

Exercise walk-through

Transport mechanisms ■ 7.2

eXercise

You must be able to

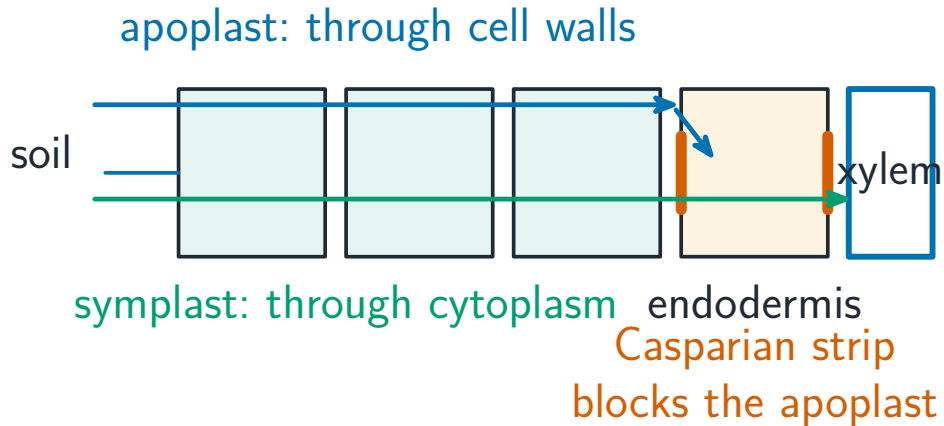
- describe the apoplast and symplast pathways and the role of the Casparian strip
- explain transpiration and how hydrogen bonding moves water up the xylem
- explain xerophyte adaptations, and translocation from source to sink by mass flow

Method — Water from soil to xylem

Water enters a root hair by **osmosis** 渗透 then crosses the root two ways:

- **apoplast** 质外体 — through cell walls (cellulose); fast.
- **symplast** 共质体 — through the cytoplasm via plasmodesmata.
- at the **endodermis** 内皮层, the waterproof **Casparian strip** 凯氏带 (suberin) blocks the apoplast, forcing water through membranes so the plant controls what enters.

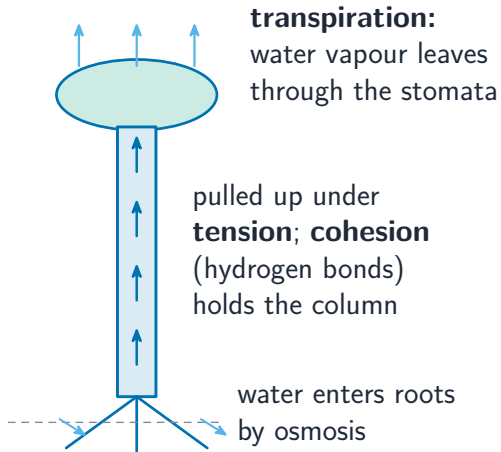
Method — Water from soil to xylem



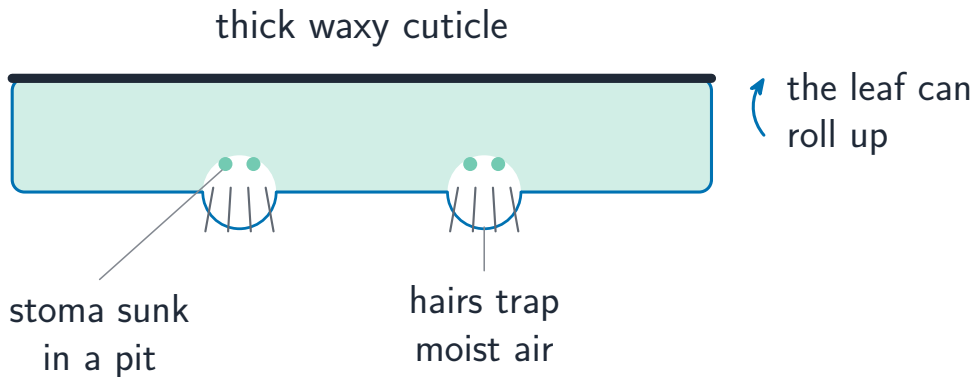
Method — Transpiration and cohesion–tension

Transpiration = evaporation of water from leaf surfaces, then diffusion of vapour out of the **stomata** 气孔. Water molecules stick together by **hydrogen bonds** (**cohesion** 内聚力), so the column is pulled up under **tension** 张力; they also stick to cellulose walls (**adhesion** 附着力).

