CHAPTER 4.1 – VASCULAR TISSUES

The necessity of transport in plants

» Plants are multicellular organisms which are formed from cells that need water and nutrients
» The large and tall size of the plants creates a total surface area that is insufficient for the plant to absorb its basic needs from the surroundings
» In order to overcome this problem, plants have vascular tissues to transport water, mineral salts and nutrients to all the cells
» Plants which have a transport system are known as vascular plants
» Non-vascular plants (alga and moss) do not have any transport system

Main function of vascular tissues

XYLEM

♥ Transports water and mineral salts absorbed by the roots to the stems and leaves
♥ Provide mechanical support to the plant

PHLOEM

- Transports organic compounds (sucrose) which are synthesised by the leaves through photosynthesis to the stems and roots
- Transports amino acids and plant hormones to all parts of the plant

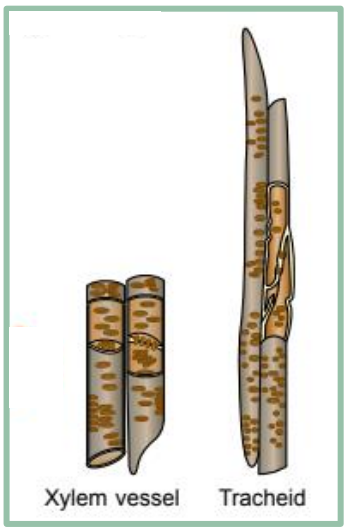
Structural adaptations of xylem vessels and tracheids to transport water and mineral salts

XYLEM VESSELS

⌂ Xylem vessel consists of dead cells at maturity which do not have cytoplasm
⌂ These cells are arranged longitudinally from end to end to form a continuous tube to allow water flow from the roots to the leaves
⌂ The walls of the xylem vessel have uneven lignin thickening to
  a. Give strength to xylem vessels to prevent them collapsing due to the tension force and pressure changes when water moves through it
  b. Prevent the plant from being bent

TRACHEID

→ The cell wall of tracheid also has lignin thickening and pits to allow water movement to adjacent cells



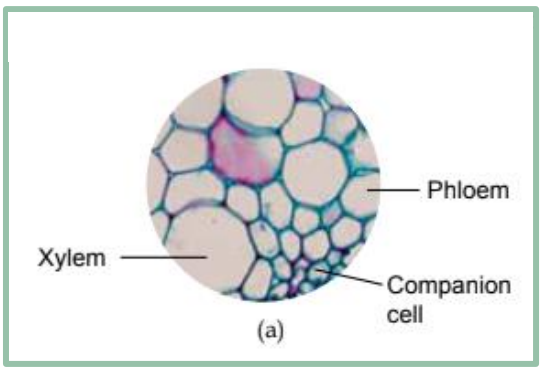
Structural adaptations of sieve tubes and companion cells to the transport of organic substances

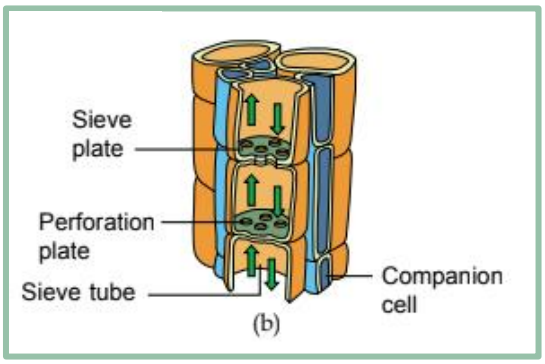
SIEVE TUBES

- Sieve tubes do not have nuclei, ribosomes or vacuoles
- This allows sucrose molecules to pass through sieve tubes easily
- On both ends of the sieve tube, there is a sieve plate that has pores through which organic compounds can flow from one sieve tube to the next

COMPANION CELLS

- Companion cells contain mitochondria to provide energy in the form of ATP to transport sucrose from the leaf to the sieve tube through active transport





CHAPTER 4.2 – TRANSPORT OF WATER AND MINERAL SALTS

Transport of water and mineral salts

- Water is very important to the growth of plants because water helps to move mineral salts from the soil to the stems and leaves
- Other than that, water also helps in giving turgidity to plant cells so that the plant remains fresh
- The water and mineral salts movement from the soil to the leaves are helped by
  1) Transpirational pull
  2) Capillary action
  3) Root pressure

