Contents of Module 3

Structure and Functions of Stems and Trunks

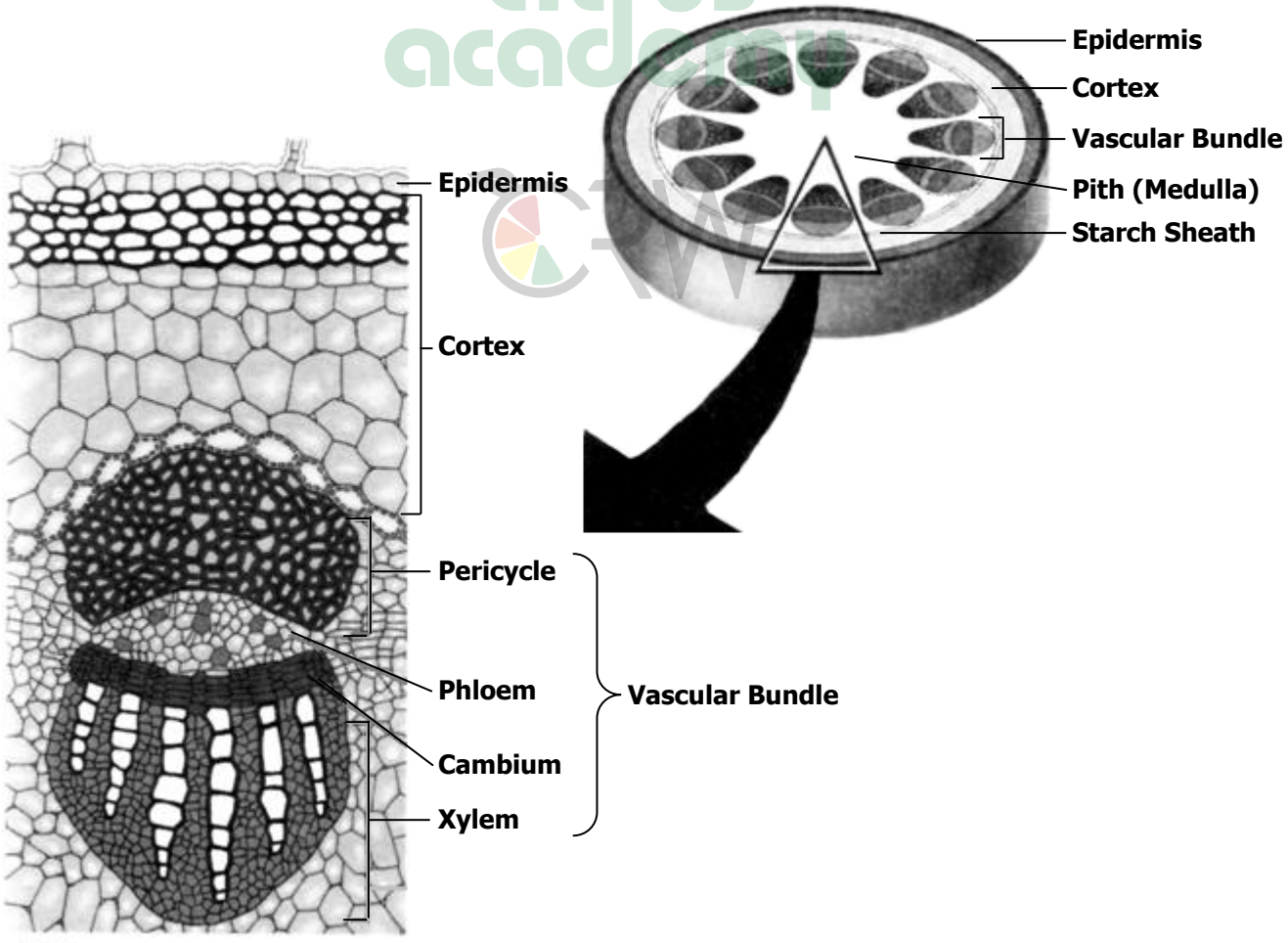
Introduction

A stem is a plant structure that develops from a bud to bear leaves and form buds. Stems have swellings at certain points called **nodes**, which is a point on a stem where a leaf is or was attached. The area between nodes is termed the **internode**.

