Cambridge (CIE) IGCSE Biology

Your notes

Transport in Plants

Contents

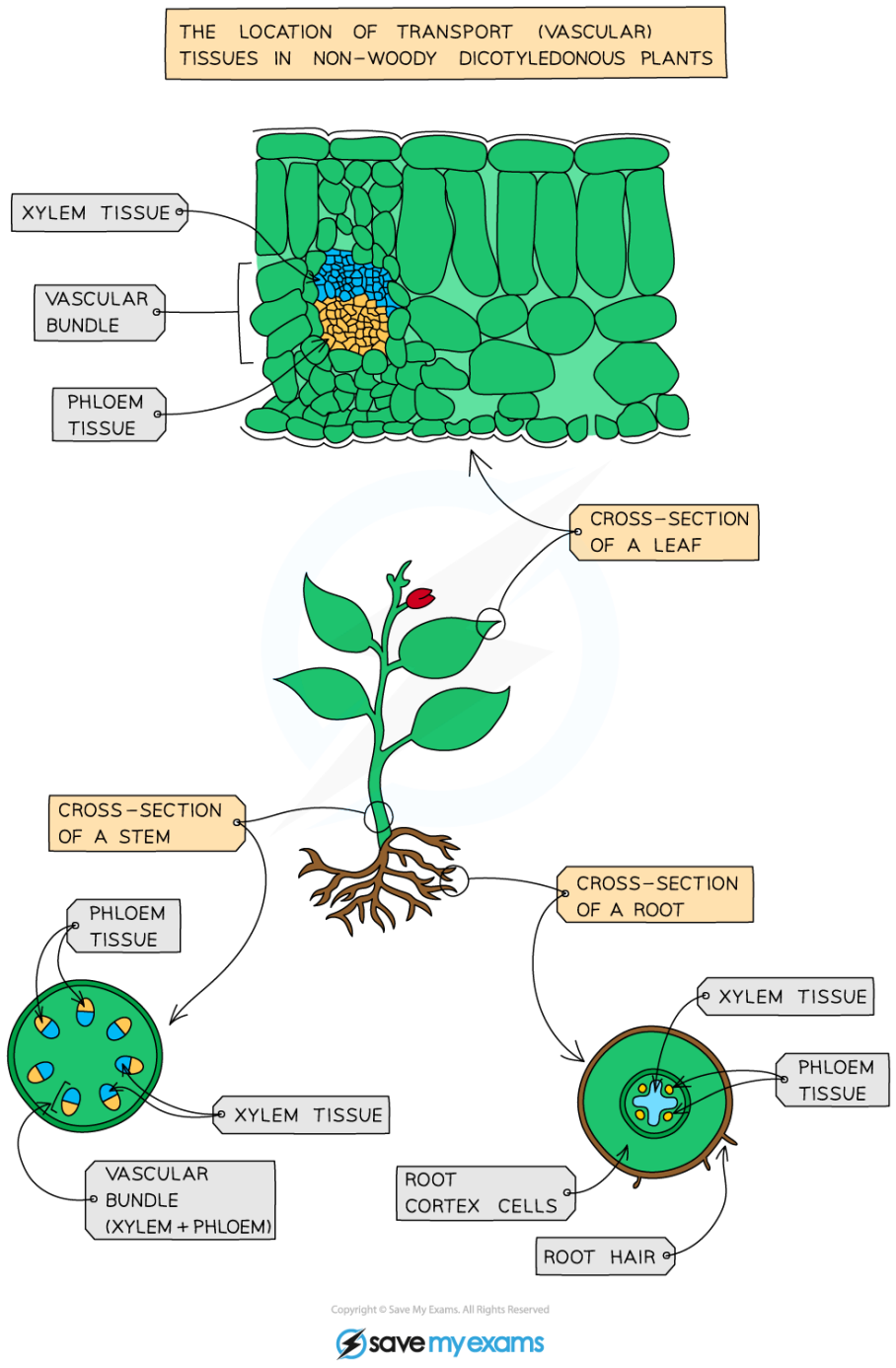
Your notes

The xylem & phloem

What is the function of the xylem and phloem

- Plants contain two types of transport vessel:
  - **Xylem vessels** – transport water and minerals (pronounced: zi-lem) from the roots to the stem and leaves
  - **Phloem 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 (pronounced: flow-em)
- These vessels are arranged throughout the root, stem and leaves in groups called **vascular bundles**

Xylem and phloem diagram



Vascular tissue in a dicotyledonous plant

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Examiner Tips and Tricks

If you are asked to identify the xylem or phloem in a diagram showing a cross-section of a root, stem or leaf just remember that **xylem is always on the inside and phloem is always on the outside.**

