e.g. *Oleander*.

4- Rosette: Leaves are borne in a cluster on ground level (e.g. on top of a reduced stem as in carrot and turnip).

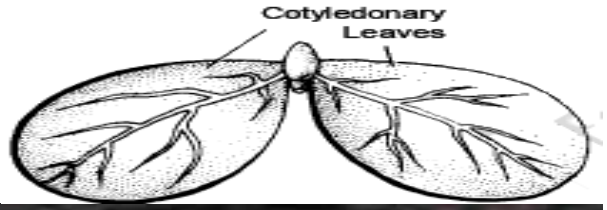
Identify ??

3. Types of Leaves

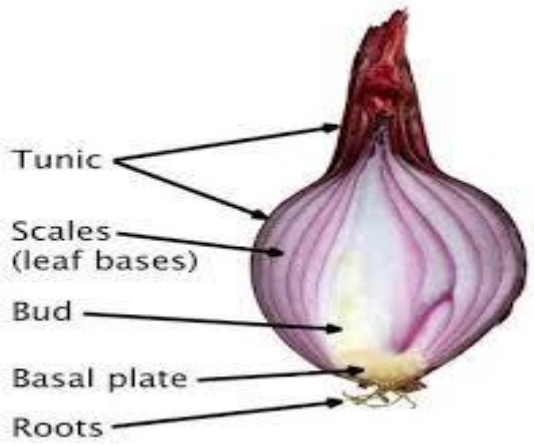
1. **Foliage leaves:** ordinary green leaves on the stems and branches. photosynthesis and transpiration.

2. **Cotyledonary leaves:**

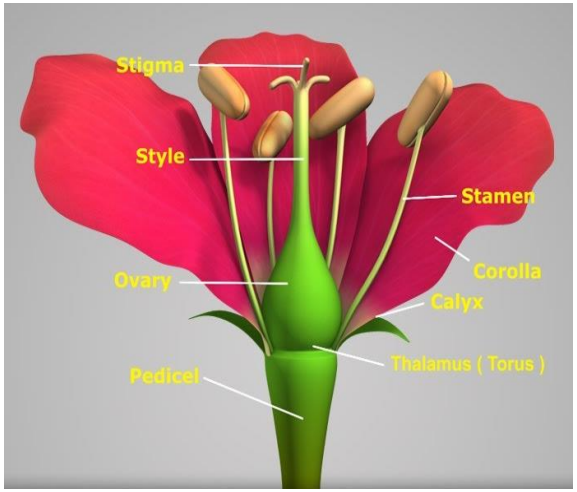
the embryonic leaves and are represented in the seed by cotyledons. They store food or absorb it form the surrounding endosperm. they may become aerial and form the first green leaves of the plant.



3. Scale leaves: thin brownish outgrowths devoid of green colour and are more frequently found on the underground stems covering the buds. They serve to protect buds and delicate organs, or store food as in some bulbs. e.g. garlic when they become thick and succulent .



4. Floral leaves: The various parts of a flower (sepals, petals, stamens and carpels) are modified leaves .



5. Bracts: small leaf-like structures and bear one or more flowers in their axils.

4. Heterophylly

- *Some plants bear different types of foliage leaves a phenomenon known by* ***heterophylly*** .

Examples :

- among water plants : some water plants have highly dissected submerged leaves and less divided aerial leaves e.g., *Ranunculus aquatitlis*.
- Certain plants, especially shrubs growing in dry climates , may also show a variation of leaf form according to the season, the normal leaves only appear during the rainy season and being substituted by reduced leaves during the dry season. e.g., *Zilla spinosa* .

Ranunculus aquatilis

- Another type of heterophylly is that associated with the change from the ***primary leaves or the seedling*** to the ***mature foliage*** in the development of the individual.

Seedling of castor bean

Seedling of wild turnip

Heterophylly in *R. aquatica*. The leaves of plants grown under aquatic conditions (left) tend to be pinnately dissected, whereas those of plants grown on land (right) tend to be simple. Bar = 1 cm. (*Adapted from Nakayama et al. [2014], Figure 1C.*)

Farquharson, Kathleen L. "Examining the Molecular Basis of Heterophylly in North American Lake Cress." (2014): tpc-114.

Parsley

Flowering or fruiting branch

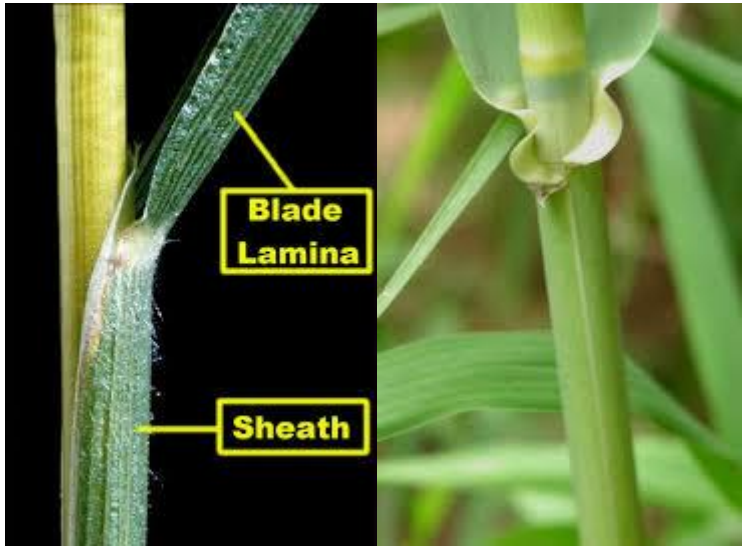
Vegetative branch

Coriander (*Coriandrum sativum*)

5. Leaf base

- It is the portion by which the leaf is attached to the stem.

