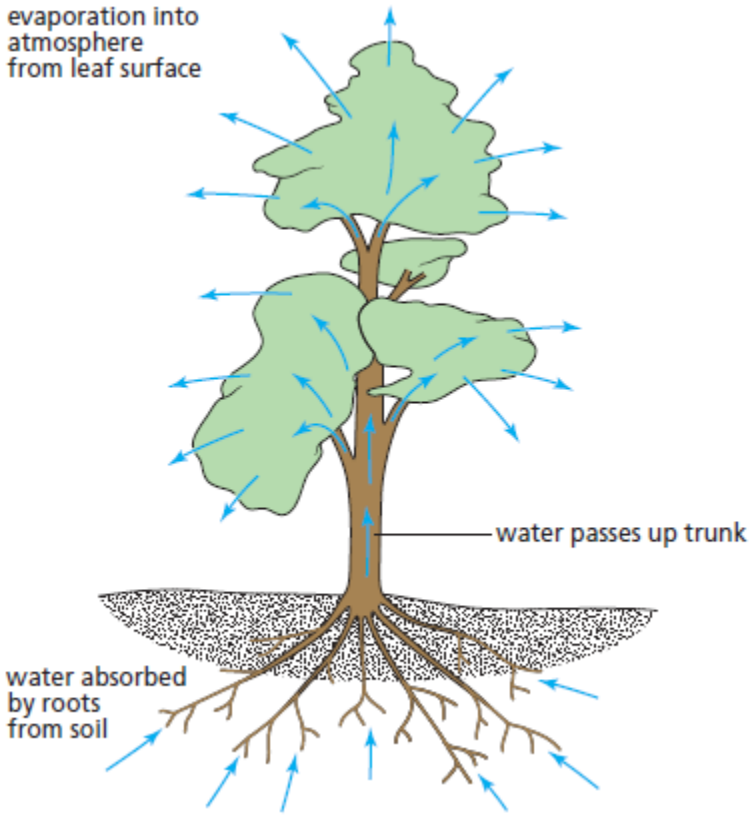
Chapter 8/Part 2

TRANSPORT IN PLANTS

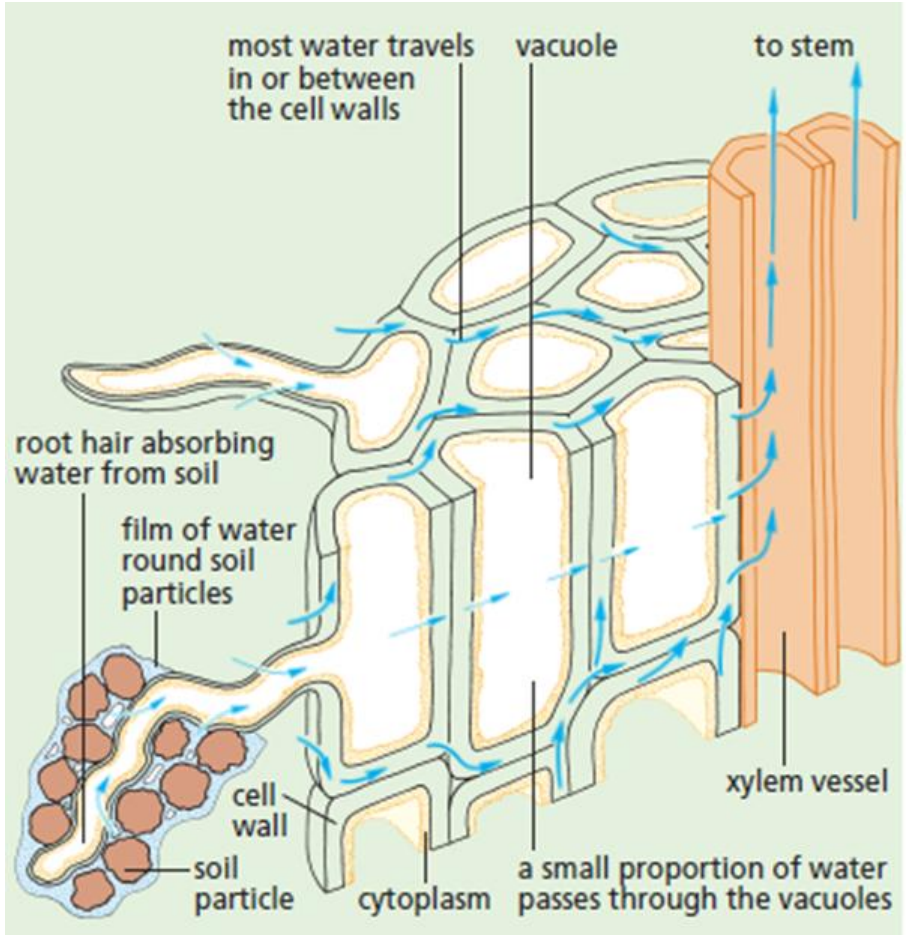
- ***Transpiration***: is the loss of water as water vapour by diffusion from a leaf through stomata.