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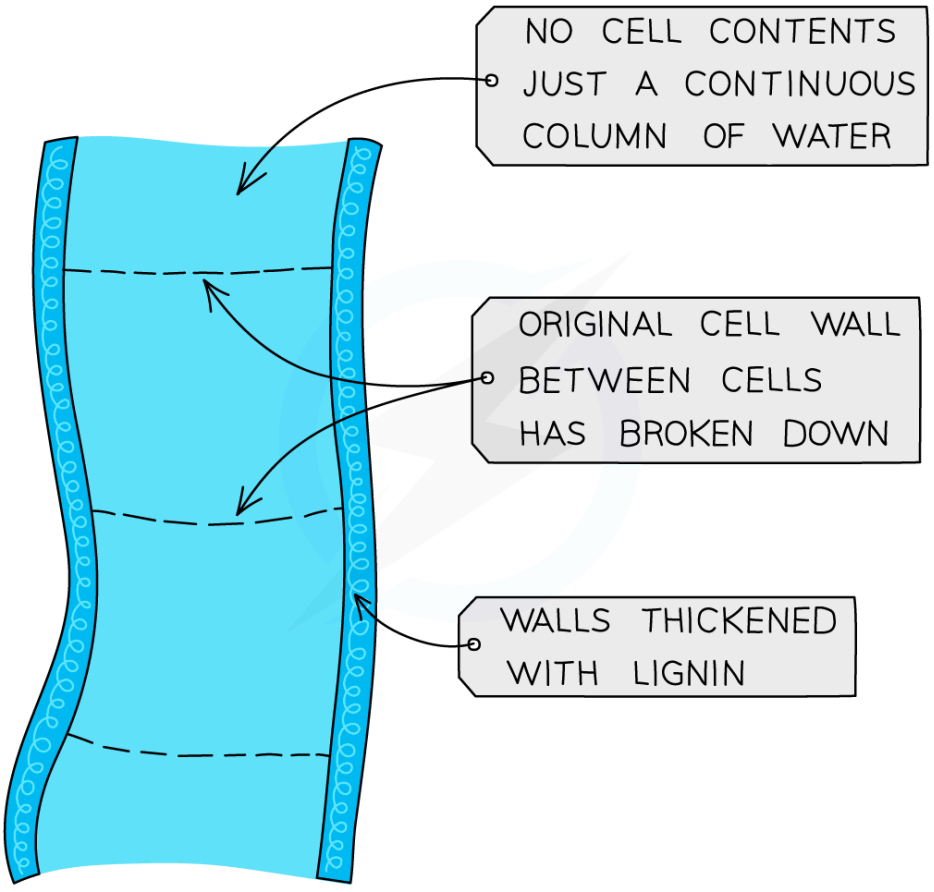
Adaptations of xylem vessels: Extended

- Function: transport tissue for water and dissolved mineral ions
- Adaptations:
  - Cells joined end to end with **no cross walls** to form a long continuous tube
  - Cells are essentially **dead,** without cell contents, to allow **free passage of water**
  - Outer walls are **thickened** with a substance called **lignin,** strengthening the tubes, which helps **support** the plant



Xylem cells lose their top and bottom walls to form a continuous tube through which water moves through from the roots to the leaves

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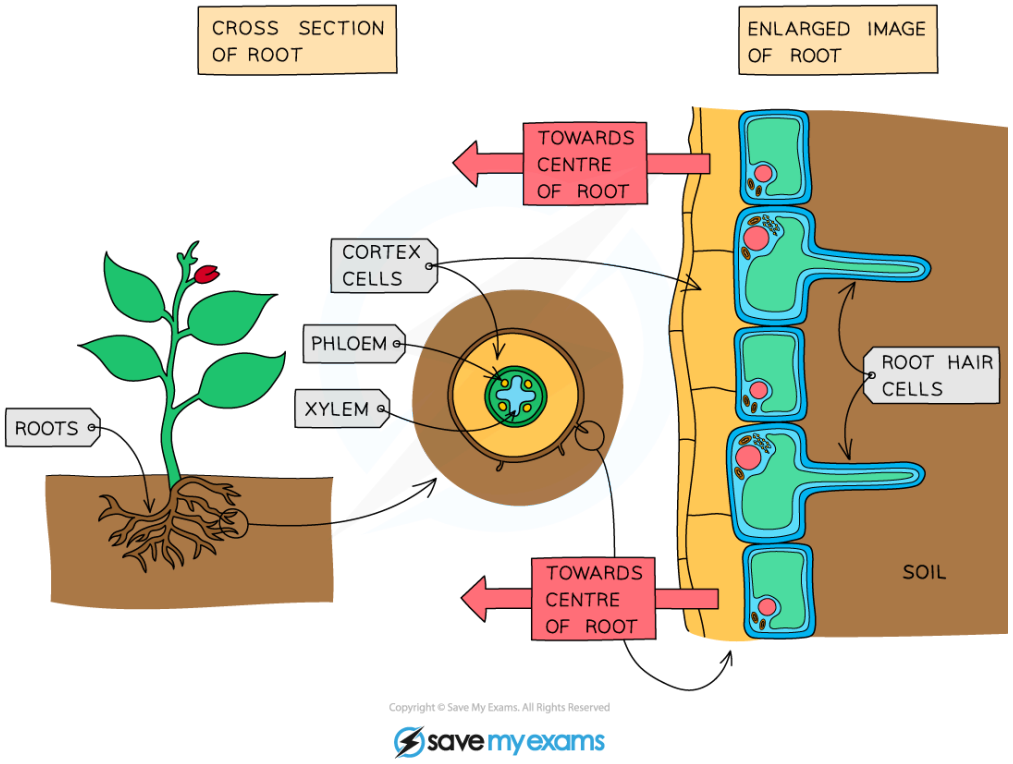
Root Hair Cells