Normal

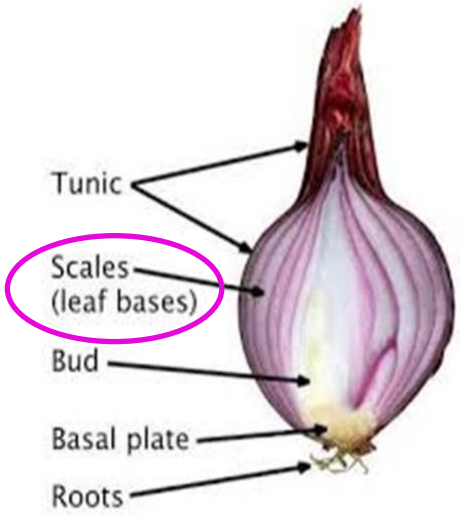


Sheathed

In some monocots , the leaf base is expanded to form a sheath which is tubular and supports the stem.

Pulvinus

The leaf base is sometimes swollen, then called pulvinus e.g., *Acacia* and *Poinciana*.



Fleshy

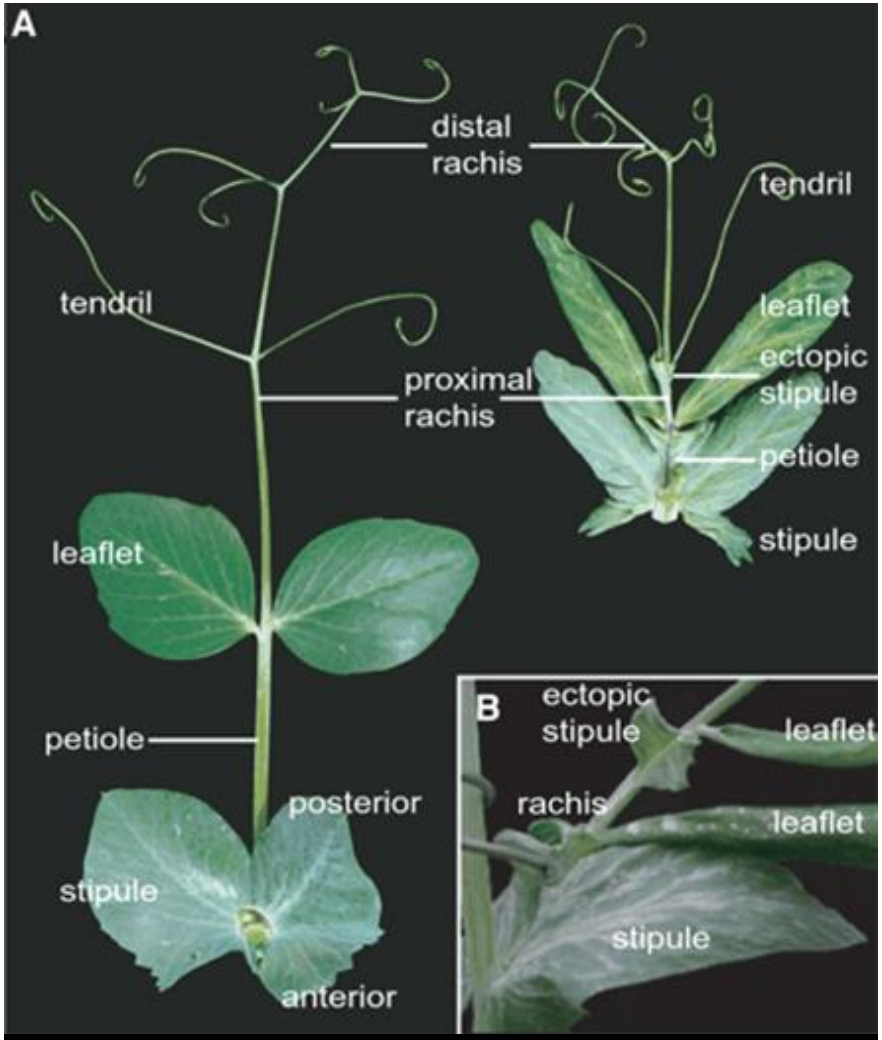
the stem is covered by thickened, over-lapping leaf bases (scales) in bulbs.

Stipulate and exstipulate leaf bases:

- **Stipulate leaf:** when ***a pair*** *of small or leaf-like out-growths* **(** *called* ***stipules*****)** are found at the leaf-base, e.g. in many dicotyledonous plants such as rose and bean, the leaf is stipulate .
- **Exstipulate leaf:** When stipules are absent, the leaf is exstipulate.

1. **Ordinary stipules:** small or leaf-like out-growths as in faba bean.
2. **Leafy stipules**: when they become large, green and leaf-like e.g. Pea.
3. **Adenate or Petiolar stipules :** when they run up and joined with the petiole for some distance, e.g. Rose.

Adenate or Petiolar stipules



Leafy stipules

https://anps.org/2019/06/26/know-your-natives-climbing-rose/

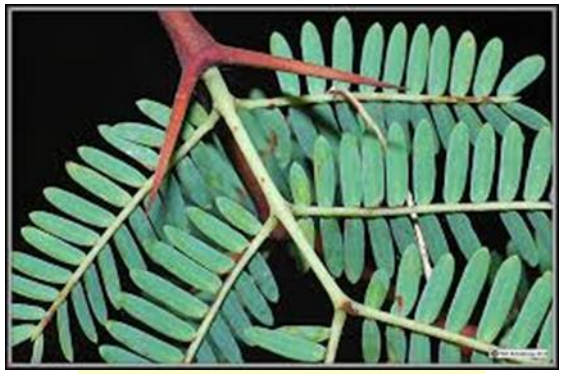
Tattersall, A. D., Turner, L., Knox, M. R., Ambrose, M. J., Ellis, T. N., & Hofer, J. M. (2005). The mutant crispa reveals multiple roles for PHANTASTICA in pea compound leaf development. *The Plant Cell*, *17*(4), 1046-1060.

4. Spiny stipules : when they are modified into spines, e.g. *Acacia* and *Zizyphus* and serve as organs of defense.

5. Ochreate stipules : when they fuse to form a membranous tubular sheath around the base of the internode as in *Polygonum* and *Rumex*. They serve to give support to the stem and to protect the axillary bud.