- ***Transpiration stream***: the flow of water up the xylem vessels in a plant.



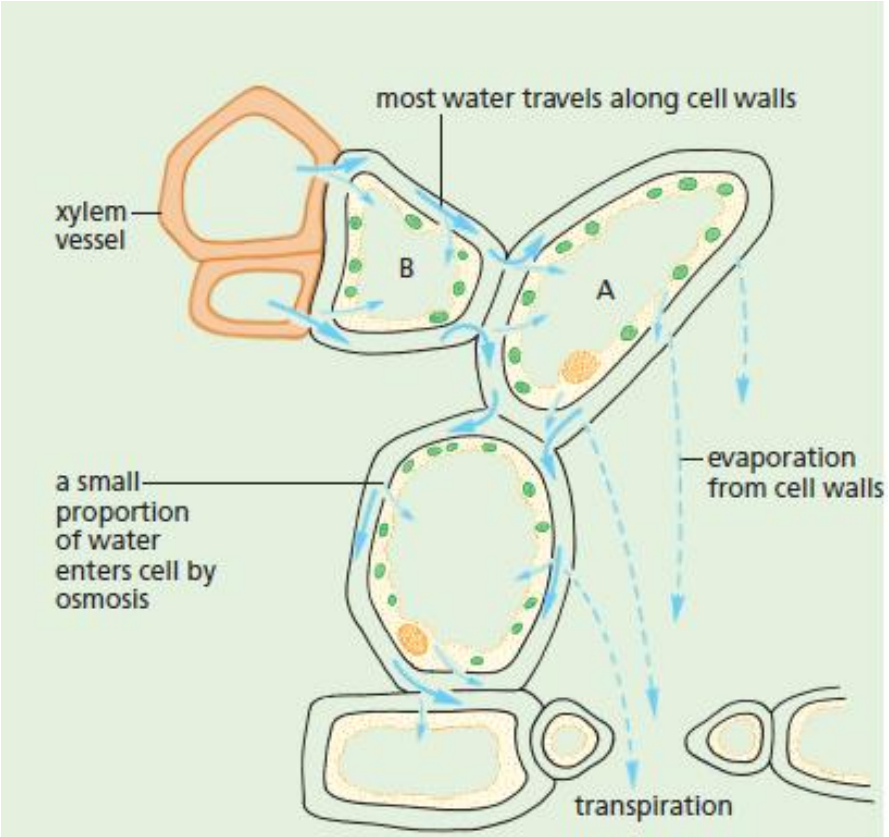
Uptake of water

- Water enters root hair cells by osmosis, from the thin film of water surrounding the particles of soil. The soil water has a higher water potential than the cytoplasm of the root hair cell, so that water moves down a water potential gradient.
- Water crosses the living cells of the cortex by:
    1. osmosis through the cells
    2. diffusion through the freely permeable cell walls. Almost all the water moves across the cortex by this route.
- Water with dissolved substances are forced to across the membrane and the cytoplasm of cells of the endodermis.
- Water enters the Xylem.