TRANSPIRATIONAL PULL

- Produced when water that is evaporated from the stoma, pulls water from the leaves

CAPILLARY ACTION

- Capillary action is produced from adhesion force and cohesion force of water molecules which moves water upwards in the stem against gravity

ROOT PRESSURE

- Moves water from the soil into the xylem vessels of the root via osmosis

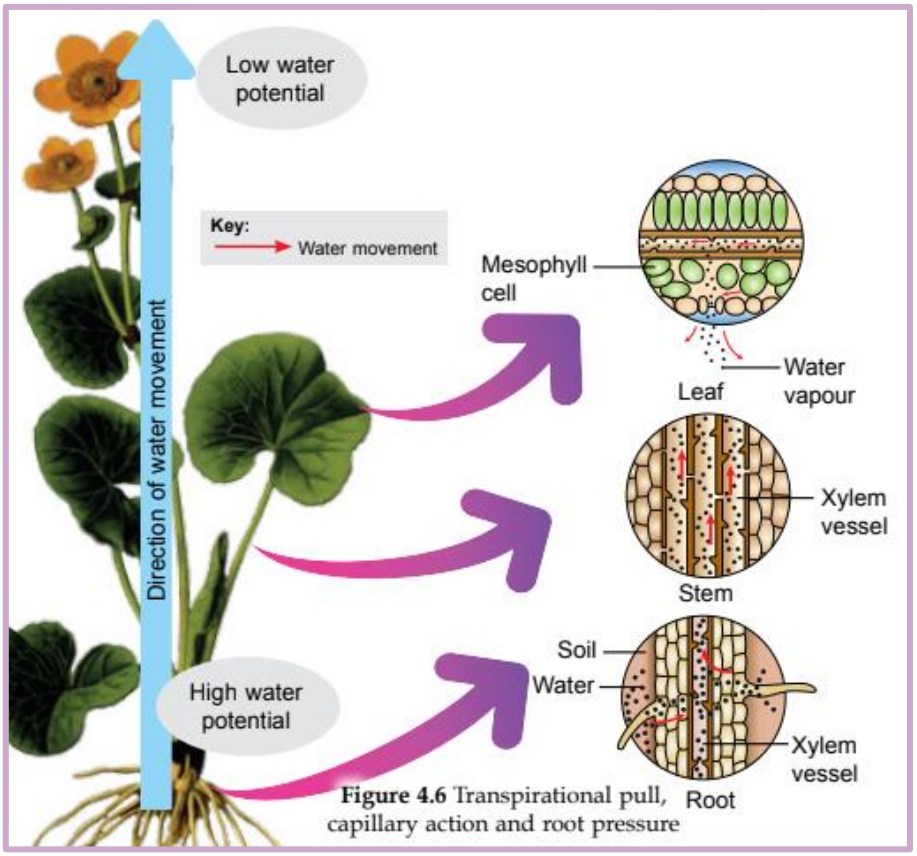


Figure 4.6 Transpirational pull, capillary action and root pressure

Water movement from the soil to the xylem vessel

1

- The water potential in the root hair cells is lower compared to water in the soil
- This is because the mineral ions are actively pumped by the root hair cells into the vacuole, causing the cell sap of the root hair to have lower water potential compared to the soil

2

→ Water from the soil diffuses into the root hair cells and epidermal cells via osmosis