6. Hairy stipules: linear, slender and tapering to a point e.g. *Corchorus olitorius*.

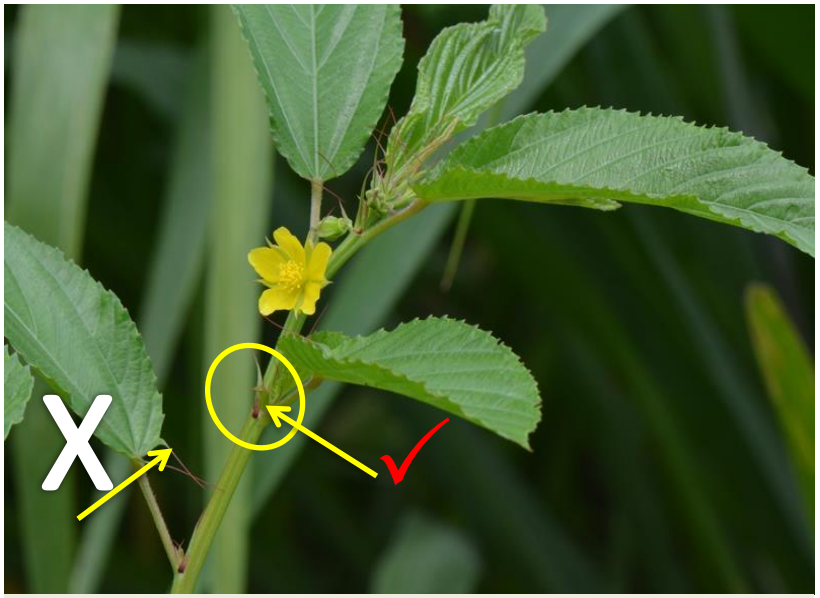
7. Tendrillar stipules: when they are modified into tendrils e.g. *Smilax*.



Acacia

Smilax

Ordinary stipules



Hairy stipules

Spiny stipules

Ziziphus mucronata

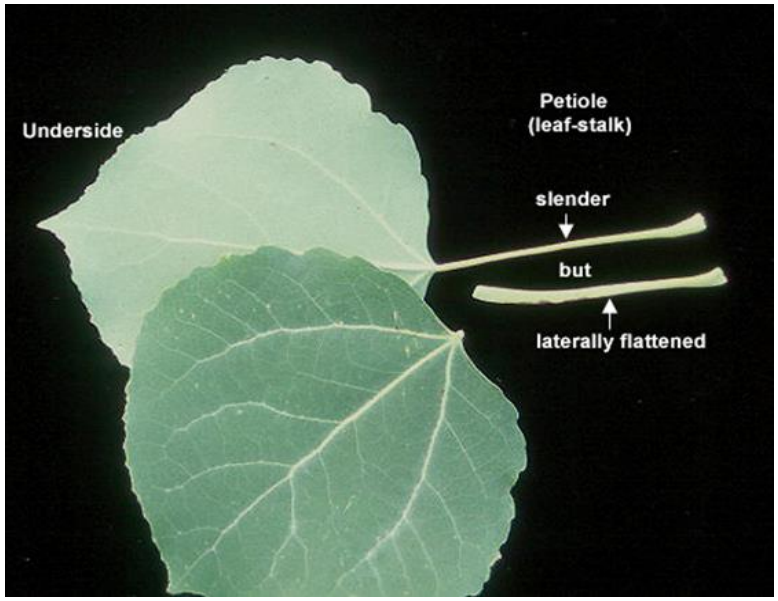
Ochreate stipules

Polygonum oxyspermum Polygonum amphibium

5. Leaf Petiole

- It is more or less cylindrical axial structure which in some cases is grooved to drain off water from the leaf.
- When the petiole is present, the leaf is described as ***petiolate*** and when it is absent, the leaf is ***sessile***.

Sessile leaf



Normal petiole

Winged petiole

1. Normal petiole: more or less cylindrical (e.g. faba bean).

2. Swollen petiole: larger or rounder in size (e.g. water hyacinth).

3. Winged petiole: it shows a membranous expansion on the sides as in *Citrus.*

4.Leafy petiole: more or less like a leaf blade (e.g. *Acacia*).

5. Succulent: thick and fleshy adapted to storing water (e.g. xerophytes).

Succulent petiole (*Zygophyllum*)

Leafy petiole (*Acacia*)

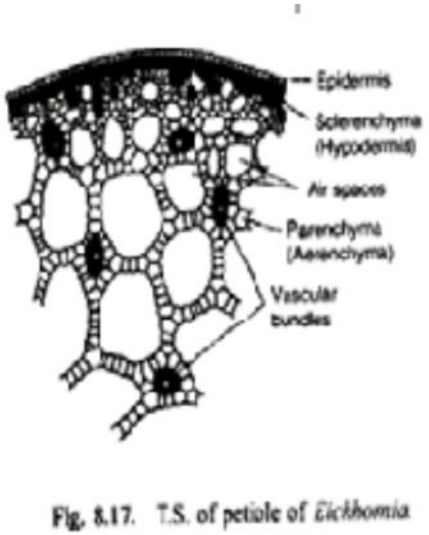


Fig. 8.17. T.S. of petiole of *Eichhornia*

Swollen petiole in water hyacinth (*Ecchornia crassipes*)

6. Leaf Venation

- There are two principal types of venation: Reticulate and Parallel Venations.

a) Reticulate venation: it is characteristic of dicots.

the veins branch and re-branch forming a sort of network on the leaf lamina.

1- Reticulate pinnate: The mid rib gives off a number of lateral veins on either side resembling a feather. e.g. mango.

2- Reticulate palmate: A large number of equally strong veins branch repeatedly and diverge from one another e.g. castor bean.

a) Parallel venation: it is characteristic of monocots.

1- Basal (longitudinally): The midrib and the principal lateral branches run parallel to one another.

2- Coastal (transversely): A single midrib gives off from its sides a number of veins which run parallel to one another (e.g. banana).