Stems usually grow above the ground and are positively phototropic, meaning that they grow towards light, and negatively gravitropic, meaning that they grow away from the ground, except in the case of certain modified, or metamorphic, stems.

The main stem develops from the plumule of the embryo, while lateral branches develop from auxiliary buds or from adventitious buds. On young stems, clearly defined internodes and nodes can be distinguished.

Internal Structure of Dicot Plant Stem



If a stem is cut across and studied under a microscope, the following areas can be identified:

- Epidermis
- Cortex
- Vascular cylinder or stele

Epidermis

In young stems, the epidermis consists of a single layer of living cells which are closely packed. The guard cells of the **stomata** and **trichomes**, which are epidermal hairs of various kinds, are modified epidermal cells.

definition

Stomata

Stomata, the plural of stoma, are tiny pores surrounded by two guard cells in the epidermis of a leaf or stem. Stomata control the passing of water vapour and other gasses into and out of the plant.

In the older stems of woody plants, a cork **cambium** develops under the epidermis and forms cork layers that protect the inner tissues. The outer cell walls of the epidermis are thickened and covered with a thin waterproof layer, called the **cuticle**.

The epidermis protects the underlying tissues. The cuticle limits water loss, and stomata allow gaseous exchange for the processes of respiration and photosynthesis.

Cortex

The cortex is the layer between the epidermis and the stele of the stem. The cortex cells may also contain **chloroplasts** if the stem is still young, which makes young stems green in appearance. The cortex consists of the **collenchyma**, **parenchyma** cells and the **endodermis**, or starch sheath.

definition

Parenchyma

Parenchyma tissue is soft plant tissue made up of thin-walled cells that forms the greater part of leaves, stem pith, roots and fruit pulp.

Vascular Cylinder

The vascular cylinder comprises the:

- Vascular bundles
- Pith (medulla)

Vascular Bundles

The vascular bundles are arranged in a ring on the inside of the **pericycle**. This distinct ring of vascular bundles is a distinguishing characteristic of the stems of dicotyledonous plants. Between each vascular bundle is a band of parenchyma cells which runs from the cortex to the pith, or **medulla**. These are referred to as the **medullary rays**.

A mature vascular bundle consists of three main tissues, being **xylem**, **phloem** and **cambium**. The phloem is located towards the outside of the bundle and the xylem towards the centre.

The 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. Phloem cells transport sugars and other metabolites from the leaves.

The xylem consists mainly of cells which have become modified. They have thickened walls and holes between adjacent cells of the same type, and have lost their original contents. They are 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.

The cambium separates the xylem and phloem and gives rise to new phloem and xylem cells. As the tree grows, new phloem is produced towards the outside and new xylem towards the inside, creating secondary, tertiary, etc. vascular tissue, causing stems to grow thicker and forming what is commonly known as annual rings or growth rings.

The vessels and tracheids of the xylem provide a passage for water and dissolved nutrients to be transported from the root system to the leaves. The xylem fibres, xylem vessels, xylem tracheids and thick walled xylem parenchyma, collectively known as wood, strengthen and support the stem. The phloem, with its sieve tube cells and companion cells, transports synthesised organic food from the leaves to other parts of the plant.

Pith (Medulla)

The pith occupies the central part of the stem. It consists of thin-walled parenchyma cells with intercellular air spaces. The medullary rays start in the pith and run between the vascular bundles to the cortex.

The cells of the pith store water and starch and allow for the exchange of gases through the intercellular air spaces. The medullary rays transport substances from the xylem and phloem to the inner and outer parts of the stem.

