Contents of Module 4

Introduction to Nursery Practices

The practices employed in the nursery are aimed at meeting the demands of the seedling and young tree for optimal growth. Because nursery trees are kept in controlled environments, their growth cycles will not necessarily correspond to the phenology of a tree growing in an orchard.

General nursery practices include the following:

- Plant nutrition
- Pest and disease control
- Weed control
- Irrigation
- Repairs and maintenance

It is important to keep in mind that nursery production is aimed at turning out uniform, healthy, true-to-type trees, and that this must be done on a large scale. Production practices must therefore be suitable to being applied for mass production, in a cost-effective and efficient manner, while promoting uniform growth amongst young trees.

It is for instance not practical to measure and correct the pH and EG of the growth medium in each individual planting bag. It is however possible to make a average, general measurement that should be valid for all the planting bags that have the same characteristics, and that have been subjected to the same environmental conditions and production practices. Actions that are applied in the nursery are based on such general, average measurements.

To understand why these practices are applied in a certain way, and how they assist the tree to optimise growth, it is however important to first understand a bit more about the structures and functions of the citrus plant. In previous modules we looked at seeds and at stems and trunks. In this module, we look at background information on leaves and roots.

Structures and Functions of Roots

Introduction

It is important to understand the functions and structures of roots and how these influence plant growth. The structure and growth habits of roots have a pronounced effect on the:

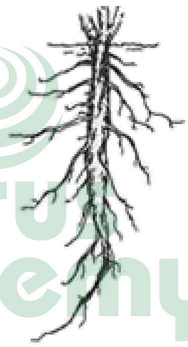
- Size and vigour of the plant
- Ability of the plant to adapt to certain soil types
- Response of the plant to production practices and irrigation
- Method of propagation

Root Systems

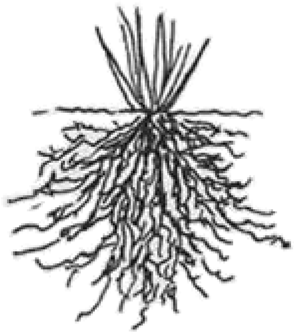
There are two types of root systems that plants can have. They are distinguished by the manner in which the roots are connected.

The two main types of root systems are:

- Tap root system
- Adventitious root system



Tap Root System



Adventitious Root System

Tap Root System

The tap root develops from the radicle during germination of the seed. In most dicot plants, the radicle grows and develops into the tap root that becomes the major root of the plant. Branch roots grow from the tap root. In most plants root hairs are found close to growing tips of roots.

Adventitious Root System

The term adventitious means developing in an unusual position. In terms of root development, it means roots that grow from the stem or leaf. In some monocot plants, the radicle does not develop into a tap root. Roots that are all more or less the same size grow directly from the bottom end of the stem. Branch roots also grow from the adventitious roots.

In grasses and some other plants the adventitious roots are fibrous, meaning they are thin and hair-like, and usually contain more fibres than other roots. The whole root system is then called a fibrous root system. The feeding roots of many other plants can however also be hair-like and fibrous, even if they form part of a taproot system.

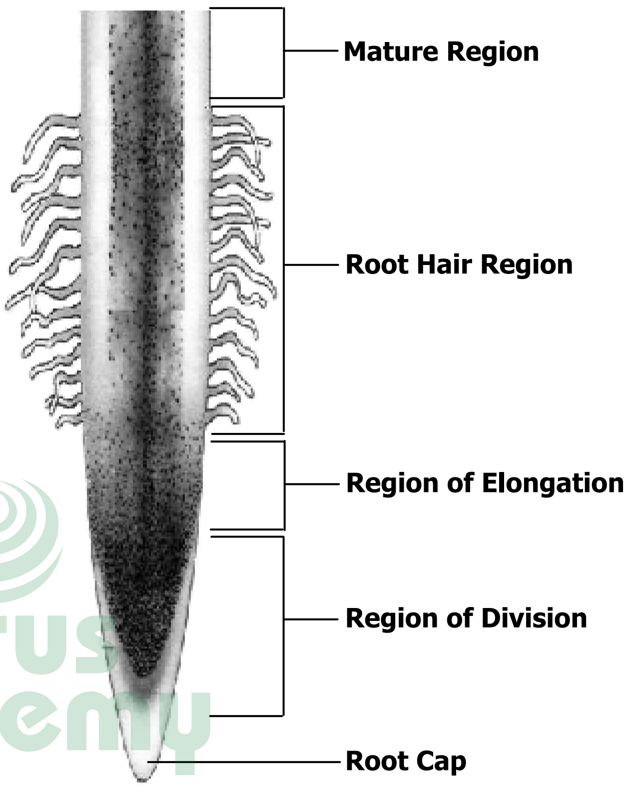
Tap Root Structure

To understand the manner in which roots perform their functions, it is important to understand the structure of a root.

