Edexcel GCSE Biology

Your notes

Transport in Plants

Contents

Your notes

Transport of Water & Mineral Ions

- The structure of root hair cells, xylem and phloem are adapted to their functions
- The **roots**, **stem** and **leaves** form a plant organ system for transport of substances around the plant

Functions of xylem & phloem

- Plants contain two types of transport vessel: **xylem** and **phloem**
- Xylem *(pronounced: zi-lem)* vessels:
  - Transport water and minerals from the roots to the stem and leaves
  - Are composed of hollow tubes strengthened by lignin adapted for the transport of water in the transpiration stream
- Phloem *(pronounced: flow-em)* vessels:
  - Transport food materials (mainly sucrose and amino acids) made by the plant from photosynthesising leaves to non-photosynthesising regions in the roots and stem
- Xylem and phloem vessels are arranged throughout the root, stem and leaves in groups called vascular bundles

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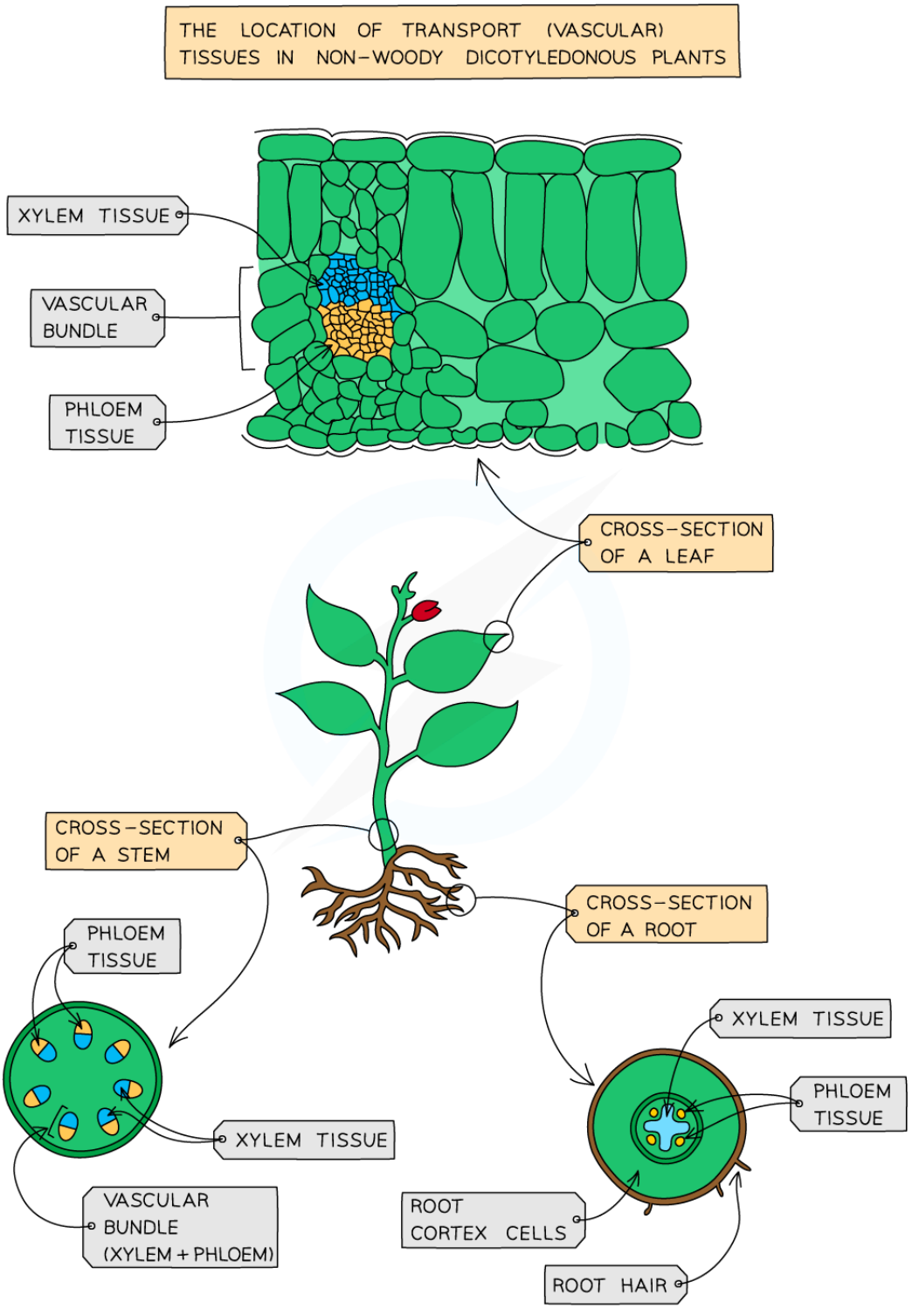