- Root hairs are single-celled extensions of **epidermis cells** in the root
- They grow between soil particles and absorb water and minerals from the soil
- Water enters the root hair cells by **osmosis**
- This happens because soil water has a **higher water potential than the cytoplasm** of the root hair cell



Structure of the root

- The root hair increases the surface area of the cells significantly
- This large surface area is important as it **increases the rate of the absorption of water by osmosis and mineral ions by active transport**

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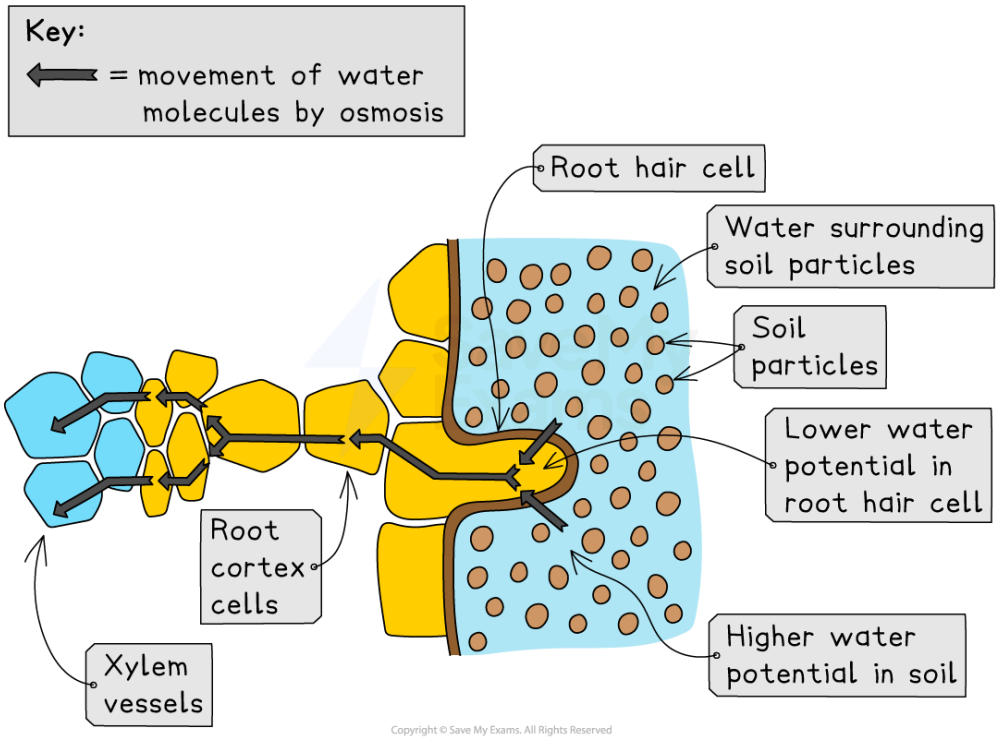
Pathway taken by water

- Water is taken up from the soil into root hair cells
- Water then moves across the root cortex and into the xylem vessels by osmosis



Pathway of water into and across a root

- Water is then transported in the **xylem** to the leaves where it enters the leaf **mesophyll cells**
- So the pathway is:

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

Investigating water movement in plants

- The pathway taken by water through a plant can be studied using a **suitable stain**, or dye, as follows:
  1. place a plant stem, e.g. celery, into a beaker of water that has had a stain added to it
  2. leave for a few hours, or until the leaves of the celery turn the same colour as the dyed water
     - This indicates that the dye has travelled all the way up the xylem

3. cut a cross-section of the stem and view the position of the coloured dye, which will correspond with the location of the xylem vessels

