**Shoot system**

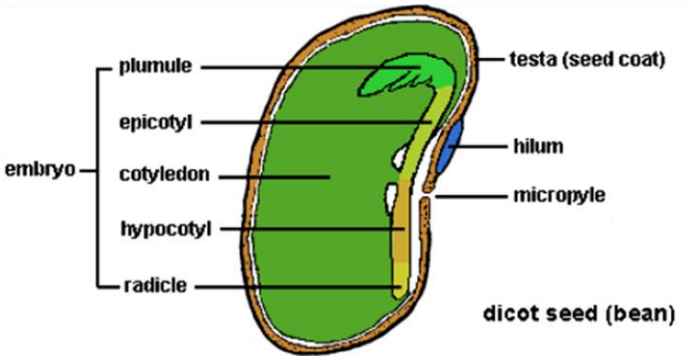
Shoots are the sporophytic organs of vascular plants consisting of stems in addition to leaves. Shoots contain an apical bud (apical meristem) of actively dividing cells, continued differentiation results in the elongation of the stem and structuring of leaves and buds.

## 2. Stems

Stem is a generally cylindrical organ that typically functions in the conduction of water and minerals from the roots and in support and elevation of both leaves and reproductive structures. Some stems undergo modifications of aerial or underground (subterranean stems) they have been highly modified for other functions (figures 1.4, 1.5, 1.6 and 1.7).

**Origin of stem;**

The first shoot of a seed plant develops from the epicotyl of the embryo. The epicotyl elongates after embryo growth into an axis (the stem) that bears leaves from its tip, which contains the actively dividing cells of the shoot **apical meristem**. Further cell divisions and growth results in the formation of a mass of tissue that develops into the immature leaf, called a **leaf primordium**.




**2. I. Stem habit** (figure 1.4)

**Aerial (Terrestrial) stem:**

1. **Erect;** The stem pointing upward ( ~ 90º) e.g. *Papaver* and *Morus* spp.
2. **Ascending;** Directed upward, with divergence angle of 15º - 45º from upper axis, e.g. *Nerium oleander*.
3. **Weak;** Some plant poses stem unable to holding itself, these includes;
   - **a.** Twining (clambering); Sprawling across objects without specialized climbing structures. e.g. *Convolvulus* .
   - **b.** Climbing; growing upward by means of tendrils, petioles, or adventitious roots. e.g. *Passiflora* and *Hedera helix*.
   - **c.** Prostrate; Some plants are adapted to lying on the ground at least in part these includes;
     - i. Decumbent; lying on the ground, but with the end ascending, e.g. *Verbena*.
     - ii. Procumbent; trailing or lying flat but not rooting. e.g. *Andrachne* and *Citrullus* .

**d.** Runner; A slender trailing shoot taking root at the nodes. e.g. *Cynodon dactylon*.

**e.** Stoloniferous rhizome; A shoot that bends to the ground and takes root, that gives rise to a new plant at its tip. e.g. *Fragaria* and *Viola* .

4. **Cespitose:** Plants growing in small dense clumps or tufts, synonyms: Caespitose
5. **Scape:** A naked (leafless) peduncle, generally arising from a basal rosette of vegetative leaves, as in Liliacea.

