PLANTS

4.2 Plant Transport

Objectives :

- Describe and explain the structure of xylem vessels

- Explain how water is transported through the xylem vessels

- Explain the effects of light, humidity, temperature and wind speed on the rate of transpiration

- Practical skill: Investigating the effect of light, humidity, temperature and wind speed on the rate of transpiration – Refer to o level book for experiments

- Explain the structure of phloem (sieve tubes and companion cells)

- Define translocation in terms of the movement of sucrose and amino acids in phloem: – from regions of production (source) – to regions of storage OR to regions where they are used in respiration or growth (sink)

*- Explain that some parts of a plant may act as a source and a sink at different times during the life of a plant * refer to the o level book*

Student book pages 88,89.90,91,92

Plants have two transport systems, one uses xylem which transports water from the roots to the leaves, and the second uses phloem which transports food from the leaves to the rest of the plant. Xylem and phloem form vascular bundles in the plant

Key terms :

https://www.youtube.com/watch?v=jtuX7H05tmQ part 1

https://www.youtube.com/watch?v=Kv_0udatlh8&t=16s part 2

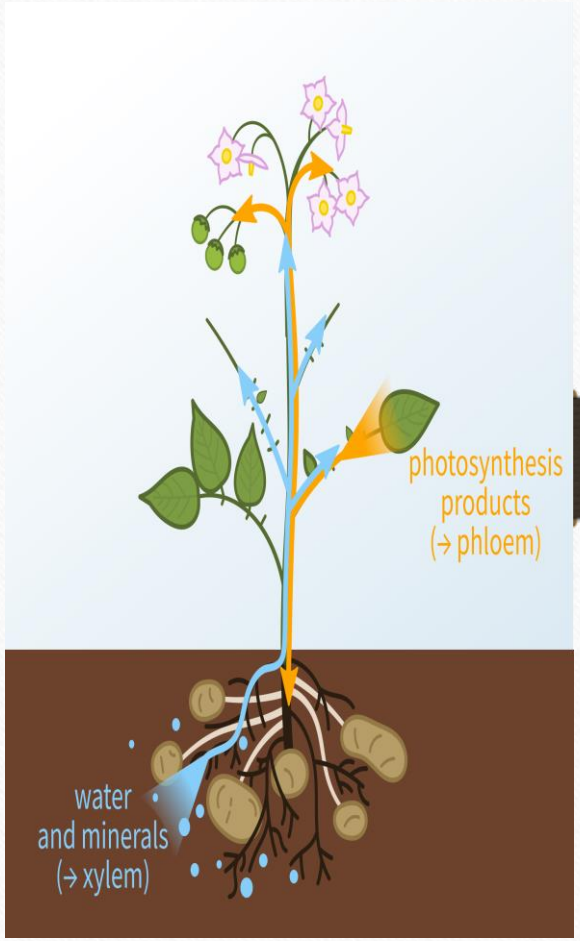
https://www.youtube.com/watch?v=QXdujo4PZ7c part 3

Xylem: *transports water from the roots to the leaves of a plant.*

Phloem *: transports organic compounds (created by photosynthesis] from the leaves to the rest of the plant.*

Vascular bundles *: are a collection of tube-like tissues including xylem and phloem which transport essential substances to the different parts of the plant.*