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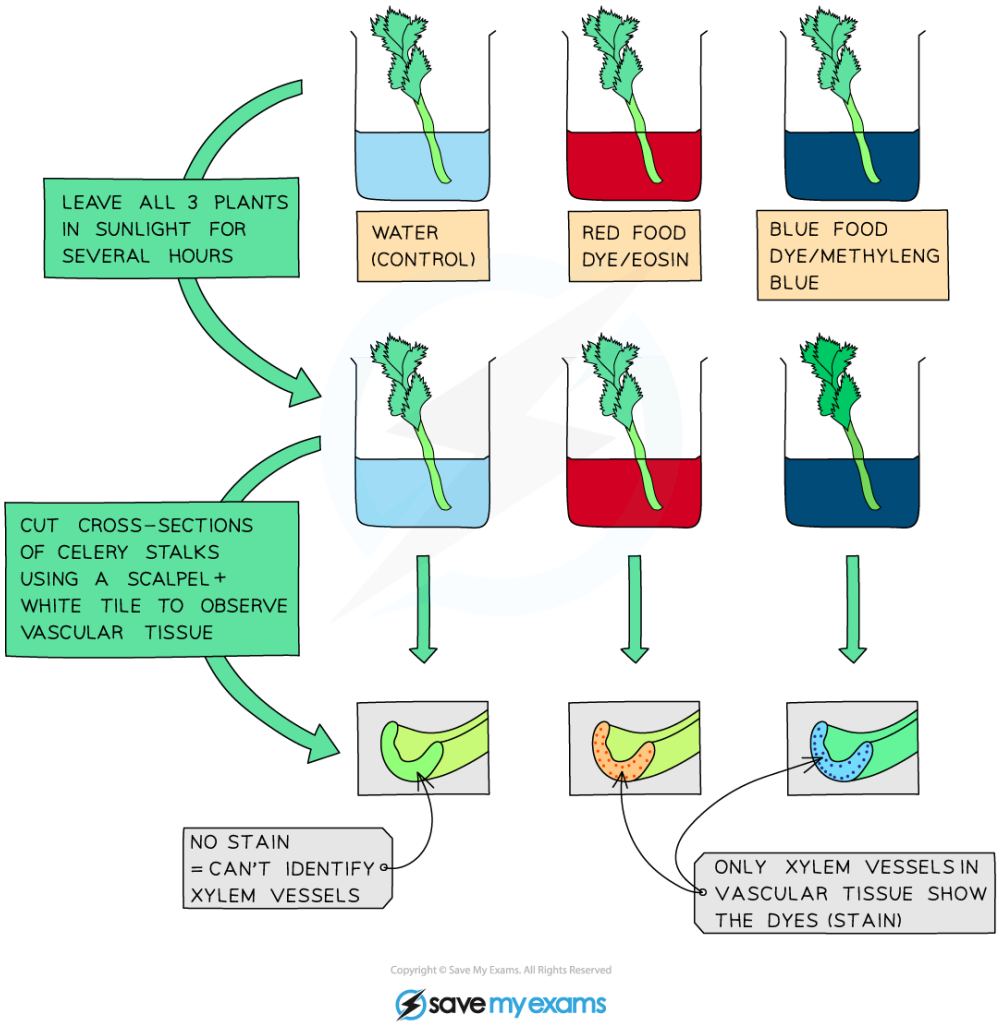
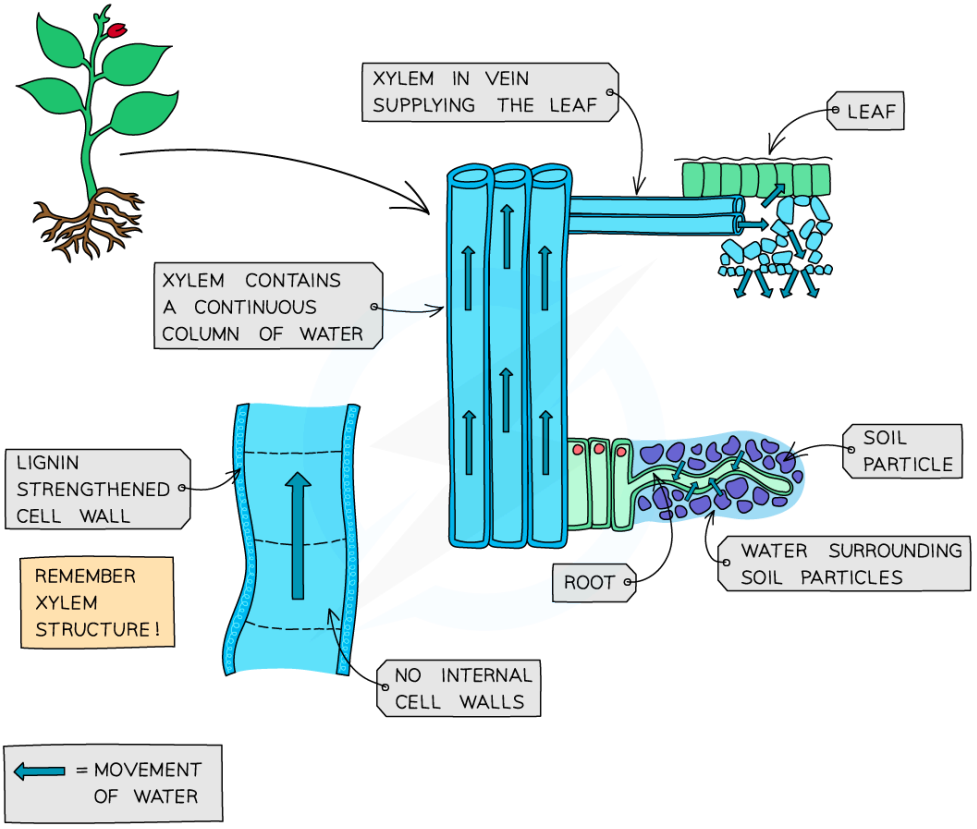