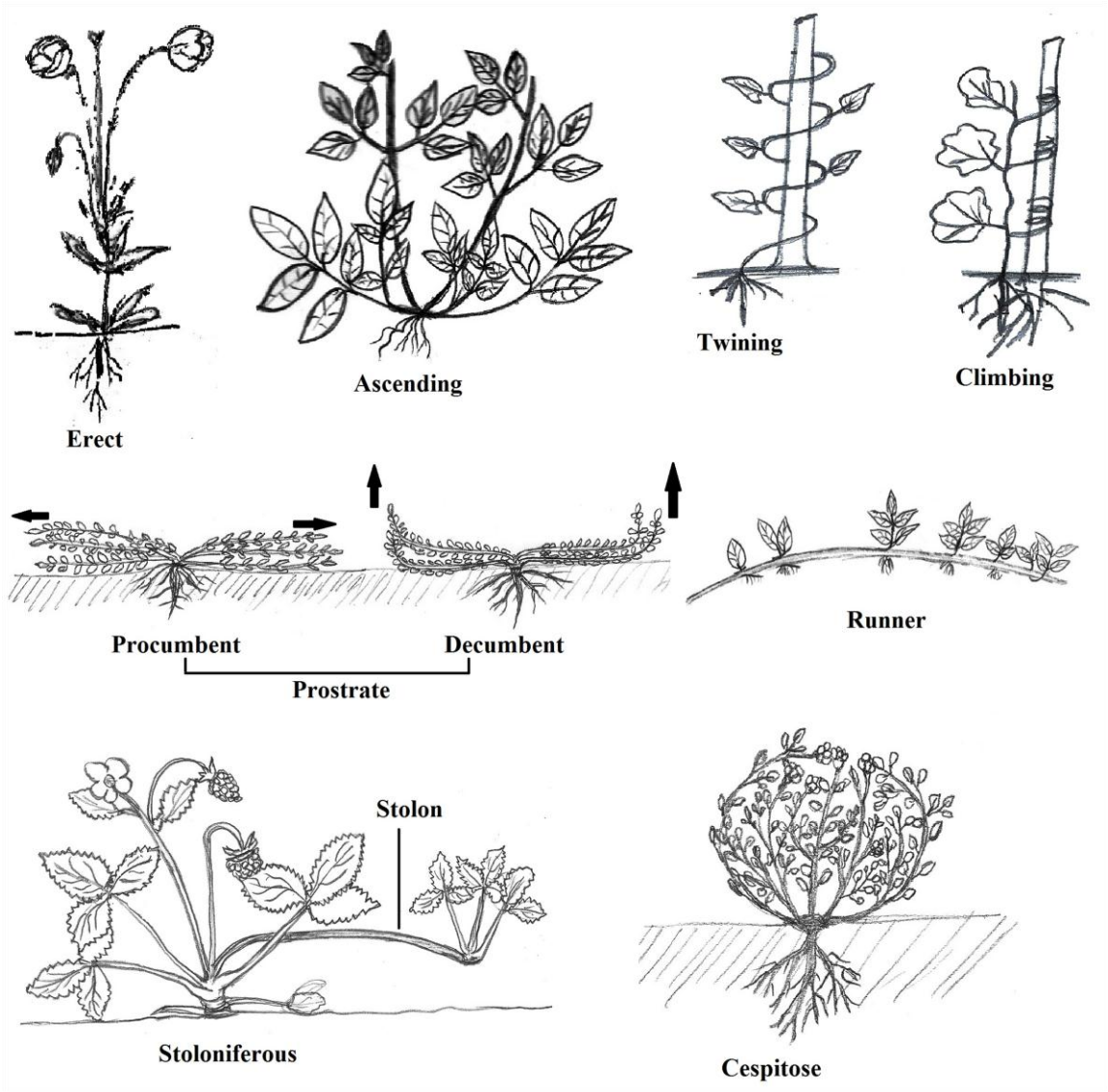



Figure 1.4: Stem habit types

**2. II. Aerial stem shapes** (figure 1.5)

a. Cylindrical stems; circular in transverse section, as fined in Poacea (Gramineae) family, these includes;
   i. Hollow cylindrical stems; e.g. *Triticum* sp. and *Hordeum* sp.
   ii. Solid cylindrical stems; e.g. *Bambusa*.

b. Angular stems; Divided according numbers of angles to;
   i. Triangular, as fined in Cyperaceae family.
   ii. Quadrangular, as fined in Labiatea family and *Vicia faba*.

c. Winged stems; Some plants possess thin flat expansion on its stem, e.g. *Verbascum, Onopordum acanthium* and *Lathyrus*.