3

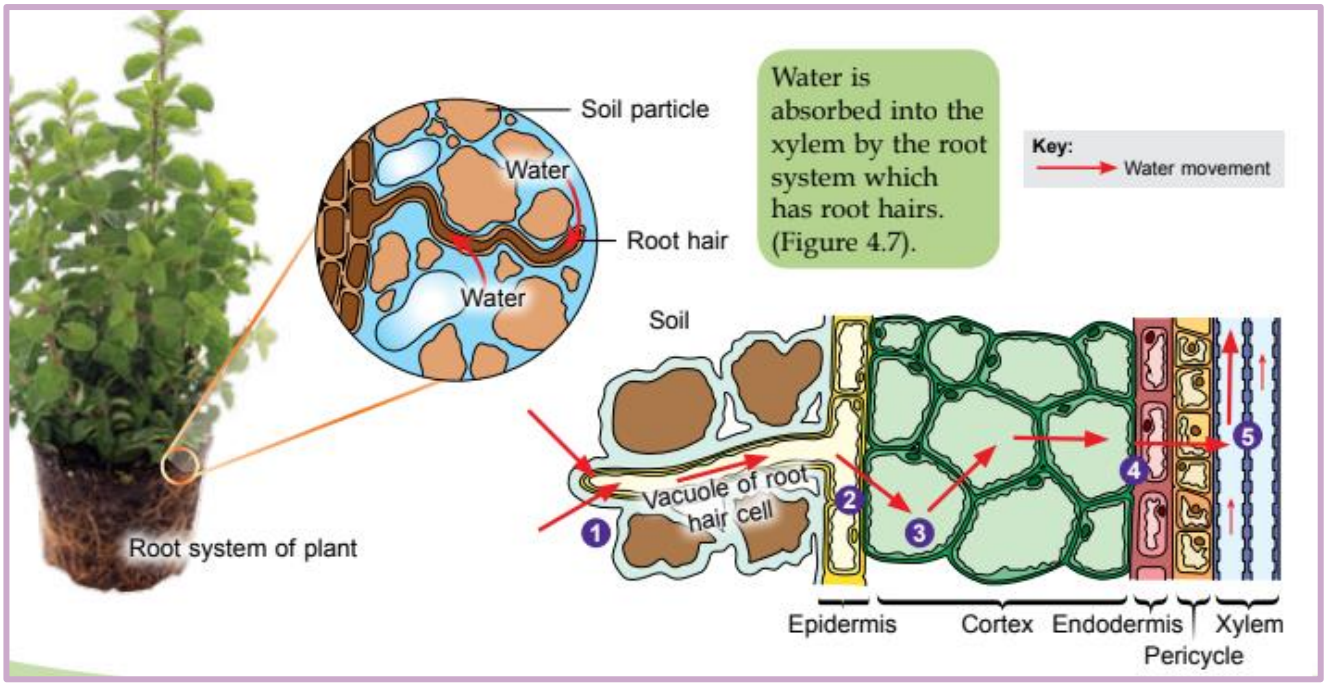
- The high-water potential in the root hair cells causes the water to diffuse from the root hair cells into the cortex via osmosis

4

➢ This condition causes osmosis to continuously occur throughout the cortex, endodermis and pericycle layers

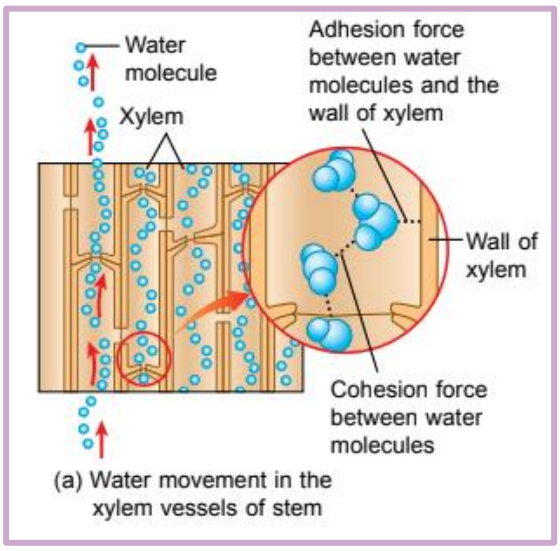
5

◊ This causes root pressure to push water into the xylem vessels of the root and then into the xylem vessels of the stem

