PLANT ORGANS- LEAVES

LEAVES

- Leaves are considered to be "food factories" of plants. Why?

- Chlorophyll is found in leaves and other green parts of the plant. Chlorophyll, the main photosynthetic pigment of plants is found within chloroplasts. Plant and algal cells may contain one or more chloroplasts; an average 40-50 chloroplasts are per cell as a general rule.

- The anatomy of a leaf is like a sandwich. On either side there are layers called **epidermis** and on top of epidermis **waxy cuticle is present** to protect the leaf against drying out. In the middle are chloroplast containing cells where photosynthesis takes place. This middle layer is called **mesophyll.**

- Some plant leaves are **covered with dense mats of hairs** that help reduce water loss (by reducing evaporation). **And some** protect the plant by secreting toxic substances

LEAF TYPES

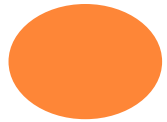
If a leaf has a single blade, then it is a simple leaf, and is the blade contains two or more leaflets then it is a compound leaf.

Simple leaves generally show undivided blade.

Compound leaves have a fragmented blade.

Simple leaves may have an integer, serrate or lobed margin. Compound leaves may be pinnate, palmate, pedate, peltate etc.

Leaves show very different vasculature. Vessels contain phloem and xylem. Monocot plants like Poaceae plants, lilies and iris species have parallel veins. Magnolias and dicot plants may have reticulate, pinnate, palmate, peltate etc. venations.



- Since many plant species have a typical leaf shape and structure, a species may be identified by just looking at the leaf shape. And since there are various shapes of leaves, other terms like vasculature, leaf arrangement, margin etc. also have been developed.
- Leaves of many plants contain a blade and a petiole. Some leaves have a leaf-like structure called **stipule** at the end of the petiole where the petiole is attached to the stem. At the conjunction part of the petiole and the stem, the axil has a special degree of angle. Buds usually form at this axil and are called **axillary buds.**

- The location that the leaf is attached to the stem is called a **node** and the part between two nodes is called **internode**.

- Many plants do not possess a petiole and are termed as **sessile** leaves since they are directly attached to the stem.

- In onions, tulips, lilies and Poaceae plants and in many monocot plants and also in some dicots, the leaf base that surrounds the stem is called a **sheath**.

SIMPLE LEAF

Some definitions:

- Linear: Leaves long and thin, many times longer than wide, with parallel margins. Grass is an example
- Lanceolate: Leaves shaped like a lance-head, much longer than wide, and, in technical usage, broader towards the base. The reverse situation would be technically termed *oblanceolate*.
- Ovate: Leaves generally egg-shaped, with the broader portion towards the base. Often pointed at the tip. Sometimes includes elliptical leaves that are not clearly broader towards the base. May be modified as in *narrowly ovate* or *broadly ovate*.
- Elliptical or elliptic: Leaves shaped like an ellipse; that is, generally symmetrical, elongated, and more or less evenly rounded at both ends.
- Cordate: Leaves heart-shaped with the lobes at the base of the leaf.

Leaf arrangement

Leaves are arranged in different styles. They may be alternate, opposite, radial etc.

COMPOUND LEAVES

Leaf Glossary:

air space - intercellular gaps within the spongy mesophyll. These gaps are filled with gas that the plant uses (carbon dioxide - CO_2) and gases that the plant is expelling (oxygen - O_2, and water vapor).

axil - the angle between the upper side of the stem and a leaf or petiole.

chlorophyll - a molecule in leaves that can use light energy from sunlight to turn water and carbon dioxide gas into sugar and oxygen (this process is called photosynthesis). Chlorophyll is magnesium-based and is green.

compound leaf - a leaf that is divided into many separate parts (leaflets) along a midrib (the rachis). All the leaflets of a compound leaf are oriented in the same plane.

crenate - having rounded teeth.

cuticle - the waxy, water-repelling layer on the outer surface of a leaf that helps keep it from dying out (and protect it from invading bacteria, insects, and fungi). The cuticle is secreted by the epidermis (including the guard cells) and is often thinner on the underside of leaves. The cuticle is generally thicker on plants that live in dry environments.

entire - having a smooth edge with neither teeth nor lobes.

epidermis - the protective, outler layer of cells on the surface of a leaf. The guard cells (and stoma) are part of the epidermis. The surface of many leaves is coated with a waxy cuticle which is secreted by the epidermis.

guard cell - one of a pair of sausage-shaped cells that surround a stoma (a pore in a leaf). Guard cells change shape (as light and humidity change), causing the stoma to open and close.

lamina - the blade of a leaf.

leaf apex - the outer end of a leaf; the end that is opposite the petiole.

lobed - divided into rounded or pointed sections and the incisions (cuts) go less than halfway to the midrib.

mesophyll - the chlorophyll-containing leaf tissue located between the upper and lower epidermis. These cells convert sunlight into usable chemical energy for the plant.