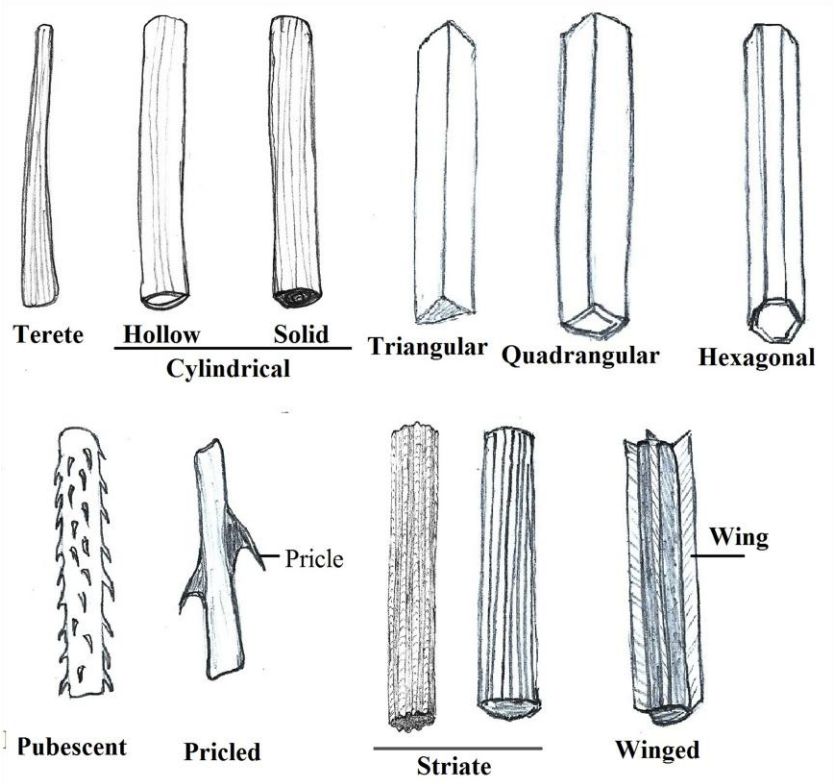



Figure 1.5: Stem shapes

**2. III. Modified stems**

**2. III. i. Aerial modified stems** (figure 1.6)

1) Stem-tendril – a modified axillary or terminal bud into tendril for climbing, e.g. *Passiflora* and *Vitis*.
2) Thorn or spiny stems – a modified straight, hard and pointed axillary branch, as fined in *Astragalus* sp., *Alhagi* sp. and *Bougainvillea*.

3) Phylloclade – a stem in which several nodes and internodes become flattened or swollen, fleshy and green leaf-like Such stem carry out photosynthesis and also store the food. Leaves present on the nodes, are reduced to scales or modified into spines, e.g. *Opuntia* and *Cactus*.
4) Cladode or Cladophyll – a special type of phylloclade consisting of one or two internodes only and occurrence of flower at the nodal points, justify their stem nature, e.g. *Asparagus* and *Ruscus*.

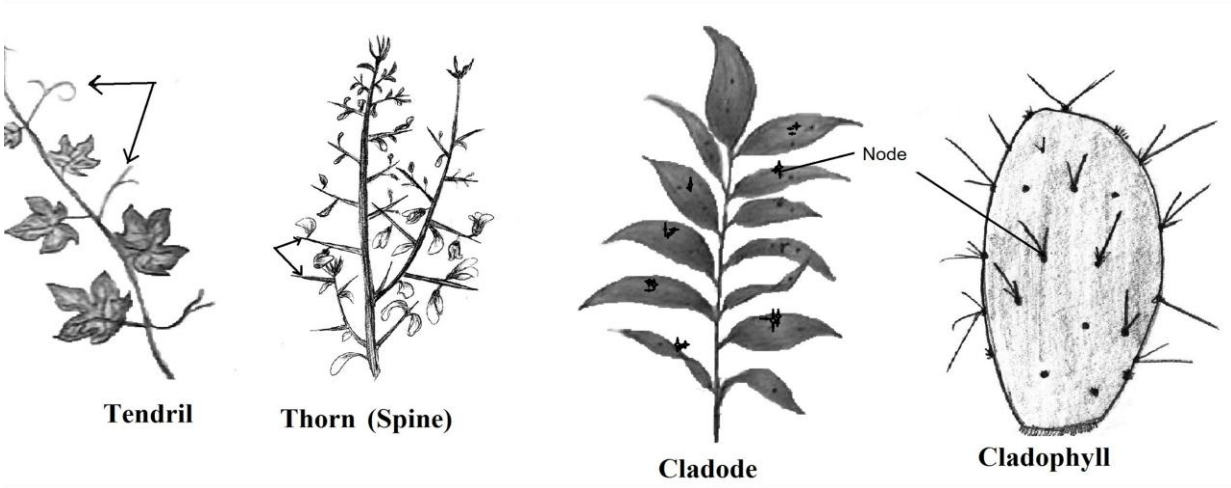



Figure 1.6: Different modifications of aerial stems.

**2. III. i. Underground modifications (Subterranean stems)** (figure 1.7)

**1)** Rhizomes – underground horizontally growing below the soil surface with distinct nodes and internodes. Nodes bear scale leaves on the upper surface and adventitious roots on the lower surface, e.g. *Zingiber officinale* and *Cynodon dactylon*.
**2)** Tubers- fleshy swollen, underground stem bearing scale leaves with buds (eyes) in their axils, each eye develops into a small shoot, e.g. *Cyperus rotundus* and *Solanum tuberosum*.
**3)** Bulbs – a rounded, modified underground bud bearing highly reduced (disk-like) stem and fleshy scale leaves which make up the bulk of the organ, e.g. *Allium cepa* and *Tulipa*.
**4)** Corms – a solid highly condensed, vertical root-stock with a large apical bud and adventitious root grow either from the base or all over its budy, e.g. *Crocus*, *Colchicum*, *Gladiolus* and *Leontice*.