Transpiration *: is the loss of water vapour from the leaves via the stomata .*



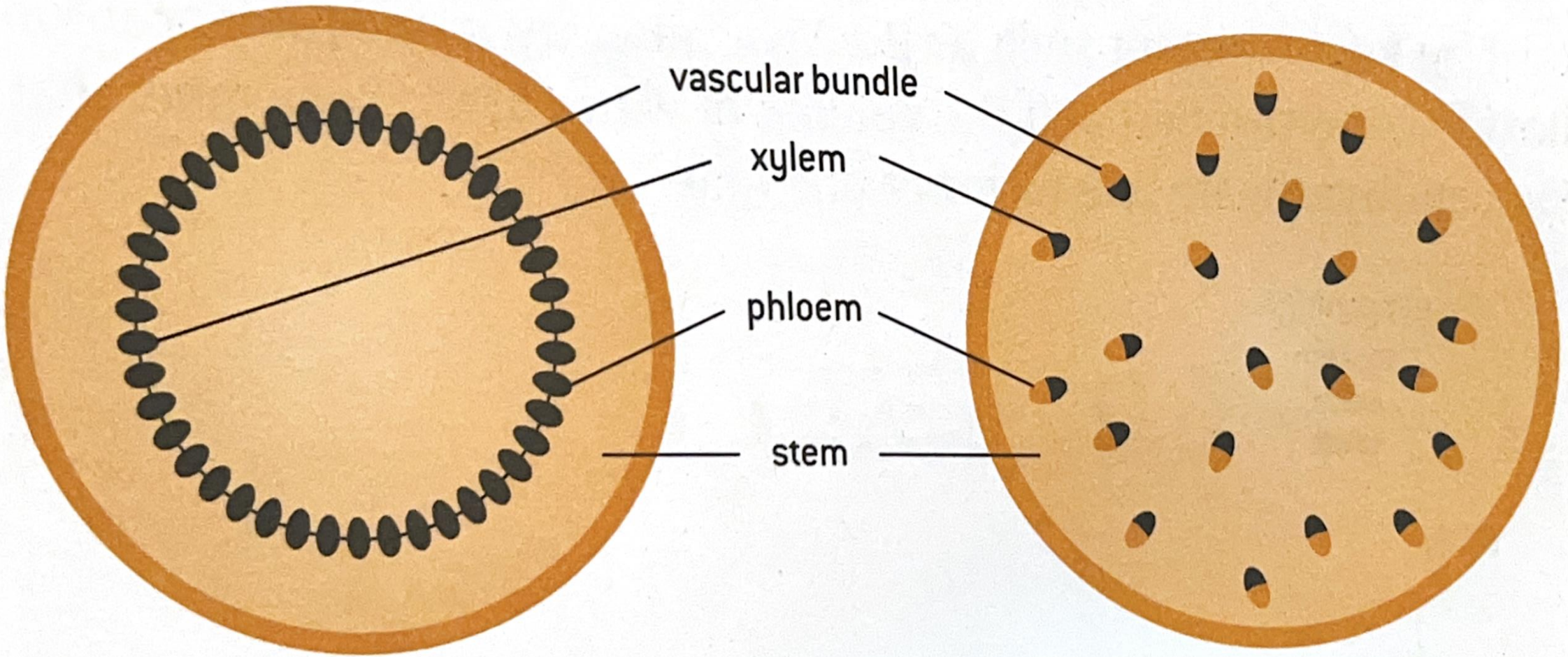
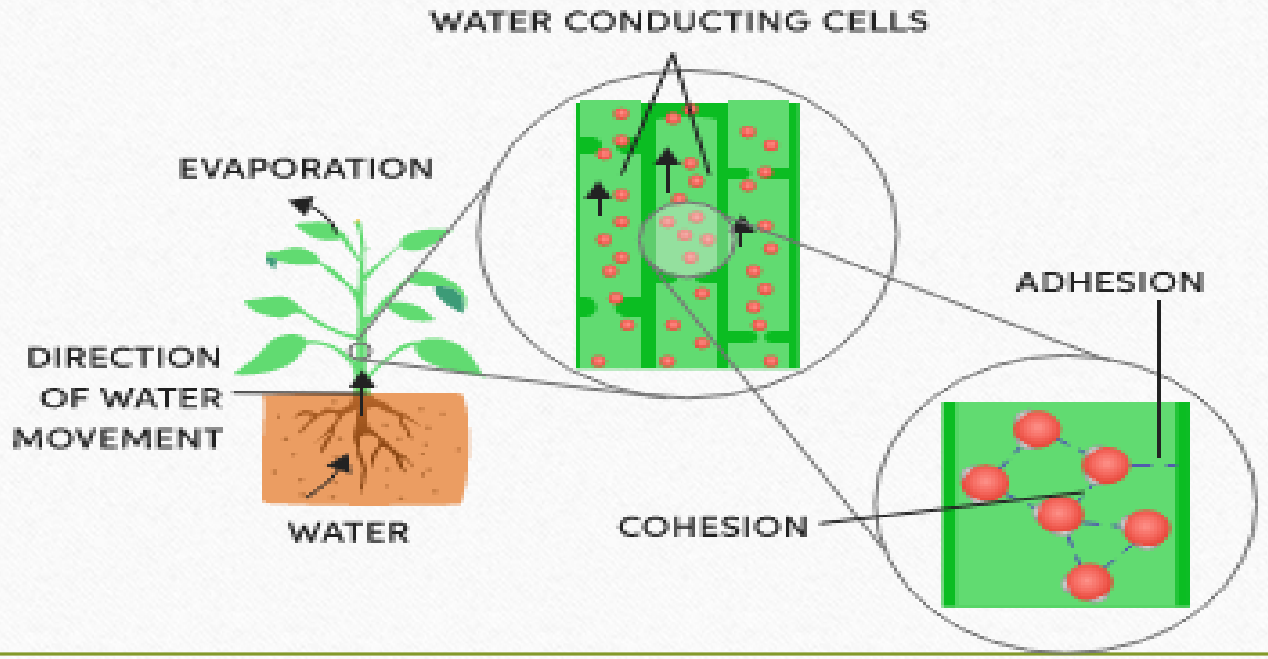


Figure 12. Vascular bundles in the stems of different types of plants

Transport in xylem

Xylem vessels transport water from the roots to the leaves. Xylem tubes are made from dead cells which are strengthened by lignin to withstand the pressure from water. The diameter of the xylem vessels is wide to transport large amounts of water throughout the plant.



How is water transported through the xylem vessels?

• Water is absorbed from the soil into the roots. The root system is branched and the individual roots have root hairs (figure 13), thus increasing the surface area for water uptake.

•Water is absorbed by osmosis because the solute concentration inside the root is higher than in the soil, due to active transport of mineral ions into the root.

• Water is transported from one root cell to another until it reaches the xylem.

Water is transported through the xylem vessels up the stem and then to the leaves.

