CHAPTER 3.1 – MAIN INORGANIC NUTRIENTS

Macronutrients and micronutrients required by plants

- ✓ Three main macronutrients (carbon, hydrogen and oxygen) can be obtained easily from air and water from the soil
- ✓ These nutrients make up most of the dry mass of plants
- ✓ Therefore, the lack of these nutrients is rarely experienced by plants
- ✓ The remaining nutrients are taken in the form of mineral salts which are dissolved in the soil through fertilisation

MACRONUTRIENTS

- ➢ Carbon (C)
- ➢ Calcium (ca)
- ➢ Hydrogen (H)
- ➢ Magnesium (Mg)
- ➢ Oxygen (O)
- ➢ Phosphorus (P)
- ➢ Nitrogen (N)
- ➢ Sulphur (S)
- ➢ Potassium (K)

MICRONUTRIENTS

- ❖ Chlorine (Cl)
- ❖ Zinc (Zn)
- ❖ Iron (Fe)
- ❖ Copper (Cu)
- ❖ Manganese (Mn)
- ❖ Nickel (Ni)
- ❖ Boron (B)
- ❖ Molybdenum (Mo)

The necessity of macronutrients in plants

The functions of macronutrients in plants

CARBON (C), OXYGEN (O), HYDROGEN (H)

- ⊕ Important components in carbon cycle and oxygen cycle
- ⊕ Components in all organic compounds of plants and important components in synthesis of sugar

NITROGEN (N)

- Gives the green colour to plants through the formation of chlorophyll
- Main components of proteins, nucleic acids and enzymes in photosynthesis and respiration

POTASSIUM (K)

- ↘ Important in protein synthesis and carbohydrate metabolism
- ↘ As cofactors for some enzymes
- ↘ Maintains plant turgidity

CALCIUM (Ca)

- ◊ Main components of middle lamellae, cell wall and spindle fibres during cell division

MAGNESIUM (Mg)

- ❑ Main component of the structure of chlorophyll molecule
- ❑ Activates some plant enzymes
- ❑ Involved in carbohydrate metabolism

PHOSPHORUS (P)

- ♥ Synthesises nucleic acids, adenosine triphosphate (ATP) and phospholipids in plasma membrane
- ♥ Act as coenzymes in photosynthesis and respiration

SULPHUR (S)

- ○ Components of a few amino acids
- ○ One of vitamin B constituents and a few types of coenzymes

The effects of macronutrient deficiency

CARBON (C), OXYGEN (O), HYDROGEN (H)

- » Photosynthesis will not take place
- » Less oxygen released by plants
- » Stunted growth which can cause death because there is no glucose

NITROGEN (N)

- ❑ Leaves undergo chlorosis (yellowing of the leaves) mainly on matured leaves
- ❑ Underlying leaves fall off
- ❑ Protein synthesis disrupted
- ❑ Stunted growth

POTASSIUM (K)

- → Protein synthesis disrupted
- → Edges of leaves become yellowish
- → Premature death of plants

CALCIUM (Ca)

- ⊕ Stunted growth
- ⊕ Leaves become distorted and lobed
- ⊕ Parts between leaf veins become yellowish

MAGNESIUM (Mg)

- ◊ Parts between matured leaf veins become yellowish
- ◊ Red spots on leaf surfaces
- ◊ Lobed leaves

PHOSPHORUS (P)

- Unhealthy root growth
- Formation of dark green and dull coloured leaves
- Red or purple spots appear on older leaves

SULPHUR (S)

- ↘ Leaves or the whole plant turns yellow

The necessity of micronutrients in plants

The functions of micronutrients in plants

CHLORINE (Cl)

- ▪ Important in the equilibrium of osmotic pressure in cells and photosynthesis reaction

IRON (Fe)

- Acts as a cofactor in chlorophyll synthesis
- Important in the growth of young plants

MANGANESE (Mn)

- Activates photosynthetic enzymes
- Important for cell respiration and nitrogen metabolism

BORON (N)

- Helps the roots in calcium ion uptake and sucrose translocation
- Involves in carbohydrate metabolism and helps in germination of pollen

ZINC (Zn)

- Important in leaf formation
- Synthesis of auxin (growth hormone)
- As a cofactor in carbohydrate metabolism

COPPER (Cu)

- Involves in nitrogen metabolism and photosynthesis
- Important for growth, reproduction and flower formation

NICKEL (Ni)

- A component of plant enzymes involved in the breakdown of urea to become ammonia which can be used by plants

MOLYBDENUM (Mo)

- Involves in nitrogen fixation and nitrate reduction during protein synthesis

The effects of micronutrients deficiency

CHLORINE (Cl)