Wheat

Musa

6. Leaf Margin

The margin may be:

1. **Entire**: perfectly even and smooth (e.g. *Ficus*).
2. **Hairy**: with hairs.
3. **Wavy or sinuate:** has a wavy outline (e.g. mango).
4. **Serrate:** cut like the teeth of a saw teeth directed towards the apex (e.g. *Corchorus*).
5. **Biserrate:** doubly serrate, each tooth serrated again (e.g. castor).
6. **dentate or toothed**: teeth sharp and directed outwards and not forward (e.g. *Duranta*).
7. **Crenate**: teeth rounded (e.g. *Morus*).
8. **Spinous:** with spines (e.g. Silybium).

MARGIN

Ciliate
with fine hairs

Crenate
with rounded teeth

Dentate
with symmetrical teeth

Denticulate
with fine dentition

Doubly Serrate
serrate with sub-teeth

Entire
even, smooth throughout

Lobate
indented, but not to midline

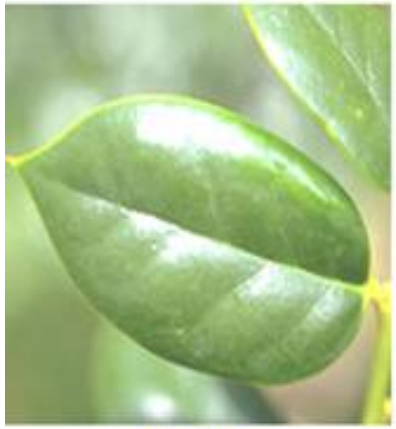
Serrate
teeth forward-pointing

Serrulate
with fine serration

Sinuate
with wave-like indentations

Spiny
with sharp stiff points

Undulate
widely wavy



Entire

Serrate

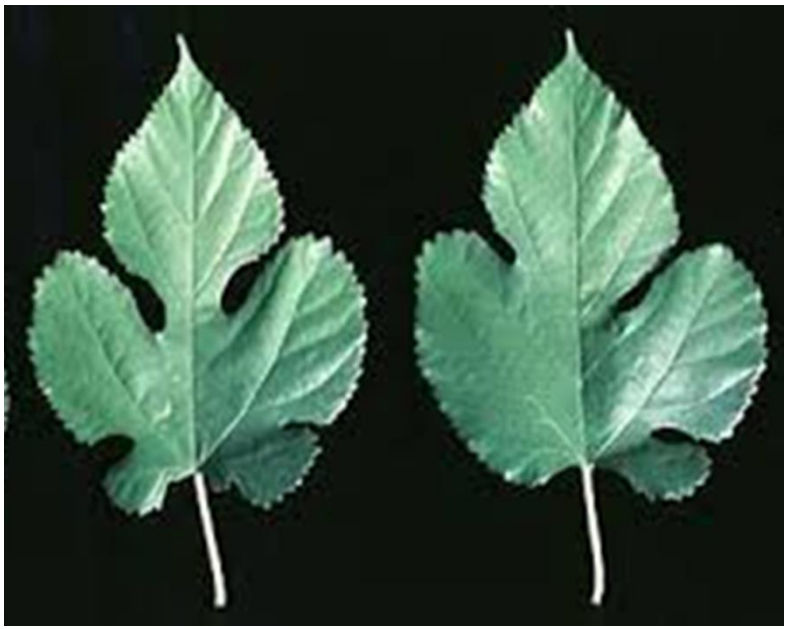
Toothed or Dentate

Crenate

Sinuate

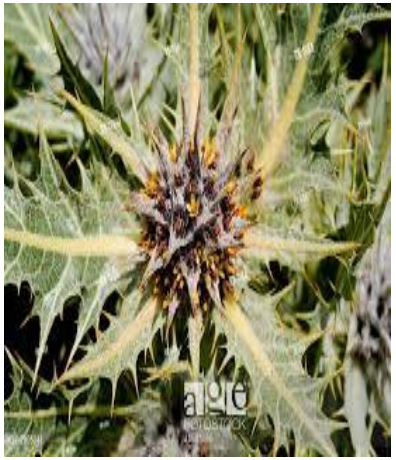
Spiny

- **The margin of a certain plant can be a combination of more than one of the previously-mentioned types.**



Sinuate and hairy

TEST YOURSELF:
Identify the type of leaf margin.