External Features

The root consists of the following regions:

- Root cap
- Region of cell division (meristematic region)
- Region of cell elongation
- Root hair region
- Mature region



Root Cap

The tip of the root is covered by a cap that is shaped like a thimble. The outer cells of the root cap are continuously worn away and new cells are added to the inner portion. As these cells disintegrate, they form a strong protective cover.

The function of the root cap is to cover and protect the delicate growing tip from injury and damage as the root pushes its way through the soil.

Region of Cell Division (Meristematic Region)

The meristematic region is covered by the root cap. In this region, cells are dividing all the time and forming new cells.

The function of the meristematic region is to produce new cells, making this the primary growth region of the root.

Region of Cell Elongation

In this region, the cells that are formed in the meristematic region elongates, meaning that they grow rapidly in length and size. This causes the root to elongate and penetrate deeper into the soil in search for water and minerals. The meristematic region and the region of elongation together are referred to as the growth region.

Root Hair Region (Cell Differentiating Zone)

Root hairs are single, elongated epidermis cells that assist with the uptake of water and nutrients because they increasing the absorption area.

The root hair region overlaps with the region of cell enlargement. In this region the young cells start maturing into cells with specific functions. The outer cell walls of the epidermis cells grow out to form root hairs to enlarge the absorption surface of the epidermis for absorbing water and nutrients form the soil. The xylem cells start to differentiate and link up with older part of the root in order to transport the absorbed water and nutrients to the rest of the plant.

information

Please Note

Be careful not to confuse root hairs with hair roots. Root hairs are single, elongated epidermis cells that are found close to the root tip. Hair roots are roots that resemble hair, but that have all the internal and external parts discussed in this section.

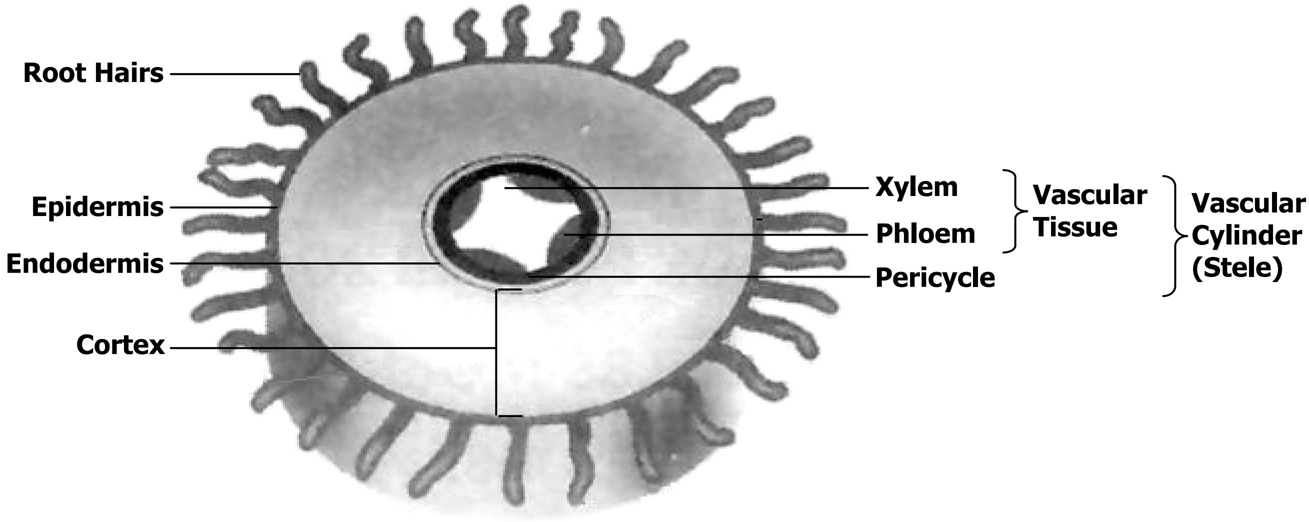
Mature Region

The mature region is above the root hair region where the root becomes thicker and secondary or lateral roots develop. Tertiary roots in turn grow from the secondary roots. Each lateral root has its own root cap, root hairs, meristematic region, region of elongation and mature region. The older part of the root develops a protective cork layer, referred to as the 'bark' of the root, and that sloughs off the epidermis.

Internal Features

If we cut a root above the root hair region, i.e. in the mature region, and study it under a microscope, the following can be identified from the outside in:

- Epidermis
- Cortex
- Vascular cylinder or stele



Epidermis

Epidermis literally means "over skin" (epi = over or around, and dermis=skin). The epidermis is the outer layer of the young root. The cells of the epidermis are closely packed, thin-walled parenchyma cells. Root hairs arise from some of the epidermal cells.

The epidermis covers the underlying tissues of the root. The epidermal cells and the root hairs absorb water and dissolved ions.

Cortex

Inside the epidermis is the cortex. The cortex in roots and stems is the layers of cells between the epidermis and the stele (vascular cylinder).

