Morphology and adaptation of higher plants

INTRODUCTION

Plant anatomy is the study of the internal structure of plants (Chap. 3). **Plant morphology**, on the other hand, is the part of botany that involves describing the shape and external structure of plants and their organs. The classification of plants and their practical identification in the field is based primarily on **morphological criteria**. The species, according to a classic definition, is "the set of individuals that most are similar each other". This lesson describes in general the morphology of the roots, stems and leaves of higher plants and their adaptation to environmental conditions.

1. Root morphology

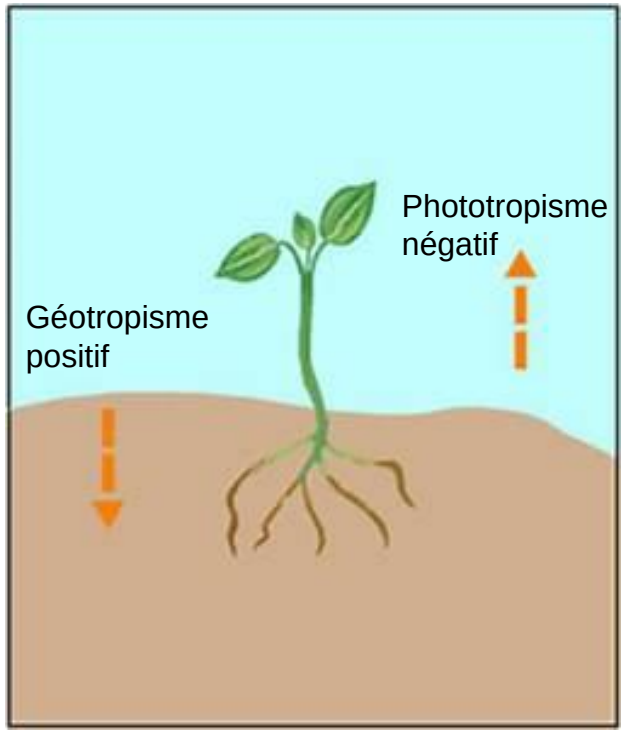
1. DEFINITION

The **root** is one of the fundamental organs of the plant, generally growing underground, with axial symmetry, positive geotropism and negative phototropism. The **root** has several functions:

-It anchors the plant to the soil;

-Absorption of water and mineral salts;

-Organ of nutrient reserves sometimes.



• **Geotropism:** The orientation of the growth of some organs (stem, root) in relation to **gravity.**

Positive geotropism: Root growth from top to bottom.

Negative geotropism: Growth of the stem from bottom to top.

• **Phototropism:** Phenomenon of attraction or repulsion of growing organs to sunlight or artificial light.

Positive phototropism (attraction) and negative phototropism (repulsion).

2. ORGANISATION OF ROOT SYSTEMS

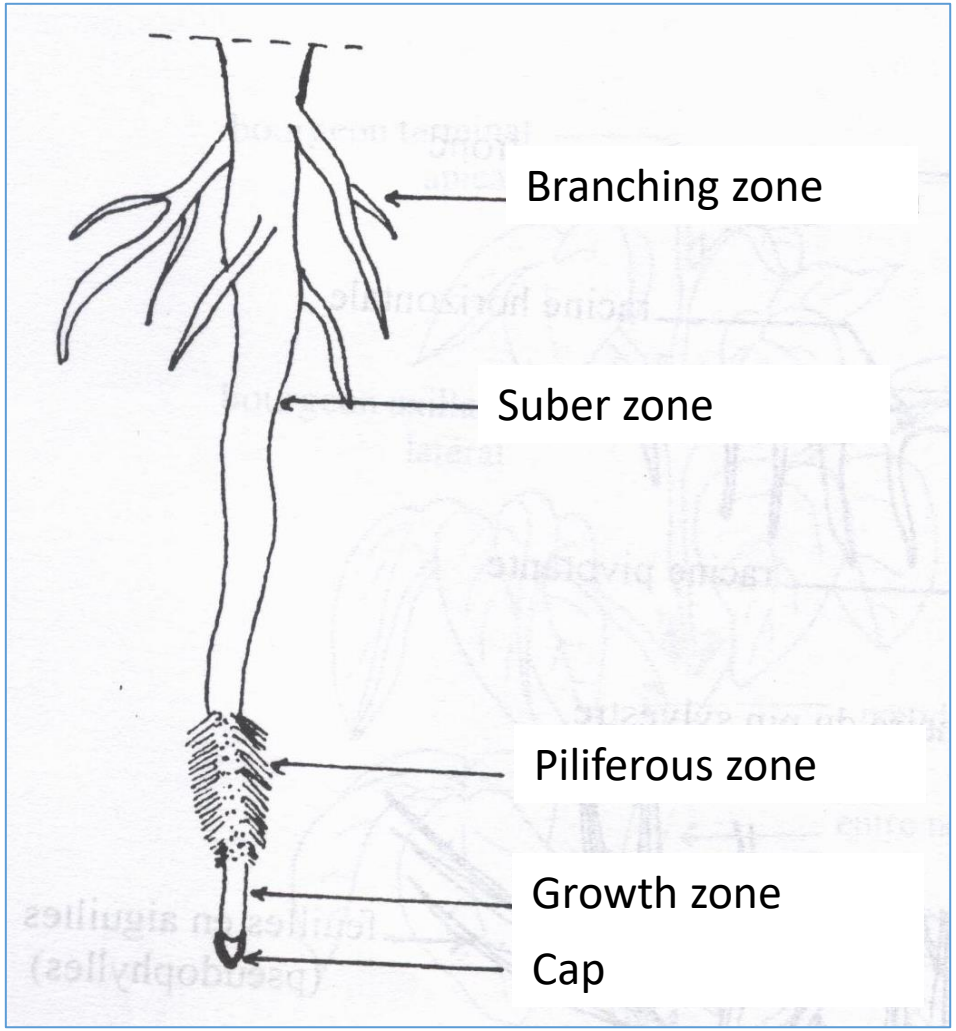
2.1. Different parts of a root

The different parts of a root system are: cap - growth zone - piliferous zone - branching zone.

- Cap: Located at the tip of the root, the cap is conical in shape. Its role is to protect the root meristem. The cap regenerates continuously.

1. Morphology of the roots

- **Growth zone:** This is the zone of tissue differentiation. It is short, smooth and clear. It ensures that the root grows in length.
- **Piliferous zone:** This is the part of the root that contains absorbent hairs. These hairs absorb water and mineral salts.
- **Branching zone:** Also known as the suberous zone, this is the longest and largest part of the root where all the branches of the root system are formed.



2.2. Different types of root systems

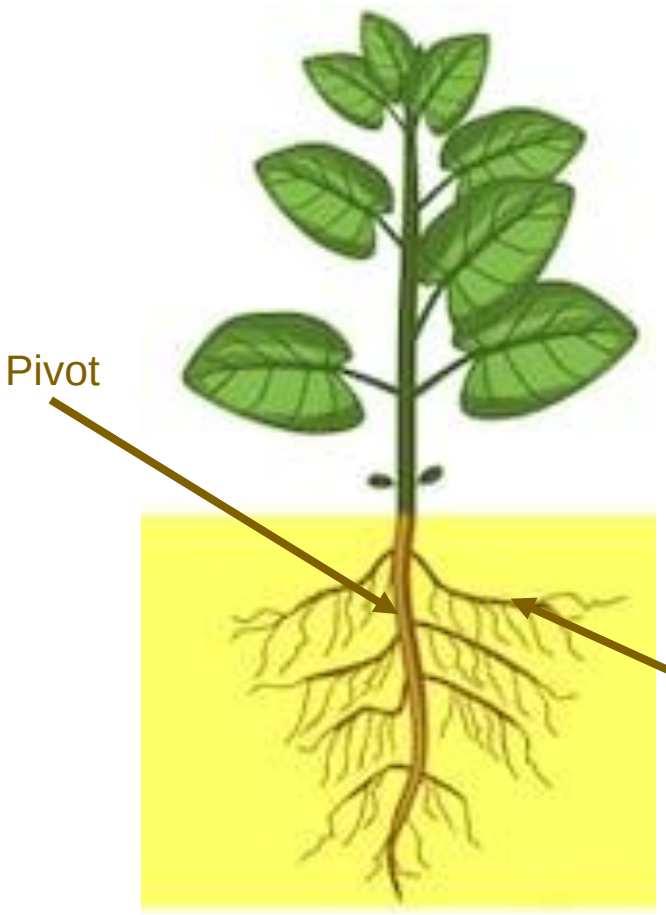
There are two main types of roots:

a. **Taproot system :** The taproot system is characterized by the predominant development of the main root. It is characteristic of Dicotyledonous Angiosperms and Gymnosperms.

b. **Fasciculated root system:** All roots in this system are more or less equal in diameter. It is characteristic of Monocotyledonous Angiosperms.

c. **Adventitious root system:** This type of root forms at the internodes of creeping stems (strawberry stolon), on underground stems (Iris - couch grass) and creeping stems (Ivy).