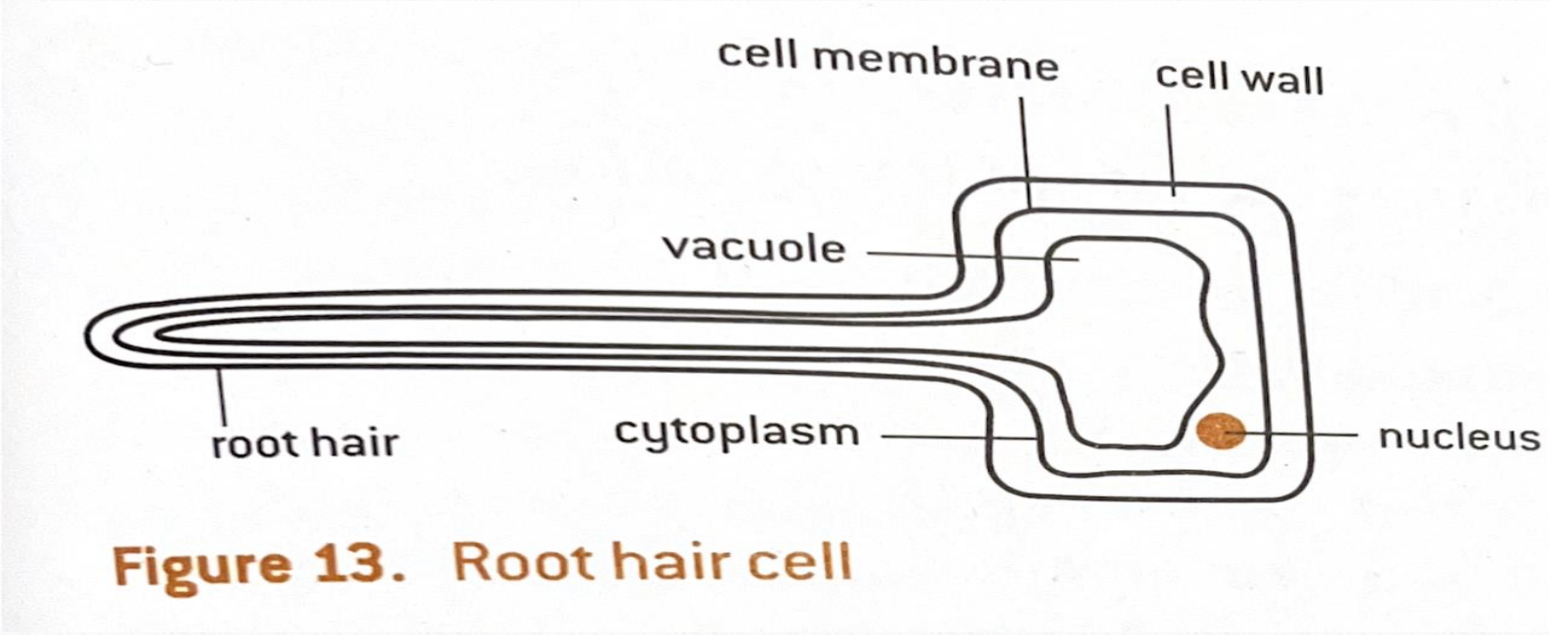


Figure 13. Root hair cell

•Water vapour evaporates from the spongy mesophyll cells and is lost via the stomata.

Evaporation of water vapour via the stomata is called transpiration.

•Water lost is replaced from the xylem.

• This causes water from the roots to be pulled upward through the xylem. This pulling of water from the roots to the leaves against the force of gravity is called the transpiration stream.

The unique properties of water allow water to be pulled upward through the xylem because:

• Water molecules are cohesive; which means they can stick together. This is due to hydrogen bonding. This allows water to be drawn up the xylem tube.

•Water molecules are adhesive; which means they adhere to the wall of the xylem. This is due to their polarity. This helps to keep water within the xylem.

Transpiration *(factors that affect transpiration)*

There are four factors that affect the rate of transpiration: **light, humidity, temperature and wind.**

Light causes the stomata to open and therefore increases the rate of evaporation, which increases the rate of photosynthesis. However, in very dry conditions the stomata may close to reduce transpiration and water loss.

Humidity describes the concentration of water vapour in the atmosphere. When conditions are humid, there is a higher concentration of water vapour in the air than in the leaf. This causes a decrease in the rate of evaporation of water vapour from the leaf and therefore a decrease in transpiration rate.

As **temperature** rises, the transpiration rate increases. This is because increased temperature increases the rate of evaporation and the diffusion of water vapour from the leaf to the air outside.

Wind increases the transpiration rate. Wind blows away water vapour around the leaf, allowing for more effective diffusion of water vapour out of the leaf.

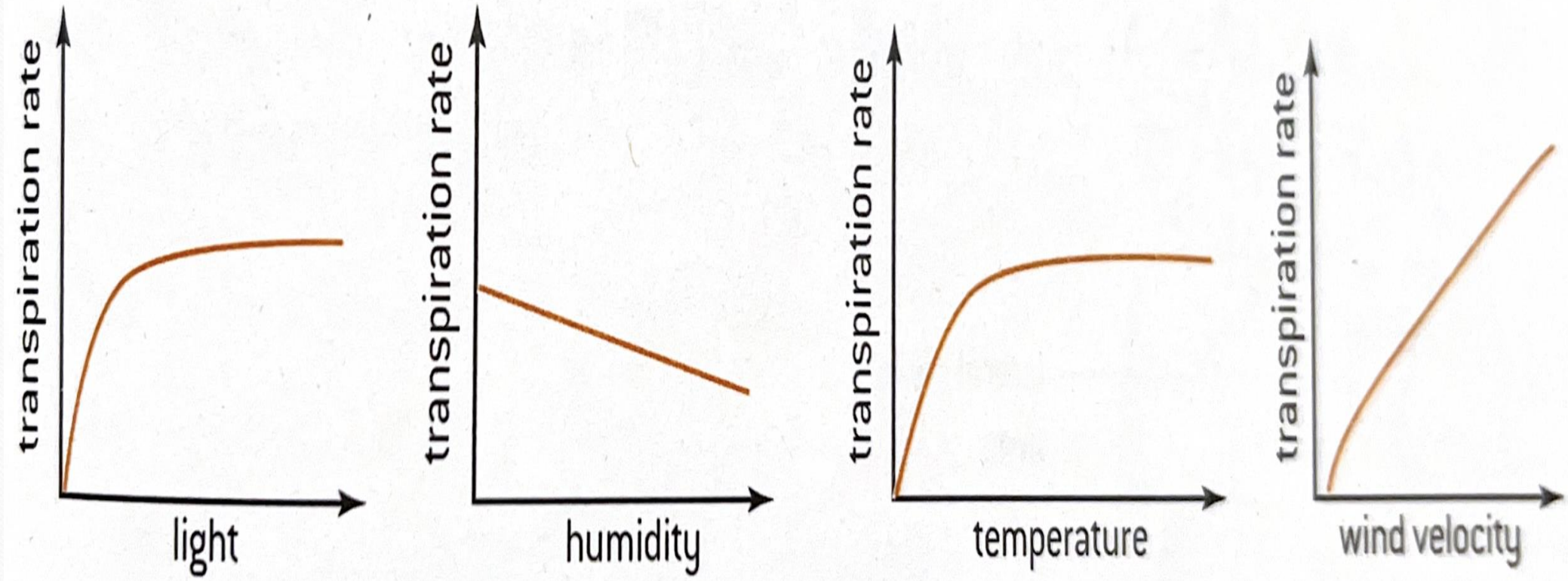


Figure 14. Factors affecting rate of transpiration

Practical skills: Measuring the rate of transpiration

A potometer is used to measure the rate of transpiration.