In many plant types, especially monocots, the cortex is divided into the exodermis (outside skin), a central cortex and the endodermis (inside skin). The central cortex usually consists of parenchyma cells with numerous spaces between cells.

The endodermis forms the innermost layer of the cortex. The cells of the endodermis are more rectangular in shape, the side walls being thickened with suberin, which is a corky substance. These thickenings are called **casparian strips**.

The cortex has several functions, including:

- Allowing for the diffusion of water, mineral salts and oxygen from the root hairs inwards
- Storage of food reserves, especially starch
- Transporting water and salts from the root hairs to the centre of the root
- With the aid of casparian strips the endodermis facilitates the movement of water from cortex to xylem, also acting as a 'security gate' to keep certain molecules out so that they cannot be transported to the rest of the plant

Vascular Cylinder (Stele)

The vascular cylinder is enclosed by the endodermis, and consists of the pericycle and vascular tissue.

The outermost layer of the stele is known as the **pericycle**, consisting of one or more layers of simple undifferentiated parenchyma cells.

The vascular tissue consists of the xylem and phloem. In dicotyledonous roots, a vascular cambium develops between the primary xylem and phloem and gives rise to secondary xylem towards the inside and secondary phloem towards the outside. The actual cambium consists of a single layer of dividing cells. The primary xylem alternates with the phloem, and is shaped somewhat like a star.

As discussed in the section on stems and trunks, phloem consists of live cells called sieve tubes that are controlled by adjacent companion cells. Sieve tubes are so named because the cross walls between the tube-like cells have minute holes in them, like a sieve. The phloem cells transport sugars and other metabolites from the leaves.

The xylem consists mainly of cells which have become modified, have thickened walls and holes between adjacent cells of the same type, and have lost their original contents. They are thus empty cells linked together in such a way that they can carry water and nutrients from the root, through the stem to the leaves of the plant. These cells of the xylem, known as vessels, also serve as strengthening units, although special strengthening cells, called fibres, usually form part of the xylem.

Root Functions

Roots have the following main functions:

- Anchoring the plant in the soil
- Taking up water and nutrients from the soil
- Transporting water and dissolved substances from the roots to the stem

Some plants have developed roots that perform other functions as well; this is discussed at the end of this section.

Stabilising and Anchoring

Roots keep plants stable and upright in the soil. Plants with tap root systems are more stable because they have a large central root that grows deep into the soil. Adventitious root systems are more common amongst monocotyledonous plants such as grasses, and occur with all plants grown from cuttings.

example

Root Functions

The stabilising and anchoring functions of roots are very important, as this example illustrates.

Plants that are propagated through asexual propagation methods, such as through tissue culture, develop adventitious roots because the roots grow directly from the stem, and no tap root can develop because a seed, that contains the radicle from which the tap root develops, is not used. When plants that naturally have tap root systems are propagated through tissue culture because asexual propagation produces true-to-type seedlings, the plants are often found to be very hard to grow, because they fall over. They need the stabilising and anchoring function of the tap root.

Uptake of Water and Nutrients

Almost all the water the plant takes up from the soil enters through the youngest part of the root in the root hair region.

Water is absorbed directly through the epidermis and root hairs, which is an enormous area for absorption. The walls of the root cells are made up of threads, referred to as **cellulose fibrils**. The open spaces between the fibrils are filled with water, which means that water can move through the cell walls from one cell to another.

Water can also be absorbed by the root hairs through the process of osmosis, where the area of high concentration is the soil and the area of low concentration is the epidermis or root hairs.

definition

Osmosis

Osmosis is the flow of water and other liquids through a semi-permeable membrane, such as the thin membrane underneath the shell of an egg, from an area with high concentration to an area with low concentration, gradually evening out the liquid balance.

(There is an old practice that many desperate students have tried. It is said that if you put this book under your pillow, the knowledge will be absorbed into your head while your sleep, moving from the area of high concentration – the book – to the area of low concentration – inside your head. This would be learning through osmosis. But osmosis unfortunately does not work for knowledge.)

Water can therefore move from the soil through the cell membranes of the root hairs, through the cell walls of the cortex, and up to the endodermis where the water is blocked by the casparian strips in the endodermis.

The water is then forced through the endodermis cells, through the pericycle and into the xylem vessels, which take the water through the root and stem into the leaves.

information

Please Note

Cell **walls** and cell **membranes** are two different things. Cell walls are dead and allow free movement of water. Cell membranes are alive and therefore selective (semi-permeable) and allow movement such as through osmosis. Cell membranes are found for example underneath the cell wall.

Transportation

We have already seen that the vascular tissue (xylem and phloem) in the stele of the root transports food and water up and down the plant. Roots can not live directly from the nutrients and water that it absorbs from the soil – if you put only a root under the soil, it will not survive.