Water movement through a plant

- When stomata are open, water evaporated from the spongy mesophyll (wet cell walls) can diffuse through the air spaces and out of the stomata of the leaf down the water potential gradient.
- This lowers the water potential in the leaf tissues.
- Water moves from xylem to enter leaf tissues down water potential gradient.
- Water moves up the stem in the xylem due to the tension, transpiration pull caused by water loss from the leaves.



Factors which allow water to travel upwards in a plant.

- ***Root pressure.***
- ***Capillarity due to adhesion***: is the upward movement of water in narrow tubes (xylem vessels)
- ***Cohesion***: is the force of attraction between water molecules.
- ***Transpiration pull***.

Importance of transpiration:

- Water evaporating from a leaf absorbs heat and cools the leaf down.
- A rapid water flow is needed to obtain sufficient mineral salts which are in very dilute solution in the soil.

- *Note: Flooding of soil with salt water lowers the water potential of the soil solution and prevents osmosis; no water uptake by roots.*
- *Wilting occurs if the water loss exceeds water uptake, cells become flaccid, and the plant is no longer supported.*

Factors which affect rate transpiration

Light intensity

- In high light intensity, the stomata of leaves open and more water vapour diffuses out into the atmosphere, rate of transpiration increases.
- At night stomata close and transpiration slows down.

Humidity

- Humid air contains great deal of water vapour and can accept very little more from the plant and transpiration slows down.
- Dry air: low humidity increases the water potential gradient between leaf and the atmosphere and transpiration increases.

Air movements

- In still air, region around transpiring leaves become saturated with water vapour and this slows down transpiration.
- In moving air, the water vapour is carried away from the leaf and this speed up transpiration

Temperature

- High temperatures increase the water-holding capacity of the air and increases transpiration.
- It also increases the rate of evaporation from the wet cell walls of spongy cells.
- High temperature increases the rate of diffusion of water vapour out through stomata.

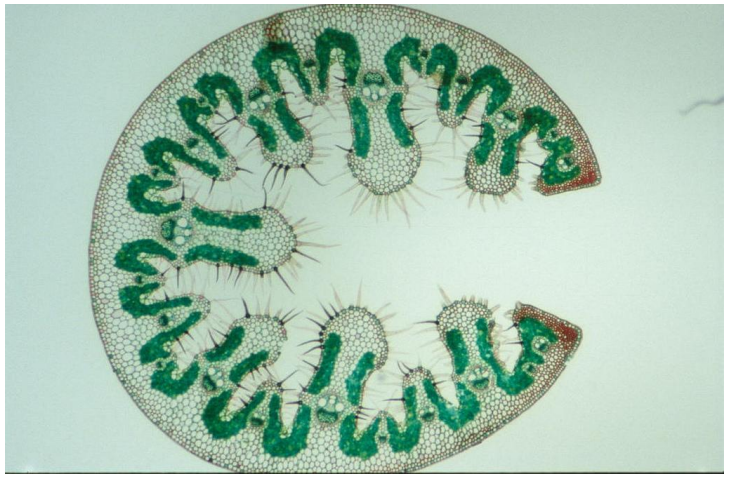
Adaptations of plants to reduce water loss in different environments

- Cacti are well adapted to hot, dry environments

- Leaves are reduced to needles to reduce surface area and water loss. Needles protect the cactus from animals eating it.
- The stem has the following features:
  - Green, to carry out photosynthesis.
  - Swollen, to store water.
  - With stomata sunken in grooves to avoid drying winds.
- The roots are usually long and spread over a wide area so that if it rains water can be absorbed quickly and stored within the stem.

The diagram shows a transverse section of a marram grass leaf as seen under a microscope

- Marram grass is a plant that grows in dry, windy environment on sandy dunes.
- The leaves are rolled up. This provides small surface area and a lower surface shields inwards.
- The leaves have thick waxy cuticle and with few stomata often sunken below the level of the epidermis.
- Rolled up leaves have tiny hairs in their inner surface. Hairs hold a layer of moist air inside and this reduces transpiration.