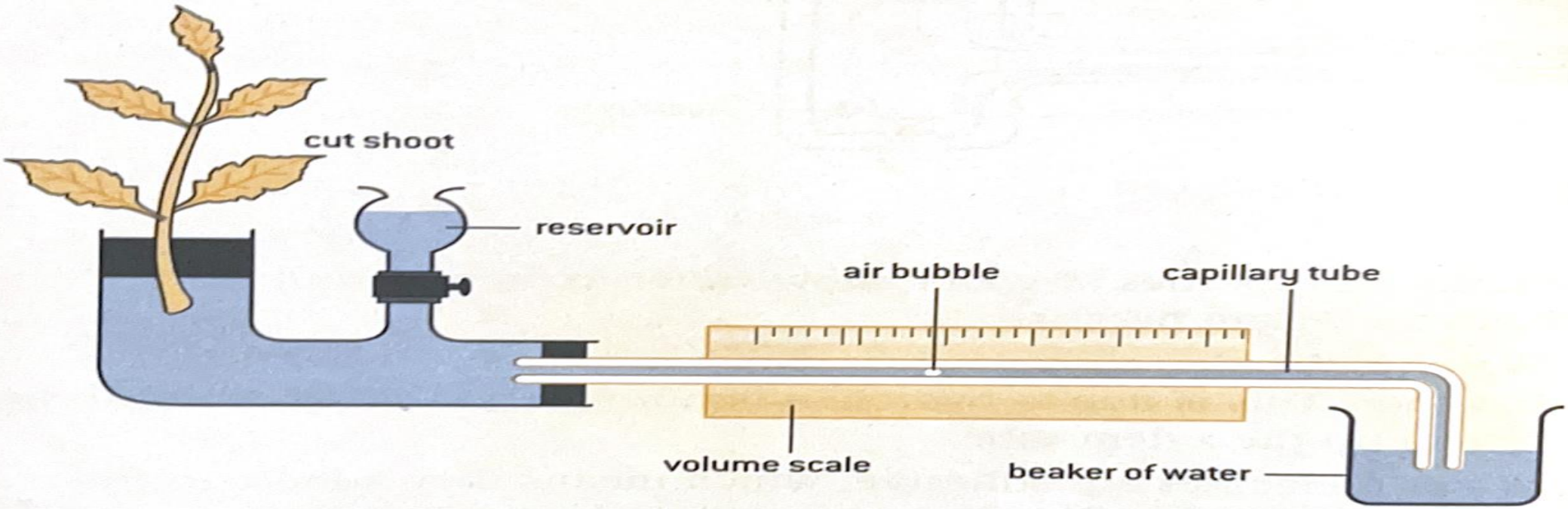


Figure 15. Potometer

The potometer measures the amount of water lost via transpiration. As water evaporates from the leaves, water moves up through the plant, causing the air bubble to move along the scale. This gives a measure of the volume of water absorbed by the plant (figure 15). Transpiration rate is the volume of water absorbed by the plant over a period of time.

Transport in phloem

In contrast to xylem, phloem consists of living tissue. The phloem tissue is made up of sieve tubes and companion cells (figure 16).

Key term

Active translocation *is the process by which organic compounds in photosynthetic tissue or storage organs are moved into phloem sieve tubes. This process requires ATP.*