Roots transport the nutrients and water that it absorbs to the stem through the xylem, from where it is transported to the leaves. Through photosynthesis, the leaves produce food in the form of carbohydrates, which are then in turn transported back through the phloem in the stem and in the root to feed the roots.

Specialised Roots

Certain plants have developed roots that perform other functions beside the primary functions discussed above. These roots or parts of the roots have adapted to specific needs of the plant.

- **Aerating** roots are roots that rise above the ground or above water, as with some mangrove genera.
- **Aerial** roots are roots that are entirely above the ground, as with ivy or epiphytic orchids. They function as prop roots or anchor roots.
- **Contractile** roots pull bulbs or corms of monocots deeper into the soil by expanding radially and contracting longitudinally.
- **Haustorial** roots are the roots of parasitic plants, such as in mistletoe, and can absorb water and nutrients from other plants.
- **Stilt** roots are adventitious support roots and are common among mangroves. They grow from lateral branches above the ground down to the soil.
- **Storage** roots are roots that have been modified for storage of nutrients, such as carrots, sweet potato, cassava and beetroot.
- **Tuberous** roots have a portion that forms into a roundish knob or sausage, called a tuber, for food storage.

Plant Fertilisation

In commercial agriculture, plants are provided with additional nutrients through fertilisation. Fertilisers can be applied directly to the leaves of the plant, but mostly they are applied to the soil in the form of granules or liquids. Fertilisers are also sometimes mixed with and applied through the irrigation water, a practice that is referred to as **fertigation**.

Mineral fertilisers are made up of salts. When a mineral fertiliser is applied to the soil, the salt dissolves in the soil water and breaks up into ions. Plants roots can only take up nutrients in the inonised form, such as Mg_2^{+} or SO_4^{2-}, the ionised form of the salt $MgSO_4$ (magnesium sulphate).

The plant does not distinguish between ions coming from organic fertilisers or mineral fertilisers. The only difference is that organic fertilisers have to be broken down by micro-organisms before the ions can be taken up by the roots.

There are many factors that affect how easily and well plants absorb nutrients from the soil, of which the most important are:

- **The form of fertiliser that is used** – Inorganic fast-release and liquid forms are absorbed faster than organic, slow-release and dry forms.
- **The type of soil that the plant grows in** – Clay particles and organic matter bind more nutrients than sand.
- **The moisture content and temperature of the soil** – Nutrient uptake is faster in moist, warm soils.
- **The vigour of the plant** – Plants under stress are less able to take up available nutrients due to damaged or reduced root systems.

Geotropism in Roots and Stems

definition

Gravitropism (Geotropism)

Gravitropism, also referred to as geotropism, is a turning or growth movement by a plant in response to gravity. 'Gravi' refers to gravity as the force that pulls everything towards the centre of the earth, and 'tropism' means the turning in response to a stimulus.

At germination, roots grow downward due to **gravitropism**, the growth mechanism of plants that also causes the shoot to grow upward. Roots show positive gravitropism, meaning that they grow downward in the direction of gravitational pull and stems show negative gravitropism, meaning that they grow upwards in the opposite direction of gravitational pull.

The root cap is essential to gravitropism, because it contains the sensors that detect gravitational pull. If the root cap is removed, the root will no longer grow downwards. The effect of gravitropism can be illustrated by planting a maize seed with the pointed end, which is the end from which the radicle will emerge, pointing upwards. At germination, the root will turn around and grow downwards.

The gravitropism of stems can be illustrated by laying a potted plant on its side. The stems will grow upward, vertical to the direction in which they grew before.

In some plants, such as ivy, the roots cling to walls and structures; this is known as **thigmotropism**, or response to touch or contact. Thigmotropism usually occurs when plants grow around a surface, such as a wall, pot or trellis. Climbing plants, such as vines, contain tendrils that coil around supporting objects. **Phototropism** means turning towards the light. Stems and leaves grow in response to negative geotropism and positive phototropism.

Root System of Citrus

The citrus tree has a tap root system, consisting of a substantial tap root and a number of lateral or side-roots that grow horizontally (plagiotropic). The root system is relatively shallow, growing only to the depth of 30cm to 60cm.

The lateral roots constitute the majority of the root system. These feeding roots are the end ramifications of the root system and are usually fibrous. Active growth of the roots is cyclical, with growth taking place when the shoots are not actively growing. In citrus, there are usually three or more growth flushes per year.

practical

Activity 4.1 – Poster

Design a poster to educate temporary and casual nursery workers. Include the poster in your workbook.

- ✓ What do the roots of citrus plants look like?
- ✓ How you can tell the difference between good root development and poor root development in young citrus plants?
- ✓ What are the functions of citrus roots?

summary

Structures and Functions of Roots

- The structure and growth habits of roots have a pronounced effect on the size and vigour of the plant, the ability of the plant to adapt to certain soil types, the response of the plant to production practices and irrigation, and the method of propagation.
- There are two main types of root systems, being the tap root system and the adventitious root system.
- A root consists of the root cap, the region of cell division (meristematic region), the region of elongation, the root hair region, and the mature region.
- The internal parts of the tap root are the epidermis, cortex, and vascular cylinder (stele).
- The vascular cylinder is enclosed by the endodermis (the innermost layer of the cortex), and

consists of the pericycle and vascular tissue, which consists of xylem and phloem.