- Plants wilt
- Slower root growth
- Leaves undergo chlorosis
- Lesser fruit production

IRON (Fe)

- Young leaves become yellowish

MANGANESE (Mn)

- Network of dark green leaf veins with a background of light green
- Light brown or grey spots in between leaf veins

BORON (N)

- Death of terminal buds and abnormal growth
- Leaves become thicker, rolled up and fragile

ZINC (Zn)

- Leaf surfaces become spotted with chlorosis parts
- Stunted growth

COPPER (Cu)

- Death of young shoot apex
- Brown spots on terminal leaves
- Plants become stunted

NICKEL (Ni)

- Stunted growth
- Reduces crop production
- Burnt effect at the end of leaves due to urea accumulation

MOLYBDENUM (Mo)

- Chlorosis in between matured leaf veins
- Leaf colour becomes pale green
- Reduces crop production

Knop's solution

- ♥ A culture solution is used to study the importance of nutrients for plant growth
- ♥ Contains all nutrients including trace elements needed by healthy plants
- ♥ A complete culture solution was prepared by a chemist named Wilhelm Knop in 1859

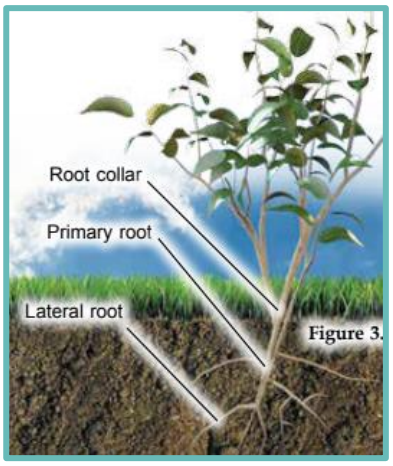
COMPLETE KNOP'S CULTURE SOLUTION	
Calcium nitrate, $Ca(NO_3)_2$	0.8 g
Potassium nitrate, KNO_3	0.2 g
Potassium dihydrogen phosphate, KH_2PO_4	0.2 g
Magnesium sulphate, $MgSO_4$	0.2 g
Iron(III) phosphate, $FePO_4$	Trace
Distilled water	1000 cm^3

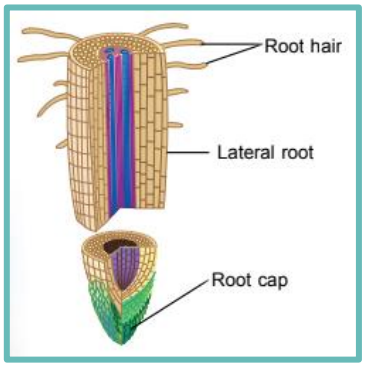
CHAPTER 3.2 – ORGAN FOR WATER AND MINERAL SALTS UPTAKE

The root structure for water and mineral salts uptake

THE MAIN FUNCTIONS OF ROOTS

- Provide support and strength to anchor the plant in the soil
- Absorb water and mineral salts from the soil and transport them to the stem and leaves





The functions of the structure of the roots

ROOT COLLAR

↘ Part of the root connected to the base of the plant stem

ROOT HAIRS

» Adapted from epidermal cells of the roots
» Increases the total surface of the roots to increase the uptake of water and mineral salts

ROOT CAP

◊ Located at the tip of the root
◊ Protects the root from damage when going through the soil

Root adaptations for water and mineral salts uptake

EPIDERMIS

⌂ Epidermal cells are closely arranged
⌂ Have thin cell walls and water-permeable cell membranes that facilitate water movement in the roots
⌂ There are epidermal cells which form root hairs by elongating towards lateral sides from the outer walls
⌂ Root hair cells are not layered with cuticle to allow water absorption

- ⌂ The root hair cells also have big vacuoles to store water and mineral salts to increase water absorption