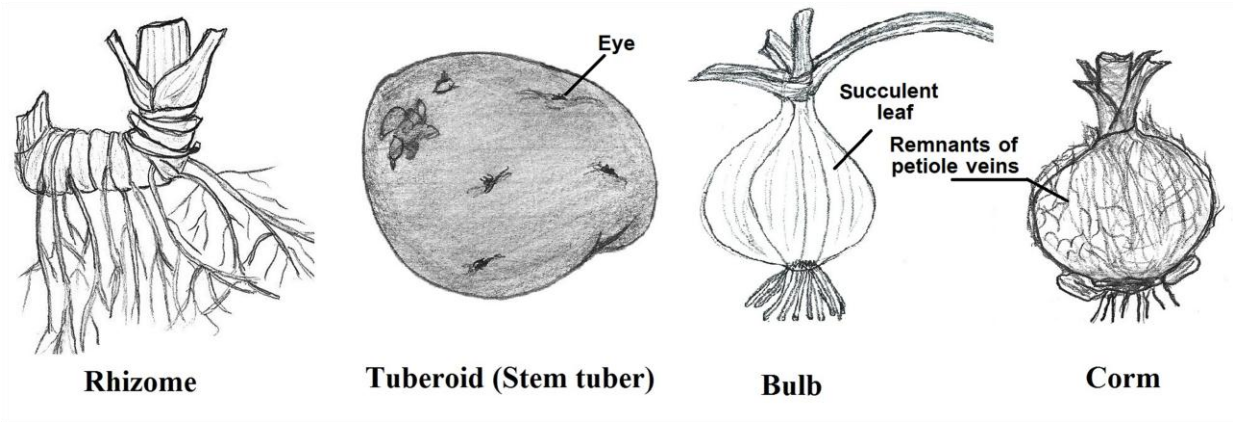



Figure 1.7: Different modifications of subterranean stems.

## 3. Leaves

Leaves that shoot-bearing organs are generally flattened dorsoventrally and normally functions in photosynthesis, respiration and transpiration. The leaves are derived from the rudimentary leaves (**leaf primordial**) that develop either by the axial bud or from the apex of the cotyledon and are often variously modified. In real vascular plants, leaves contain one to many vascular bundles that make the veins and while in some mosses, the gametophytic leaves may contain a vein-like costa, consisting of conductive tissue of unreal vascular.

### 3.1. Leaf types

According to the indentation of the lamina margins, they are recognized into two main categories; leaf having entire margin (not divided) **simple leaves**; or **compound leaves** (figure 1.8).

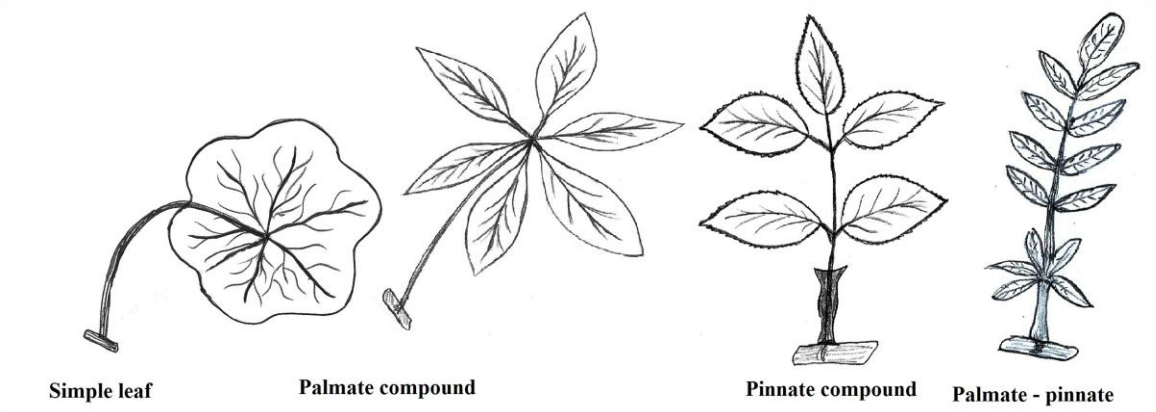



Figure 1.8: Leaf types

**3.2. Phyllotaxy (Leaf arrangement)** (figure 1.9).

Mode of leaves arrangement on the stem (**phyllotaxy)** includes;

1. **Alternate:** leaves being produced alternately or spirally on the long axis or stem.
2. **Opposite:** leaves occurring in pairs at the node, they may be – the leaves that stand at right angle to next upper or lower pair **decussate,** or successive pairs of leaves stand directly over a pair in the same plane **superposed.**
3. **Whorled** or **verticillate:** in which 3 – 5 leaves form a whorl in each node.

