

Transport in Plants

A-Level Biology ■ Topic 7

A-Level Biology



What we will cover

- 1 Xylem & phloem
- 2 Vessel & sieve-tube structure
- 3 Water across the root
- 4 Transpiration
- 5 Xerophytes
- 6 Translocation



wood is xylem – one ring a year



The two transport tissues

xylem

water and minerals up
from the roots; dead ligni-
fied vessels; also support

phloem

sugars in either direction; living
sieve tubes with companion cells

What each tissue carries, and where

Xylem

Xylem carries water and dissolved **mineral ions** **up** from the roots. Dead, hollow, lignified – no contents to get in the way.

Phloem

Assimilates such as **sucrose** and **amino acids** travel from a **source** to a **sink** – in either direction.

Sieve tube

To leave room for flow, a sieve tube cell loses most of its contents and has **no nucleus**.

Companion cell

So its companion cell does the living for it: it keeps its nucleus and has many **mitochondria** to power loading.

In a **transverse section** of a **dicotyledonous plant**, xylem and phloem sit together in vascular bundles – a ring in the stem, a star in the root.

Worked example – which way does water move?

A plant cell with a water potential of -800 kPa is placed in a solution of -500 kPa. What happens?

- water moves from **higher** (less negative) to **lower** water potential
- the solution is -500 , the cell -800 , so the solution is higher
- water moves **into the cell**
- the cell becomes turgid; **hydrostatic pressure** rises until ψ inside matches outside

Water potential is **always negative or zero**, so “higher” means *closer to zero*. Reading the numbers as ordinary magnitudes reverses the answer.

Reading a transverse section

In a **transverse section** of a **dicotyledonous** stem the **vascular bundles** sit in a ring, each with **xylem** toward the inside and **phloem** toward the outside.

- xylem carries **water and minerals**, upward only
- phloem carries **assimilates** – mostly sugars – to wherever they are needed

A **plan diagram** shows the *outlines of the tissues* and no individual cells. Drawing single cells on a plan diagram loses the mark.

In translocation a **source** is where the assimilate is made or released – a photosynthesising leaf – and a **sink** is where it is used or stored.

Xylem vessels and phloem sieve tubes

xylem vessel



dead, empty cells;
thick lignified walls;
no end walls →
one open pipe

phloem



sieve plate (holes)

sieve tube (no nucleus)
companion cell
(nucleus, mitochondria)

- **xylem vessels** – dead, hollow, **lignin** -strengthened pipes
- **sieve tubes** – living, with **sieve plates** & a **companion cell**

Structure suits the job.

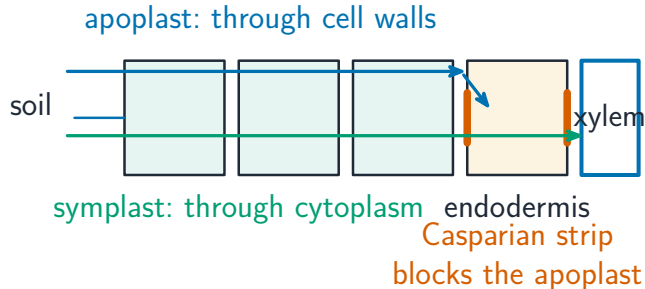


Water across the root

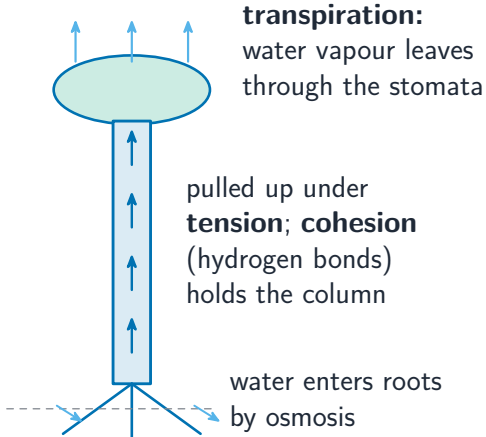
Water enters a **root hair cell** by osmosis, then crosses by:

- **apoplast** – through the walls (fast)
- **symplast** – through the cytoplasm

The **Casparian strip** blocks the apoplast, so the plant controls entry.



Transpiration



Transpiration : water evaporates inside the leaf and diffuses out of the **stomata** .

This pulls a continuous water column up the xylem – held together by **cohesion** (hydrogen bonds) under **tension** .

Transpiration, in the order it happens

Evaporation

Water *evaporates* from the wet cell surfaces inside the leaf – this step is **evaporation** .

Diffusion out

The **water vapour** then **diffuses** out through the **stomata** into the **atmosphere** .

The pull

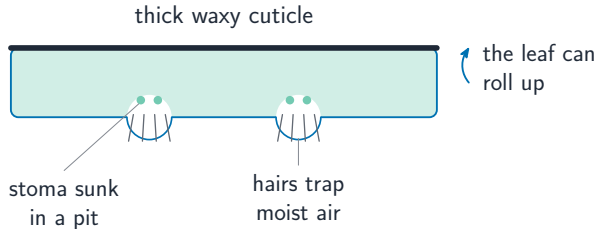
That loss lowers the water potential at the top of the column, and cohesion drags the whole thread of water up the xylem.