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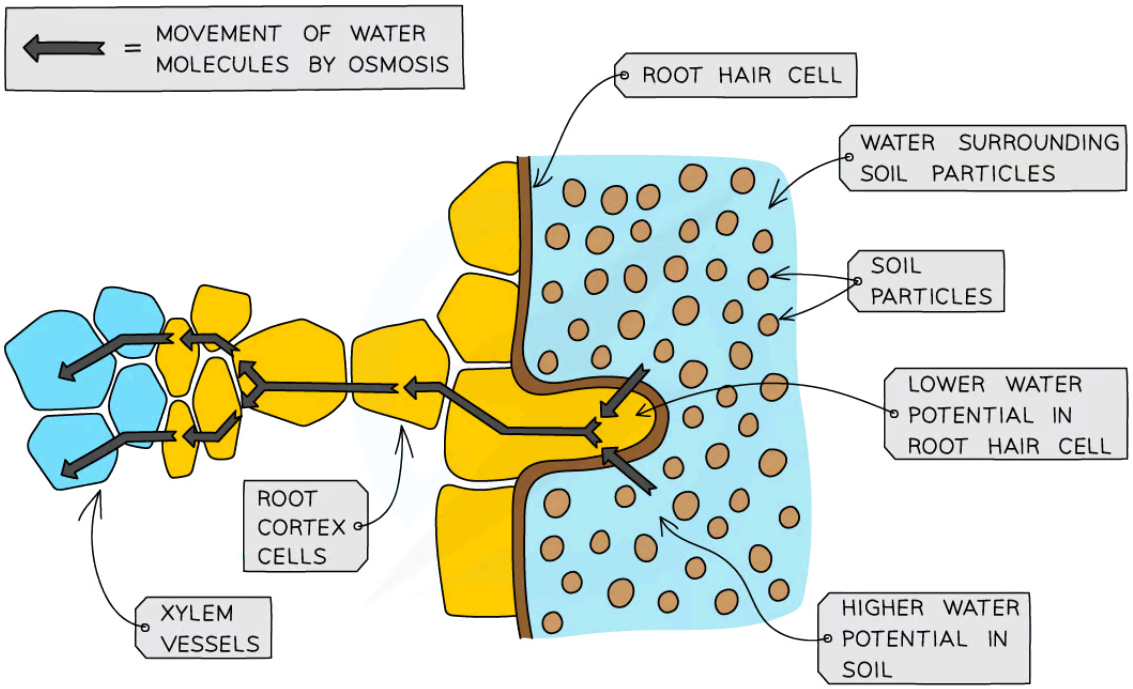
The location of vascular tissues in the stem and roots of a plant

- Osmosis causes water to pass into the root hair cells, through the root cortex and into the xylem vessels:



Pathway of water into and across a root

- Once the water gets into the xylem, it is carried up to the leaves where it enters mesophyll cells
- The pathway is:

root hair cell → root cortex cells → xylem → leaf mesophyll cells

Stomata and guard cells

- **Stomata** (specifically the **guard cells**) control the diffusion of gases in and out of leaves
  - This means stomata **control the entry of carbon dioxide** into leaves
- Stomata **open** and **close** in a **daily rhythm**

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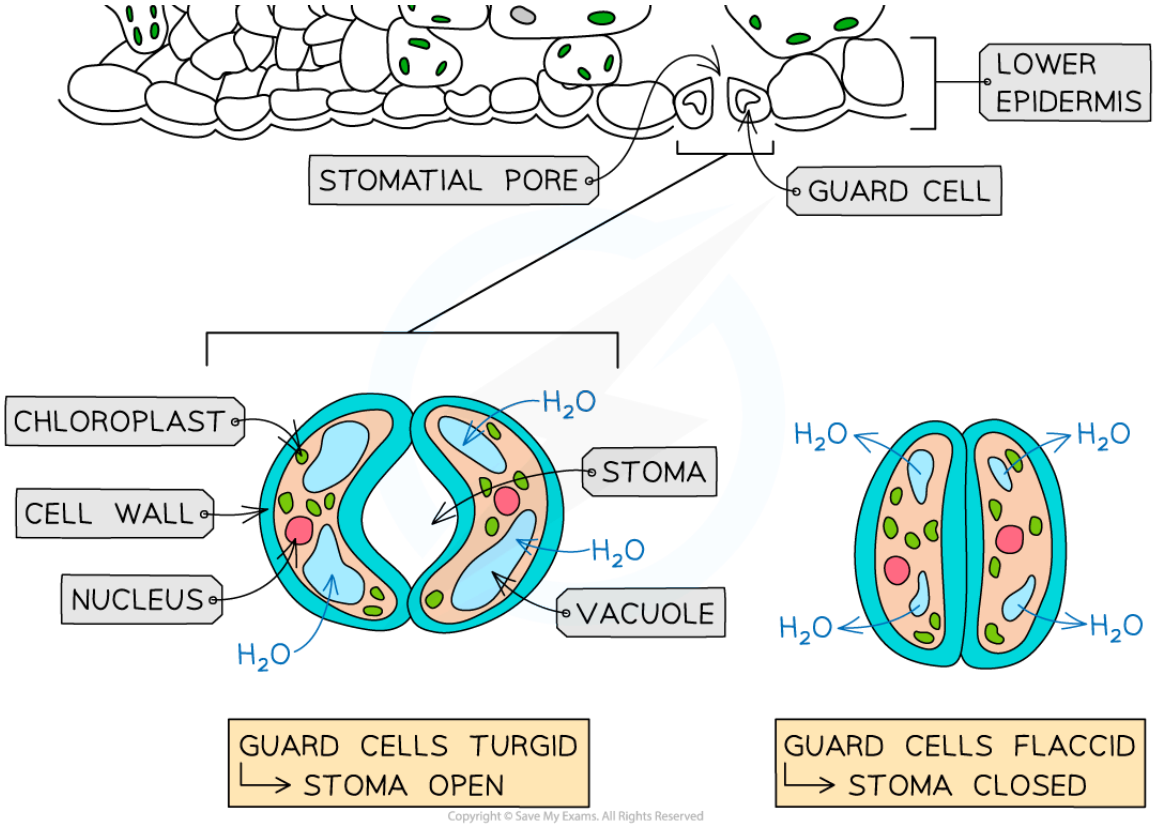
- Even when the plant is kept in **constant light** or **constant darkness**, the daily rhythm of opening and closing of the stomata continues
- Opening of stomata **during the day**:
  - Maintains the **inward diffusion of carbon dioxide** and the **outward diffusion of oxygen**
  - Allows the **outward diffusion of water vapour** in **transpiration**
- Closing of stomata **at night** when photosynthesis cannot occur:
  - **Reduces** the rate of **transpiration**
  - Conserves water