Method — Transpiration and cohesion–tension



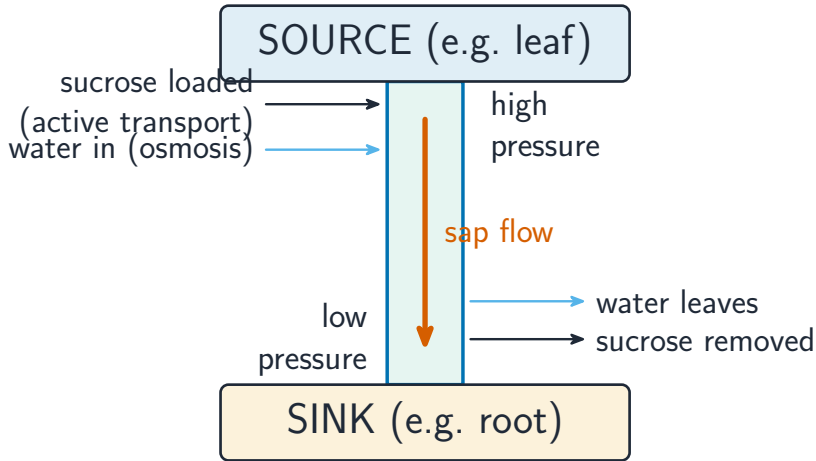
Method — Xerophyte adaptations



Method — Translocation by mass flow

Assimilates (**sucrose** 蔗糖, amino acids) move from **source** 源 to **sink** 库. Companion cells load sucrose by **active transport** 主动运输 (proton pumps + cotransporters), lowering water potential so water enters and raises pressure.

Method — Translocation by mass flow



Practice 2.1 ■ 2 marks

State the difference between the apoplast and symplast pathways.

Solution 2.1

Method: Water from soil to xylem

Worked steps

apoplast — water moves through the cell walls and spaces **B1**; symplast — water moves through the cytoplasm from cell to cell via plasmodesmata **B1**.

Practice 2.2 ■ 2 marks

Define a **source** and a **sink** in translocation.

Solution 2.2

Method: Translocation by mass flow

Worked steps

source — where the assimilate is made/released (e.g. a leaf) **B1**; sink — where it is used or stored (e.g. a root) **B1**.

Exam-style 3.1 ■ 1 mark

What is the role of the Casparian strip?

- A** to carry water up the xylem
- B** to block the apoplast pathway so water passes through cell membranes
- C** to load sucrose into the phloem
- D** to store water in the root

Solution 3.1

Method: Water from soil to xylem

- A to carry water up the xylem
- B to block the apoplast pathway so water passes through cell membranes** 
- C to load sucrose into the phloem
- D to store water in the root

Worked steps

B. The Casparian strip blocks the apoplast, forcing water through the cell membranes.

Exam-style 3.2 ■ 1 mark

Which property of water, caused by hydrogen bonding, allows a continuous column to be pulled up the xylem?

- A** adhesion to air
- B** cohesion between water molecules
- C** high density
- D** low specific heat capacity

Solution 3.2

Method: Transpiration and cohesion–tension

- A adhesion to air
- B cohesion between water molecules**
- C high density
- D low specific heat capacity



Worked steps

- B. Cohesion between water molecules holds the column together under tension.**

Exam-style 3.3 ■ 2 marks

A potometer measures water uptake. In 10 minutes the meniscus moves 60 mm along a tube of cross-sectional area 2.0 mm^2 .

- (a) Calculate the volume of water taken up, in mm^3 .
- (b) Calculate the rate of water uptake, in mm^3 per minute.

Solution 3.3

Worked steps

(a) volume = $60 \text{ mm} \times 2.0 \text{ mm}^2 = 120 \text{ mm}^3$ **M1** **A1**.

(b) rate = $120/10 = 12 \text{ mm}^3 \text{ min}^{-1}$ **A1**.

Exam-style 3.4 ■ 4 marks

Explain how sucrose is loaded into the phloem at a source and how this drives mass flow.

Solution 3.4

Method: Translocation by mass flow

Worked steps

companion cells use proton pumps to pump H^+ out, then cotransporters bring sucrose in with H^+ — active transport **B1** **B1**; this lowers the water potential in the sieve tube so water enters by osmosis, raising the hydrostatic pressure **B1**; sap then flows down the pressure gradient to the sink (mass flow) **B1**.