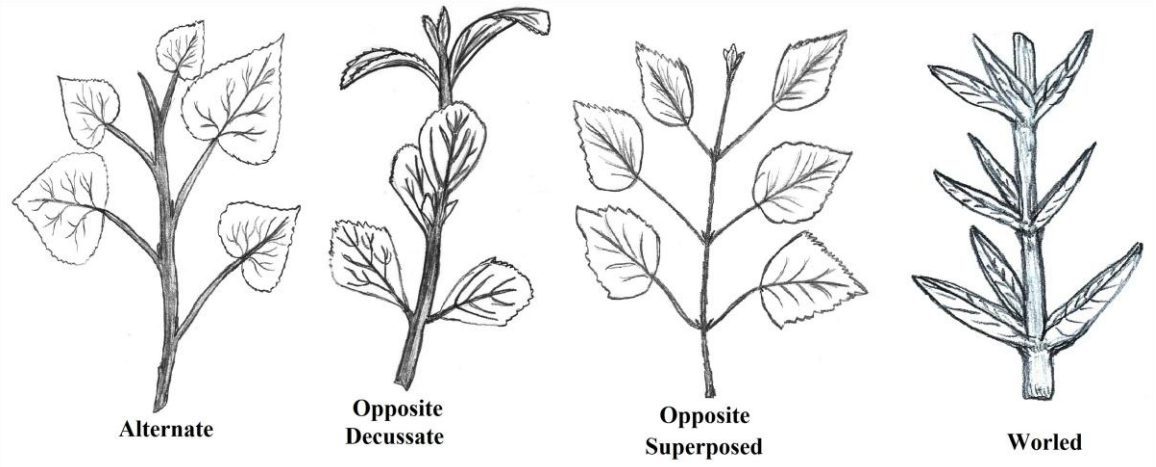



Figure 1.9: Leaf arrangement patterns (Phyllotaxy)

**3.3. Duration of leaves;**

i. **Caducous;** leaves fall of as soon as they are formed as in *Opuntia*.
ii. **Deciduous** or **annual;** leaves fall of at the end of a particular season as in *Acer* and *Prunus*.
iii. **Persistent;** leaves last for a long time as in most tropical trees, as in *Eucalyptus, Citrus*, and *Rosa* spp.

**3.4. Leaf parts**

**3.4.I. Lamina (Blade)**

Lamina or blade is the most important part of the leaf and a seat of gaseous exchange for photosynthesis, respiration, and transpiration. The blade shapes and forms almost of taxonomic value (figures 1.10 and 1.11).

**Shapes of Blades or lamina:**

Important shapes of lamina are:

1. **Acicular –** needle shaped, as in *Pinus*.
2. **Linear –** longer and slightly broader, as in grasses (Poaceae).
3. **Lanceolate –** lance shaped, as in *Nerium* and *Eucalyptus*.
4. **Subulate-** narrow and gradually tapering apex, as in *Fragaria ananassa*.

5. **Obsubulate-** revers of subulate, as in *Valeriana* sp.
6. **Falcate-** similar to a sickle or beak of a falcon as in *Albizia julibrissin.*
7. **Ovate –** egg shaped, as in Rosacea and *Hibiscus rosa*.
8. **Obovate –** revers of ovate, as in *Zizyphus*.
9. **Cordate –** heart shaped, as in *Morus*.
10. **Obcordate –** reverse of cordate, as in *Oxalis*.
11. **Pandurate-** fiddle-like or violin-shaped, as in *Ficus pandurate.*
12. **Oblong –** Margins straight, parallel, length: width ratio 2:1 to 3:2. as in *Mentha*.
13. **Reniform –** kidney shaped, as in *Malva* and *Alcea*.
14. **Hastate –** like sagittate but the two basal lobes are directed outwards, as in *Convolvulus* and *Ipomoea*.
15. **Sagittate –** With two basal lobes, more or less pointed and oriented downward, away from apex (base), as in *Convolvulus*.
16. **Spathulate –** spatula shaped, as in *Lactuca* and *Calendula officinalis.*
17. **Elliptical –** like an ellipse, as in *Salvia* and *Ficus benjamina.*
18. **Deltate –** triangular, as in *Populus*.
19. **Orbicular-** rotund **–**or circular, as in *Pelargonium* sp. and *Ficus*.
20. **Peltate –** attached to its stalk inside the margin, shield shaped, as in *Tropaeolum*.
21. **Tendril leaf–** the terminal leaves modified to tendril, as in *Lathyrus*.
22. **Carnivorous-** Three types of leaves are very specialized adaptations of carnivorous plants (figure 1.11):
    i. **Snap traps** of the Venus flytrap and waterwheel plant are hinged leaves that snap shut when trigger hairs are touched.
    ii. **Pitcher leaves** are those that are shaped like a container, which bears an internal fluid and functions in the capture and digestion of small animals.
    iii. **Tentacular leaves** are those bearing numerous, sticky, glandular hairs or bristles that function in capturing and digesting small animals.