Note

- *The stomata of many desert plants close during the day, when temperatures are high and open at night when evaporation is at a minimum.*
- *At night carbon dioxide diffuses and is fixed as organic acid which breaks down to give carbon dioxide when light is available to be used in photosynthesis.*

Aquatic plants

Aquatic plants have leaves with:

- Little lignin in the xylem, since the leaf is supported by the water.
- A very thin cuticle, since water conservation is not a problem.
- Stomata on the upper surface to allow carbon dioxide uptake from the atmosphere.
- Aquatic plants also have flexible stem to with stand water currents.

Translocation

- Translocation is the movement of assimilates, like sucrose and amino acids in the phloem.

- Vital materials are transported from source, where they are made to sinks ,where they are used or stored.

Absorption by leaves

- Leaves are able to absorb certain substances if these are sprayed on them through the epidermis or stomata (foliar feeding).

Example: Pesticides.

- They are called systemic because they are absorbed through the leaves and translocated through the plant to all systems and tissues.
- Systemic insecticides when absorbed into the phloem tissue, they only kill aphids. Why ?

- *Aphids are serious pests of many crops, they can take food from plants by inserting their mouthparts (the stylet) through the plant tissues into the phloem.*

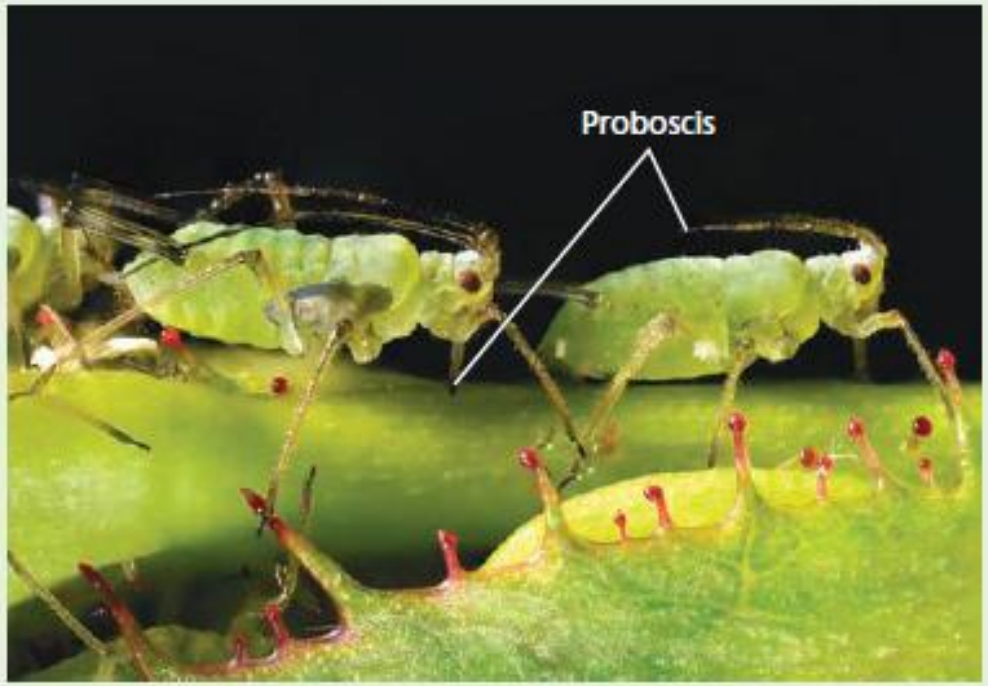


Figure 8.21 Aphids feeding on a rose plant

Experiments on transport in plants

- A potometer is an apparatus, designed to measure the rate of water uptake in a cut shoot.