midrib - the central rib of a leaf - it is usually continuous with the petiole.

palisade mesophyll - a layer of elongated cells located under the upper epidermis. These cells contain most of the leaf's chlorophyll, converting sunlight into usable chemical energy for the plant.

parted (or cleft) - the margins between the irregular teeth go more than halfway to the midrib.

petiole - a leaf stalk; it attaches the leaf to the plant.

photosynthesis - the process in which plants convert sunlight, water, and carbon dioxide into food energy (sugars and starches), oxygen and water. Chlorophyll or closely-related pigments (substances that color the plant) are essential to the photosynthetic process.

pinnate - a compound leaf that is made up of many small leaflets arranged in pairs on either side of a long central midrib (the rachis). There is often a single terminal leaflet at the end of the midrib.

serrate (or toothed) - having small, pointy teeth that point toward the tip of the leaf.

spongy mesophyll - the layer below the palisade mesophyll; it has irregularly-shaped cells with many air spaces between the cells. These cells contain some chlorophyll. The spongy mesophyll cells communicate with the guard cells (stomata), causing them to open or close, depending on the concentration of gases.

stem - (also called the axis) the main support of the plant.

stipule - the small, paired appendages (sometimes leaf-life) that are found at the base of the petiole of leaves of many flowering plants.

stoma - (plural stomata) a pore (or opening) in a plant's leaves where water vapor and other gases leave and enter the plant. Stomata are formed by two guard cells that regulate the opening and closing of the pore. Generally, many more stomata are on the bottom of a leaf than on the top.

vein (vascular bundle) - Veins provide support for the leaf and transport both water and minerals (via xylem) and food energy (via phloem) through the leaf and on to the rest of the plant.

Basic Tissues of Leaves

- Basic tissues of leaves are xylem, phloem, mesophyll and epidermis.

- Epidermis is the durable outer layer that protects the inner tissues and provide structural support to the leaf. Mesophyll (the soft inner part of the leaf) is the photosynthetic tissue of the leaf. Xylem and phloem are conducting tissue.
- The structure of the plant mostly depends on the environmental conditions that the plant leaves in and especially to the amount of usable water that is present in its habitat. Plants that grow totally or partially within water in wetlands are called **hydrophytes**.

- Plants that adapt to arid environment are called **xerophytes**.

Epidermis

- Epidermis is the durable outer layer that protects the inner tissues and provide structural support to the leaf. Most epidermal cells lack chloroplasts, therefore these cells are semi-transparent and sunlight can pass to the mesophyll tissue through epidermis. Epidermis cells are strong and they are arranged tightly to support the plant. Since leaves have a large surface area, they are prone to losing water from these surfaces.

- However epidermal cells release a waxy layer called cuticle to the outside and help to reduce water loss. Cuticle layer of plants living in arid or semi-arid environment is thicker, i.e. sometimes this layer is thick enough to be scraped with a blade.

- In the Mediterranean region where summers are hot and arid and winters are warm and rainy, therefore plants growing in this region mostly have multilayered epidermal cells in order to prevent excessive water loss.
- Upper sides of the leaves of **mesophytes** (plants that adapt neither to dry or wet environment – hygrophilous plants living in somewhat humid areas) have a thicker layer of cuticle compared to their lower sides since the upper sides are exposed to sunlight more.

- Cuticle thickness in hydrophytes depends on the extent of staying under water. Hydrophyte plants that have leaves in the water have a thin layer of cuticle and leaves that float on the water or found above the water level have a well-developed cuticle layer.

- In some plants, epidermal cells form hairy protrusions called **trichomes**.

- In some plants, these trichomes are so dense that leaves seem gray, grayish-white or white.

Trichomes have different functions:-

- They reflect excessive sunlight
- Prevent over-heating of the leaf.
- Release irritant chemical substances to protect the plant from herbivores.

- Epidermal tissue contains hundreds of small holes, "**breathing pores**" called **stomata.** These holes enable gas exchange when stomata is open; water vapor and oxygen is released outside and carbon dioxide and air is transferred to the leaf.The location of the stomata in the lower epidermis keeps them from becoming plugged with dust that normally gathers on the top surface and **prevents entry of harmful air borne fungal spores.** Leaves tending to stand upright, such as Iris, have stomata in both leaf surfaces, and sincesurface the lower surfaces of waterlily leaves are submerged, the stomata are on the top.

- **Stomatal openings permit gases to enter the leaf and water vapor to escape.** Periodic stomatal closures are used to regulate such water losses. In most plants, **stomata routinely close at night** as the absorption of carbon dioxide is not necessary when photosynthesis is not taking place. They may also close on hot, dry days, in heavy winds or when the soil gets dry or anytime that the uptake of water does not keep up with the rate of water loss.