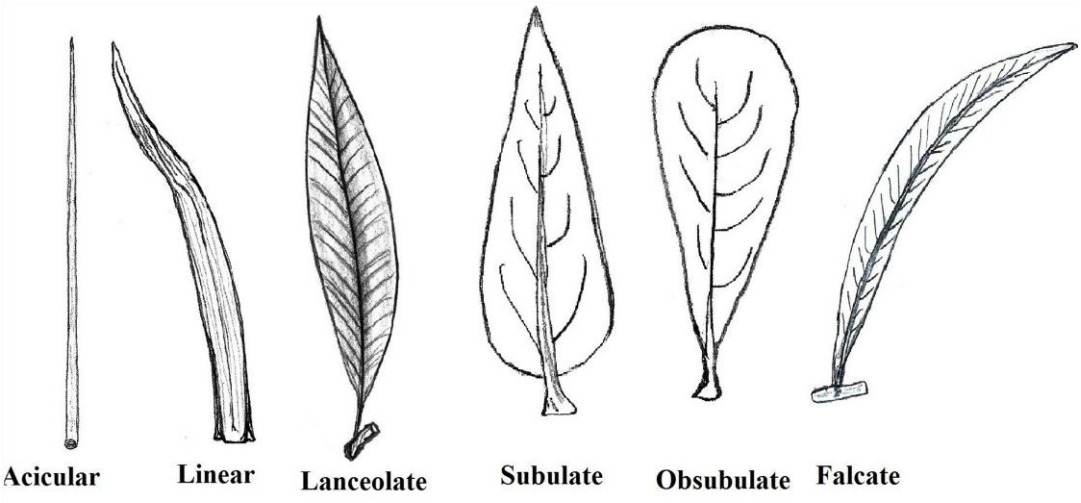



Figure 1.10: Leaf blade shapes

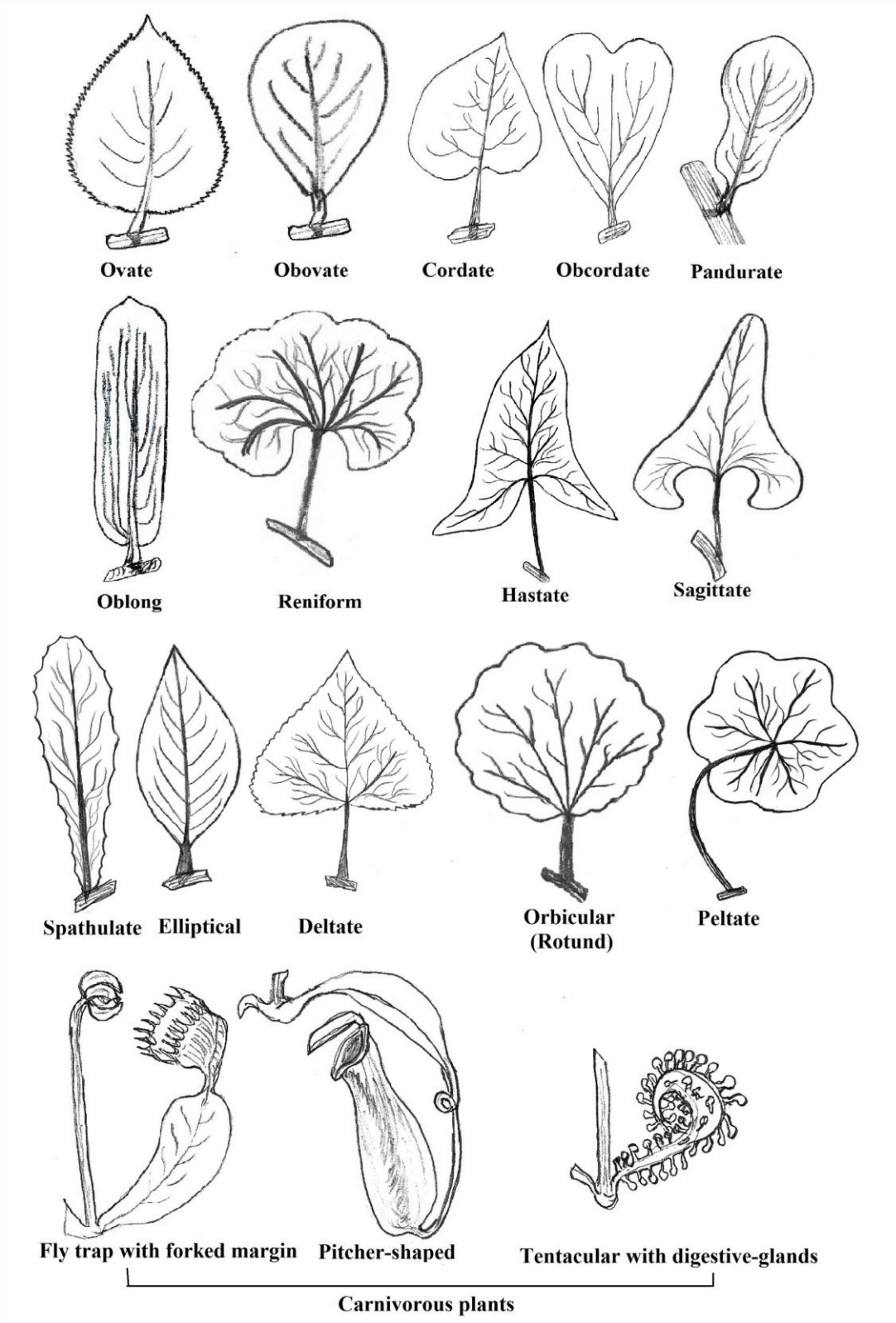



Figure1.11: Leaf blade shapes

### 3.4.II. Leaf base attachment types and shapes

Petiole is the basal leaf stalk, in general, a leaf having a petiole is called **petiolate**, and without a petiole is called **sessile**. The point of attachment of the leaf to the stem. In general, leaves may be **petiolate**, with a petiole, or **sessile**, without a