CORTEX

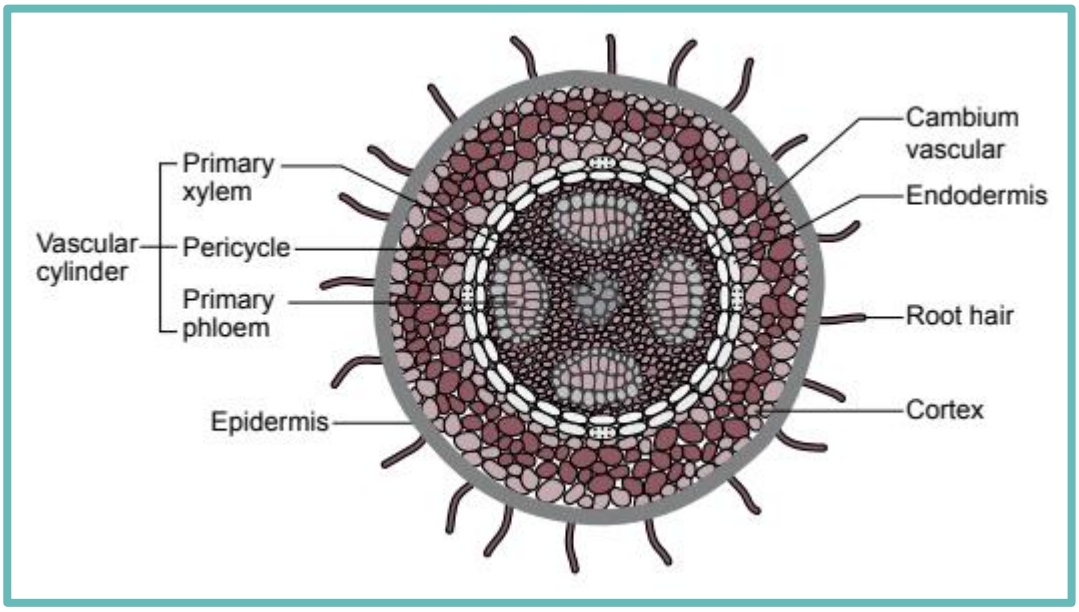
- Δ Cortex is located under the epidermal layer
- Δ Has thin cell walls that facilitate water movement in the roots
- Δ The cells are loosely arranged to facilitate gaseous exchange
- Δ Most of the cortex consists of parenchyma cells

ENDODERMIS

- → Separating layer between cortex and vascular cylinder
- → Endodermal cells are closely arranged and one cell thick
- → Most of the endodermal cells have suberin or lignin thickening at the walls which form Casparian strips
- → Endodermis allows water and mineral salts absorbed from the soil to enter the vascular cylinder but not air bubbles

VASCULAR CYLINDER

- ❑ Vascular cylinder in the root core that consists of xylem and phloem tissues surrounded by one cell thick pericycle cell tissues
- ❑ Pericycle in involved in the secondary growth and the formation of lateral roots
- ❑ Usually, xylem and phloem tissues are arranged in a star-shaped pattern
- ❑ Xylem tissue transports water and mineral salts
- ❑ Phloem tissue transports organic substance (sucrose and plant hormone)



CHAPTER 3.3 – DIVERSITY IN PLANT NUTRITION

Nutritional adaptations of plants

- Nutrition is a process of organisms obtaining energy and nutrients from food for growth, maintenance and repair of damaged tissues

PARASITIC PLANTS

- Parasitic plants live by growing on other plants which are the hosts
- The roots of this plant absorb organic substances, minerals and water from the host by penetrating the stem up to the vascular bundles of the host
- This causes the parasitic plant to grow faster and flourish, whereas the host is malnourished, dried and will eventually die
- Examples of parasitic plants
  i) *Rafflesia* sp. / *rafflesia arnoldii* (corpse flower)
  ii) *Pilostyles* sp. / *pilostyles thurberi* (Thurber's stemsucker)
  iii) *Cuscuta* sp. / *cuscuta gronovii* (dodder)
  iv) *Arceuthobium* sp. (dwarf mistletoe)
  v) *Nuytsia* sp. (Australian Christmas tree)

EPIPHYTIC PLANTS

- Epiphytic plants are green plants which live on other plants which are the hosts
- Epiphytic plants receive more sunlight for photosynthesis by living on taller hosts
- These plants synthesise their own food
- Epiphytes do not harm the host because the roots of epiphytes can absorb nutrients accumulated in the gaps of the plant's stem
- Most epiphytes have swollen stems that are able to store a lot of water
- Examples of epiphytic plants
  1) *Asplenium ridus* (bird's nest fern)
  2) *Bulbophyllum* sp. (orchids)
  3) Spanish moss
  4) Ascocenda
  5) Java moss

CARNIVOROUS PLANTS

- ✓ Carnivorous plants are able to synthesise their own food y carrying out photosynthesis
- ✓ Carnivorous plants secrete nectar and they have cups to trap their prey, typically insects
- ✓ The prey then slowly digested by digestive enzymes
- ✓ The trapped animals can supply nitrogen to the plants
- ✓ Nitrogen is important for growth
- ✓ This is because carnivorous plants live in soil which lacks nitrogen sources
- ✓ Examples of carnivorous plants
  - a) Nepenthes sp. (pitcher plant)
  - b) Dionaea muscipula (venus fly trap)
  - c) Cobra lily
  - d) Butterwort
  - e) Big floating bladderwort