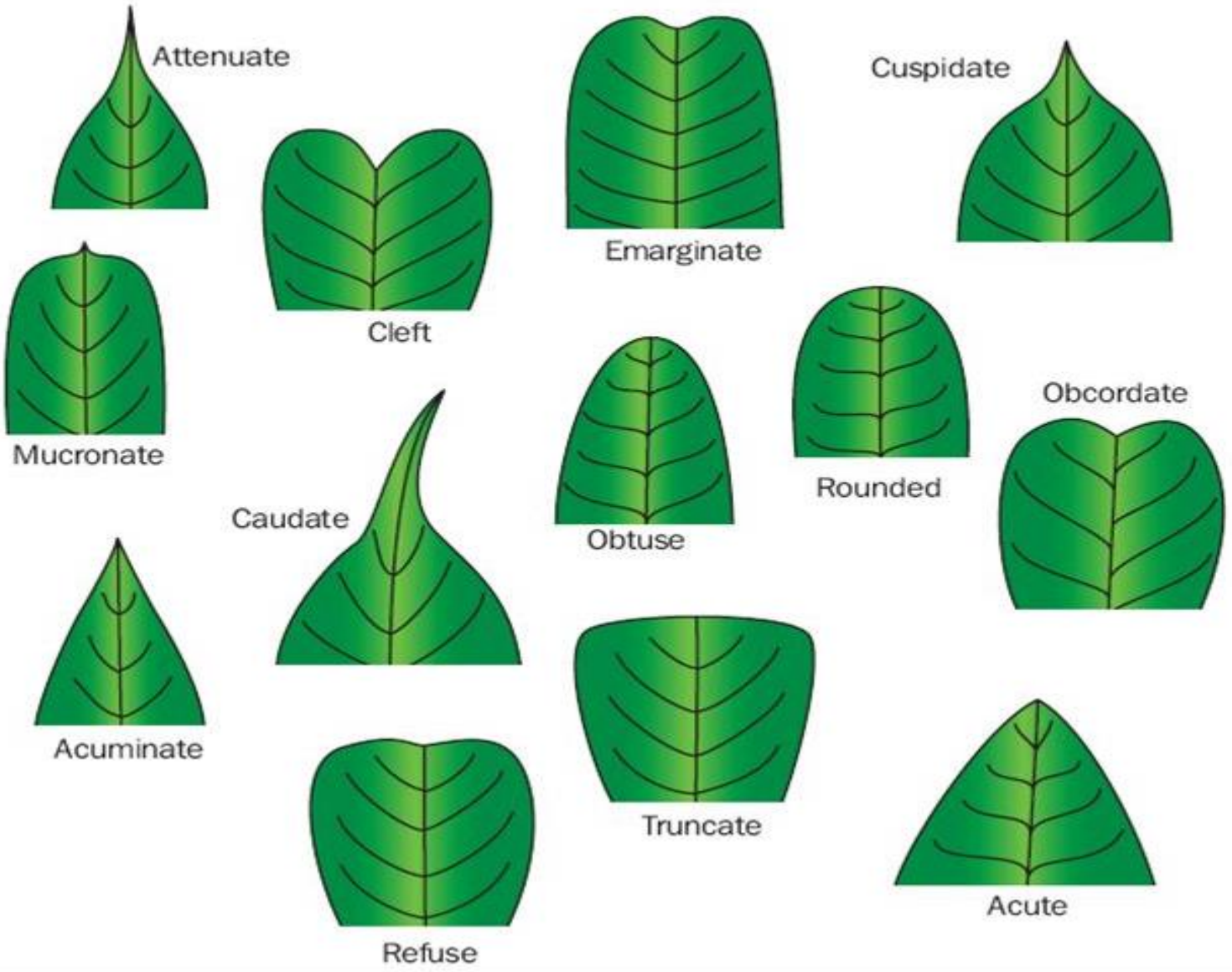
Gundelia

7. Leaf Apex

The apex may be:

1. **Acute:** pointed (e.g. *Nerium oleander*).
2. **Obtuse**: rounded (e.g. *Poinciana*).
3. **Acuminate:** pointed and drawn out into a long slender tail, the sides of the apex are somewhat concave (e.g. *Dalbergia*).
4. **Mucronate:** acute ending suddenly sharp point (e.g. *Cassia*).
5. **Cuspidate**: pointed and ending in a sharp spiny point (e.g. date palm).
6. **Emarginated**: deeply notched and the depression is sharp (e.g. *Bauhinia*).
7. **Caudate:** bearing a tail-like appendage (e.g. *Ficus benjamina*).

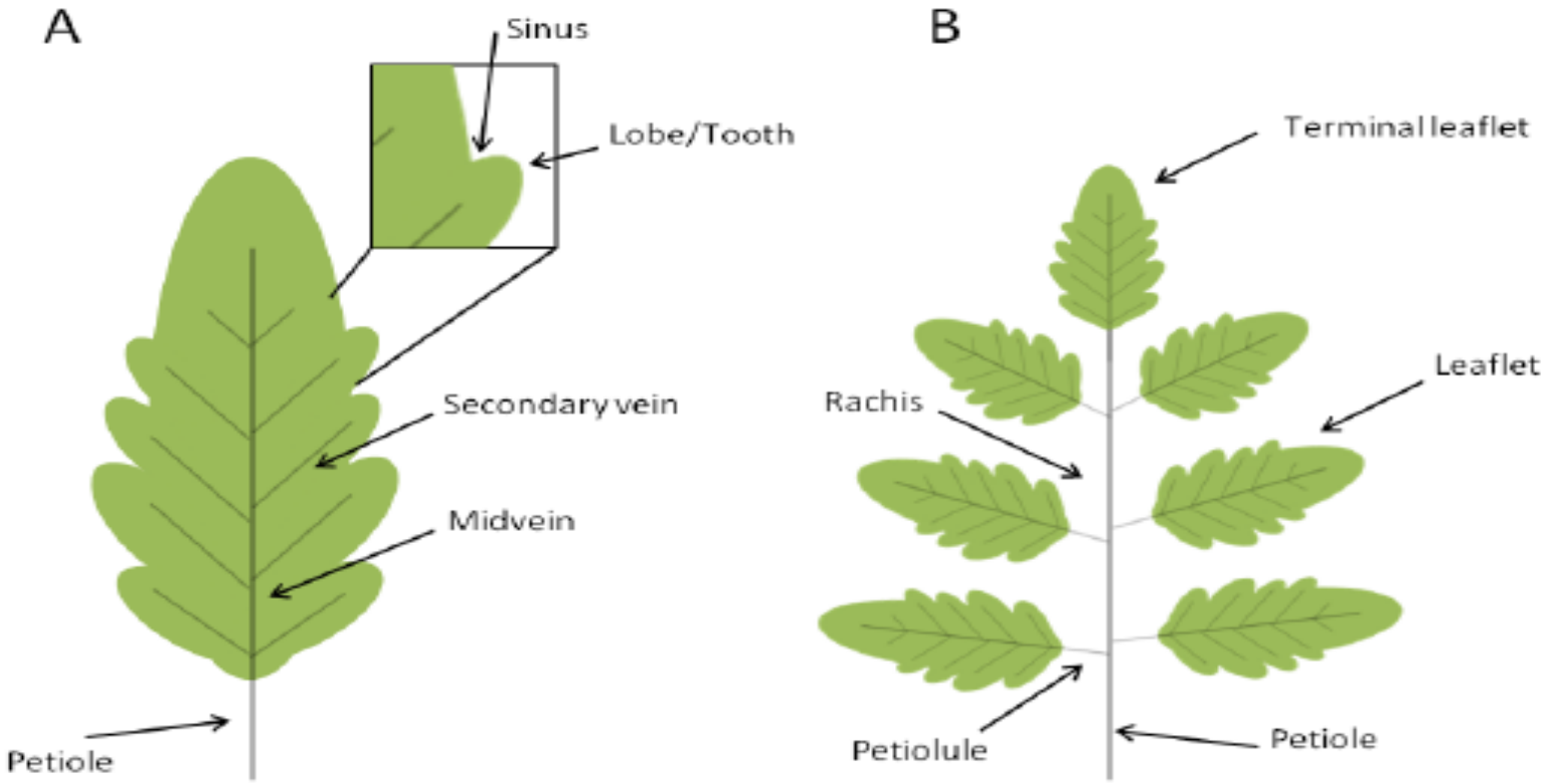
LEAF APICES


Attenuate
Emarginate
Cuspidate
Cleft
Mucronate
Rounded
Obcordate
Caudate
Obtuse
Acuminate
Truncate
Acute
Refuse