petiole. Leaflets of a compound leaf are, correspondingly, either **petiolulate** or **sessile**. In addition, the distal down part of the lamina where the blade attaches to the petiole or stem (if sessile) is called the base, it may be of various shapes (figure 1.12).

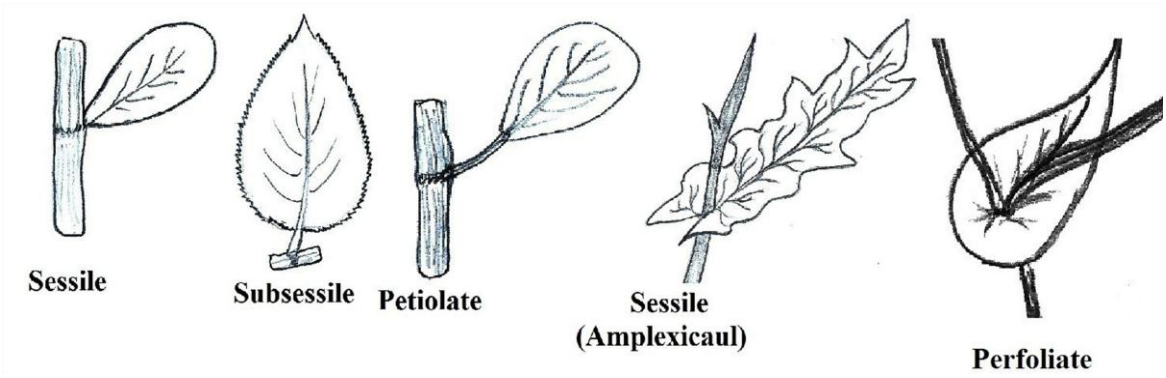



Figure 1.12: Leaf base shape and types

### 3.4.V. Leaf blade apex

The anterior tip of the lamina is called apex. It may be of various shapes (figure 1.13).