1. Morphology of the roots

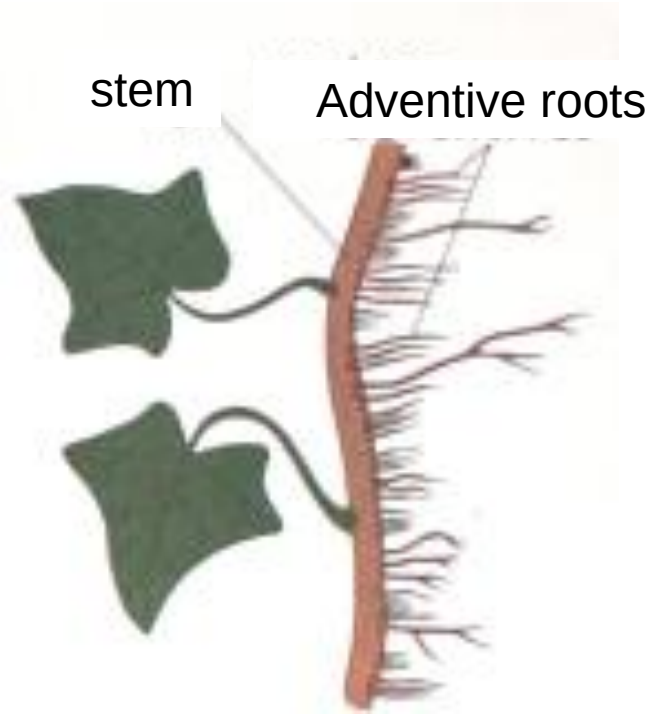


a. Taprooting system

Angiosperms Dicotyledons and Gymnosperms.

b. Fibrous root system

Angiosperms Monocotyledons



c. Adventive roots system

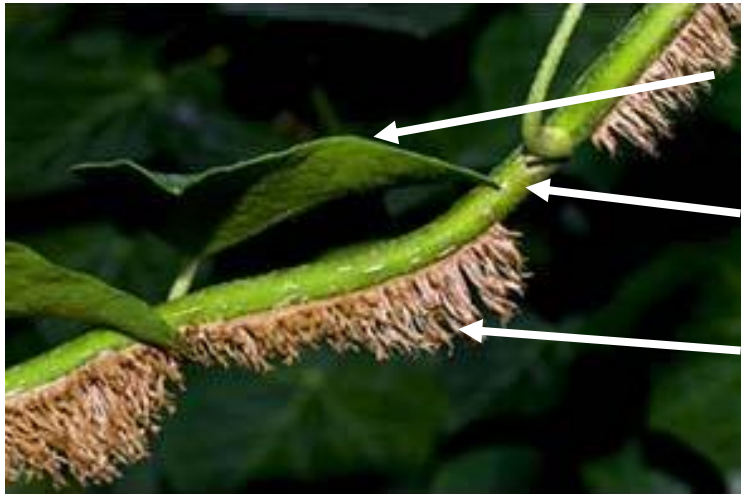
(strawberry stolon), on underground stems (Iris - couch grass) and creeping stems (Ivy).

2.3. Special types of roots

- **Spiked roots:** These are adventitious roots that enable the plant to cling to its support (e.g. ivy);
- **Tuberised roots:** These are swollen roots that have accumulated reserves (e.g. carrot, beetroot, radish, turnip, etc.). These roots generally live for 2 years, and during the bad season the accumulated reserves are used to feed the plant;
- **Stilt roots:** These are arched roots anchored in the mud, adapted to the passage of the tides, typical of mangroves.

Tuberised taproots (A-B)

Tuberised fasciculated roots (C-D)



Adventicious Root or tendrils
(Ivy = Lierre)

Aerial Roots (Mangrove)

1. Morphology of the roots

- **Buttress roots:** These are aerial adventitious roots that grow on the branches of certain arborescent species in tropical zones. Their development towards the soil and their anchorage in the soil mean that they play a supporting role.
- **Pneumatophore roots:** These are secondary roots with negative geotropism that grow vertically in a flooded environment and provide oxygen. They are characteristic of marsh trees in particular. For example, in mangroves, where the roots are immersed in a brackish environment that is not conducive to life, they emit respiratory roots called pneumatophores, which allow them to breathe more easily.
- **Trap roots:** These are found in parasitic plants such as mistletoe (*Viscum album*, Loranthaceae)

1. Morphology of the roots

Buttress roots

Pneumatophore roots

Trap roots

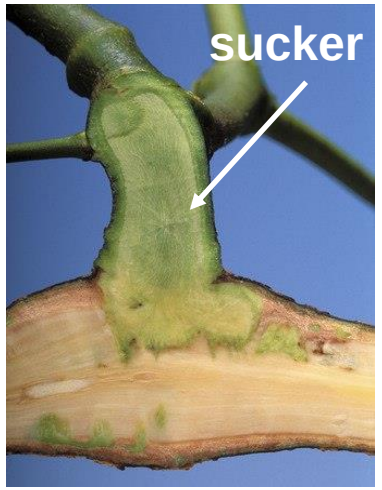
3. FUNCTIONAL ADAPTATIONS

Roots can be adapted to different environments or have special functions. Some types of adaptation are linked to fixation and reserves: Adaptation of roots in plant fixation : In addition to their underground root system, some plants have adventitious (or supplementary) roots on the stem which serve as a means of attachment.

- **Adaptation of the roots to the absorption function:** The absorption of water and mineral salts is maximised in the piliferous zone due to the absorbent hairs.

In **parasitic plants**, the main root is transformed into a sucker, an organ that burrows into the vascular tissues of the host plant to draw sap (e.g. mistletoe).

Epiphytic plants have hanging aerial roots that absorb atmospheric water through perforations in their walls. These plants have no absorbing hairs, so they do not parasitise the host plant (e.g. Ficus, Philodendron).



Ex of mistletoe

- **Adaptation to the absorption function:** Absorption of water and mineral salts is at its highest at the end of the day.
- **Adaptation to the reserve function:** Some roots are tuberised following an accumulation of reserves (starch, inulin or other). These nutrients are accumulated in various tissues.
- **Examples :** The bast for carrots; Cortical parenchyma for Asphodel; Cortical parenchyma and wood for Radish; Secondary parenchyma for beetroot.

2. Morphology of the stems

1. Definition

- The **stem** is the generally aerial organ that bears the leaves, the reproductive system (flower), the fruit and the seeds. Stems also bear buds (in the leaf axils) and other branches (from old buds).
- The **stem** conducts sap and supports the plant. The part that connects the stem to the root is called the neck of plant, which is a transitional zone between the two organs. The stem grows in the opposite direction to the earth's attraction (negative geotropism) and towards the light (positive phototropism).