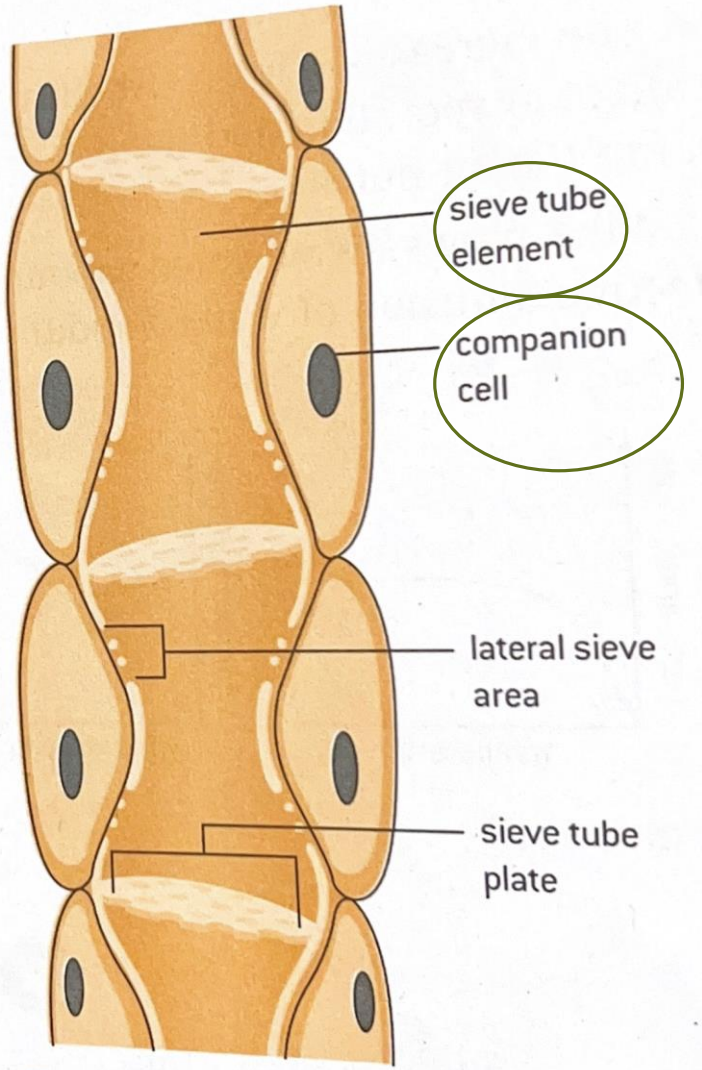


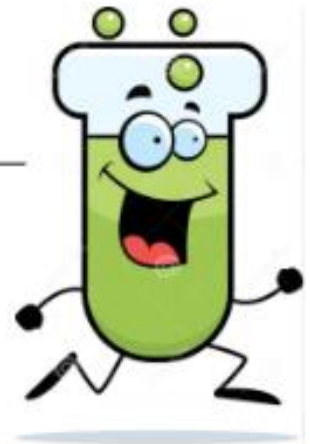
Figure 16. Phloem structure

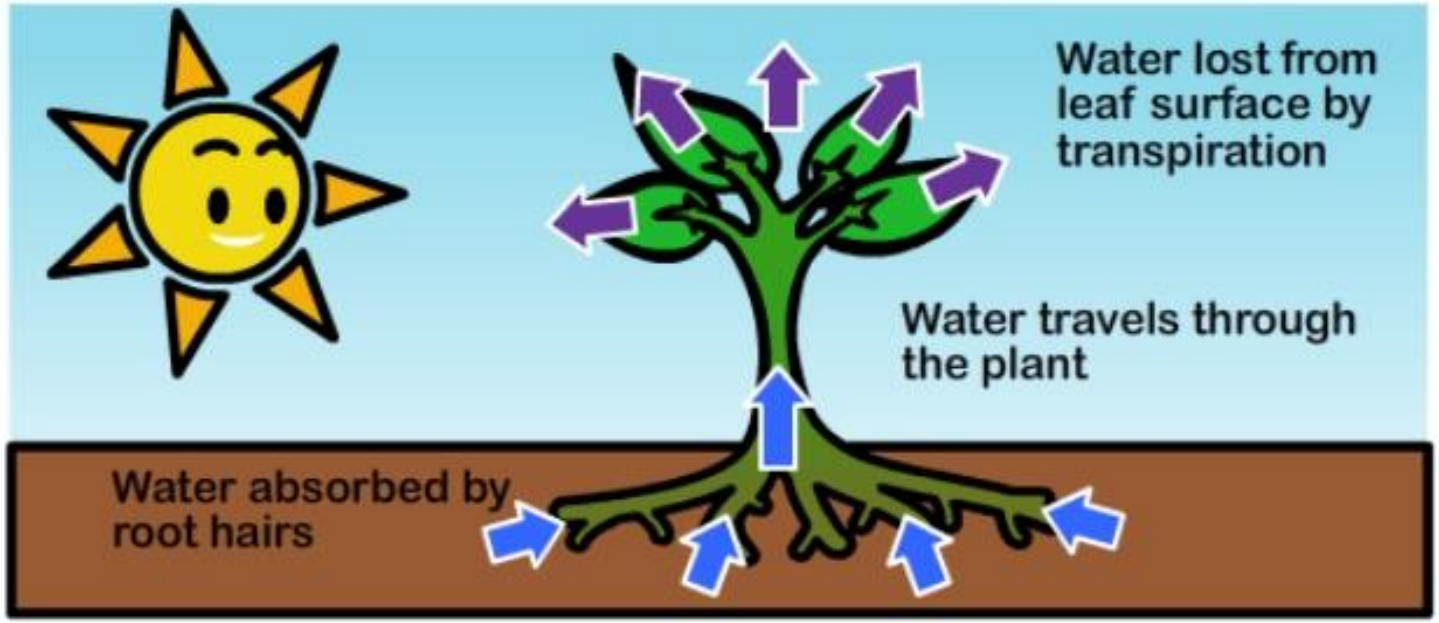
One of the first carbohydrates to be made in photosynthesis is **glucose**. There are several things that may happen to it

Some of the glucose made in leaves is changed into the complex sugar sucrose. Sucrose is carried to all parts of the plant including the roots. Amino acids are also carried in the phloem tubes. **The transport of substances in the phloem is called Translocation**

Leaves are **the main source of carbohydrates,** so they are referred to as **source**. From leaves, carbohydrates are carried to the other parts of the plant that stores starch or cannot photosynthesize; these parts are referred to as **Sinks.**