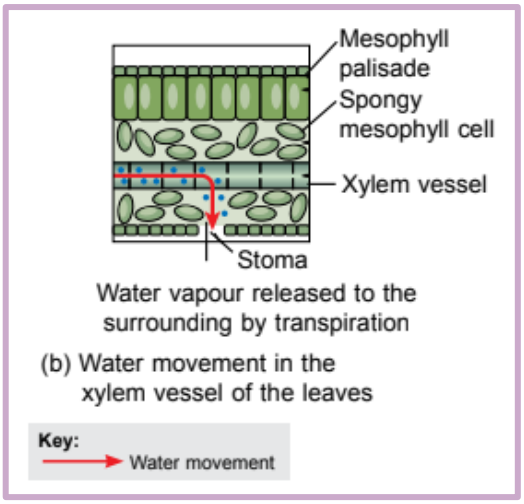


Water movement in the xylem vessels

- For tall plants, root pressure cannot transport water to the leaves, especially the shoots
- Therefore, the movement of water molecule in the xylem vessel is also helped by the capillary action of xylem produced by adhesion and cohesion forces and also transpiration pull
- Adhesion and cohesion forces produce a pulling force which continuously moves water in the xylem vessel
- When transpiration process happens, water diffuse out as water vapour from the spaces between the cells to be surroundings through opened stoma
- Spongy mesophyll cells lose water and they have lower water potential towards adjacent cells
- Water molecules diffuse from neighbouring cells via spongy mesophyll cells by osmosis
- This movement produces a force called transpirational pull that pulls water molecules in the xylem vessel of the leaves to the outside of the leaves



(a) Water movement in the xylem vessels of stem



(b) Water movement in the xylem vessel of the leaves

Guttation in plants

- Guttation is a secretion of water droplets through a special structure (hydathode) at the end of the leaf veins without involving the stomata caused by a high root pressure
- Guttation occurs when the root pressure and the rate of transpiration is low
- This condition usually occurs at night and early morning when the air humidity is high and the surrounding temperature is low
- The root pressure formed pushes water to the leaves and stems of the plant

Comparison between guttation and transpiration

SIMILARITIES

SIMILARITIES
• Both processes occur through the leaf • Both processes cause permanent water loss from the plant

DIFFERENCES

GUTTATION	TRANSPIRATION
Happens at night and early morning	Happens on hot and windy days
Only happens in herbaceous plant	Happens in all plants
Water released in the form of water droplets	Water is released as water vapour
Water is released through a special structure (hydathode) at the end of the leaf veins	Water is released through stomata
Happens when root pressure is high	Controlled by the stomatal opening and closing
Releases water that is rich in minerals	Releases pure water

The condition of plants that do not undergo transpiration and guttation

EFFECTS TOWARDS PLANTS THAT DO NOT UNDERGO GUTTATION

- ✓ Without guttation, effective root pressure cannot be maintained
- ✓ Therefore, water absorption by root hair cells is disrupted in a surrounding with high relative humidity
- ✓ Without guttation, plant waste substances cannot be eliminated
- ✓ If guttation does not occur, the leaf vein pressure becomes high and causes the leaf vein to burst
- ✓ This leads to the leaves being exposed to pathogen, eventually fall

EFFECTS TOWARDS PLANTS THAT DO NOT UNDERGO TRANSPIRATION

- ❖ Without transpiration, optimum temperature of plants cannot be maintained
- ❖ Increase in temperature can denature enzymes and disrupt biochemical processes (photosynthesis and respiration)
- ❖ Without transpiration, mineral ions (potassium ions) cannot be transported from the roots to the leaves for photosynthesis
- ❖ Without transpiration, water transport throughout the plants will be disrupted and causing the plants to wilt
- ❖ Plants can die in the long run

CHAPTER 4.3 – TRANSLOCATION

Definition of translocation

◊ Translocation is a process of transporting organic substances (sucrose, amino acids and hormones) in the phloem from the leaves to other parts of the plant (roots and stems)

The necessity of translocation in plants

→ Translocation helps in transporting photosynthetic products from the leaves to other parts of the plant that need them for growth and respiration (roots, fruits, tip of shoots or developing flowers)

→ Translocation also transports excess photosynthetic products to other parts of the plants (rhizomes, tubers and bulbs)

Pathways of translocation in plants

1

Sucrose is actively transported into the sieve tube

2

⊕ The transport of sucrose into the sieve tube from the leaf cells through companion cell reduces the water potential in the sieve tube

⊕ This causes water to diffuse from the xylem into the sieve tube via osmosis

3

❑ The water diffusion increases the hydrostatic pressure in the sieve tube

4

↘ The increase in the hydrostatic pressure causes the phloem sap to be pushed along the sieve tube to other organs of the plant