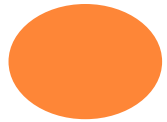
Every stoma has a pore and two guard cells. When the guard cells are filled with water, they are plump and make the pore stay open. If guard cells do not have water, then the pores constrict, then the pore is closed and by this way stoma prevents water loss.

More than 90% of water is released (lost) during a process called **transpiration**. Transpiration has to occur since carbon dioxide can only enter the mesophyll cell if it is soluble in water and therefore mesophyll cells have to be humid all the time. Thus plants lose considerable amount of water while obtaining carbon dioxide.

- Each stoma is bordered by two special cells, called **guard cells**, controlling the size of the opening. Inner walls of the guard cells that are adjacent to the openings are **thicker than the outer walls**. In a relaxed state, the guard cells lie parallel to each other with no opening between them.

- When the plant pumps water into them, the thin walls stretch, the shape of the cells change, curving away from each other, and the stoma opens. Loss of water to the guard cells reverses the process. The anatomy of leaves is perfectly designed to bring together the ingredients for the chemistry of photosynthesis. **Water and dissolved minerals flow through the plants xylem, connecting roots and stems with leaf petioles, midribs and veins. Carbon dioxide enters the leaf through open stomata, and then defuses into the mesophyll cells, where the gas collects. Finally, in the chloroplasts, light and raw materials converge in the process upon which all life depends.**

- Stomata are usually found in the lower epidermis of the leaf where the leaf is protected from sunlight in most mesophytes.
- In hydrophytes (plants that usually have leaves floating on water, stomata are only found on the upper epidermis.
- Leaves of xerophytes can have many stomata, however they shed their leaves when humid is scarce.
- In developed dicot plants, stomata spread to every part of the leaf surface; however in monocot plants like corn and Poaceae family plants, stomata are arranged as parallel to conducting tissue.



- On the bases of the number and position of subsidiary cells, various types of stomata are distinguished. If the subsidiary cells cannot be distinguished from the ordinary epidermal cells, the stoma is called anomocytic. If two subsidiary cells are born in the complex, the stoma is either paracytic (the longitudinal axis of subsidiary cells is parallel with those of the guard cells) or diacytic (the longitudinal axis and the common wall of subsidiary cells is perpendicular to those of the guard cells). Besides, the stoma may be of tetracytic (four subsidiary cells, two of them in polar, the other ones in lateral position), anisocytic (three subsidiary cells, one being smaller or larger than the other ones), actinocytic (radiate-celled stomata) or any further types.

MESOPHYLL

- Mesophyll is found between the upper and the lower epidermis and consists of parenchyma cells filled with chlorophyll. These parenchyma cells consist of **palisade parenchyma** and **spongy parenchyma**.

- Palisade parenchyma cells are like column and spongy parenchyma cells are irregular. Photosynthesis is usually performed within palisade parenchyma cells. Spongy parenchyma cells are scattered and they facilitate the entrance of carbon dioxide via gas exchange. Especially hydrophyte plants have air spaces or **aeration parenchyma** (**aerenchyma**) in their mesophyll tissues (aerenchyma allow for the storage and transport of gas to the submerged tissues).

These cells not only enable floating of the leaves on water, but also help in the transfer of air to the roots and every part of the plant.

aerenchyma

- In general, palisade parenchyma is only found at the upper part of the plant and spongy parenchyma is found at the lower part. Palisade parenchyma cells may be present in more than one layer in plants that grow in an environment where they are exposed to more sunlight likewise, xerophyte plants may have palisade parenchyma layer both at the upper and lower parts. In corns and in similar Poaceae plants, monocot plants have a simpler mesophyll tissue in which mesophyll cells have similar shapes – it is not possible to differentiate palisade and spongy parenchyma layers.

Types of Mesophyll

- Bifacial (Dorsiventral) Leaves: Having distinct upper and lower surfaces, as most common leaves.

- Monofacial (Isolateral) leaves: Upper and lower surfaces of the leaves can not be distinguished.

Xylem and Phloem

- Xylem carries water and water-soluble minerals and phloem carries soluble sugars and other photosynthesis products to the other plant organs.

Xylem

- Water and mineral conduction occurs in one direction only.
- It consists of tracheids, vessels, xylem fibers and xylem parenchyma.
- Only xylem parenchyma is living, the other elements are dead.
- Xylem also gives mechanical strength due to lignified vessels

PHLOEM

- Phloem conducts food
- Consisting of sieve elements, companion cells, phloem parenchyma and phloem fibers
- Transfer occur in 2 directions upward and downward
- Conducting channel are sieve tubes
- All elements are living, only phloem fibers are dead.
- Phloem gives no mechanical strength.

Other Functions of Leaves

- Due to modifications, leaves may perform different functions other than photosynthesis:

- Support the plant
- Function as the petals of the flower
- Function as a trap to catch bugs etc.
- Protect the growing tissues from cold in winter (bud scales)
- Food storage
- Protection from animals