It is possible to study the pathway taken by water in a plant stem using a suitable stain

Your notes

Transpiration

- **Water** travels up **xylem** from the roots into the leaves of the plant to replace the water that has been lost due to **transpiration**
- Transpiration is defined as the **loss of water vapour from plant leaves by evaporation of water at the surfaces of the mesophyll cells followed by diffusion of water vapour through the stomata**
- Xylem is adapted in many ways:
  - A substance called **lignin** is deposited in the cell walls which causes the xylem cells to die
  - These cells then become **hollow** (as they lose all their organelles and cytoplasm) and join end-to-end to form a **continuous tube** for water and mineral ions to travel through from the roots
  - Lignin strengthens the plant to help it withstand the pressure of the water movement
- Movement in xylem **only takes place in one direction** - from **roots to leaves** (unlike phloem where movement takes place in different directions)



Water uptake, transport and transpiration

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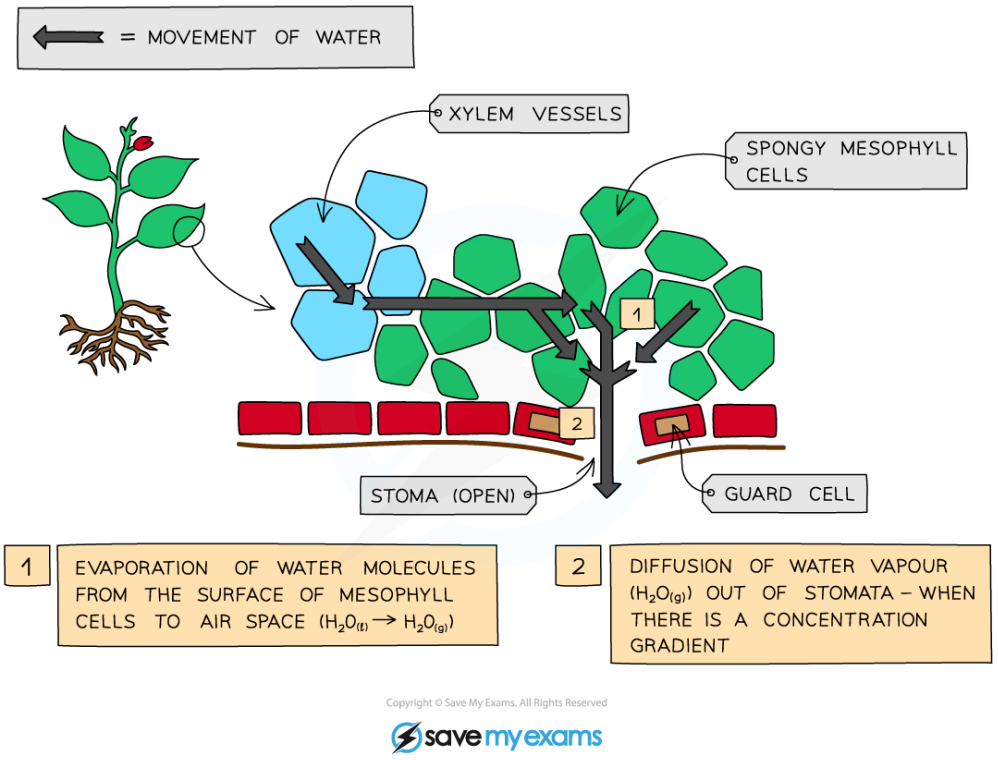

Transpiration in plants

- **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 using up of heat to convert water into water vapour helps to cool the plant down)

