

7.2 Transport mechanisms

Name: _____ Class: _____ Date: _____

Total: 13 marks

KEY WORDS source • sink • mass flow • apoplast • transpiration

Objective

Build the skills to answer exam questions on **transport mechanisms** in plants – water from soil to xylem, **transpiration** and cohesion–tension, **xerophyte** adaptations, and **translocation** by mass flow.

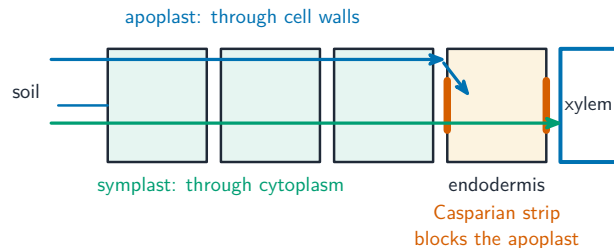
You must be able to:

- 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

1 Key knowledge and worked examples

■ Water from soil to xylem

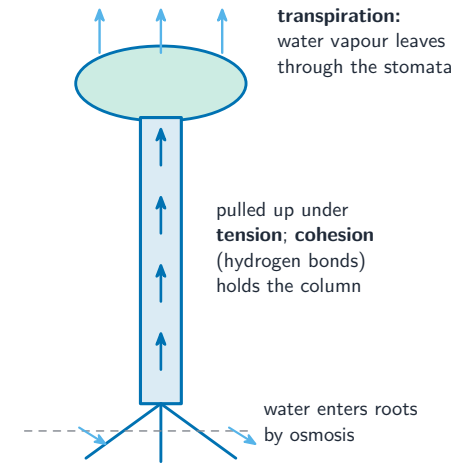
Water enters a root hair by **osmosis** then crosses the root two ways:



Apoplast = through the walls; symplast = through the cytoplasm; the Casparian strip blocks the apoplast

- apoplast** – through cell walls (cellulose); fast.
- symplast** – through the cytoplasm via plasmodesmata.
- at the **endodermis**, the waterproof **Casparian strip** (suberin) blocks the apoplast, forcing water through membranes so the plant controls what enters.

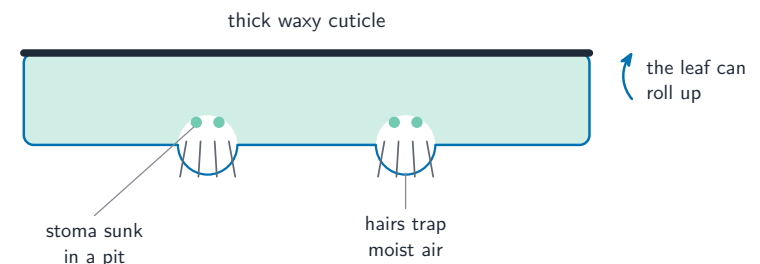
■ Transpiration and cohesion–tension



Water evaporates in the leaf and diffuses out of the stomata; this pulls the whole column up

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

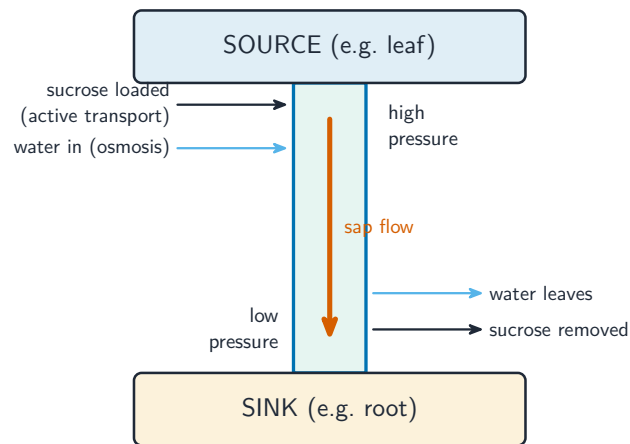
■ Xerophyte adaptations



Xerophytes cut water loss: thick cuticle, sunken stomata, trapped moist air, rolled leaves

■ Translocation by mass flow

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



Loading sucrose at the source raises the pressure; sap flows by mass flow to the sink

2 Practice

2.1 State the difference between the apoplast and symplast pathways. [2]

2.2 Define a **source** and a **sink** in translocation. [2]

3 Exam-style questions

3.1 What is the role of the Casparian strip? [1]

☐

- 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

3.2 Which property of water, caused by hydrogen bonding, allows a continuous column to be pulled up the xylem? [1]

☐

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

3.3 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 . [2]

(b) Calculate the rate of water uptake, in mm^3 per minute. [1]

3.4 Explain how sucrose is loaded into the phloem at a source and how this drives mass flow. [4]

Solutions

Each answer shows the steps, then the **result**.

2.1

- apoplast – water moves through the cell walls and spaces; symplast – water moves through the cytoplasm from cell to cell via plasmodesmata

2.2

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

3.1 B

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

3.2 B

- Cohesion between water molecules holds the column together under tension

3.3

(a)

- volume $V = l \times A = 60 \text{ mm} \times 2.0 \text{ mm}^2 = 120 \text{ mm}^3$

(b)

- rate $= 120/10 = 12 \text{ mm}^3 \text{ min}^{-1}$

3.4

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