Transpiration Experiments





Experiment 1 https://www.youtube.com/watch?v=FWxh28CTEcM

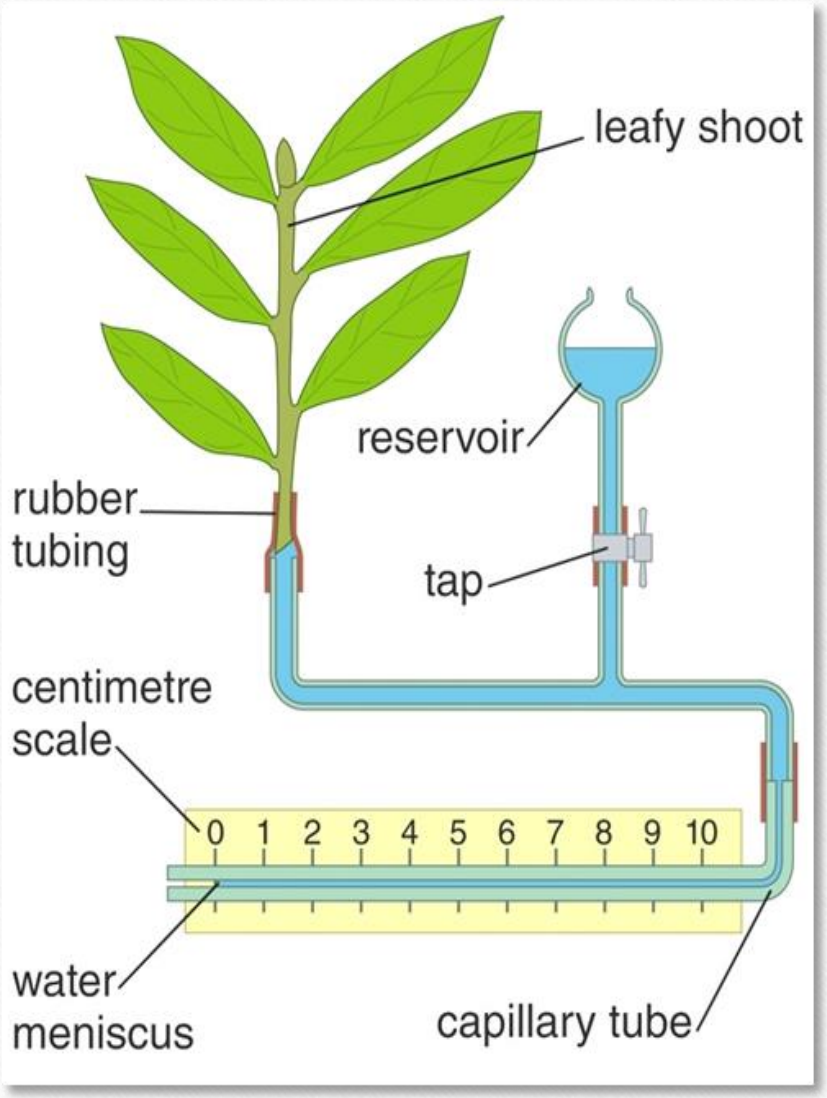
Rates of water uptake in different conditions:

This is done by an apparatus called "potometer (or Transpirometer) which is designed to measure the rate of water uptake in a cut shoot at different conditions (CHANGING ONE FACTOR AT A TIME).

This is done by cutting a plant shoot and placing it in a graduated capillary tube (representing the xylem) that contains water as shown in the figure below.

How can we use this apparatus to calculate the rate of transpiration (the speed at which water is lost from the plant)?

- As the shoot transpires, it will start withdrawing water from the capillary tube and water will start to move along the capillary tube to compensate for the water loss from the leaves.
- Water reservoir is used to refill the capillary tube with water to return the meniscus to the starting point



How can we measure rate of transpiration?

$$\frac{\text{Distance moved by water meniscus}}{\text{Time Taken}}$$

Using a potometer

Factors Affecting Transpiration rate

Humidity-- Wrapping the shoot with a plastic bag	Light Intensity -- varying the distance of the lamp	Temperature-- Placing the plant at different temperatures	Air Movement--- Using a fan to create different wind speeds

If you want to study the effect of one factor → keep the other Factors constant! → Fair Test

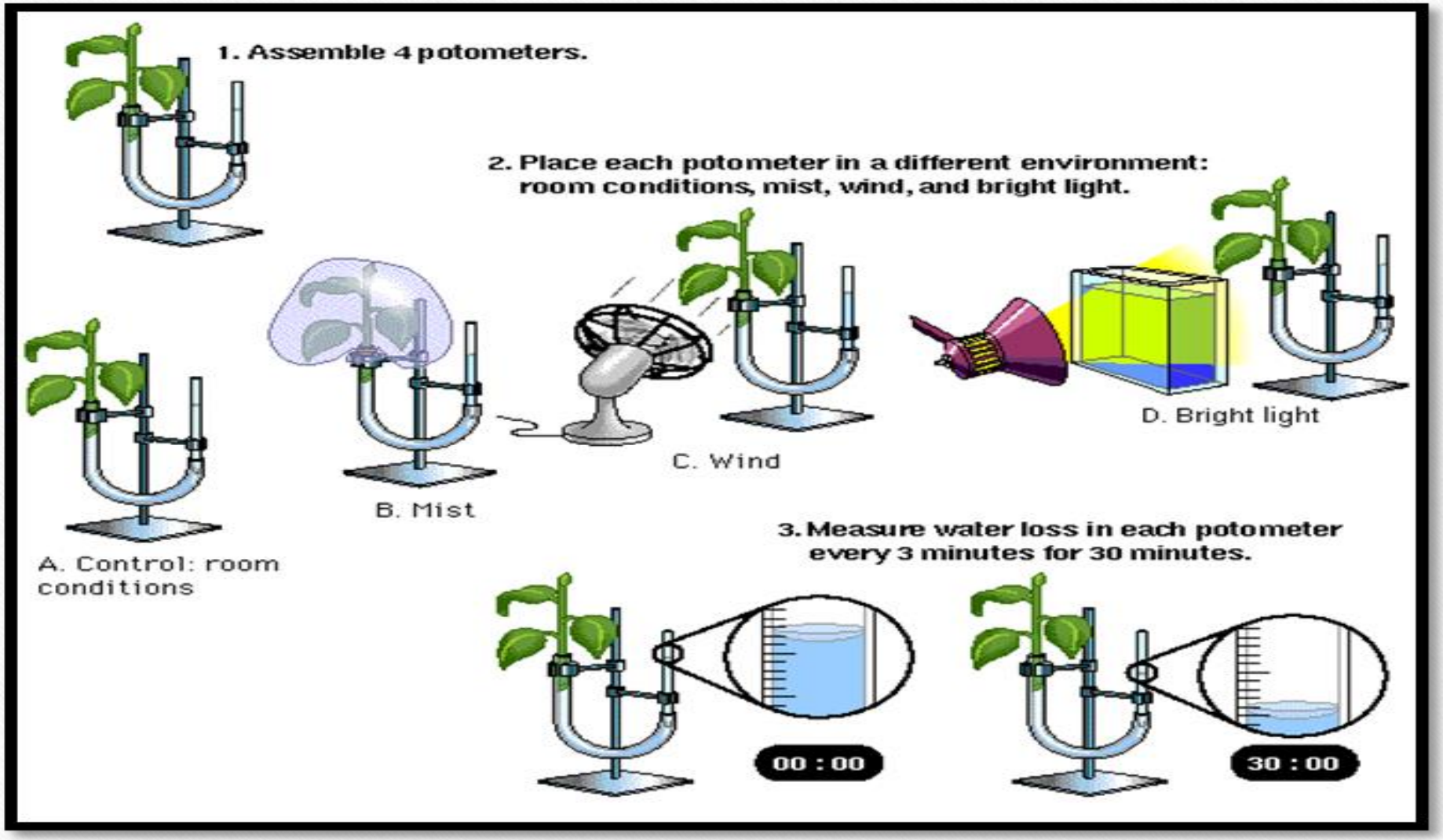
Notes to remember :