- The primary functions of roots are to anchor the plant, to take up water and nutrients, and to transport water and nutrients into the stem and carbohydrates back to the roots.
- Certain plants have developed roots that perform other functions beside the primary functions.
- In commercial agriculture, plants are provided with additional nutrients through fertilisation.
- Gravitropism, also referred to as geotropism, is a turning or growth movement by a plant in response to gravity. Roots have positive gravitropism and stems have negative gravitropism.
- The citrus tree has a tap root system, consisting of a substantial tap root and a number of lateral or side-roots, which grow horizontally. The root system grows relatively shallow.
- The feeding roots are the end ramifications of the root system and are usually fibrous.

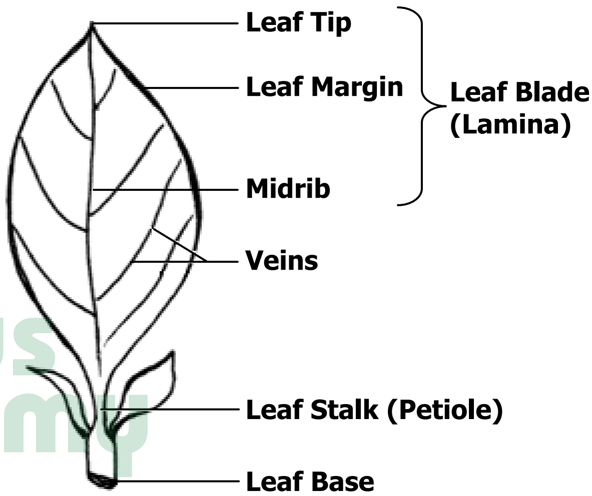
Structures and Functions of Leaves

Introduction

The leaves, or foliage, of a plant are probably their most noticeable organs. Leaves grow from the stem apex or stem apical meristem, of plants. During their development, leaves can take on different forms, depending on the function that they have to perform.

External Leaf Structure

A typical foliage leaf consists of a large, flat leaf blade (lamina), a leaf stalk (petiole) and a leaf base with which the leaf is attached to the stem. The leaves of monocot plants do not have petioles, and are attached to the stem by means of a leaf sheath, which is a special kind of leaf base enclosing part of the stem above the node.



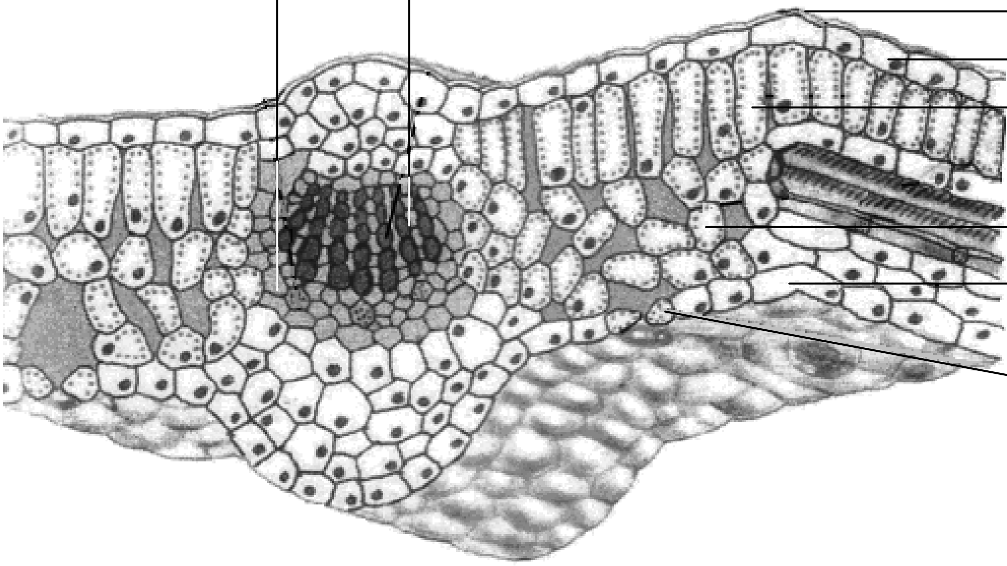
Veins are visible on the lamina of some leaves. Veins are in fact the vascular cylinders of leaves, which may continue from the petiole along the middle of the leaf to form a midrib, with smaller cylinders branching out to form veins. The vascular cylinders may also run parallel on the lamina. The way in which the veins are arranged, is called the **venation** of the leaf.