Guard cells and the stomata. When the guard cells are turgid the stoma is open. Once the guard cells lose water by osmosis and become flaccid, the stoma closes.

Transpiration

- Transpiration is defined as the **loss of water vapour from the parts of the plant that are above ground** (leaves, stem, flowers)

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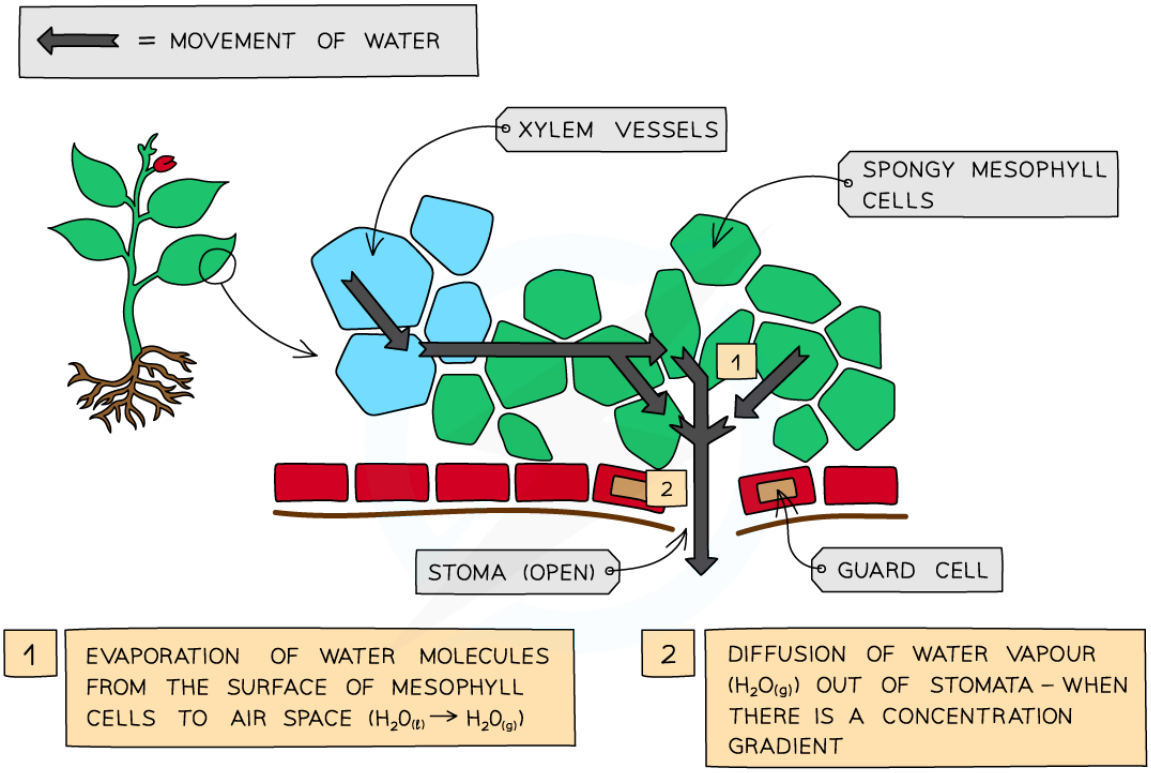
- Loss of water occurs through **evaporation** of water at the surfaces of the **spongy mesophyll cells** followed by diffusion of **water vapour** through the **stomata**
- The **many interconnecting air spaces** between the mesophyll cells and the stomata creates a **large surface area**
- This means evaporation can happen rapidly when the **stomata are open**



Transpiration in plants

- **Water** moves through the **xylem** vessels in a continuous **transpiration stream** from the roots to the leaves via the stem to replace the water that has been lost due to **transpiration**
- Due to **cohesion,** the water in the xylem creates a **continuous unbroken column** (each individual molecule 'pulls' on the one below it)
- Transpiration produces **tension** or 'pulls' on the water in the xylem vessels

- If the rate of transpiration from the leaves **increases**, water molecules are pulled up the xylem vessels **quicker**