Transpiration is the loss

Transpiration is the loss of water vapour from a plant – evaporation and diffusion together, not one of them.

The plant spends water to gain carbon dioxide. Every xerophyte adaptation is a way of paying less for the same gas.

Xerophytes

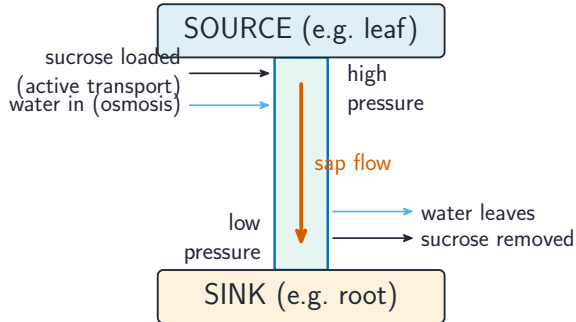


A **xerophyte** is adapted to live where water is scarce. Its leaves cut water loss with:

- a thick waxy **cuticle**
- **sunken stomata** & trapped moist air
- leaves that roll up



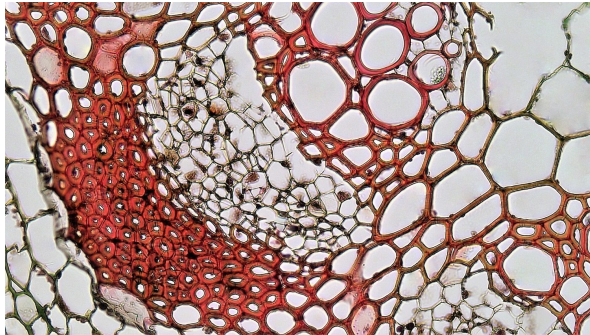
Translocation by mass flow



Translocation carries sugars from a **source** to a **sink** .

Loading sucrose (active transport) lowers water potential, so water enters & pressure rises – sap then flows to the sink by **mass flow** .

Phloem sieve tubes and companion cells



A real

Phloem sieve tubes and companion cells

The two pathways across a root, and what phloem needs

the apoplast pathway

through the **cellulose** cell walls and the spaces between them – fast, and it carries dissolved ions with it

the symplast pathway

through the cytoplasm, cell to cell via plasmodesmata – slower, and selective

the Casparian strip

blocks the apoplast route at the endodermis, forcing everything through a membrane

why that matters

it lets the plant **control** what enters the xylem

cotransporter proteins

load sucrose into the phloem against its gradient, using the proton gradient set up by active transport

the vascular bundle

xylem and phloem together – in a **dicotyledonous** stem they ring the outside

Water reaching the xylem must cross **at least one** membrane. That single fact is what makes the root a filter rather than a pipe.

Two pathways, one waterproof band

Apoplast

Water travels through the cell walls and the spaces between them – fast, and no membrane to cross.

Symplast

Through the cytoplasm, from cell to cell via plasmodesmata.

The Casparian strip

At the **endodermis** the apoplast route is blocked by the **Casparian strip**, a waterproof band of **suberin**.

Why that matters

Everything must pass through a membrane there – which lets the plant *select* what enters the xylem.

Loading the phloem uses **proton pumps** to push hydrogen ions out, then **cotransporter proteins** bring sucrose back in with them.

The two transport tissues, continued



stem: bundles in a ring root: xylem in a central star
xylem phloem

Where the tissues sit: stem bundles form a ring near the edge (xylem inside); in the root the xylem makes a central star

Exam tips

- State the tissue for each direction: **xylem** carries water up (dead, lignified), **phloem** carries assimilates both ways (living sieve tubes + companion cells).
- Explain water movement by **cohesion-tension**: transpiration pulls a continuous water column held by cohesion (H-bonds) and adhesion.
- List the factors affecting **transpiration rate** (light, temperature, humidity, air movement) and how a potometer measures uptake.
- For **xerophytes**, link each adaptation (thick cuticle, sunken stomata, rolled leaves, hairs) to reduced water loss.



Worked example – how water reaches the leaf

Explain how water moves from root to leaf against gravity, with no pump.

- Water **evaporates** from the mesophyll cell walls and diffuses out of the stomata: transpiration.
- That lowers the **water potential** at the top, putting the xylem column under **tension**.
- **Cohesion** (hydrogen bonds) holds the column together, so it is pulled up as one.
- **Adhesion** to the walls stops it breaking
⇒ **cohesion-tension theory**.

The pull comes from the **leaf**, not a push from the root. Evidence: the trunk narrows by day (tension) and a broken xylem stops the flow – the column must be continuous.

Topic 7 – key takeaways

1

Tissues

xylem carries water up; phloem carries sugars

2

Root

apoplast & symplast; Casparian strip controls entry

3

Transpiration

cohesion–tension pulls the column up

4

Translocation

source to sink by mass flow

Check yourself

- 1 Which tissue carries water up the plant?
- 2 What blocks the apoplast at the endodermis?
- 3 What keeps the xylem water column together?
- 4 Phloem carries sugars from a source to a what?



Answers 1. xylem 2. the Casparian strip 3. cohesion (hydrogen bonds) 4. a sink