Stem and Trunk Types

There are different types of stem and trunks that perform a variety of functions. The main types are:

- **Herbaceous** stems are the stems of herbs with very little secondary growth and those of most monocot plants, such as grasses, that have no secondary growth.
- **Woody** stems are the stems of dicot plants, have extensive secondary thickening growth and are therefore a source of wood. Stems of some monocot plants, such as bamboo and some palms, can also be woody, but have no secondary thickening growth.
- Stems of **vines**, such as runner beans, are long, slender stems that cannot support themselves and use other plants or structures to support them.
- **Tubers** are the fleshy, terminal ends of underground stem. Tubers can be used for propagation, and some tubers are edible, such as potatoes.
- **Rhizomes** are swollen underground stems with distinct nodes and internodes, which is how they can be distinguished from roots. Examples are the iris and kikuyu grass. Rhizomes can be used for propagation.
- **Corms** are swollen stem bases, as found with gladiolus, and can be used for propagation.
- **Bulbs** are reduced stems with succulent leaf bases covering the growth point, such as is found with onions. Bulbs can be used for propagation and some bulbs are edible.

Stems can also be adapted as runners, tendrils, or thorns. The tendrils of grapes and virginia creeper are modified stems. Keep in mind however that in some species tendrils may be modified leaves.

Stem Functions

Stems form the framework of the plant and their purpose is to expose the leaves to the maximum available sunlight. A good example is vines that are often found in forests. They do not spend energy to develop strong stems, but rather use other supports to grow out of the forest canopy as quickly as possible to expose their leaves to the sun.

Stems contain vascular tissue, such as the vessels and tracheids of the xylem that transport water and dissolved minerals from the roots to other plant organs, such as the leaves, flower and fruit. The sieve tubes and sieve cells of the phloem transport sugars and other metabolites that have been manufactured by the leaves through photosynthesis, to other plant organs, such as stem growing points, flowers, fruit, seed and roots where it is utilised for energy or stored as reserve food.

practical

Activity 3.1 – Poster

Design a poster that can be put up in the learning area of the class to explain the following. Include the poster in your workbook.

- ✓ What does a citrus stem looks like?
- ✓ What are the functions of the stem?
- ✓ What role does the stem play in citrus propagation?
- ✓ How are stems grafted in citrus propagation?

summary

The Structures and Functions of Stems

- Stems usually grow above the ground and grow towards light and away from the force of gravity.
- On normal stems, clearly defined internodes and nodes can be distinguished.
- The internal areas that can be identified in a stem are the epidermis, the cortex and the vascular cylinder.
- The vascular cylinder consists of the pericycle, the vascular bundles and the pith, or medulla.
- The vascular bundle contains xylem and phloem and the cambium.
- Stems form the framework of the plant, exposing the leaves to the maximum available sunlight.
- The vascular tissue in the stem (xylem and phloem) transports water and dissolved minerals from the roots, and manufactured sugars and other metabolites from the leaves, to other plant organs.

Budding Tools and Equipment

Budding Tools

The following tools are used during budding:

- **Budding knife** – A razor sharp knife used to make cuts on the seedlings and to cut off the bud-eye. The knife must always be sharp and in a good working condition to prevent tissue damage to the plant when cutting through it. If tissue damage occurs, the graft will most likely fail.

- **Budding tape** – Clear polyethylene strips, used to maximise contact between the bud and the rootstock until the union and the healing is complete. It also prevents drying and excess water from getting in and rotting the bud.
- **Pruning shears** – Bud-wood is cut using pruning shears. Pruning shears are also used when cuttings are used for propagation.
- **Sharpening stone** – All blades become blunt with use and require periodic sharpening. A sharpening stone, or wet stone, and honing oil are required.
- **Sterilisation liquid** – Knives and shears must be periodically cleaned and sterilised properly with a suitable sterilisation medium.

Sanitation and Sterilisation

The propagation of a citrus tree, most commonly, begins with raising a seedling to be used as rootstock. At this stage, the plant is at a vulnerable stage. Germination takes place in a warm and humid environment that is also conducive to the development and growth of pathogens that cause diseases. The most common pathogens are *Phytophthora* that cause root rot, and *Fusarium oxysporum*, that causes damping-off. To prevent the infection by pathogens, sanitation and sterilisation is essential.