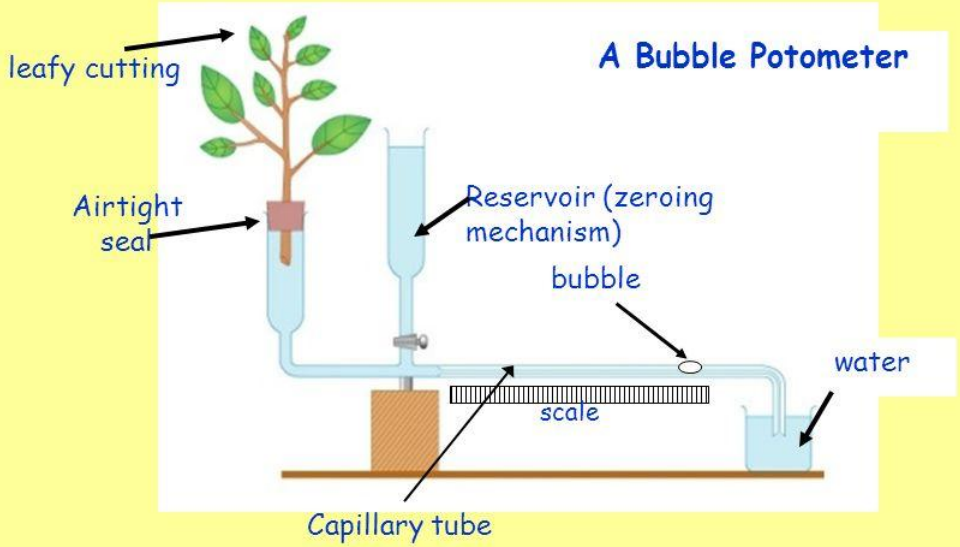
Using the potometer to compare rates of transpiration:

- Not all water taken by a plant will be transpired, some will be used in photosynthesis and for cell expansion. However, these quantities are very small compared with the volume of water transpired and they can be disregarded. So any factor that affects transpiration will affect water uptake.

•A bubble is introduced to the capillary tube.

•As water is taken up by the plant and lost from the leaves the bubble moves along the scale.

•By comparing the start and end position of the bubble, it is possible to measure the transpiration rate.