7. Incision of The Lamina
Simple And Compound Leaves

- A simple leaf: the lamina is either entire or incised but does not break up Into completely separate parts.
- A compound leaf: the lamina incisions go very deep, so lamina becomes split up into a completely separate leaf-like lobes called the leaflets.

Figure 2. Schematic representation of simple and compound leaves. Leaves are traditionally divided into two major morphogenetic classes: simple (**A**) and compound (**B**). Simple leaves have a single flat blade/lamina, the margins of which are continuous and may be smooth, lobed, or serrated (with asymmetrical teeth pointing forward). The blades of compound leaves of eudicot plants are composed of several regularly spaced sessile or petiolated appendages called leaflets that are attached to a central rachis, the latter corresponding to the middle vein of a simple leaf. The leaf blade, or the rachis in compound leaves, is attached to the stem by the petiole.



Di Giacomo, E., Iannelli, M. A., & Frugis, G. (2013). TALE and shape: how to make a leaf different. *Plants*, *2*(2), 317-342.

Simple leaf

Simple with entire blade: e.g. *Eucalyptus*.

1. **Simple Lobed**: Pinnate and palmate.
2. **In a lyrate leaf**: e.g. *Raphanus*, *Eruca* and some *Brassica* species the incisions take place in such a way that there is a large terminal division, followed by others which become gradually smaller towards the base.

Simple Lobed Leaf

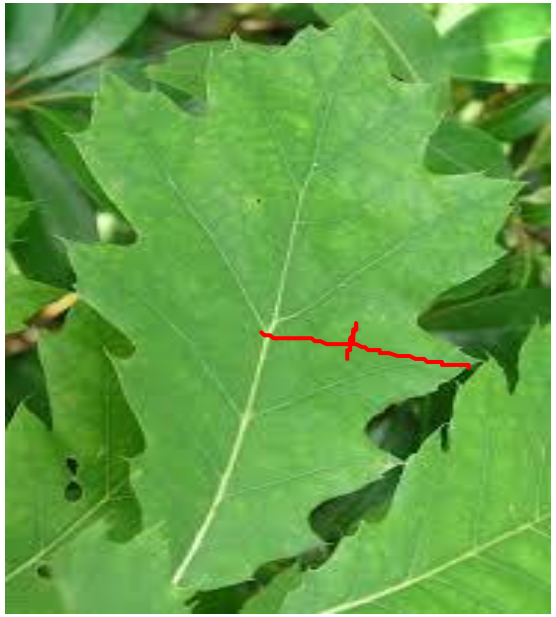
- When the divisions of the lamina are directed towards the mid-rib, the leaf is **pinnately lobed,** while when they appear directed towards the base the leaf is **palmately lobed.**

Simple Pinnate

1. **Pinnatifid:** the incisions are less than half the distance between the margin and the midrib e.g. *Chrysanthemum frutescens* .
2. **Pinnatipartite:** incisions extend more than half way down towards the midrib, e.g. *Citrullus*.
3. **Pinnatisect :** the incisions so deep as almost reach the midrib e.g. Papaver.

Simple Palmate

1. **Palmatifid** : e.g. *Malva* and *Althaea* .
2. **Palmatipartite**:e.g. , *Ricinus* .
3. **Palmatisect**: e.g. *Ipomoea*.



Simple lobed pinnatified

Simple lobed pinnatipartite

Simple lobed pinnatisect

Simple lobed palmatified

Simple lobed palmatipartite

Simple lobed palmatisect

Compound Leaf

compound pinnate

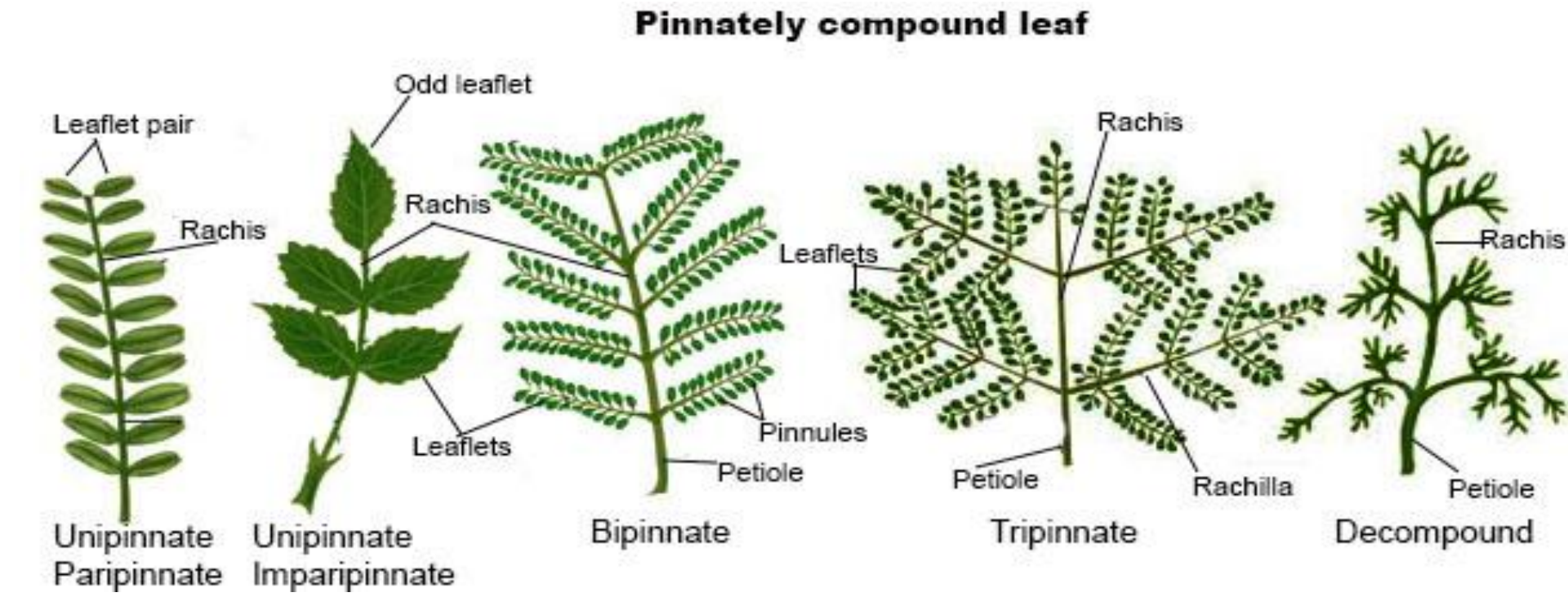
- *Leaflets are arranged in two rows, one on either side of the leaf stalk the leaf.*