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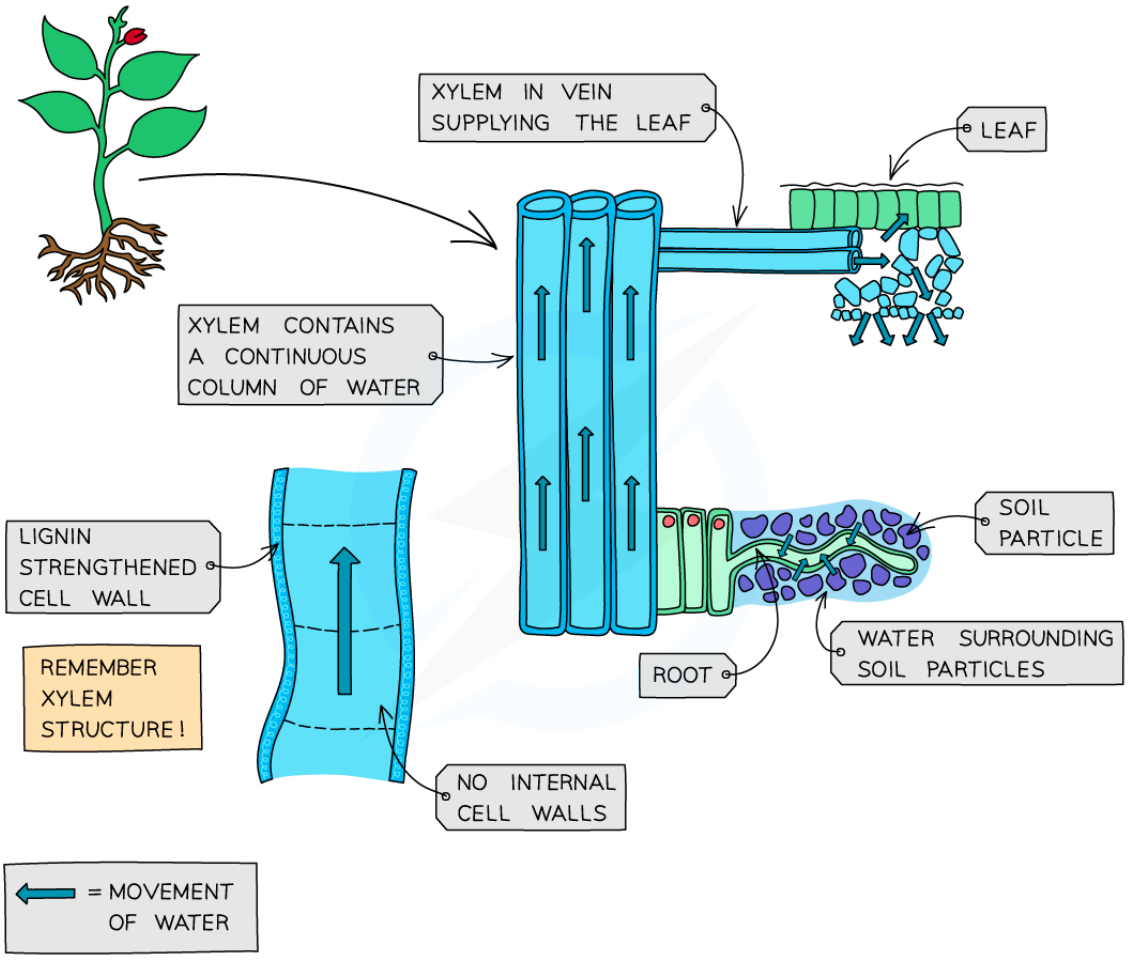

Water uptake, transport and transpiration

The function of transpiration

- Transpiration has several functions in plants:
  - Transporting **mineral ions**
  - Providing **water to keep cells turgid** in order to support the structure of the plant
  - Providing **water** to leaf cells for **photosynthesis**

- Keeping the **leaves cool,** the conversion of water (liquid) into water vapour (gas) as it leaves the cells and enters the airspace requires heat energy. The use of heat to convert water into water vapour helps to cool the plant down


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Factors Affecting the Rate of Water Uptake

- There are several **environmental conditions** that have an impact on the **rate of transpiration or water uptake**
  - **Air movement**
  - **Humidity**
  - **Light intensity**
  - **Temperature**
- The table below explains how these four factors affect the rate of transpiration when they are all **high**; the **opposite effect** would be observed if they were **low**

Factors Affecting the Rate of Transpiration Table

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Factor	Condition	Effect on the rate of transpiration (more/less)
Air movement	High	More – good airflow removes water vapour from the air surrounding the leaf which sets up a concentration gradient between the leaf and the air, increasing water loss
Humidity	High	Less – humidity is a measure of moisture (water vapour) in the air; when the air is saturated with water vapour the concentration gradient is weaker so less water is lost
Light intensity	High	More – guard cells are responsive to light intensity; when it is high they are turgid and the stomata open allowing water to be lost
Temperature	High	More – at higher temperatures, particles have more kinetic energy so transpiration occurs as a faster rate as water molecules evaporate from the mesophyll and diffuse away faster than at lower temperatures

Investigating the effect of environmental factors on the rate of transpiration

- We can investigate the effect of different environmental conditions (such as temperature, humidity, light intensity and wind movement) on the **rate of transpiration** using a piece of apparatus called a **potometer**
- There are 2 types of potometer:
  - A **mass potometer** measures a change in mass of a plant as a measure of the amount of water that has evaporated from the leaves and stem