Internal Leaf Structure

If the leaf of a citrus plant is cut the following types of tissue can be distinguished under a microscope, as can be seen in the sketch below:

- Upper epidermis
- Palisade parenchyma
- Spongy parenchyma
- Vascular cylinders
- Lower epidermis with stomata

The palisade parenchyma and spongy parenchyma is collectively known as **mesophyll**. 'Meso' means middle or between, and 'phyll' means leaf. Mesophyll refers to the position between the upper and lower epidermis.



information

Please Note

Bifacial means having two faces, and refers to the upper and lower leaf surfaces. Some leaves, such as round leaves, are **unifacial**.

Upper Epidermis

The upper epidermis is usually only one cell layer thick. The epidermis protects the underlying tissue.

Palisade Parenchyma

The upper epidermis encloses long, vertical and tightly packed cells known as palisade cells. This layer contains an abundance of chloroplasts containing the green chlorophyll. This is the site where photosynthesis takes place. Note that the palisade and spongy parenchyma are only differentiated in some dicot plants, such as citrus.

Spongy Parenchyma

The spongy parenchyma cells are between the palisade parenchyma cells and the lower epidermis. These are irregularly shaped cells with many air spaces between them, and the tissue is therefore spongy. The vascular system is embedded in the spongy parenchyma cells.

The spaces between the spongy parenchyma cells allows for the interchange of gasses. The spaces are connected to the stomata in the lower epidermis.

Vascular Cylinders

The vascular cylinders, or veins, contain the vascular tissue which consists of xylem and phloem. The xylem cells are situated towards the upper epidermis and the phloem towards the lower epidermis. In large veins, the vascular bundles are usually surrounded by a bundle sheath.

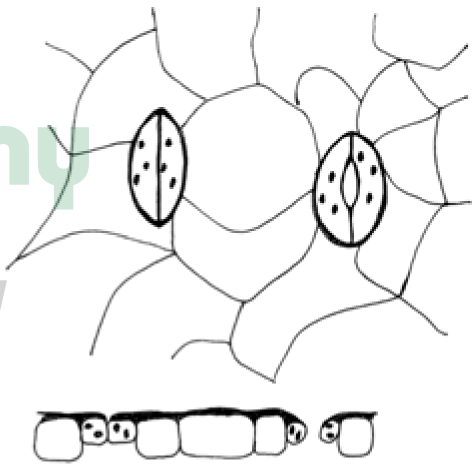
The xylem cells are empty, modified cells that help to strengthen the leaf. The xylem cells carry water and nutrients for the photosynthetic process to the palisade parenchyma, and are therefore the input line for the carbohydrate factory.

The phloem cells are live cells that translocate carbohydrates that have been manufactured in the palisade parenchyma to the rest of the plant. The phloem is the output line for the carbohydrate factory.

Lower Epidermis

The spongy parenchyma is enclosed by the lower epidermis. The lower epidermis has openings, referred to as stomata (singular: stoma).

Stomata



Each stoma pore is surrounded by two modified epidermal cells known as guard cells. The guard cells pull apart and cause the stoma to open when they are hydrated due to the differential thickening of their walls. When not turgid, the guard cells collapse and close the stoma.

Stomata perform the very important functions of allowing for exchange of carbon dioxide and oxygen during photosynthesis, and for the movement of water vapour out of the leaf, referred to as transpiration.

The movement of water vapour out of the leaf in turn drives the movement of water from the roots to the leaves through the xylem cells, bringing with it the minerals and other compounds necessary for photosynthesis and growth.

In citrus leaves, the stomata are only found on the lower surface of the leaf, but in some plants stomata also appear in the upper epidermis and also on young stems. Stomata are also found on fruit, since the fruit develop from carpels that are actually modified leaves.

Leaf Types

Trees are classified as evergreen or deciduous, depending on whether they lose their leaves during the year or not. Evergreen trees retain their leaves for longer periods and do not lose all their leaves at the same time, while deciduous trees lose all their leaves, normally in autumn. Citrus is an example of an evergreen tree, while apples and pears are examples of deciduous trees.