1. **Imparipinnate:** leaves ending with a terminal leaflet (e.g. *Rosa*).
2. **Paripinnate:** leaves ending in a pair of leaflets (e.g. *Cassia*).
3. **Bipinnate:** the leaflets are further divided in a pinnate manner so as to form small leaflets of the second order (pinnules) e.g. *Poinciana*.
4. **Tripinnate:** the leaflets are further incised in a pinnate manner into very small leaflets of third order or pinnullulus.
5. **Decompound** : A leaf consists of indefinite number of leaflets on a rachis which may have great variation in size and shape. (e.g. Coriander).

compound palmate

- *Leaflets are radiating from a point at the top of the petiole the leaf.*
- *According to the number of leaflets present, they are divided into following types:*

1. **Unifoliate**: A single leaflet is jointed on the tip of the petiole (e.g. *Citrus*).
2. **Bifoliate**:a pair of leaflets (e.g. *Zygophyllu*m).
3. **Trifoliate**: 3 leaflets (e.g. *Trifolium*).
4. **Quadrifoliate**: 4 leaflets (e.g. *Marsilia*).
5. **Multifoliate**: many leaflets (e.g. *Lupinus termis*).



Paripinnate

Imparipinnate

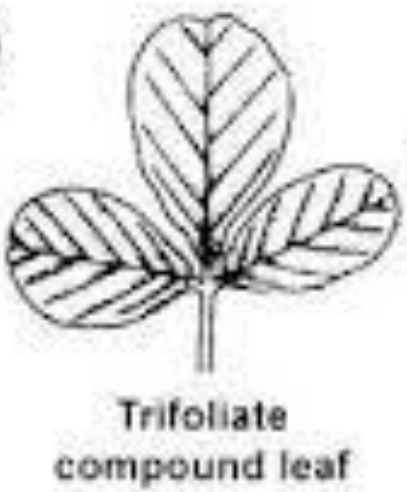
Bipinnate

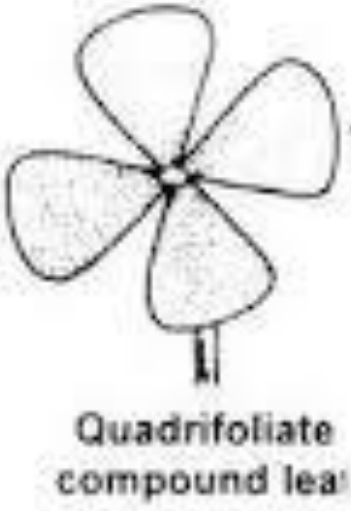
Tripinnate

Decompound


Unifoliate
compound leaf


Bifoliate
compound leaf


Trifoliate
compound leaf


Quadrifoliate
compound lea


Multifoliate
compound leaf

How can you differentiate between a branch of stem carrying simple leaves and a compound leaf?

1. Look for: "the lateral bud" only occurs at the base of the petiole in both leaves but, not at the base of the leaflets.
2. Look for: "the leaf base", The stipules, if present, are found at the base base of a simple leaf ,but in compound leaf, the stipules, if present, are found at the base of the leaf.
3. Look for: repetition of the pattern.

8. Shape or outline of the lamina (leaf or leaflet)

1. Acicular: needle like (e.g. Pine).

2. Linear: long and narrow with more or less parallel edges (grasses).

3.Tubular or fistulose: the leaf in the form of a hollow tuba (onion).

4. Lanceolate: Lancet-like and gradually tapering towards base and apex as in *Eucalyptus* and *Salix* .

5. Elliptical: as in lanceolate but smaller in length.

6. Ovate: with outline like an egg rounded at the base and pointed at the apex (e.g. *Ficus*).

7. Obovate: rounded at the apex and pointed at the base .

8. Oblong : as long as broad; rounded at the apex and base.

9.Cordate: a heart-shaped, if pointed at the apex and with a sinus and rounded lobes at the base where the petiole is attached (e.g. Ipomoea)