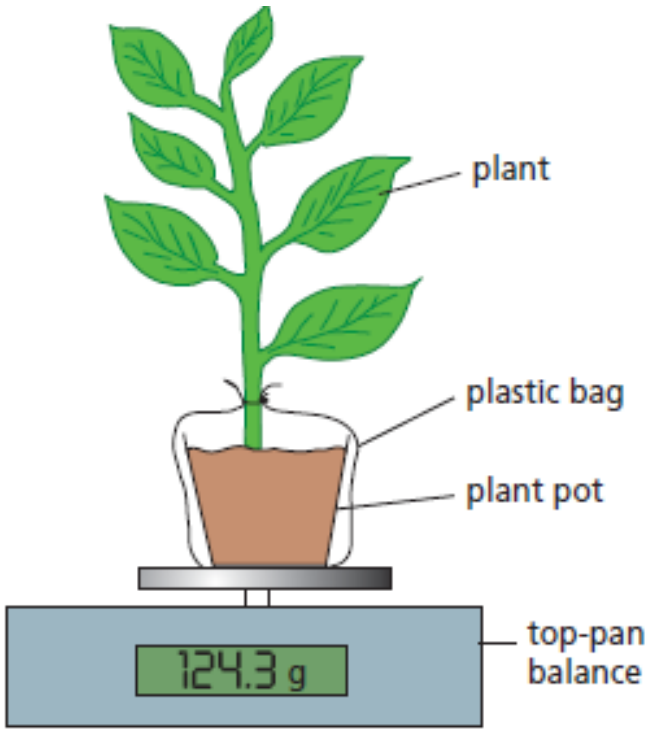


Figure 8.14 A weight potometer

To find which surface of a leaf loses more water

By using cobalt chloride paper

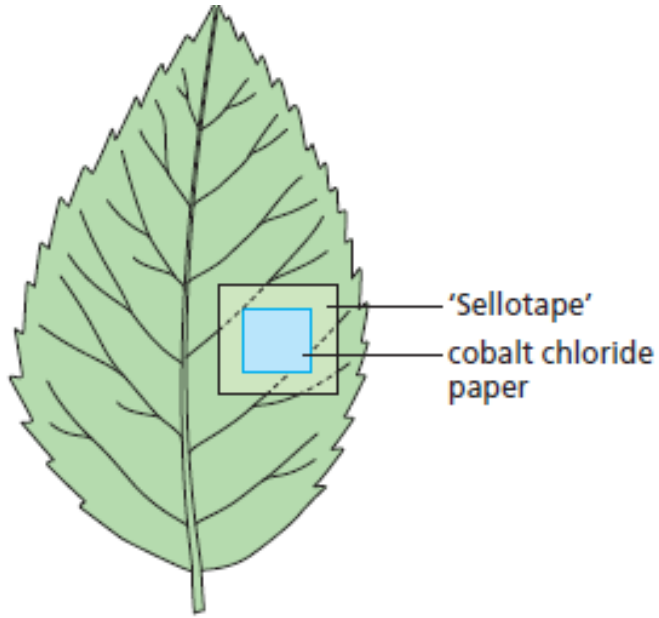
- Stick small squares of blue cobalt chloride paper to the upper and lower surface of the small leaf using transparent adhesive tape;

Special property of cobalt chloride paper:

It always changes color from blue to pink as it takes up moisture.

- Result: the lower surface of the leaf goes pink first.

- Explanation: the lower surface of the leaf evaporates most water, because of stomata are found in the lower epidermis of leaf.



To find which surface of a leaf loses more water

By using Vaseline

- Choose and cut four leaves of about the same size from a plant.
- Treat each leaf as follows:

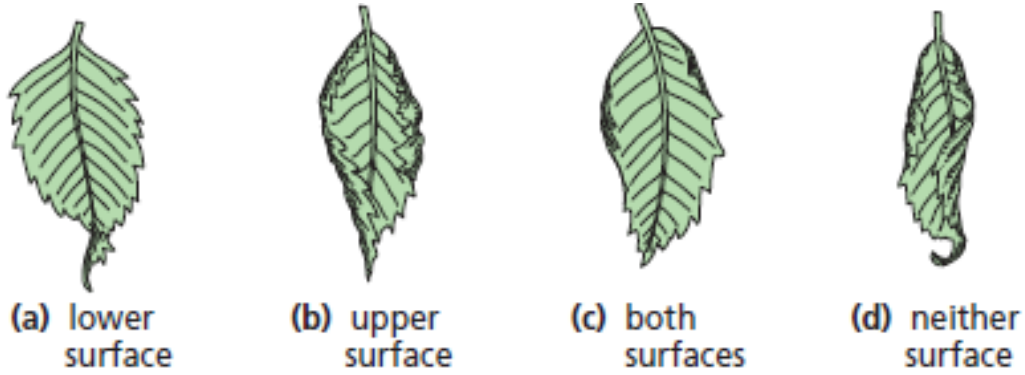
a. smear a thin layer of Vaseline on the lower surface

b. smear Vaseline on the upper surface

c. smear Vaseline on both surfaces

d. no Vaseline on either surfaces

- Keep the leaves in similar conditions for several days.



Result

- As shown in the drawing, leaves will shrivel and curl up to some extents.

Explanation

- Vaseline prevents evaporation;
- The untreated leaf, and the leaf with its upper surface sealed show the greatest degree of shriveling, so it's the lower surface of leaves evaporate most water because most stomata are found there.

Transport of water in xylem

- Cut 3 leaf shoots, which have same length and number of leaves.
- For the first shoot, remove a ring of bark (including the phloem).
- For the second shoot, keep it untreated (control).
- For the third shoot, cover the cut end by vaseline.
- Place the 3 shoots (twigs) in water jar exposed to direct sunlight. Leave for two hours.

Result

- The shoot (with blocked vessels) shows signs of wilting, but the other two shoots still have turgid leaves.

Explanation

- Removal of bark including the phloem has not prevented water from reaching the leaves, but blocking the xylem vessels has. Therefore water is transported in xylem.