5

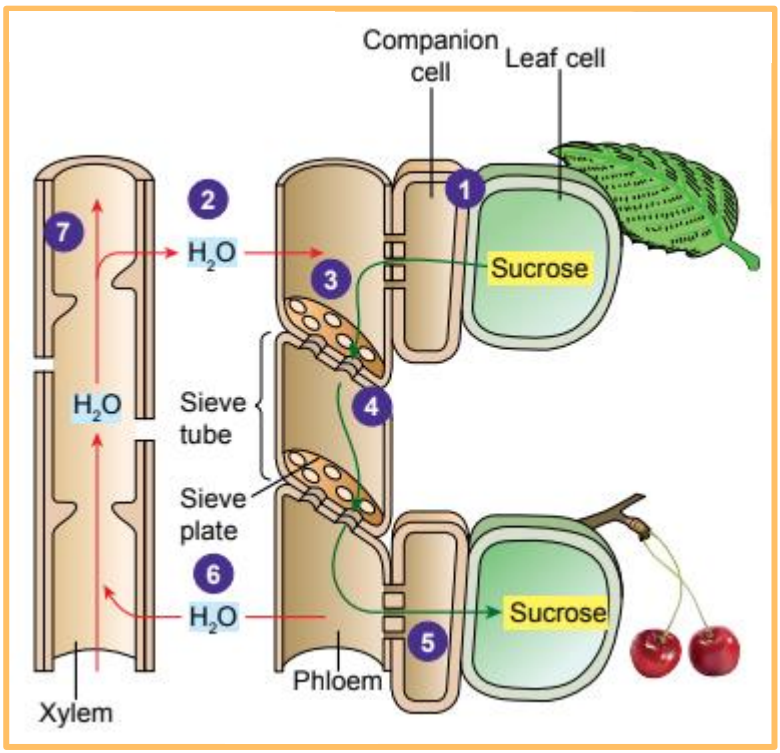
» The phloem sap (sucrose) is transported from the sieve tube to other parts (stems, roots, shoots, fruits and tubers) by active transport

6

Δ The high-water potential in the phloem causes the water to diffuse back into the xylem by osmosis

7

○ Transpiration pulls water along the xylem vessel against the direction of gravitational pull


Companion cell
Leaf cell
1
2
H_2O
3
Sucrose
7
H_2O
Sieve tube
4
Sieve plate
6
H_2O
Sucrose
5
Phloem
Xylem

CHAPTER 4.4 – PHYTOREMEDIATION

Definition of phytoremediation

- Phytoremediation is one of the treatment methods which uses the plant for the purpose of degradation, extraction or elimination of pollute substances from soil and water
- Examples of plants used for phytoremediation
  I. *Eichhornia crassipes* (water hyacinth)

The necessity of phytoremediation

- The environment and human health can be affected if waste water from domestic, agricultural, breeding and industrial activities is not treated
- The need of management and waste water treatment is important in order to overcome the lack of clean water, issue of water pollution and increasing cost of water treatment
- To overcome these problems, phytoremediation is one of the alternatives in waste water treatment by eliminating heavy metals and also trapping harmful nutrients and microorganisms
- Uses aquatic plants that can absorb heavy metals and nutrients contained in waste water

The uses of phytoremediation in life

CHARACTERISTIC OF WATER HYACINTH

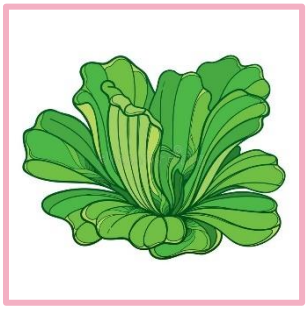
- ✓ Has long roots which can accumulate heavy metals in water
- ✓ Heavy metals that can be accumulated
  a. Copper
  b. Lead

CHARACTERISTIC OF SUNFLOWERS

- Sunflowers are used for remediation of soil polluted by the explosion of the nuclear plant in Chernobyl, Russia
- Sunflower acts as a hyperaccumulator which can eliminate heavy metals such as
  1. Zinc
  2. Chromium
  3. Copper
  4. Lead
  5. Nickel
- Sunflower also can eliminate radioactive substances such as
  A. Caesium
  B. Strontium

