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

1 The transport tissues

The two transport tissues

xylem

water and minerals up from the roots; dead lignified vessels; also support

phloem

sugars in either direction; living sieve tubes with companion cells

What each tissue carries, and where

Xylem	**Xylem** 木质部 carries water and dissolved **mineral ions** 矿物离子 up from the roots. Dead, hollow, lignified – no contents to get in the way.
Phloem	Assimilates such as **sucrose** 蔗糖 and **amino acids** 氨基酸 travel from a **source** 源 to a **sink** 库 – in either direction.
Sieve tube	To leave room for flow, a sieve tube cell loses most of its contents and has no **nucleus** 细胞核.
Companion cell	So its companion cell does the living for it: it keeps its nucleus and has many **mitochondria** 线粒体 to power loading.

In a **transverse section** 横切面 of a **dicotyledonous plant** 双子叶植物, 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** 静水圧 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

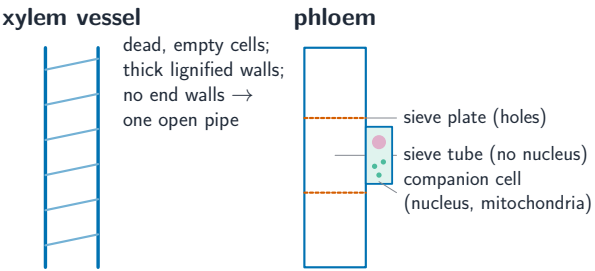
In a **transverse section** 横切面 of a **dicotyledonous** 双子叶植物 stem the **vascular bundles** 维管束 sit in a ring, each with **xylem** 木质部 toward the inside and **phloem** 韧皮部 toward the outside.

- xylem carries water and minerals, upward only
- phloem carries **assimilates** 同化物 – 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 vessels** 导管 – dead, hollow,
  lignin 木质素-strengthened pipes
- **sieve tubes** 筛管 – living, with **sieve plates** 筛板 & a **companion cell** 伴胞

Structure suits the job.

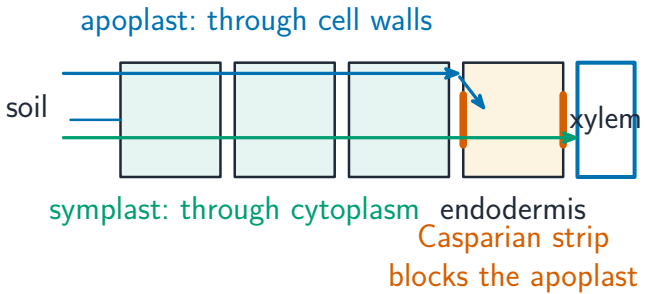
2 Water transport

Water across the root

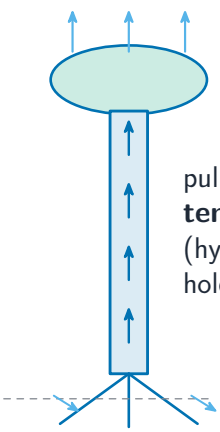
Water enters a **root hair cell** 根毛细胞 by osmosis, then crosses by:

- **apoplast** 质外体途径 – through the walls (fast)
- **symplast** 共质体途径 – through the cytoplasm

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



Transpiration



Transpiration 蒸腾作用: water evaporates inside the leaf and diffuses out of the **stomata** 气孔.

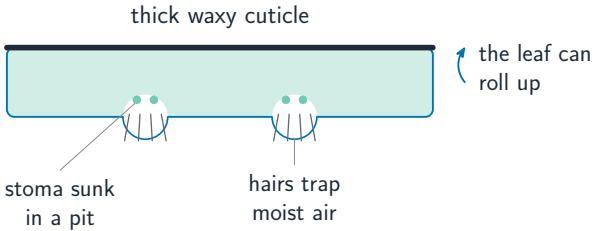
> This pulls a continuous water column up the xylem – held together by **cohesion** 内聚力 (hydrogen bonds) under **tension** 张力.

Transpiration, in the order it happens

Evaporation	Water *evaporates* from the wet cell surfaces inside the leaf – this step is **evaporation** 蒸发.
Diffusion out	The **water vapour** 水蒸气 then **diffuses** 扩散 out through the **stomata** 气孔 into the **atmosphere** 大气.
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** 蒸腾 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

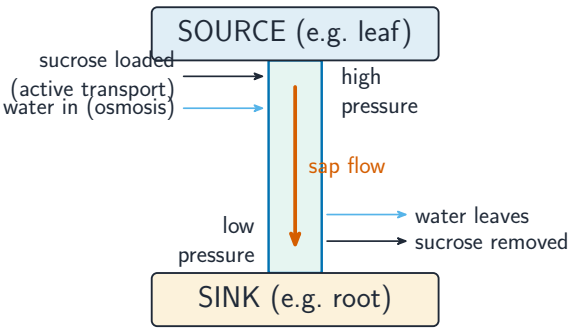


A **xerophyte** 旱生植物 is adapted to live where water is scarce. Its leaves cut water loss with:

- a thick waxy **cuticle** 角质层
- **sunken stomata** 下陷气孔 & trapped moist air
- leaves that roll up

3 Translocation

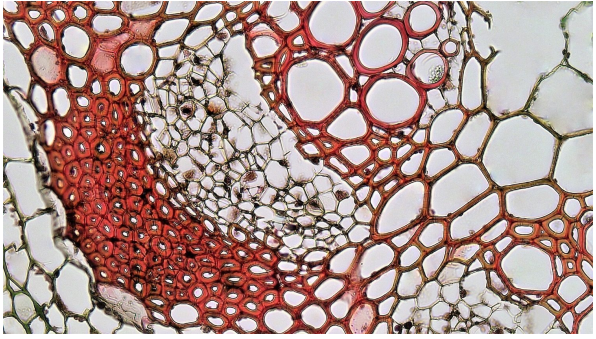
Translocation by mass flow



Translocation 运输 carries sugars from a **source** 源 to a **sink** 库.

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

Phloem sieve tubes and companion cells



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Phloem sieve tubes and companion cells

The two pathways across a root, and what phloem needs

the apoplast pathway 质外体途径	through the **cellulose** 纤维素 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 共转运蛋白	load sucrose into the phloem against its gradient, using the proton gradient set up by active transport
the vascular bundle 维管束	xylem and phloem together – in a **dicotyledonous** 双子叶 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** 内皮层 the apoplast route is blocked by the **Casparian strip** 凯氏带, a waterproof band of **suberin** 木栓质.
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** 质子泵 to push hydrogen ions out, then **cotransporter proteins** 共转运蛋白 bring sucrose back in with them.

The two transport tissues, continued

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.

4 Recap

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** 内聚力 (hydrogen bonds) holds the column together, so it is pulled up as one.
- **Adhesion** 附着力 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

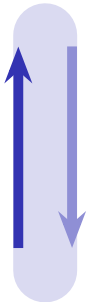
cohesion–tension pulls the column up

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