2. Organisation of the stem system

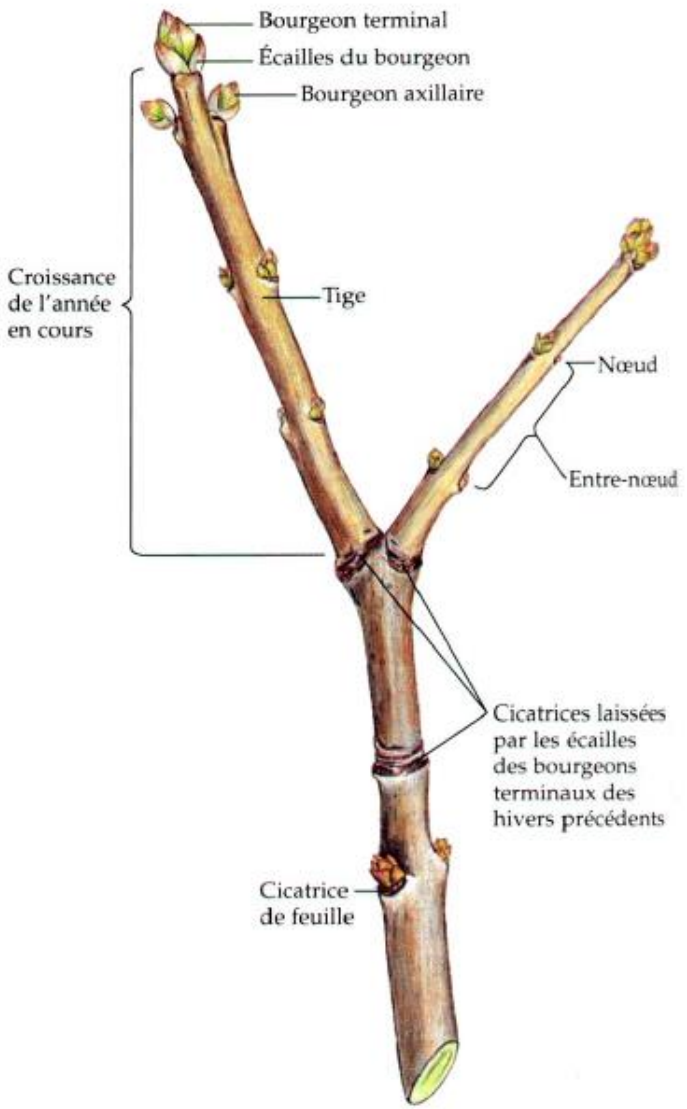
2.1. The different parts of the stem :

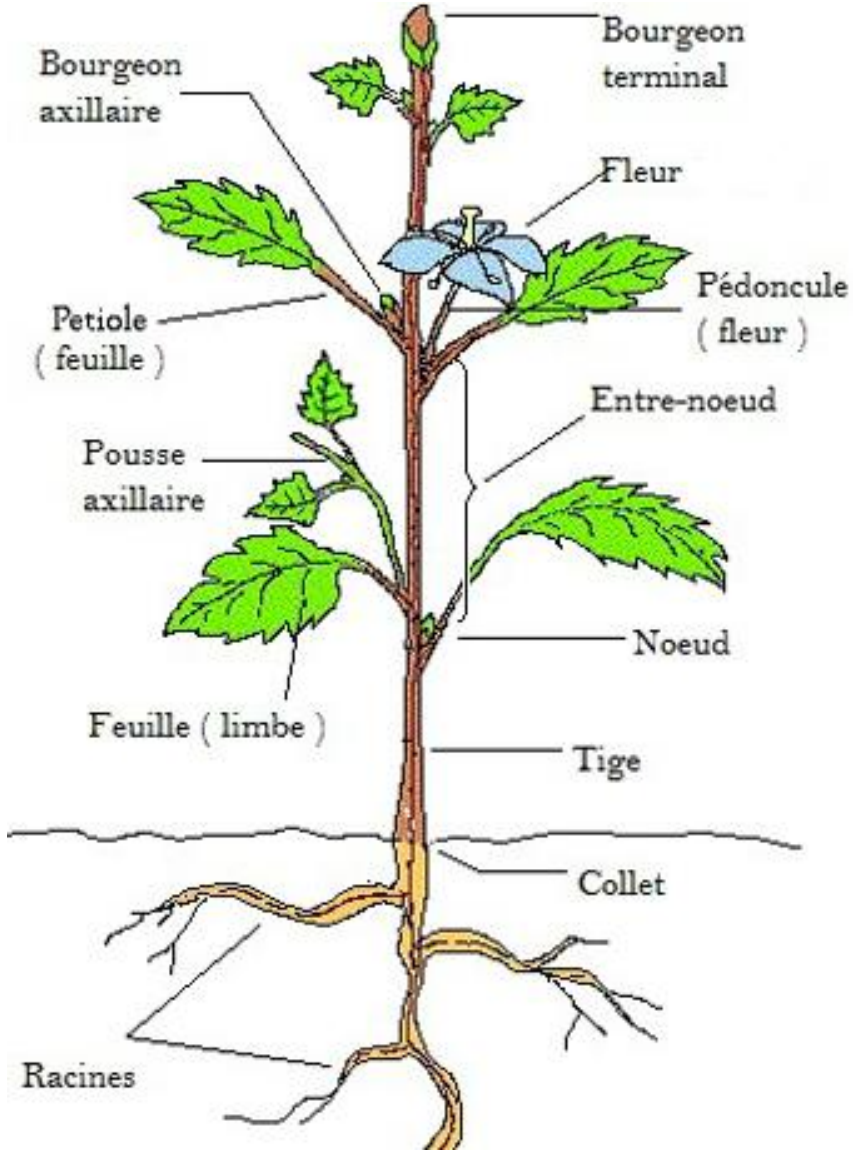
- The main axis : The main axis of a stem bears the leaves, buds and leafy branches. It is also called the main stem;

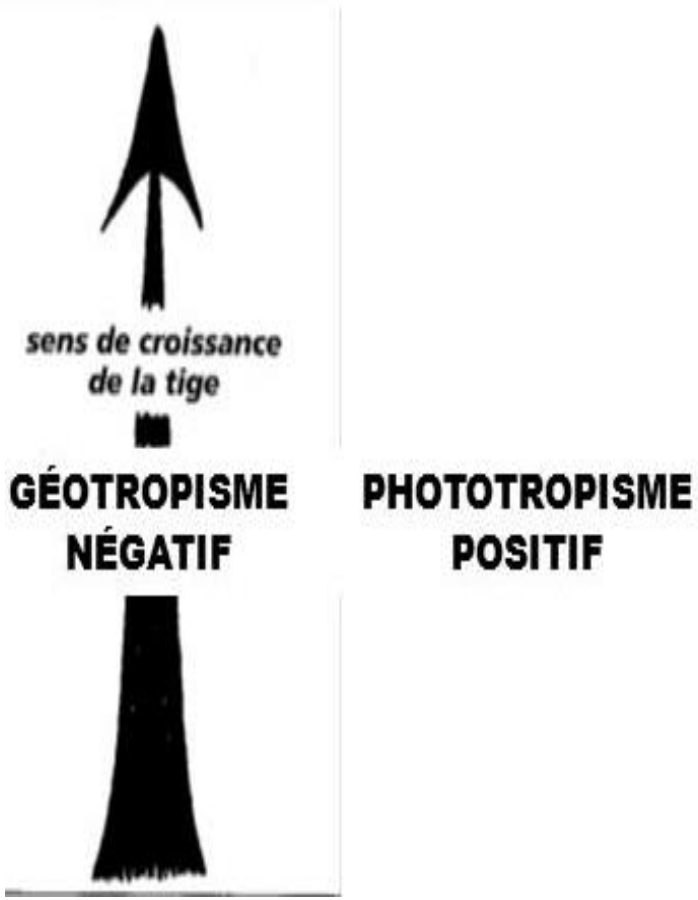
- Nodes: The node is where a leaf or shoot is attached. Two successive nodes are separated by an internode;

- Buds : The bud is made up of very young leaves tightly pressed together and surrounding a vegetative point (meristematic zone). The bud allows the apical elongation of the stem and the formation of leaves and branches.