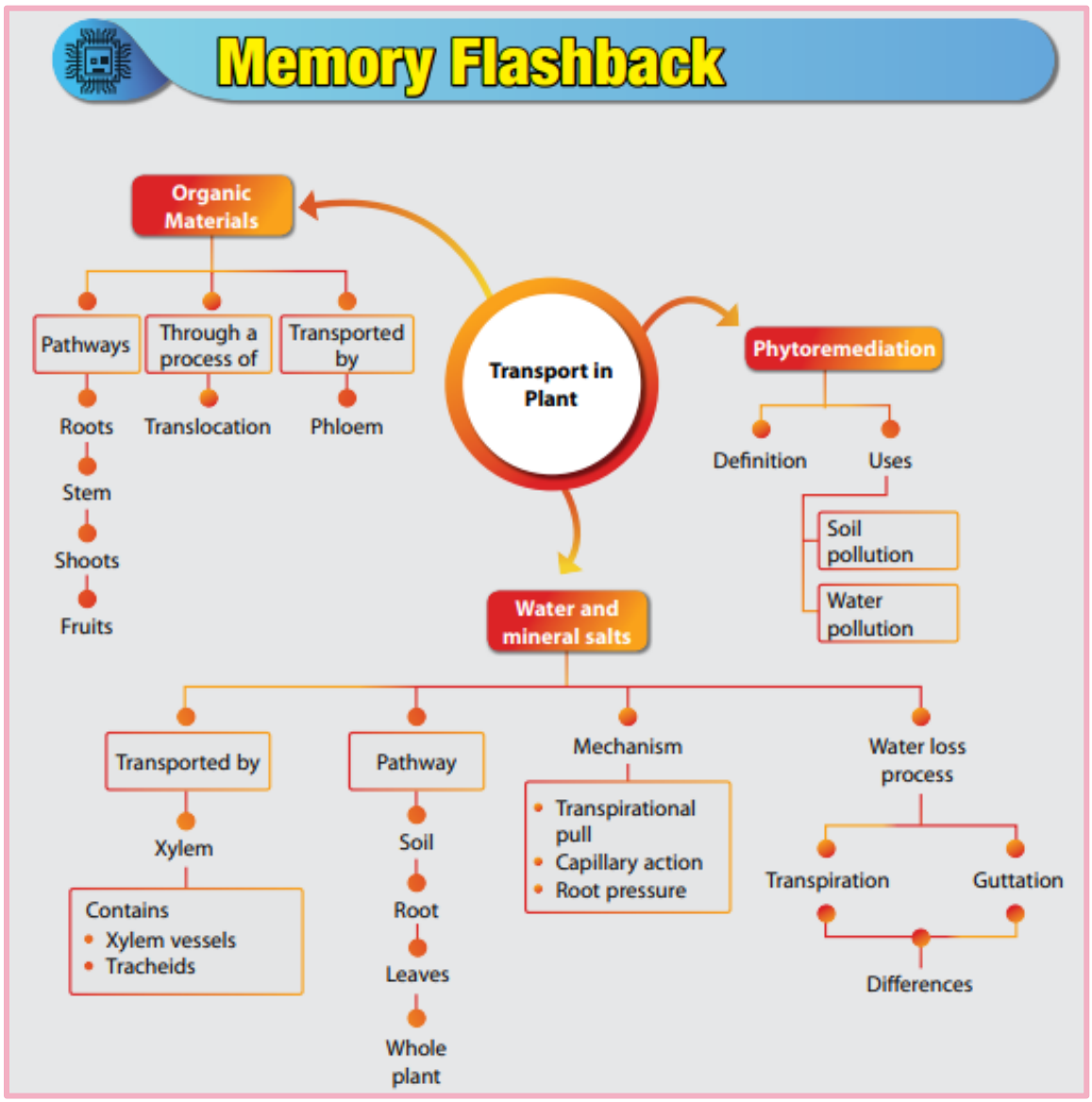
CHARACTERISTIC OF WATER LETTUCES

- There is aquatic plant that is suitable to treat waste water in a waste plant through the phytoremediation method that *Pistia stratiotes* (water lettuce)
- Water lettuce has a fast growth rate, can accumulate heavy metals and absorb nutrients in the waste plant



CHARACTERISTIC OF WATER SPINACHES

- The roots of ground water spinach are able to absorb mercury from the soil whereas the roots of river water spinach are able to absorb heavy metals (cadmium) from the water


Memory Flashback
Transport in Plant
Organic Materials
Pathways
Through a process of
Transported by
Roots
Stem
Shoots
Fruits
Translocation
Phloem
Phytoremediation
Definition
Uses
Soil pollution
Water pollution
Water and mineral salts
Transported by
Xylem
Contains
Xylem vessels
Tracheids
Pathway
Soil
Root
Leaves
Whole plant
Mechanism
Transpirational pull
Capillary action
Root pressure
Water loss process
Transpiration
Guttation
Differences