For budding and cuttings, sterilisation of pruning shears and budding knives ensures that the propagation material remains virus-free. Budding tools should be sterilised every time varieties are changed.

skills

Please see the instructions on **Sterilising and Maintaining Equipment** in the Skills module.

practical

Activity 3.2 – Workplace Report

Compile a short report from your experience in the nursery where you work, about the following:

- ✓ What equipment is used during budding in the workplace?
- ✓ How is the equipment handled and stored?
- ✓ What safety precautions must you take when using this equipment?
- ✓ How and how often is the equipment sterilised?

summary

Budding Tools and Equipment

- ➢ The tools that are used during budding are a budding knife, budding tape, pruning shears, sharpening stone, and sterilisation liquid.
- ➢ Sterilisation of pruning shears and budding knives ensures that propagation material is not needlessly exposed to pathogens.

Budding

Introduction

Budding is the method where the bud-eye along with some bark is taken from a bud stick, referred to as bud-wood, and inserted into the rootstock seedling. The bud-wood, referred to as the scion, forms the fruit bearing part of the tree and is cut from a plant of the selected fruit variety and with desirable traits.

Sometimes cultivar change is required on older citrus trees in orchards. This procedure is referred to as top-working and involves grafting a scion of a new cultivar onto the existing trees.

Bud-Wood

In commercial citrus propagation, bud-wood is obtained only from sources that are certified to be free of diseases, such as Tristeza and Exocortis. These sources are strictly managed and regularly tested and evaluated for presence of diseases.

New sources of scion material are kept in quarantine to prevent the spread of diseases from or to other citrus areas. The material is first 'cleaned' of all known diseases before being released for propagation purposes.

Budding Procedure

Budding is done when the bark of the rootstock is "slipping", meaning when the bark separates easily from the wood. The most appropriate period for budding in South African nurseries that use shade-houses is from end August to April. In the case of plants that are kept in greenhouses with a controlled environment, the bark slips anytime the plant is actively growing, which is practically year-round.

An inverted T-cut is made into the bark on the stem of the rootstock. A very thin slice of bark and a piece of wood beneath the bud is cut away evenly and smoothly from the bud-wood with a knife. The upper end of the bud piece is placed beneath the bark flaps at the bottom of the inverted T-cut. The join is wrapped with budding tape to hold the bud firmly in place on the rootstock until union and healing of wounds is complete. The wrap also prevents rain and irrigation water from entering the budding area, thereby reducing the risk of infection. The wrap is applied from below the incision in overlapping turns around the stem until the entire bud and incision are covered.

Depending on the season, rootstock and scion type, the process from budding to ready for planting, takes about six to eight months.

After 15 to 20 days, when healing and union have occurred, the tape is removed by making a vertical cut through it behind the budded area. A live bud will still be as green as it was when inserted, while a dead bud will look brown or blackish, meaning that it did not take. If the bud did not take, another spot on the rootstock is selected for re-budding.

The growth energy of the seedling must now be directed to the green bud, forcing it to grow. The rootstock seedling is subjected to practises, such as looping (bending) or topping to direct all its energy into the bud. These practices break bud dormancy and force the bud to grow within one to three weeks.

Other shoots that grow from the rootstock influence bud-growth. To reduce competition for food, side shoots are trimmed as soon as they are noticed on the rootstock.

When the new scion shoot reaches 20cm to 25cm, a treated stake, such as a wooden cleat, a bamboo stick or twisted thick wire, is inserted alongside the plant extending 20cm into the medium and about 80cm above. The plant is tied to the stake for stability and directed growth. As the plant grows, it is continually tied up until it reaches the top of the stake.

When the plant reaches pencil-thickness at the top of the stake, it is topped to suppress apical dominance and to allow branching. The topped tree is ready to be planted.

definition

Apical Dominance

Apical dominance refers to powerful tip growth that suppresses the growth of lateral buds.

skills

Please see the instructions on **Budding** in the Skills module.

practical

Activity 3.3 – Mind Map

Design a mind map with your group, to be presented to the rest of the learners in the class, about the following:

- ✓ What is budding?
- ✓ What are the functions of scions?
- ✓ Why is budding important in the citrus nursery?