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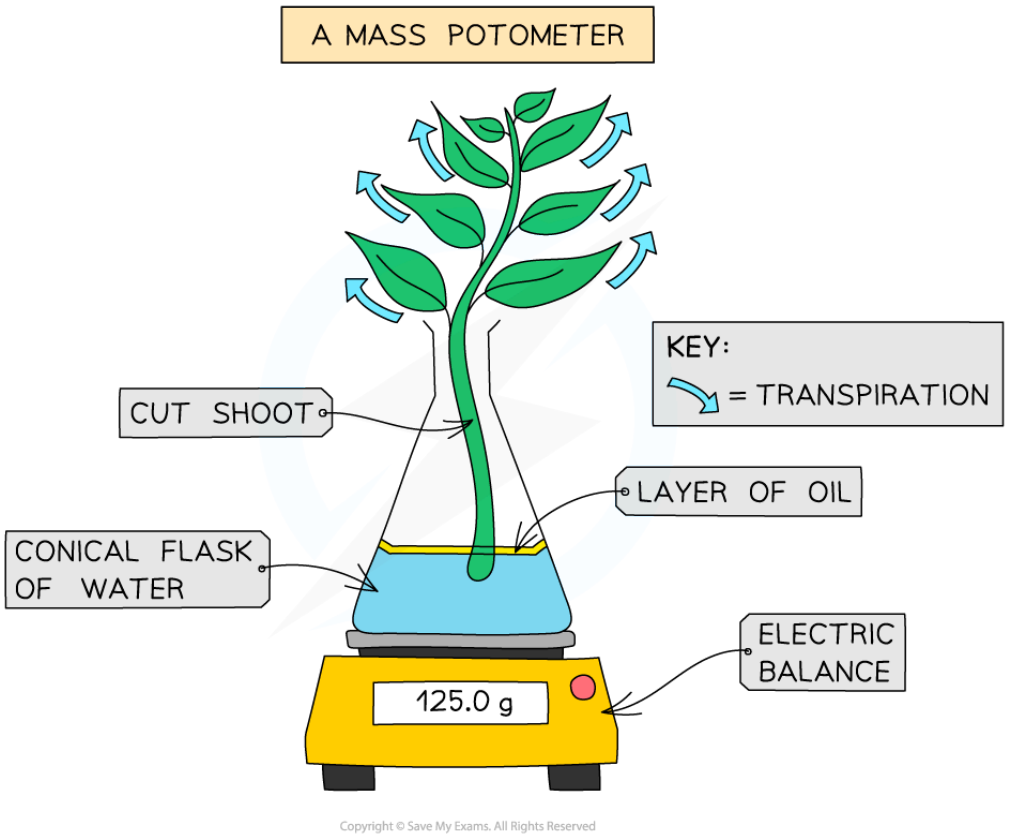
- A **bubble potometer** measures the uptake of water by a stem as a measure of the amount of water that is being lost by evaporation consequently pulling water up through the stem to replace it



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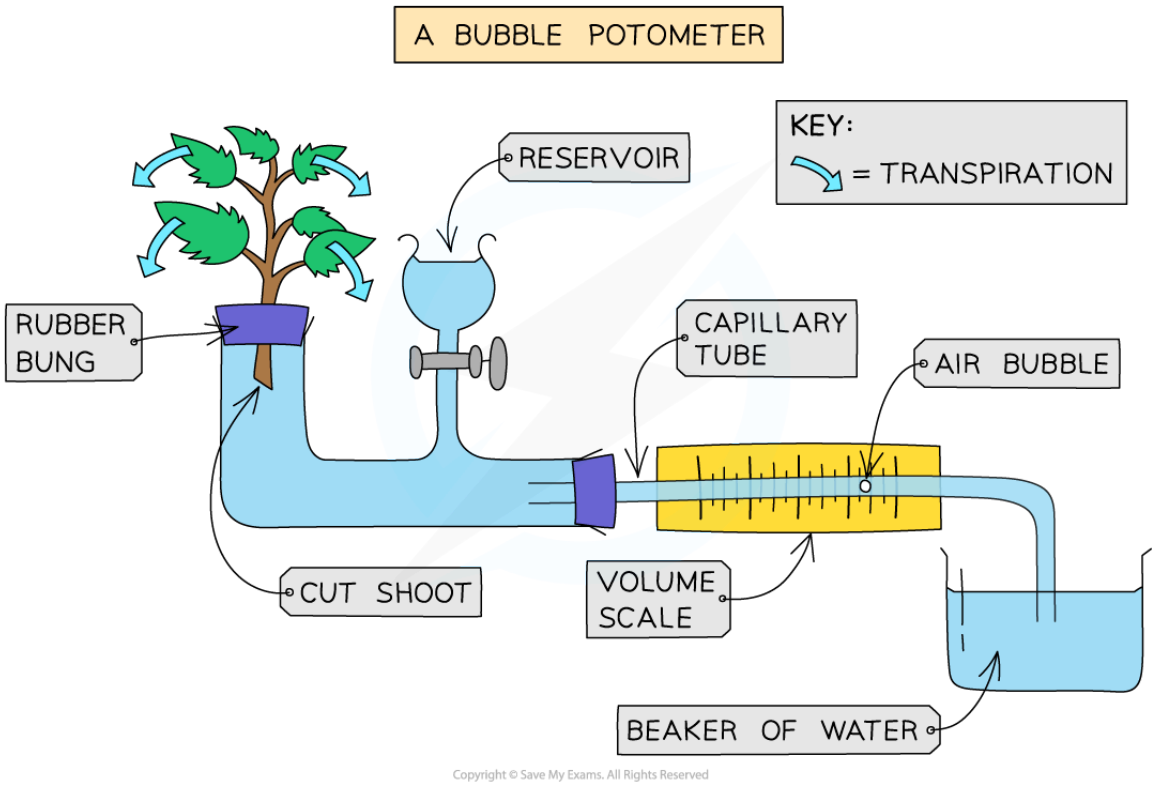