2. Morphology of the stems







2.2. Types of stems

Herbaceous stems : The stem of herbaceous plants is characterised by a small diameter and a soft, green colour. They are generally the stems of annual plants. There are different types of herbaceous stems:

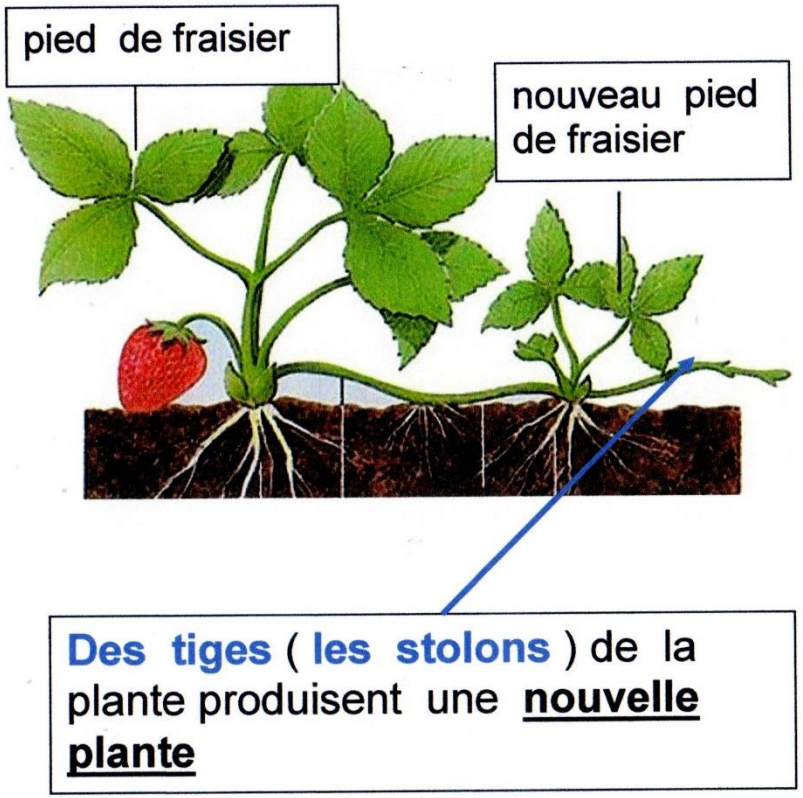
- Upright stems: The position of the main axis is vertically upright.

- Creeping stems: These stems are very long with a very small diameter and have no supporting tissue. This type of stem grows horizontally on the ground, e.g. strawberry stolons.

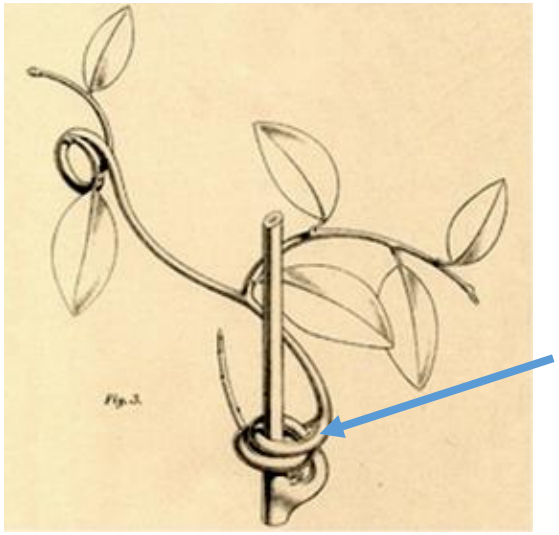
- Climbing stems : These are very long and grow upwards by twisting around a support using tendrils or spikes, e.g. vines and ivy.

2. Morphology of the stems

Upright stem



Creeping stems



(a) tendril rod

(b) voluble stems

Climbing stems (a et b)

b. Woody stems: The stems of woody plants are hard, thick and brown in colour.

The main morphological types can be distinguished according to the branching of the woody stems:

- Arboreal stem : The main stem is called the trunk. It is thick and has branches that spread out from a certain height. Trees, shrubs and saplings are affected by this type of growth habit;

- Bushy habit : This is a group of woody stems forming a tuft, sprouting from the base and with a trunk that is difficult to distinguish.

2. Morphology of the stems

Arboreal stem

Bushy habit

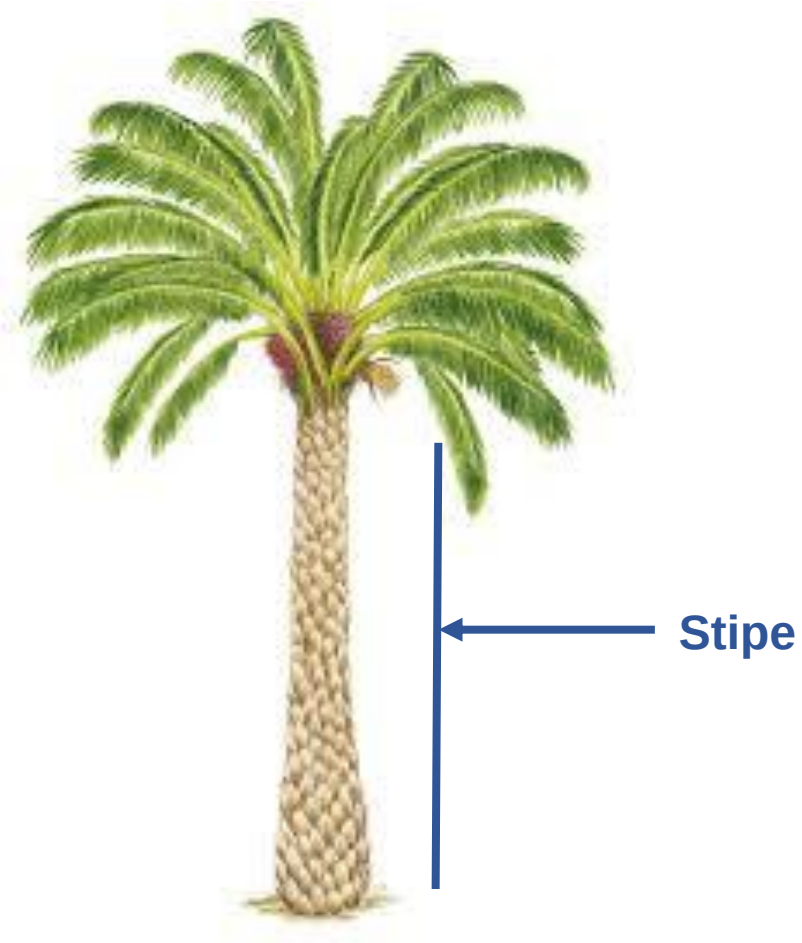
2.3. Particular types of stem

There are other types of stem, such as..:

- Stipe: This is not a true trunk. It is an unbranched cylindrical axis marked by scars at the base of the leaves (fallen palms). It is essentially characterised by the absence of thick growth (no woody tissue). It is characteristic of arborescent monocotyledonous Angiosperms.

- Culm: This is a hollow stem, except at the nodes where there is a fine partition called a diaphragm. Thatch is a slender, resistant stem that can reach several metres in height (e.g. reed and bamboo).

2. Morphology of the stems



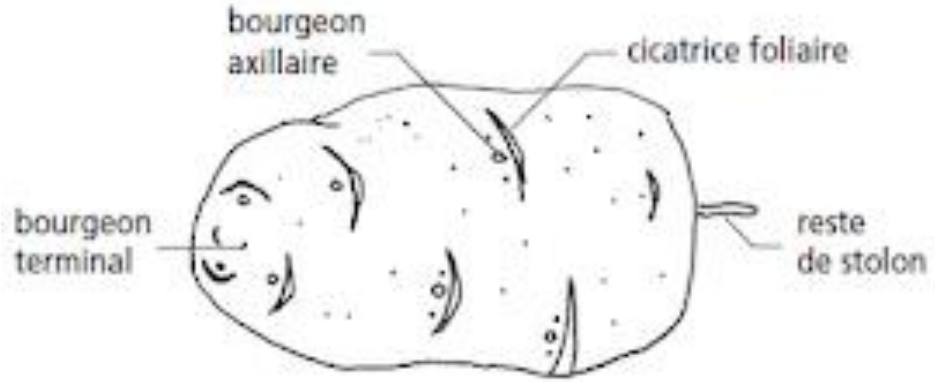
Example of a palm stipe

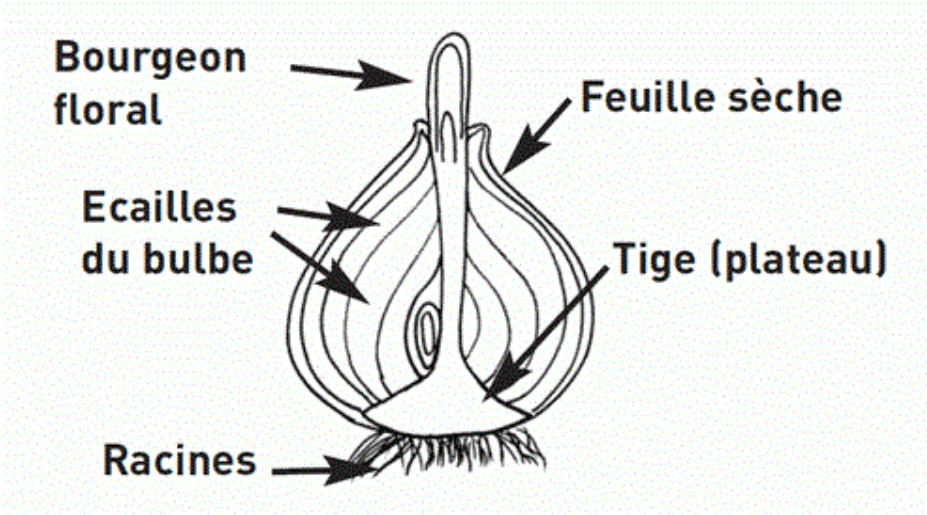
Example of thatch in a reed

• **Subterranean stems:** These are stems living in the soil, profoundly modified by the environment in which they are found. Their colour is similar to that of the roots, and they bear buds, non-chlorophyllous scaly leaves and adventitious roots.