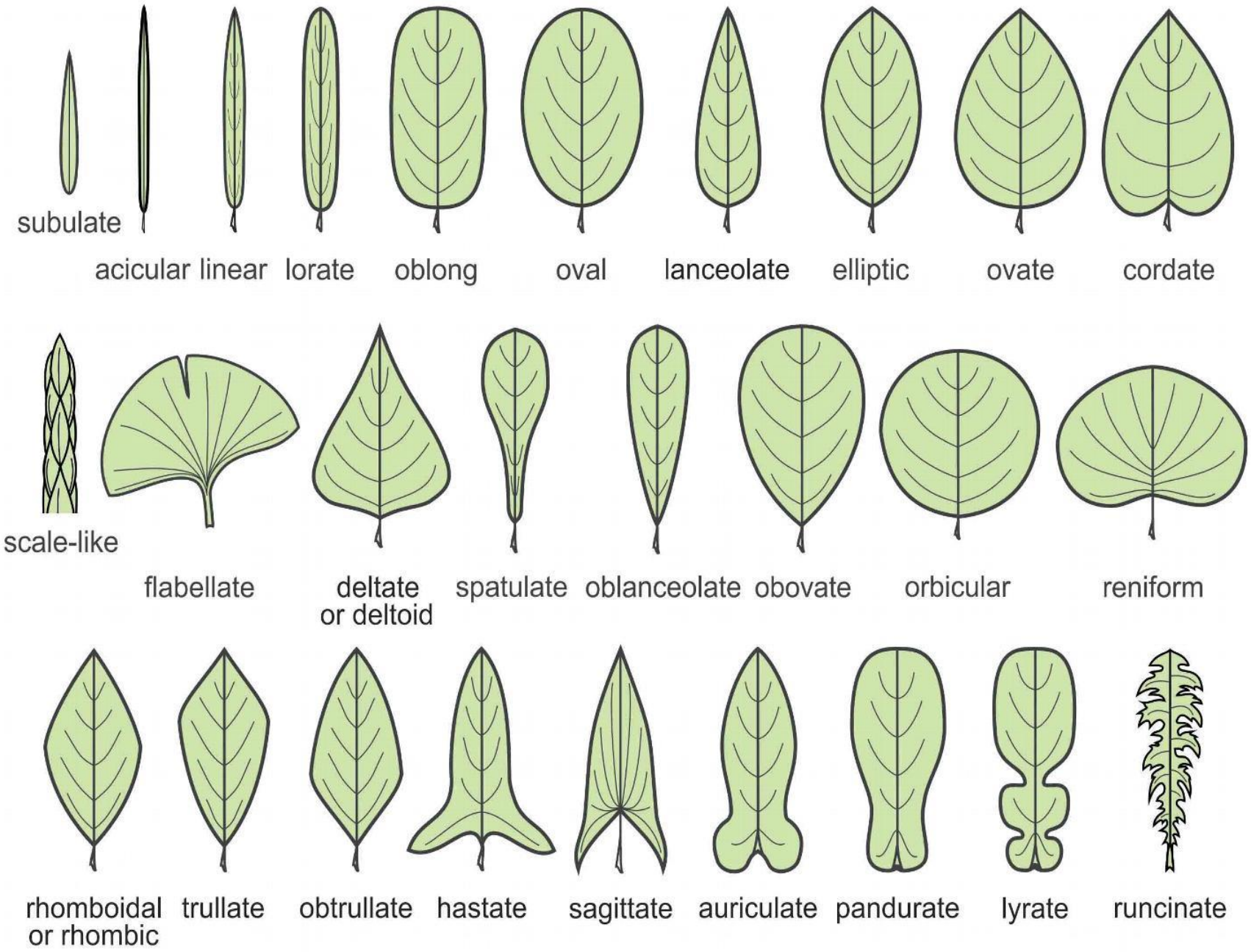
10.Orbicular: rounded (e.g. Lotus).

11. Peltate: When the petiole emerges from the lower surface not from the base of lamina it termed (e.g. Tropaelum).

12. Reniform: kidney shaped i.e. broad at the base out with a deep notch so as to form two lobes and rounded at the apex (e.g. *Malva*).

13. Sagittate: shaped like an arrow-head, the two basal lobes being directed downward (*Colocasia*).
14. Hastate: narrow-head-shaped, but the side lobes pointing outward or standing at right angles (e.g. *Convolvulus)*.
15. Spathulate: club-shaped, wide and rounded at the apex and gradually narrowing towards the base as in calendula.
16. Rhomboid: like a rhombus (*Solanum nigrum*) .

Sometimes, the outline of the lamina cannot be described, by any single term. For accurate description it then, becomes necessary to combine two terms as for example Ovate-lanceolate.


subulate
acicular
linear
lorate
oblong
oval
lanceolate
elliptic
ovate
cordate
scale-like
flabellate
deltate
or deltoid
spatulate
oblanceolate
obovate
orbicular
reniform
rhomboidal
or rhombic
trullate
obtrullate
hastate
sagittate
auriculate
pandurate
lyrate
runcinate

8. leaf surface

1. **Hairy** : covered with hairs (e.g. *Pelargonium*).
2. **Glaucous** : surface smooth and shining (e.g. *Nerium*).
3. **Glabrous** : smooth but dull (e.g. *Eucalyptus*).
4. **Rough** : it has projection (e.g. wheat).
5. **Spiny** : covered with spines .

9. Base of the lamina

- As a general rule the two halves of the blade are similar in size that is to say **symmetric** (e.g. *Clerodendron*).
- But when one is larger than the other the leaf is said to be **asymmetric** (e.g. *Datura*).
- The leaf is described as **auriclate** when it has ear-sheped parts or appendages at the base of lamina (e.g. *Hordeum*).
- **Decurrent**: when the base of the sessile blade extend down and adenates to the stem.

Base of the lamina

Symmetric

Asymmetric

Decurrent

Auriculate

10. Modification of Leaf or Its Parts

- Many, modifications of foliage leaves have arisen in nature as adaptation to certain special conditions.
- Such specialized structures, whatever their external appearance are always recognized as leaves if they have in their axil a branch or a bud.
- **Some Examples:**

1. The whole leaf or any part of it maybe modified into **tendrils** for climbing purposes (e.g. pea).
2. **Fleshy or succulent**: the scales of bulbs become flashy as reserve organs.

3. In some plants leaves or parts of it are modified into **spines** to protect the plants against attacks of herbivorous animals and to reduce excessive transpiration (e.g. *Opuntia*).
4. In insectivorous plants, **pitchers** are formed from the petiole, blade or both of them, for the purpose of entrapping small insect and digesting them.
5. **Phyllodes**: in certains species of *Acacia*s the petiole gets flattened thus taking up the appearance and functions of the lamina. To reduce excessive water loss.