There are 2 different types of potometer that could be used to investigate the effect of environmental conditions on transpiration

Apparatus

- Potometer (bubble or mass potometer)
- Timer
- Lamp
- Ruler
- Plant

Method

- Cut a shoot underwater
  - To **prevent air entering the xylem** and place in tube

- Set up the apparatus as shown in the diagram and make sure it is airtight, using Vaseline to seal any gaps
- Dry the leaves of the shoot
  - Wet leaves will affect the results
- Remove the capillary tube from the beaker of water to allow a single **air bubble** to form and place the tube back into the water
- Set up a lamp 10 cm from the leaf
- Allow the plant to adapt to the new environment for 5 minutes
- Record the **starting location** of the air bubble
- Leave for 30 minutes
- Record the **end location** of the air bubble
- Change the light intensity
- Reset the bubble by opening the tap below the reservoir
- Repeat the experiment
- Calculate the rate of transpiration by dividing the distance the bubble travelled by the time period
  - The **further the bubble travels in the same time period, the greater the rate of transpiration**

$$\text{RATE OF TRANSPIRATION} = \frac{\text{DISTANCE MOVED BY AIR BUBBLE (m)}}{\text{TIME (min)}}$$

Calculating the rate of transpiration using a bubble potometer

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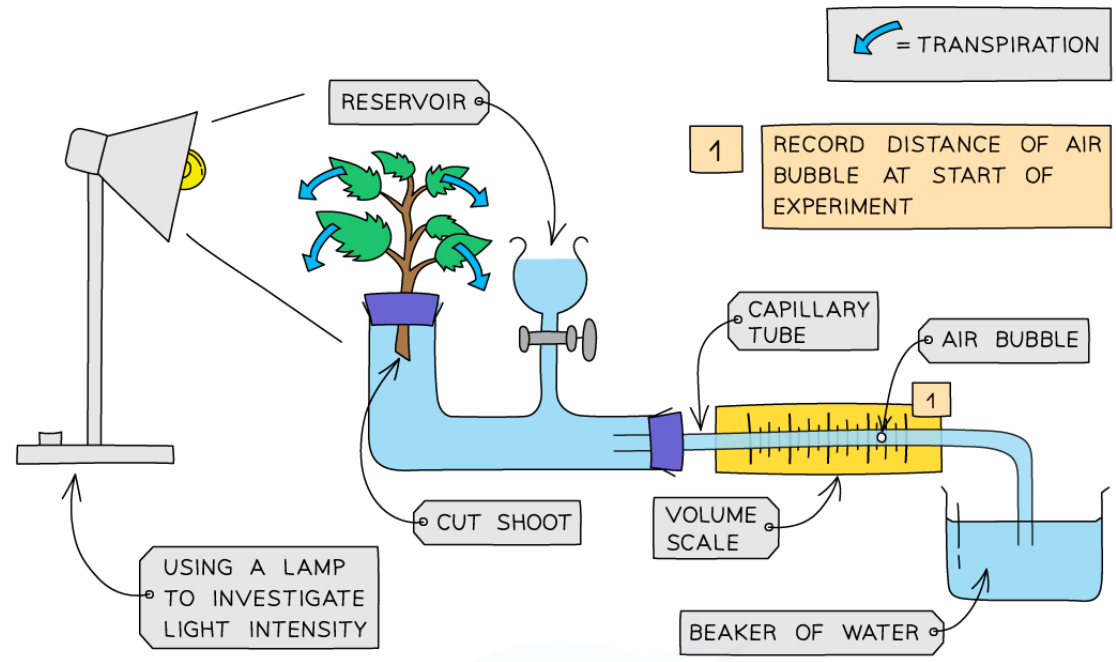