1. Blow air past the shoot with electric fan or using your book (Remember that in moving air the rate of transpiration increases, so water will move faster along the capillary tube)

2. Cover the shoot with a plastic bag (this increases humidity which will decrease the rate of transpiration by decreasing the diffusion gradient)

3. Move the apparatus to sunlight (Light intensity increases so rate of photosynthesis increases as a result, the stomatal pores open thus more water vapour is lost through them (Rate of transpiration increases)

*** A change in condition may take 10-15 minutes before it produces a new steady rate of uptake**


1. Assemble 4 potometers.
2. Place each potometer in a different environment: room conditions, mist, wind, and bright light.
A. Control: room conditions
B. Mist
C. Wind
D. Bright light
3. Measure water loss in each potometer every 3 minutes for 30 minutes.
00 : 00
30 : 00

Limitations of potometer :

1) Not all the water taken up will be transpired → however, these quantities are very small compared with the volume of water transpired so they can be disregarded
2) If the root system were present, it might offer resistance to the flow of water, or it could be helping the flow by means of its root pressure

Mass Potometer for measuring the rate of transpiration

Fig. 3.1 shows a simple apparatus to investigate the rate of transpiration by recording the mass of a potted plant over a period of time.

Fig. 3.2 shows the results over a number of hours.

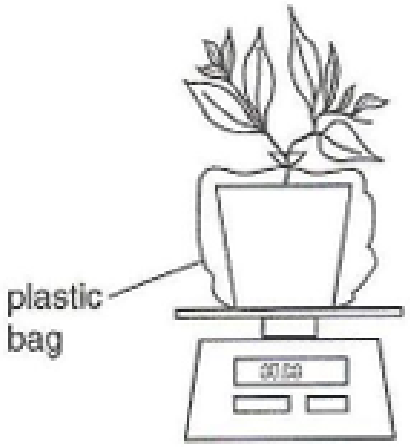


Fig. 3.1

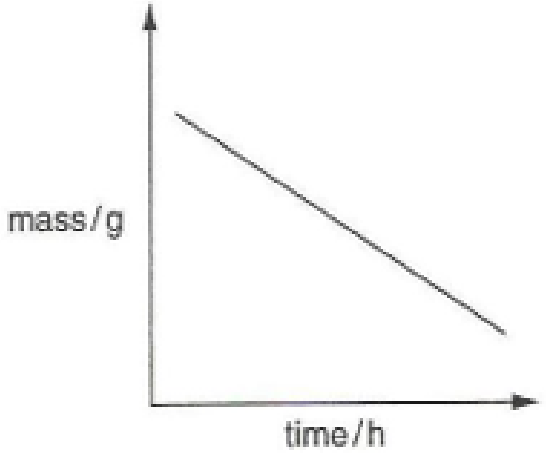
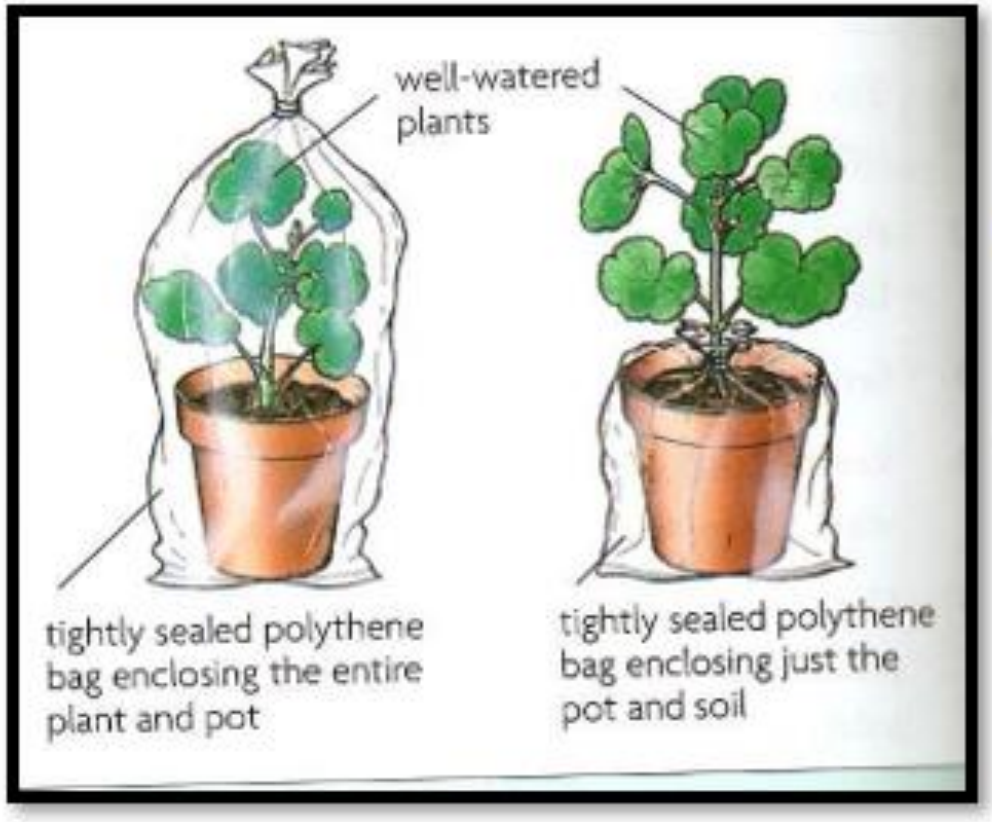


Fig. 3.2

To compare the rates of transpiration for two different plants:

1) Temperature should be the same for both
2) Same air movement
3) Same time for reading
4) Same conditions of light

The pot in enclosed in plastic bag to minimize loss of water from the soil by evaporation



Question:

Use two **similar potted** plants, enclose one plant entirely, and enclose only the pot of the second plant. Place both plants on balances, and record the mass of each every day at the same time for at least a week.