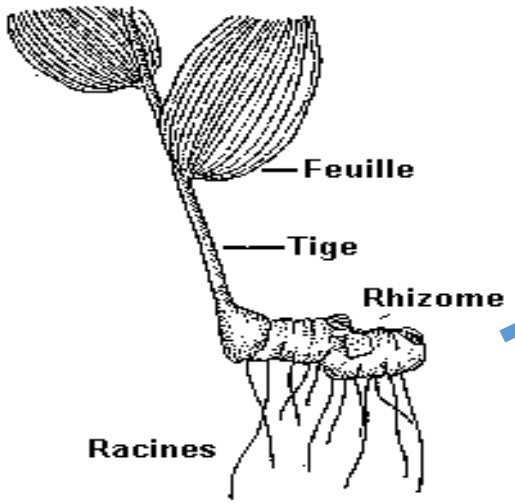
Some examples: iris or reed rhizomes, potato tubers with starch reserves and onion bulbs.

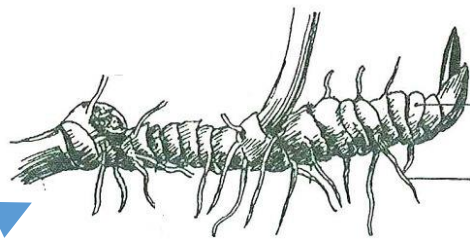
2. Morphology of the stems





- Le tubercule de pomme de terre est une tige souterraine, renflée qui accumule des réserves à son extrémité.





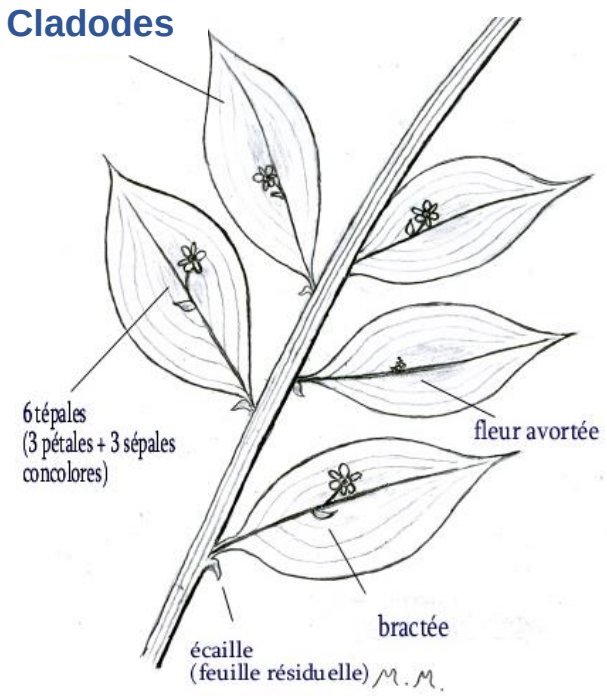
Rhizome

3. Functional adaptations

Some stems are adapted to different environments or to particular functions. Some of these adaptations are linked to :

• **Sap conduction:** This is characterised by the importance of conductive tissues and the reduction in cortical parenchyma. The importance of conductive tissues is very clear in climbing stems (which are very long) and in woody stems (which are very thick).

- **The chlorophyll assimilation function:** **Cladodes** are flattened stems that morphologically looks like a leaves.



Rameau d'un pied femelle fleuri

2. Morphology of the stems

- **The reserve function:** Certain stems, often underground, can hypertrophy and accumulate reserve substances. Examples: iris or reed rhizomes, potato tubers with starch reserves or onion bulbs.

- **Adaptation to drought:** succulents store water in their aquifer parenchyma. This modification of the leaves or stems is an adaptation to drought. Spiny stems are short branches that become spines. This type of stem is characteristic of plants in arid zones (e.g. cacti). This adaptation reduces evapotranspiration and protects the species from herbivores.

- **Note:** There are plants without stems, known as acacia plants.

2. Morphology of the stems

Greasy plant: the cactus

Stemless plants: acacia plants

3. Morphology of the leaves

1. Definition

- The **leaf** is a flattened organ, usually green, attached to a node. Its shape varies greatly;
- The **leaf** is bilaterally symmetrical and is responsible for photosynthesis, respiration and transpiration.

2. Organisation

2.1. Leaves of Dicotyledonous Angiosperms :

a. Blade: This is the flat, green part of the leaf. It has an upper (ventral) and lower (dorsal) surface. The morphology of the leaf blade varies.

The shape of the leaf blade

Simple blade: A single blade that may be whole, toothed or lobed.

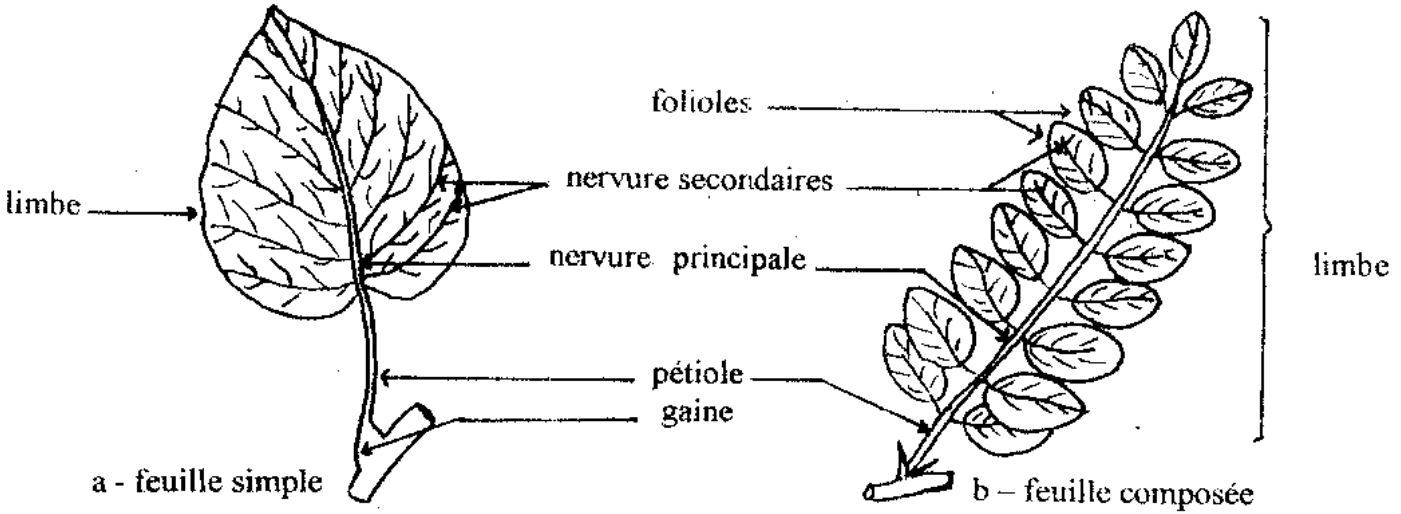
Compound leaf blade : Divided into leaflets completely separated from each other

• The venation of the leaf blade

The veins of the leaf blade ensure sap conduction. There are two types of venation:

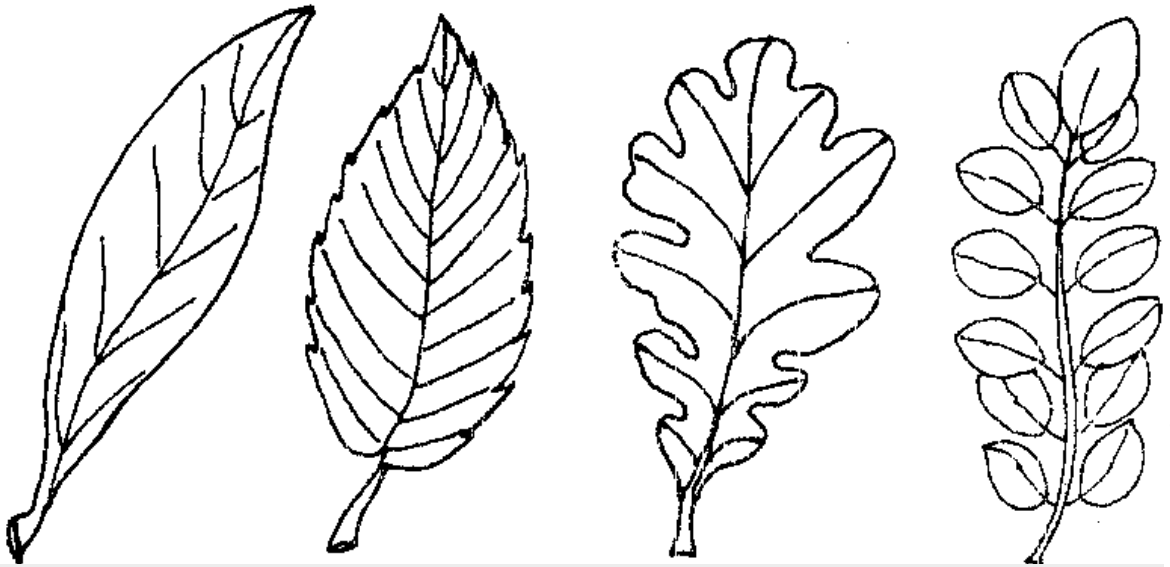
- Pinnate venation: formed by a main vein bearing secondary veins, which branch into finer veins forming a reticulated network. A leaf with this type of venation is called a simple pinnate leaf (with a simple blade) or a compound pinnate leaf (with a compound blade).

2. Morphology of the leaves



Pinnately-veined leaves (Dicotyledonous angiosperms)

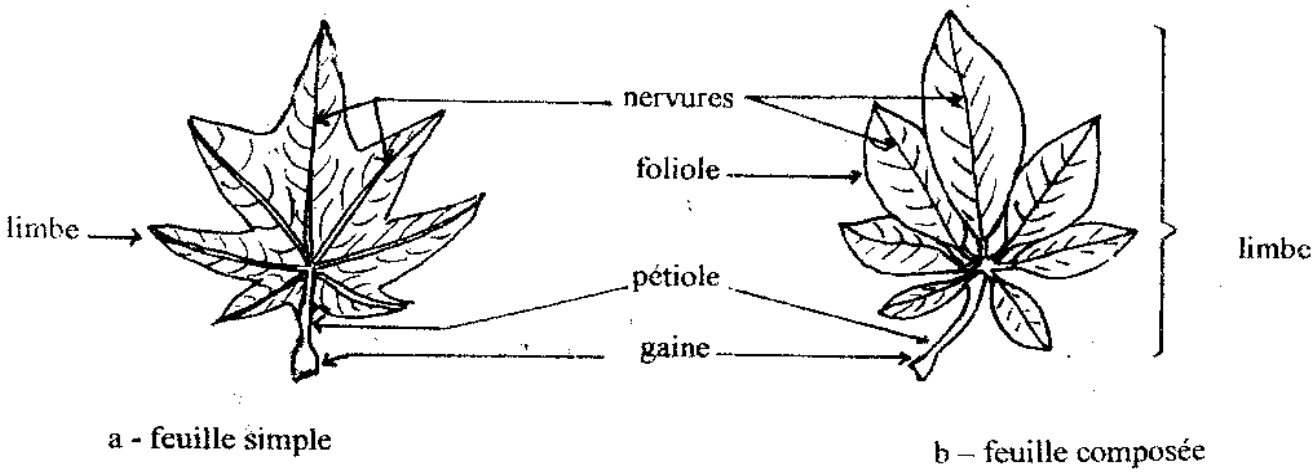
Pinnate leaves



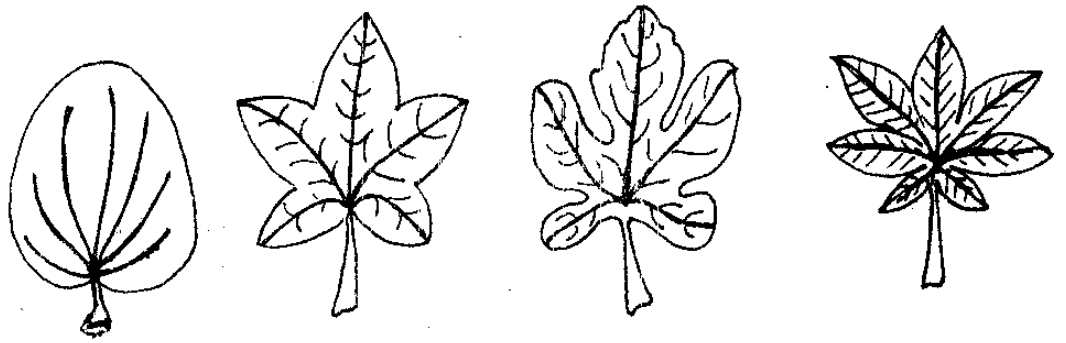
a. Entiere limb (olive) | b. toothed limb (chestnut) | c. lobed leaf blade (oak) | d. trimmed limb (locust)

2. Morphology of the leaves

• **Palmate venation:** Several veins diverge from the base of the leaf blade. These branch into secondary veins, which in turn branch into finer veins forming a network. A leaf with this type of venation is called a simple palmate leaf (with a simple blade) or a compound palmate leaf (with a compound blade).



Palmate-veined leaves (Dicotyledonous angiosperms)



a. Entire limbe (Judean tree) b. toothed leaf blade (Ivy) c. lobed leaf blade (Fig tree) d. leaf blade cut (Chestnut tree)

Palmate leaves

b. The petiole : The petiole connects the leaf blade to the stem and varies in length. It may be enlarged at the base to form a leave or absent (known as a sessile leaf).

c. Stipules : The stipules are generally one or two leafy blades carried by the shoot and located on either side of the petiole; sometimes they take the form of spines.

2.2. Leaves of the Angiosperms Monocotyledons

a. The leaf blade: Monocotyledonous leaves are also morphologically diverse. The venation is parallel.

- Simple blade: Elongated, more or less broad or tapered and often folded. The leaf is called a simple leaf with parallel venation;

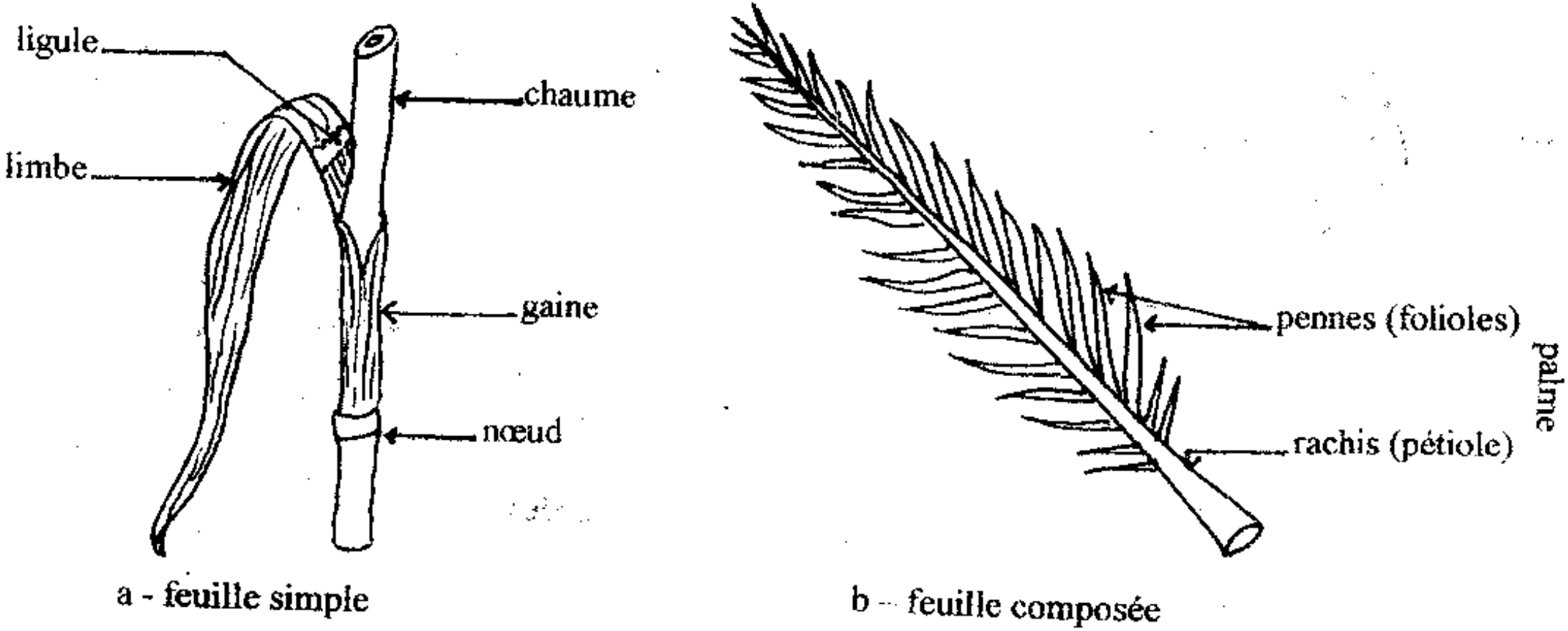
- Compound leaf blade : Composed of a central rachis on which are arranged the leaflets (pinnae), which are elongated, tapered and fairly strong. The leaf is called a compound leaf with parallel venation or a palm leaf in palms.