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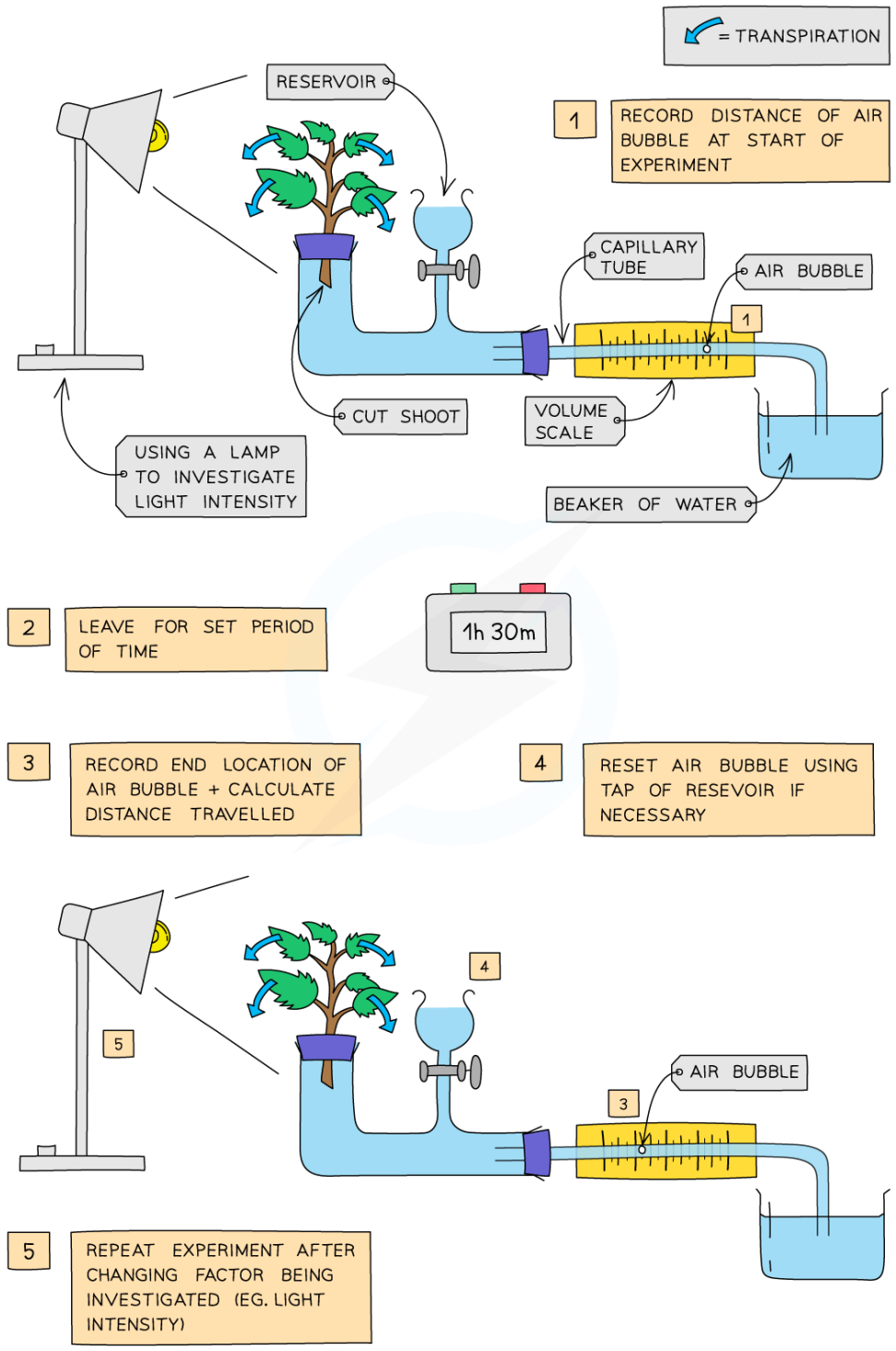
Investigating the Effect of Temperature & Wind Speed on Transpiration Rate

Investigating the role of environmental factors in determining the rate of transpiration from a leafy shoot

- 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 the environmental factor you are investigating
- Allow the plant to adapt to the new environment for 5 minutes
- Record the **starting location** of the air bubble
- Leave for a set period of time
- Record the **end location** of air bubble
- Change the wind speed or temperature (only one - whichever factor is being investigated)
- Reset the bubble by opening the tap below the reservoir
- Repeat the experiment
- The **further the bubble travels in the same time period, the faster transpiration is occurring** and vice versa



An experimental setup for testing the effect of light intensity on transpiration rates. The apparatus can be modified to test the effects of temperature and wind speed.

- Environmental factors can be investigated in the following ways:

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- **Temperature**: Temperature of room (cold room and warm room)
  - As temperature increases, the rate of transpiration also increases
- **Wind speed**: Use an electric fan to mimic different wind speeds
  - As wind speed increases, the rate of transpiration also increases

Examiner Tips and Tricks

Remember when designing an investigation to ensure a fair test you must keep all factors the same other than the one you are investigating.