Activity 3.4 – Logbook

Hand in a logbook, proving that you have successfully participated in budding techniques in the citrus nursery. Write all the procedures down that you participated in and have your supervisor sign off that you have completed all the tasks successfully.

summary

Budding

- Budding is the method where the bud-eye, along with some bark is taken from a bud stick, referred to as bud-wood, and inserted into the rootstock seedling.
- In commercial citrus propagation, bud-wood is obtained only from sources that are certified to be free of diseases.
- Budding is done when the bark of the rootstock seedling is "slipping" by making an inverted T-cut on the stem of the seedling, cutting a bud piece from the bud-wood, inserting the bud piece into the T-cut, and wrapping the join with clear tape.
- After about two weeks the wrapping is removed, and if the union was successful, growth energy is directed to the bud by looping or topping the rootstock seedling.
- Plants are staked for support and directed growth of the budwood.
- Depending on the season, rootstock and scion type, the process from budding to ready for planting, takes about six to eight months.

Rootstock and Scion Compatibility

Introduction

Incompatibility between the rootstock and the scion is a problem that can occur. Possible incompatibility must be taken into account when combinations are selected.

Scion and Rootstock Combinations

In the table below the possible combinations for use in various climatic regions of Southern Africa are summarised:

Scion Cultivar	Rough-Lemon	Swingle Citrumelo	Carrizo Citrange	X639	C-35	MXT	Volka-meriana
Hot, warm and intermediate areas							
Hot / warm areas: Tshipise, Letsitele, Lower Letaba, Hoedspruit, Malelane, Swaziland Lowveld, Pongola, Nkwaleni **Intermediate areas:** Marble Hall, Nelspruit, Ngonini Swaziland, Karino, Barberton, White River, Letaba, Levubu							
Navels	X	√	√	√	√	√	X
Delta Valencia	X	√	√	√	√	√	X
Turkey Valencia	X	√	√	√	√	√	?
Benny Valencia	√	√	√	√	√	√	√
Du Roi Valencia	√	√	√	√	√	√	√
Rosé Grapefruit	X	√	√	√	√	√	X
Star Ruby Grapefruit	X	√	√	√	√	√	X
Eureka Lemon	√	X	X	√	X	√	√
Bears Lime	√	√	√	?	?	?	?
Clementine	X	√	√	√	√	√	X
Empress Mandarin	X	√	√	√	√	√	X
Cool and cold areas							
Cold areas: Eastern Cape Midlands, Gamtoos Valley, Sundays River Valley, Amanzi, Western Cape, Central KZN Midlands **Cool areas:** Rustenburg, Potgietersrus (Modimole), Lydenburg, Zebediela							
Navels	√	√	√	√	√	√	√
Delta Valencia	√	√	√	√	√	√	√
Turkey Valencia	X	√	√	√	√	√	?
Benny Valencia	√	√	√	√	√	√	√
Du Roi Valencia	√	√	√	√	√	√	√
Rosé Grapefruit	X	√	√	√	√	√	X

Scion Cultivar	Rough-Lemon	Swingle Citrumelo	Carrizo Citrange	X639	C-35	MXT	Volka-meriana
Star Ruby Grapefruit	X	√	√	√	√	√	X
Eureka Lemon	√	X	X	√	X	√	√
Bears Lime	√	√	√	?	?	?	?
Clementine	X	√	√	√	√	√	X
Empress Mandarin	√	√	√	√	√	√	√

Adapted from Citrus Rootstocks: The Choice You Have – Louis A. Von Broembsen

Note that apart from incompatibility, certain rootstocks may be suitable with certain varieties only in certain areas, but not in others. For example, navels on Rough Lemon rootstock are not suitable in the hot areas of Southern Africa, as the internal quality and rind colour development is poor, while in the cooler and cold areas this does not present a problem.

summary

Rootstock and Scion Compatibility

- Incompatibility between the rootstock and the scion is a possible problem that can occur.
- Apart from incompatibility, certain rootstocks may be suitable with certain varieties only in certain areas, but not in others.