b. The petiole: The petiole does not exist in many Monocotyledonous species.

c. The sheath of leaves : The sheath is a dilatation of the base of the leaf blade, which is highly developed in grasses and partially or completely surrounds the culm.

d. Stipules: Where they exist, the stipules are both located at the base of the leaf blade and may be fused to form the ligule between the shoot and the leaf blade.

2. Morphology of the leaves



Parallel-veined leaves (Angiosperms monocotyledons)

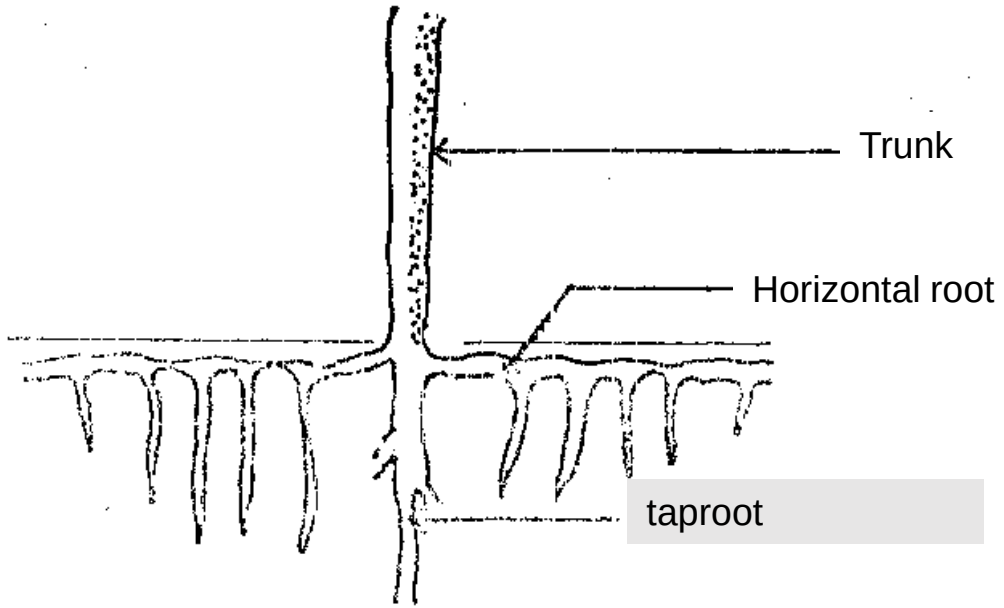
2.3. Gymnosperm leaves :

Gymnosperms have two types of leaves:

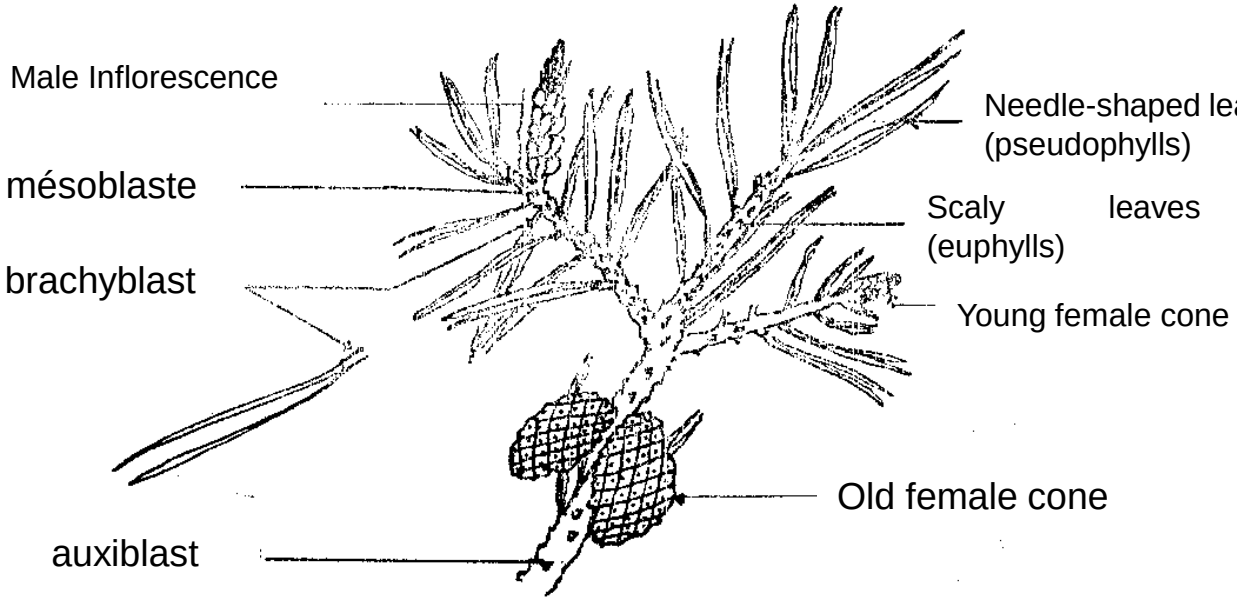
- **True leaves (Euphylls):** Pine Euphylls are hard, non-chlorophyllous, scale-like leaves with a very short lifespan. Cypress leaves, on the other hand, are soft, chlorophyllous scales covering the young shoots.

- **False leaves (Pseudophylls):** These are distributed along the middle shoots and are long, needle-like, thin, chlorophyllous leaves.

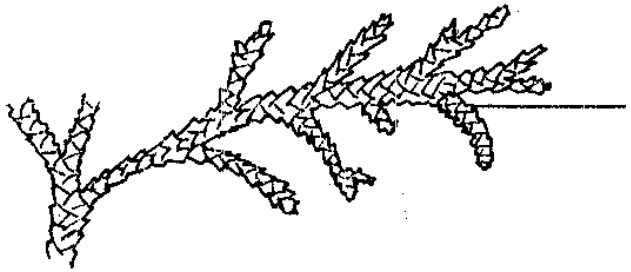
2. Morphology of the leaves



Root Systems of pinus sylvestre



Leafy branch of Aleppo pine

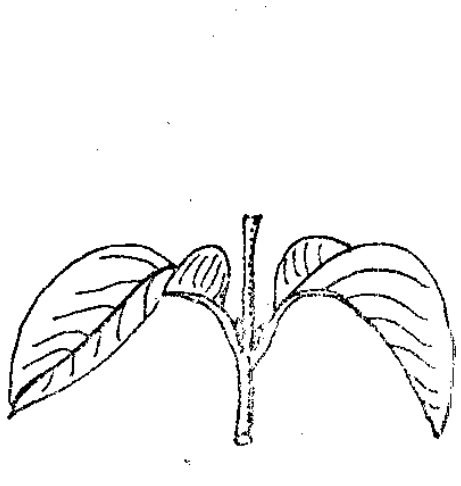


Leafy branch of Cypress

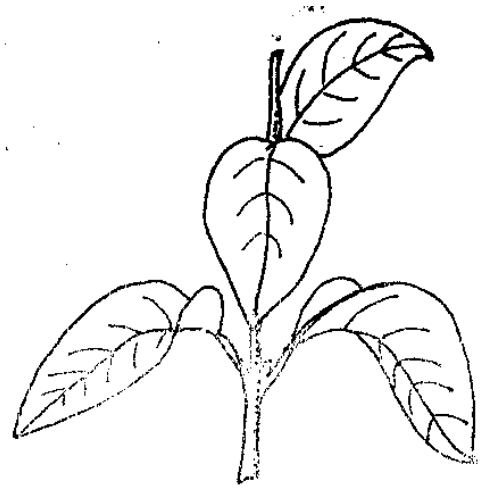
3. Phyllotaxy

Phyllotaxy is the arrangement of leaves along the stem.