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Water Vapour Loss: Extended

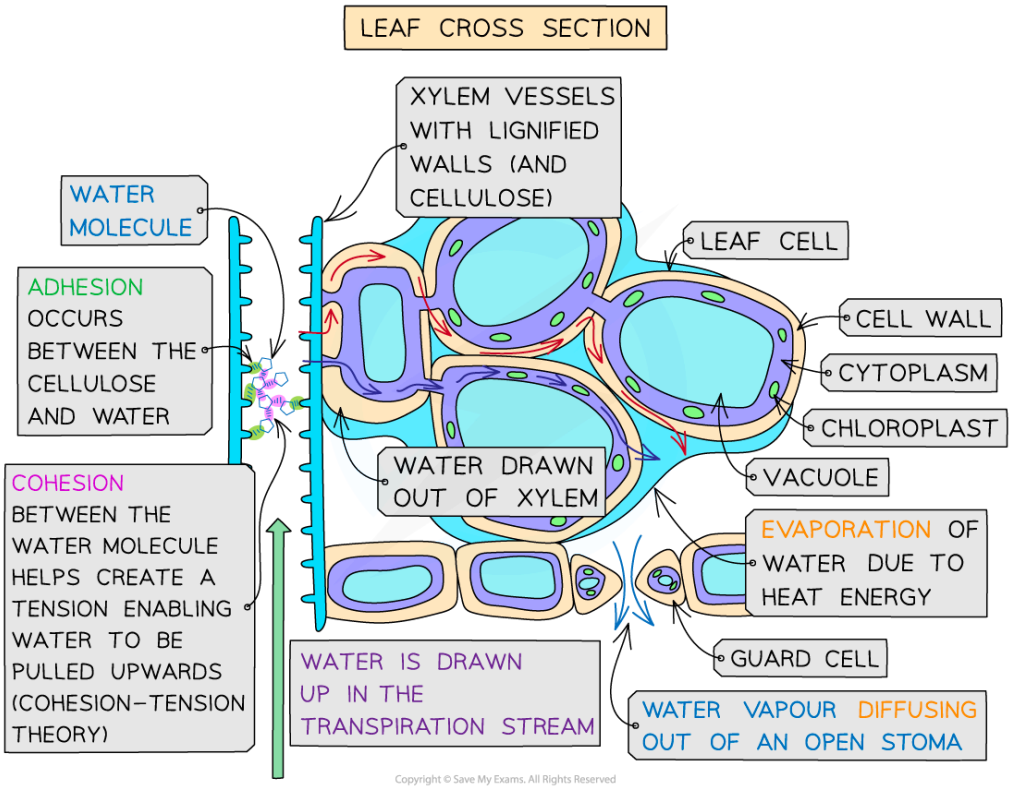
Extended Tier Only

- **Evaporation** takes place from the surfaces of spongy mesophyll cells
- The **many interconnecting air spaces** between these cells and the stomata create a **large surface area**
- This means evaporation can happen rapidly **when stomata are open**

Transpiration Stream: Extended

Extended Tier Only

- Water molecules are attracted to each other by **cohesion** - creating a continuous column of water up the plant
- Water moves through the xylem vessels in a continuous **transpiration stream** from roots to leaves via the stem
- Transpiration produces a **tension** or 'pull' on the water in the xylem vessels by the leaves
- As water molecules are held together by **cohesive forces** (each individual molecule 'pulls' on the one below it), so water is pulled up through the plant
- If the rate of transpiration from the leaves **increases**, water molecules are pulled up the xylem vessels **quicker**



The generation of the transpiration stream

Your notes

Your notes

Explaining the Effects of Temperature, Wind Speed & Humidity: Extended

Extended Tier Only

- Wind speed, humidity and temperature all have an effect on the rate at which transpiration occurs
- The table below explains how these factors affect the rate of transpiration when they are all high; the opposite effect would be observed if they were low