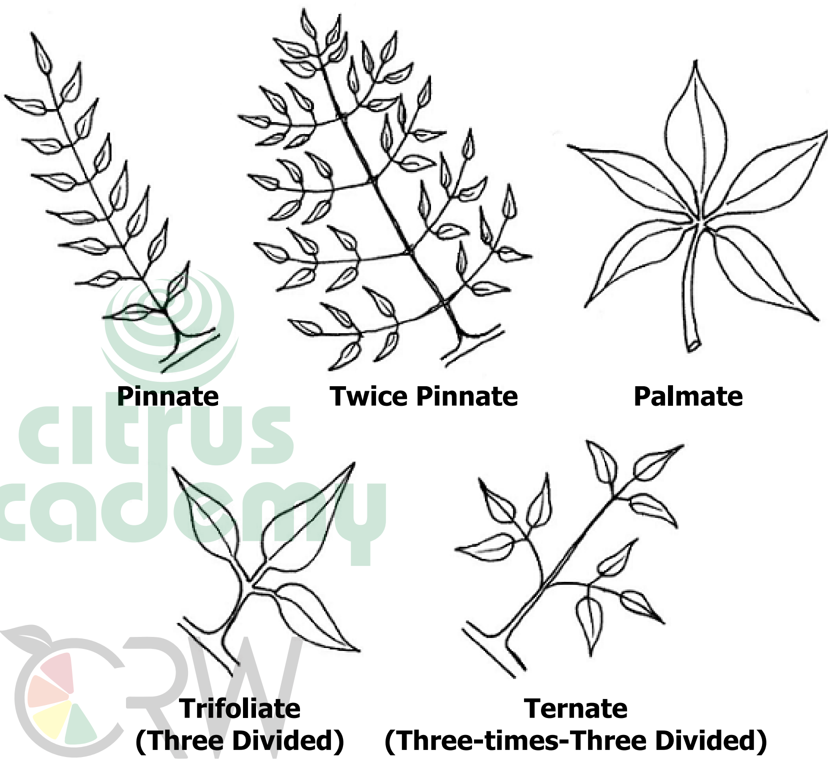
Leaves are classified in many different ways. The simplest classifications are by:

- Composition
- Venation
- Position

Composition

The leaf blades of some plants show indentations or clefts on the outer edges. If these indentations reach all the way to the midrib so that the leaf blade is divided into a number of smaller leaflets, called **pinnae**, the leaf is called a compound leaf. If the leaf blade is not divided into leaflets, the leaf is termed a simple leaf.

Most monocot plants have simple leaves, while dicot plants can have simple or compound leaves. There are different types of compound leaves, where the tiny pinnae arranged in a set pattern make one compound leaf.



definition

Pinnae (S: Pinna)

Pinnae are the leaflets that make up a compound leaf.

Pinnate

Pinnate means resembling a feather in appearance or structure, especially in having a central axis or stem with parts branching off.

Palmate

Palmate means forming a branching pattern that spreads like fingers from a hand.

Trifoliate

Trifoliate means 'with three leaves', and the term is used to describe a compound leaf consisting of three pinnae that arise from the same point.

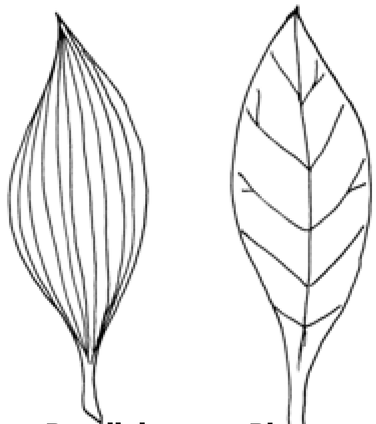
Ternate

Ternate means divided in three, and the term is used to describe a compound leaf that is divided into three more or less equal parts.

Venation

The manner in which the veins are arranged in the lamina is referred to as the venation of the leaf. It is described as either parallel or pinnate. With parallel venation, a number of vascular cylinders branch from the leaf base and run parallel on the lamina.

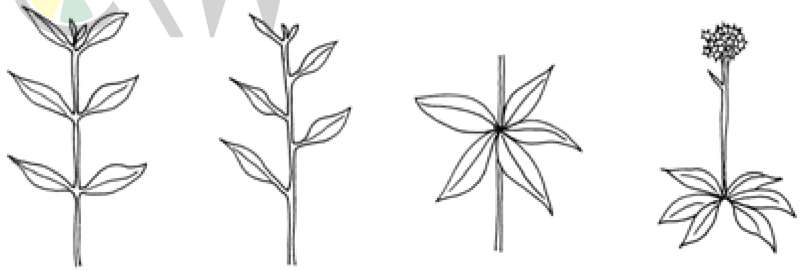
With pinnate leaves, the vascular cylinder continues from the stem through the petiole and then as the midrib of the leaf, with subsidiary vascular tissue branching from the midrib.



Parallel **Pinnate**

Position

Leaf position refers to the arrangement of the leaves on the stem.



Opposite **Alternate** **Whorled** **Basal**

Leaf Functions

Leaves perform three very important functions, being:

- Photosynthesis
- Transpiration
- Respiration

Photosynthesis

The leaf is a very important part of the plant, because it is mainly here that carbohydrates are produced in the process of photosynthesis. This is the energy source for further growth and development, including that of the fruit. Photosynthesis occurs throughout the lifespan of the plant.

Chlorophyll is the main pigment responsible for photosynthesis. The formula below summarises the process:

$$6CO_2 + 12H_2O \xrightarrow{\text{Light Energy}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

Remember that:

- CO_2 = Carbon dioxide
- H_2O = Water
- $C_6H_{12}O_6$ = Carbohydrates (sugars)
- O_2 = Oxygen

This formula means that through light energy the plant is able to convert six molecules of carbon dioxide and twelve molecules of water to one molecule of carbohydrates. Six molecules of oxygen and six molecules of water come free in the process.