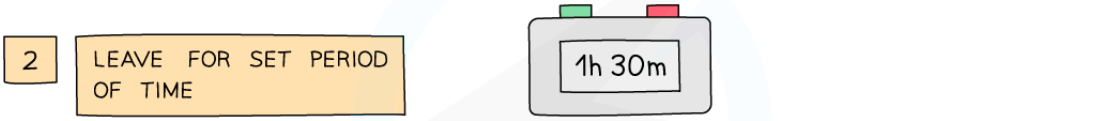

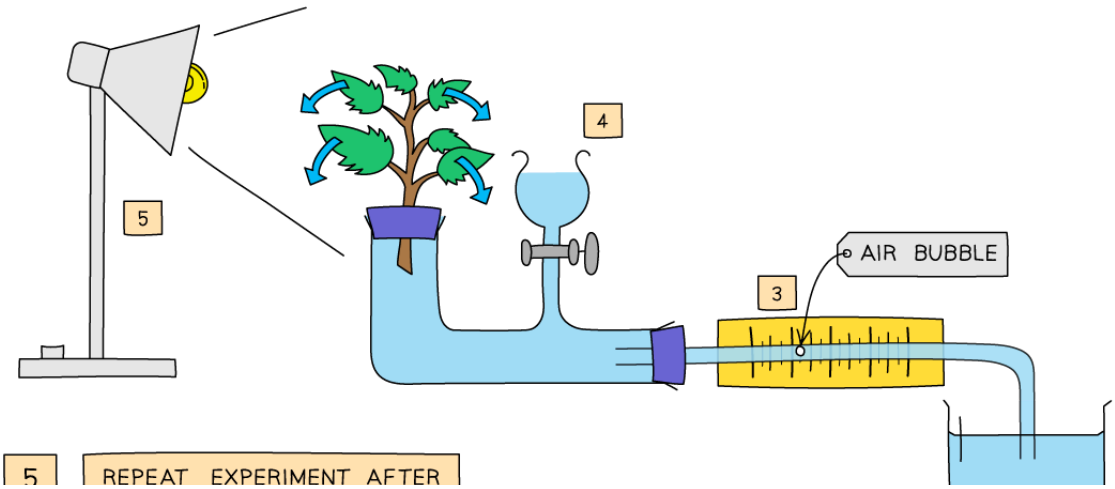

Investigating transpiration rates using a potometer

- Other environmental factors can be investigated in the following ways:
  - **Airflow**: Set up a fan or hairdryer to blow air over the plant (this investigation can be extended by putting the fan at different distances from the plant or at different fan-speed settings)
  - **Humidity**: Spray water in a plastic bag and enclose the plant within the bag
  - **Temperature**: Change the temperature of room (e.g. cold room or warm room)

Results

- As **light intensity increases, the rate of transpiration increases**
- This is shown by the bubble moving a **greater distance** in the 30 minute time period when the lamp was placed **closer to the leaf**
- Transpiration rate increases with light intensity because **more stomata** tend to be **open** in bright light in order to maximise photosynthesis
- The more stomata that are open, the **more water** can be lost by evaporation and diffusion through the stomatal pores

Limitations

- The potometer equipment has a leak
  - Solution: Ensure that all equipment fits together rightly around the rubber bungs and assemble underwater to help produce a good seal
- The plant cutting has a blockage
  - Solution: Cut the stem underwater and assemble equipment underwater to minimise opportunities for air bubbles to enter the xylem
- The potometer has shown no change during the experiment
  - Solution: Use the plant cuttings as soon as they have been cut, as transpiration rates may slow down when the cuttings are no longer fresh

Applying CORMS to practical work

Your notes

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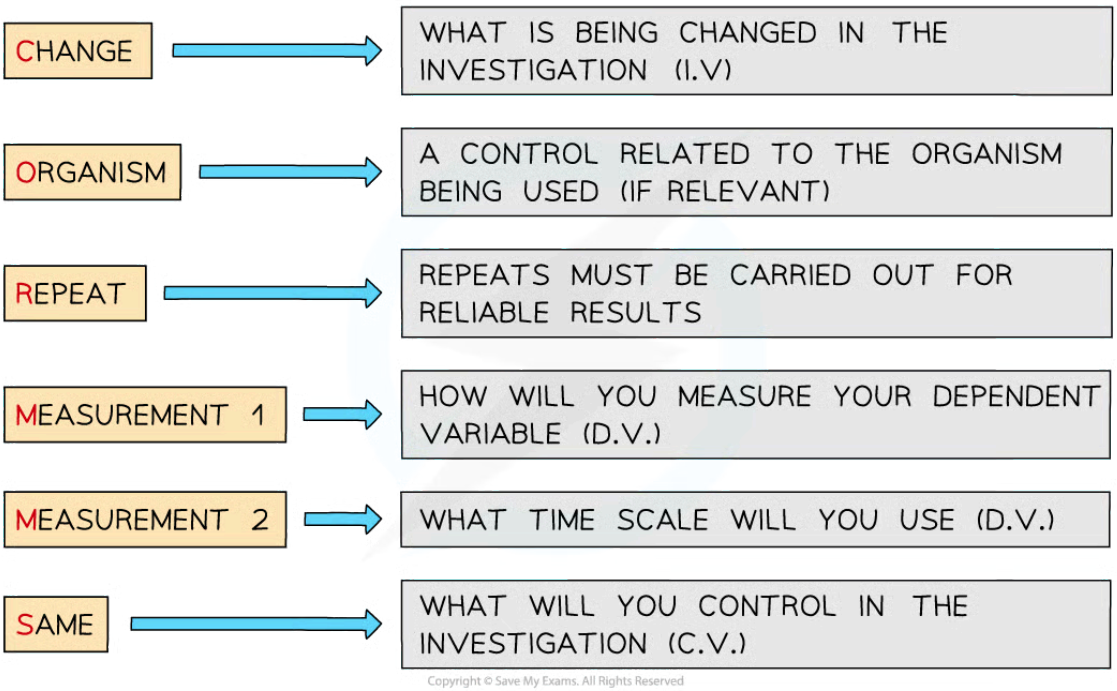
- When working with practical investigations, remember to consider your CORMS evaluation



CORMS evaluation

- In this investigation, there are several different variations of the method depending on which **environmental factor** you are testing. However, if testing the effect of light intensity, your evaluation should look something like this:
  - **Change** - We will change the intensity of the light
  - **Organisms** - The plants used in each repeat should be the same species, size, age, number of leaves
  - **Repeat** - We will repeat the investigation several times to ensure our results are reliable
  - **Measurement 1** - We will measure the distance travelled by the bubble
  - **Measurement 2** - ...in 30 minutes (calculate the **rate of transpiration**)
  - **Same** - We will control the temperature, wind speed and humidity of the environment

Examiner Tips and Tricks

Remember that calculating the 'rate of transpiration' provides both M1 and M2 in the CORMS evaluation as the rate is calculated based on a distance (M1) and time period (M2)