Transpiration Rate Factors Table

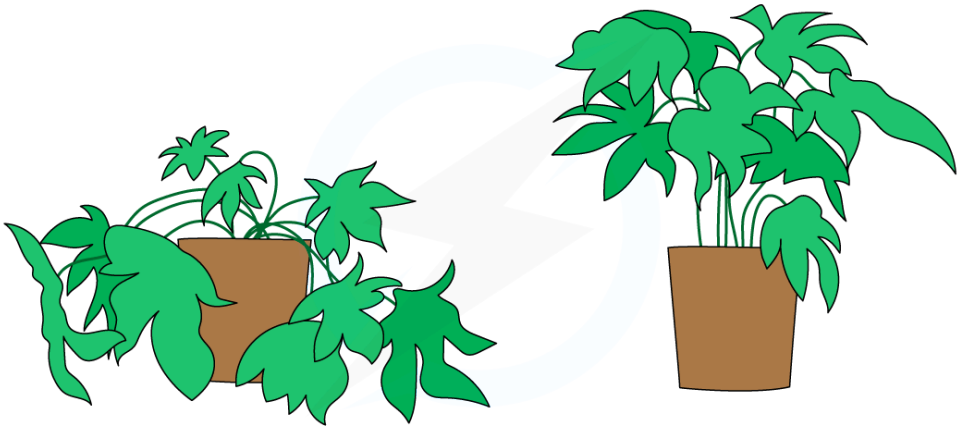
Factor	Condition	Effect on the rate of transpiration (more/less)
Wind speed	High	More – good airflow removes water vapour from the air surrounding the leaf which sets up a concentration gradient between the leaf and the air, increasing water loss
Humidity	High	Less – humidity is a measure of moisture (water vapour) in the air; when the air is saturated with water vapour the concentration gradient is weaker so less water is lost
Temperature	High	More – at higher temperatures, particles have more kinetic energy so transpiration occurs as a faster rate as water molecules evaporate from mesophyll and diffuse away faster than at lower temperatures

- A potometer can be used to investigate the effect of environmental factors on the rate of transpiration

Wilting: Extended

Extended Tier Only

- If more water evaporates from the leaves of a plant than is available in the soil to move into the root by osmosis, then **wilting** will occur
- This is when all the cells of the plant are not full of water, so the strength of the **cell walls cannot support the plant** and it starts to collapse



A wilted plant cannot support itself and starts to collaps

Your notes

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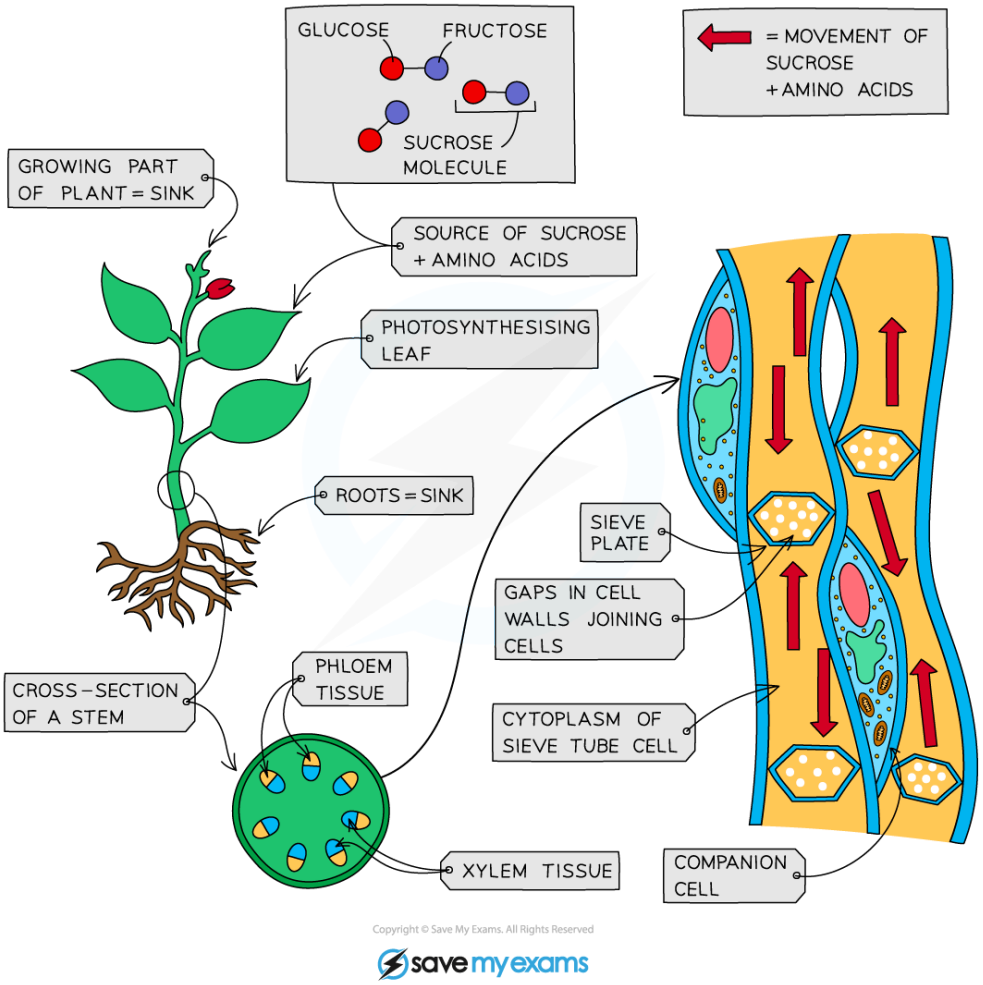
Translocation: Extended

- 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**
- 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 the **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



Translocation through the phloem

Comparison between Xylem and Phloem Tissue 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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