This formula summarises the gaseous exchange that takes place and promotes plant growth. During photosynthesis, the plant absorbs CO_2 through the stomata in the leaves, and water through the roots that is taken to the leaves by the xylem in the vascular tissue of the roots and stem. The green pigments (chlorophyll) in the chloroplast absorb sunlight and with this energy the plant manufactures sugars (carbohydrates). Oxygen and water molecules come free, and are released through the stomata.

information

Global Warming

Ever heard it said that the destruction of vast tracts of natural forest, especially the rain forests, contributes to there being too much carbon dioxide in the air, leading to the greenhouse effect and global warming? This is because plants are able to absorb carbon dioxide and produce oxygen during photosynthesis.

Transpiration

The loss of water vapour through the stomata is known as transpiration. Transpiration helps to cool the plant, which is why more transpiration occurs during the hot summer months, leading to a greater need for water and increased irrigation.

The loss of water through the stomata also caused water to move from the roots to other plants parts. Remember that xylem cells are empty, almost like an open pipeline, and water must be 'pulled' through them. When water is lost through transpiration, osmosis causes water to move from the soil into the roots, and from there the water is 'pulled' through the roots and stem to the leaves.

Respiration

Not all carbohydrates made by the plant during photosynthesis are used right away. Some carbohydrates are stored. The process by which a plant uses the stored food is called respiration. Only cells with chlorophyll can carry out photosynthesis, whereas all live cells carry out respiration.

During respiration, oxygen is taken in through the stomata, and the oxygen is used to break the stored food down into energy. Respiration produces water and carbon dioxide which is released through the stomata.

The Effect of Environmental Conditions on Leaves

As can be seen from the metabolic processes described above that are carried out by leaves, leaves require water, sunlight and air (oxygen and carbon dioxide) to perform its functions well.

In the absence of light or in greatly reduced light, leaves become yellow due to the breaking down of the chlorophyll in the chloroplasts. Leaves are then said to be etiolated. The green colour will return if the plants are returned to light.

Leaves are also sensitive to heat. As soon as the temperature rises above a certain level, the stomata close, and photosynthesis ceases.

Some leaves are sensitive to touch. The pinnae of the leaves of the Mimosa pudica close when they are touched. The leaves of the Venus Fly Trap contain sensitive hairs and when the hairs are touched by an insect, the two halves of the leaf close quickly to catch the insect. Leaf tendrils of plants such as the sweet pea will turn around a support when they make contact.

Citrus Leaves

Although the leaves of the citrus plant look like simple pinnately veined leaves, they are actually modified trifoliate leaves where the two lateral leaflets were lost during the evolution.

Some rootstocks still have trifoliate leaves, which can be seen after germination. The leaf structure is the main characteristic by which off-type seedlings are identified when seedlings are transplanted.

Citrus trees are evergreen, but the leaves in fact live only for about three years, depending on conditions such as pests and disease pressure. During early leaf growth, the leaves are net importers of carbohydrates, becoming contributors only once fully expanded at four to six weeks old. They reach maximum capacity after about six months.

practical

Activity 4.2 – Samples Collection

- ✓ Find samples of citrus tree leaves from all the different cultivars that you work with in the nursery where you are employed.
- ✓ Dry the leaves by pressing them between tissue paper, and then paste them in your workbook.
- ✓ Identify the leaves by cultivar.
- ✓ Explain the functions of citrus leaves in terms of their role in plant growth.

Activity 4.3 – Worksheet

Sketch the process of photosynthesis and summarise your understanding of the process in your own words. Explain how the environmental conditions in a nursery promote photosynthesis.

summary

Structures and Functions of Leaves

- During their development, leaves can take on different forms, depending on the function that they have to perform.
- A typical foliage leaf consists of a large, flat lamina (leaf blade) with a midrib and veins, and a petiole (leaf stalk).
- The internal structure of a leaf is made up of the upper epidermis, palisade parenchyma, spongy mesophyll parenchyma, vascular cylinders, and the lower epidermis with stomata.
- The midrib and veins are the vascular cylinders inside the leaves.
- Stomata allows for exchange of carbon dioxide for photosynthesis, and for the movement of water vapour out of the leaf, referred to as transpiration.
- Leaves are classified in many different ways; the simplest classification is by composition, venation, and position.
- Compound leaves are where the tiny pinnae are arranged in a set pattern making one compound leaf. There are different types of compound leaves, being pinnate, twice pinnate, palmate, three-divided (trifoliate), and three-times-three-divided (ternate).
- Venation of a leaf can be either parallel or pinnate.
- Leaves perform three very important metabolic functions, being photosynthesis, transpiration and respiration.
- Leaves require water, sunlight and air, containing oxygen and carbon dioxide, to perform its metabolic functions well.