- Which one do you think will lose mass? And why?

Experiment 2

How to know which surface of a leaf loses more water ?

Procedure:

1) Get 4 leaves

2) Leaf A: smear a layer of Vaseline on the lower surface

3) Leaf B: smear a layer of Vaseline on the upper surface

4) Leaf C: smear a layer of Vaseline on the both surfaces

5) Leaf D: No Vaseline on either.

* Place a little Vaseline on the cut end of the leaf stalk.

Note: Vaseline Prevents evaporation.

All leaves will have shriveled to some extent but the ones that had lost more water will be the most shriveled.

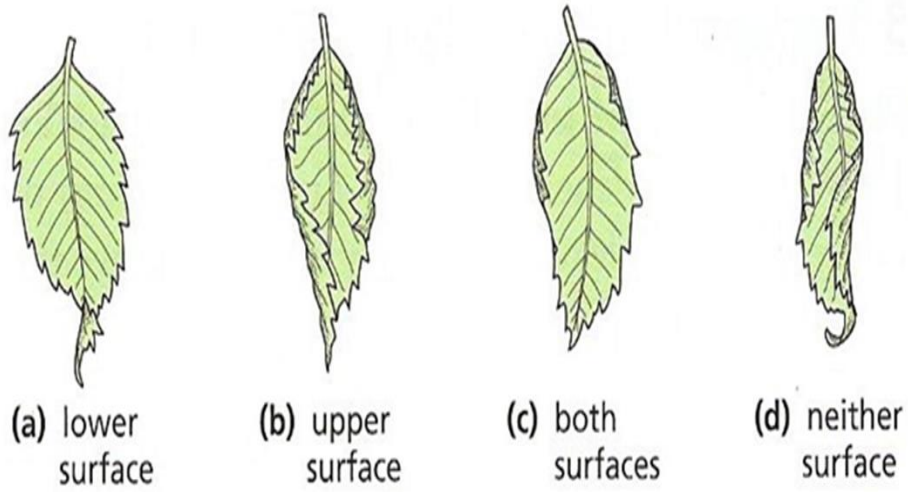


Figure 7.9 The results of evaporation from leaves subjected to different treatments

Results :

The untreated leaf and the leaf with its upper surface sealed will show the greatest degree of wilting.

✓ **This proves that most evaporation occurs from the lower epidermis of the leaf.**

- **For more accurate results** :

Weigh the leaves at the beginning of the experiment and then again at the end, the leaf that has lost more weight is the one from which more water had evaporated.

For more rapid results:

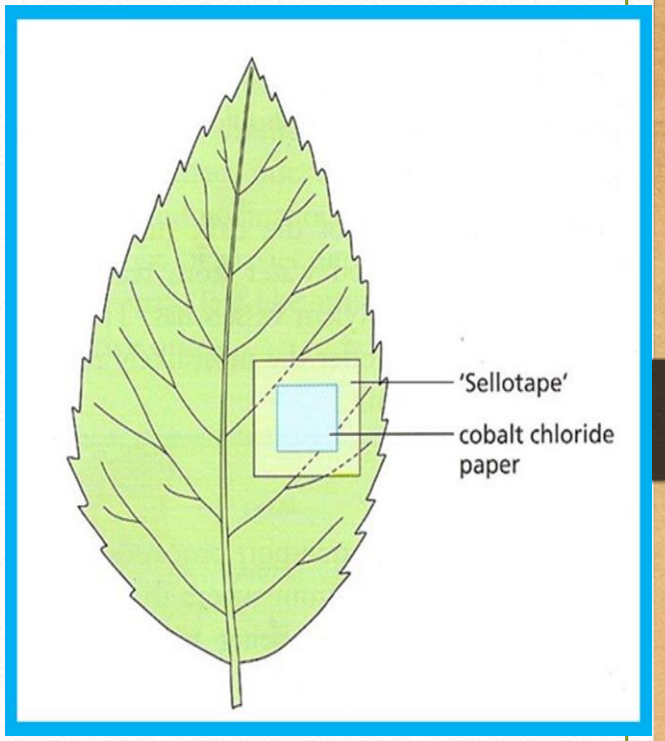
Use cobalt chloride: stick small squares of cobalt chloride on both surfaces of a leaf (***These are handled with forceps to avoid dampness from the fingers affecting its colour***

- Cobalt chloride is **blue** when anhydrous (dry) and turns **pink** when hydrated (moist).

Thus when evaporation of water from the leaf takes place water will touch the dry anhydrous cobalt chloride squares and hydrates them (moistens them) so they turn pink up on contact with water.

So the surface that changes color faster is the surface from which water evaporates more (Higher rate of transpiration).

The results from the last two experiments can be correlated with the number of stomata the surface that loses more water contains more stomata. But these only give you a qualitative comparison.



For Quantitative results , you have to count the number of stomata on both the upper and lower epidermis

How can we count the number of stomata?

This is done by painting a clear nail varnish on both surfaces of the leaf.

Wait until it dries, then peal it off carefully

Add a dye to be able to see the outline of guard cells easily.

Using the magnifying power of the microscope examine the samples.

Compare the number of stomata found on the upper surface with those found on the lower surface.