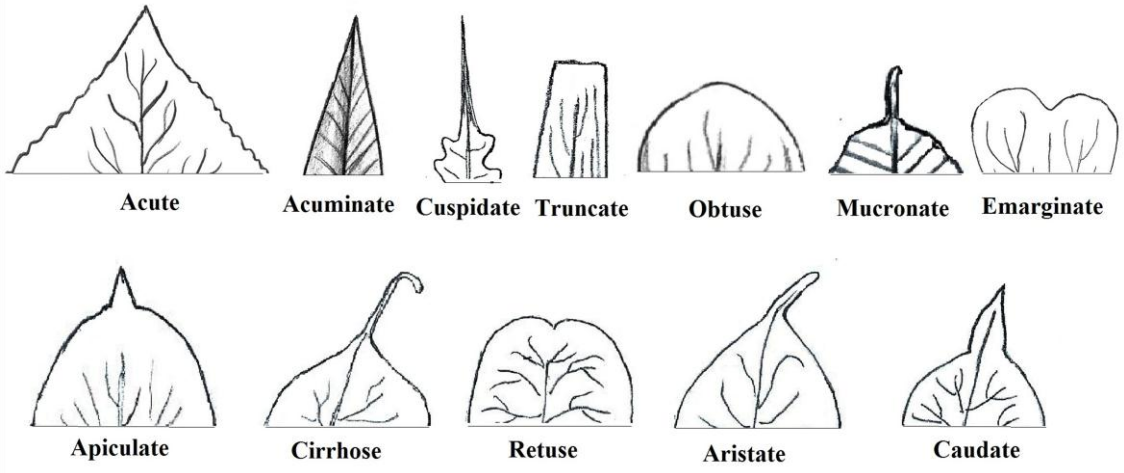



Figure 1.13: Leaf blade apex shapes

### 3.4.VI. Leaf blade margins

The margin is the outermost boundary of the lamina, and have different shapes as in (figure 1.14).

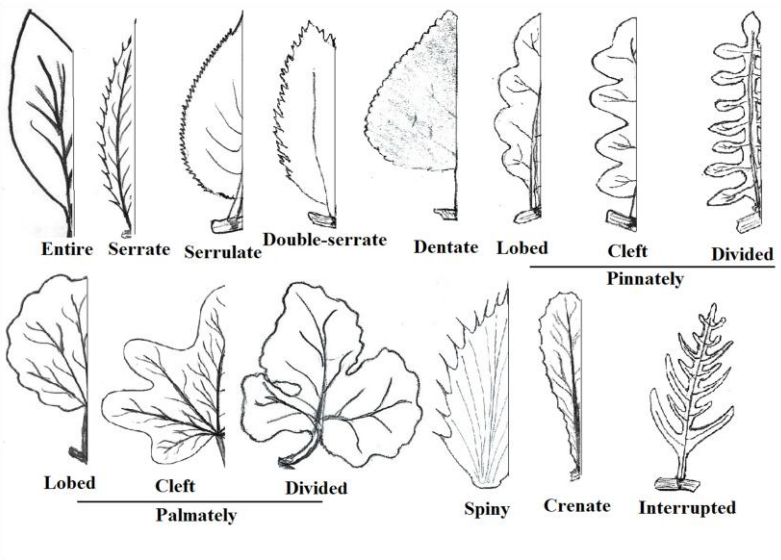



Figure 1.14: Leaf blade margin shapes

### 3.5. Stipules

Stipules are pair of lateral outgrowth present at the base of the leaf leaves possessing stipules are called **stipulate** and those lacking are **exstipulate** leaves. Sometimes the stipules undergo different modified shapes as in (figure 1.15).

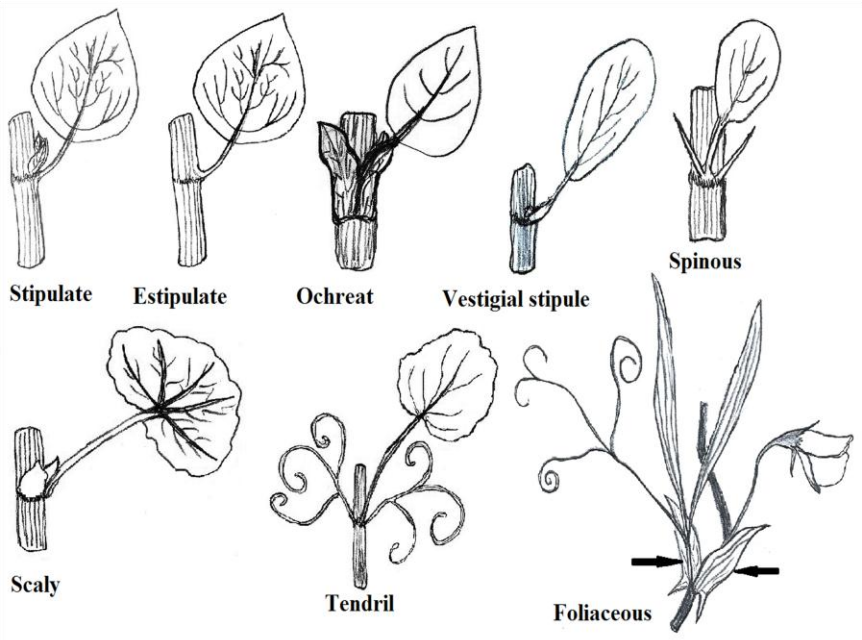



Figure 1.15: Leaf stipule types