- **Opposite leaves** are inserted in pairs, one opposite the other, on the same node. These opposite leaves are decussate when the pairs cross at right angles from one node to the next.

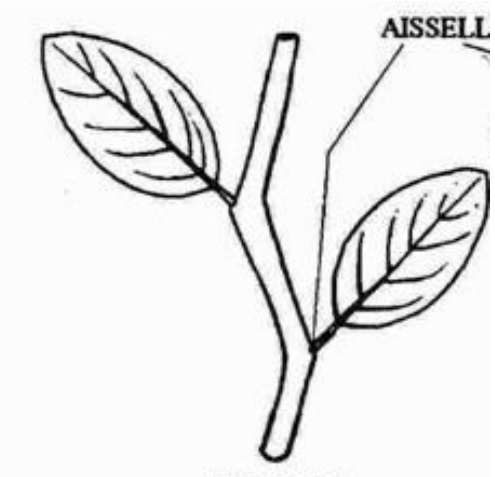


Opposite leaves



Opposite decussate leaves

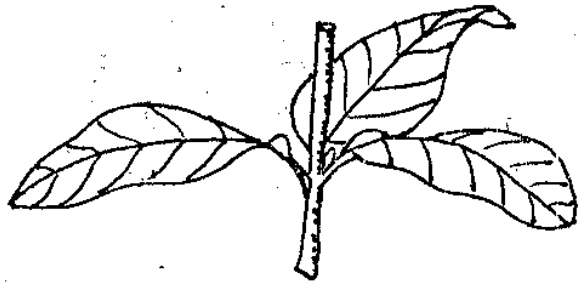
• **Alternate leaves** are inserted individually on a node. They are also called isolated or spiral.

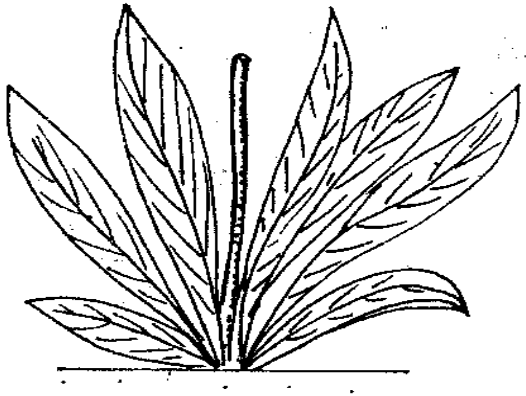


Alternate leaves

- **Whorled leaves** are inserted by more than two on a node; the set of leaves attached to the same node is called a whorl.

- **Rosette leaves** are found on plants with a single leaf crown at the base of the stem.


Whorled leaves


Rosette leaves

4. Functional adaptations

Some leaf adaptations are linked to :

- The nutritional function: The organisation of the mesophyll into palisading and lacunar parenchyma is an adaptation of the leaf of dicotyledonous angiosperms to two essential functions:

The palisading parenchyma is responsible for photosynthesis;

The lacunar parenchyma plays a role in gas exchange (respiration, transpiration).

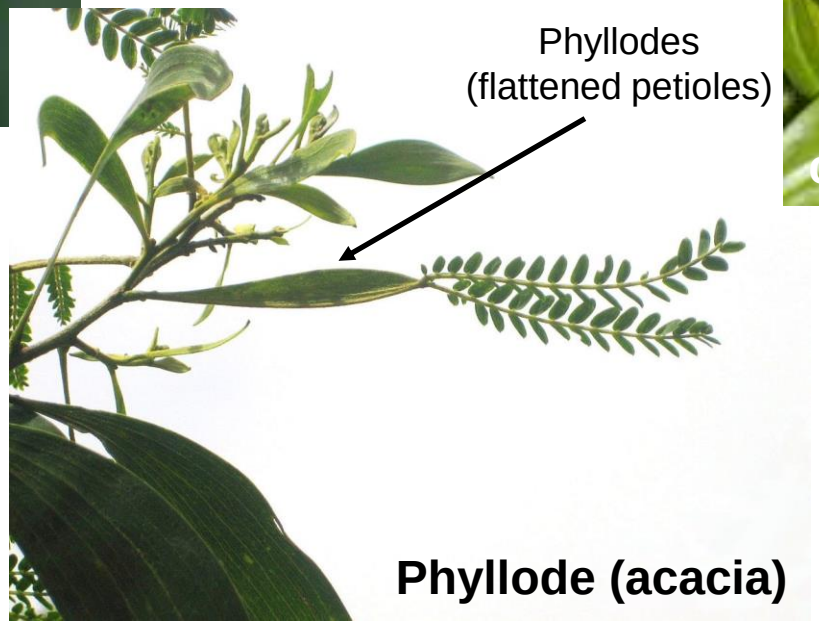
Examples of adaptations to nutrition :

- The **tendrils** resulting from the total transformation of the leaf blade enable the plant to climb by wrapping itself around a support to seek light;

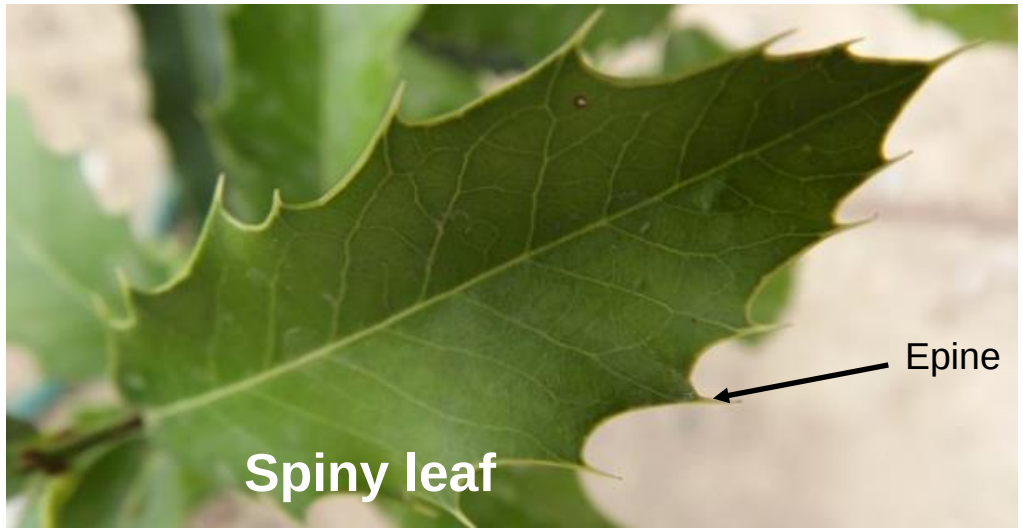
- Phyllodes are flattened petioles that morphologically look like leaves. They are involved in chlorophyll assimilation instead of leaves, which are much reduced in size;

- The modified leaves of carnivorous plants are very distinctive. The flattened, winged petiole has an urn-shaped blade at its tip, making it easier to capture the insects they need for nutrition.

2. Morphology of the leaves



- **Protective role:** the thorny leaves, which are partially or totally transformed into spines, prevent the plant from drying out in the dry season.



- **Reserve role:** Some leaves hypertrophy by accumulating reserve substances; these are known as fleshy leaves.

Like the carbohydrate reserves in the scales of garlic or onion bulbs and the water reserves in Aloe vera leaves.

Garlic

Onion

Aloe vera