Your notes

Translocation

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Translocation

- The soluble products of photosynthesis are **sugars (mainly sucrose) and amino acids**
- These are transported around the plant in the **phloem tubes** which are made of living cells (as opposed to xylem vessels which are made of dead cells)
- The cells are joined end to end and contain holes in the end cell walls (called **sieve plates**) which allow **easy flow of substances** from one cell to the next
- The transport of sucrose and amino acids in the phloem, from regions of production to regions of storage or use, is called **translocation**
  - Translocation is an active process that requires energy
- Transport in the phloem **goes in many different directions** depending on the stage of development of the plant or the time of year; however, dissolved food is always transported from **source** (where it's made) to **sink** (where it's stored or used):
  - During **winter**, when many plants have no leaves, the phloem tubes may transport dissolved sucrose and amino acids from the storage organs to other parts of the plant so that respiration can continue
  - During a **growth period** (eg during the spring), the storage organs (eg roots) would be the source and the many growing areas of the plant would be the sinks
  - **After the plant has grown** (usually during the summer), the leaves are photosynthesizing and producing large quantities of sugars; so they become the source and the roots become the sinks – storing sucrose as starch until it is needed again

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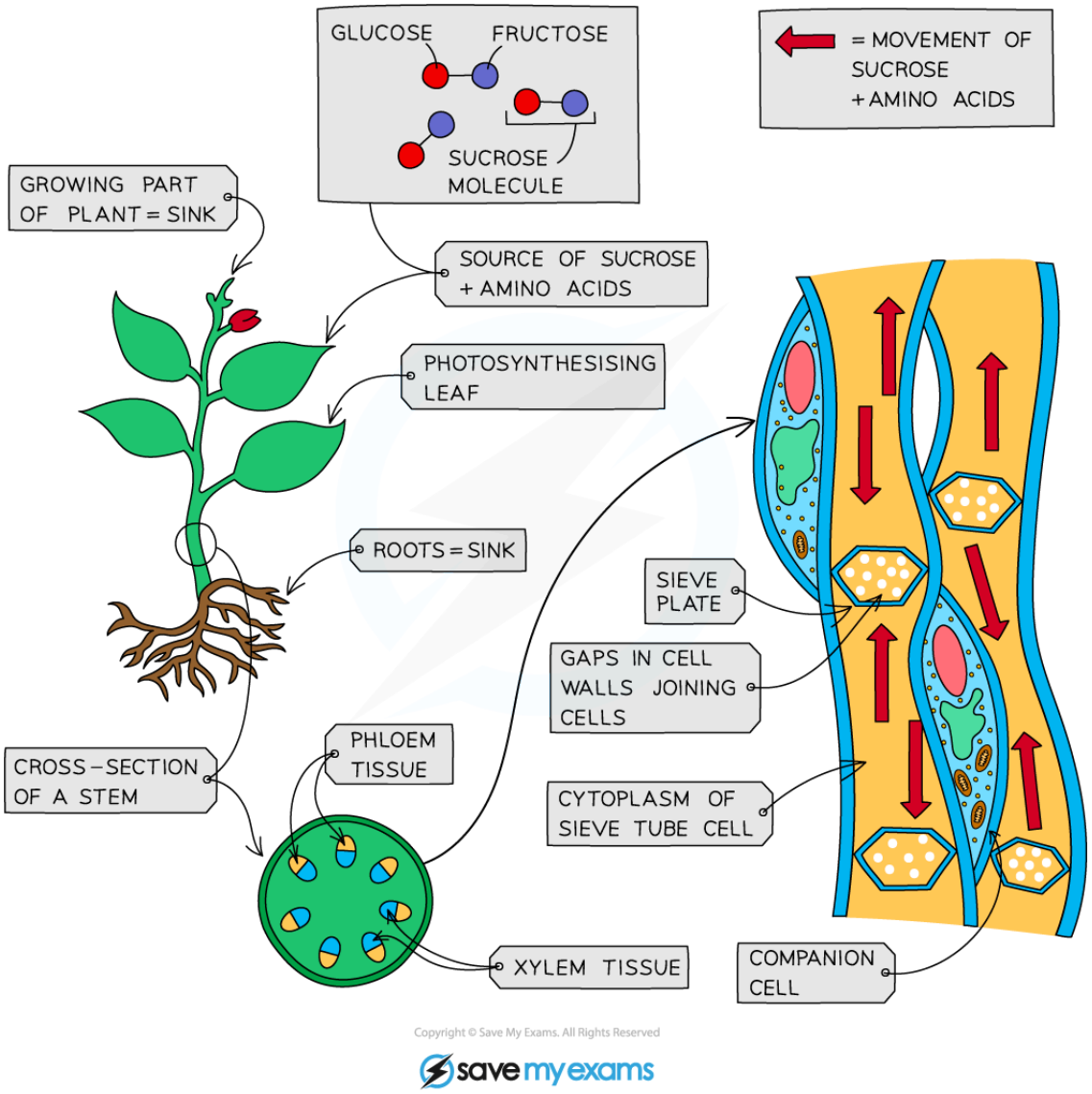

Translocation through the phloem

Comparison of Transport in the Xylem and Phloem Table

TISSUE	WHAT IS MOVED	PROCESS	DIRECTION OF FLOW	CELLS
XYLEM	WATER AND MINERAL IONS	TRANSPIRATION STREAM	ONE WAY FROM ROOTS TO LEAVES	DEAD
PHLOEM	SUCROSE AND AMINO ACIDS	TRANSLOCATION	IN ALL DIRECTIONS	LIVING


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