A-LEVEL BIOLOGY • EXERCISE SHEET

7.2 Transport mechanisms

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

Objective

Build the skills to answer exam questions on **transport mechanisms** in plants —water from soil to xylem, **transpiration** 蒸腾作用 and cohesion–tension, **xerophyte** 旱生植物 adaptations, and **translocation** 易位 by mass flow.

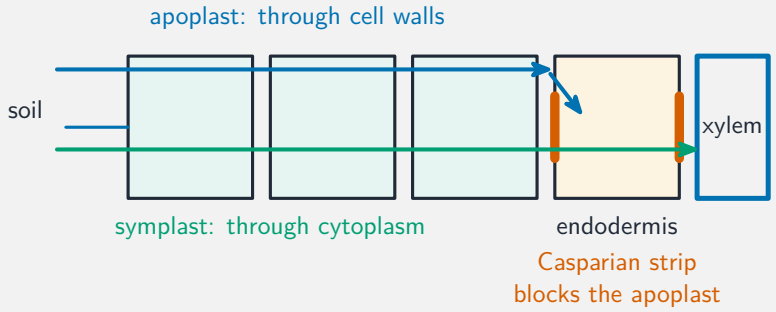
You must be able to:

- 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 Worked examples

■ Water from soil to xylem

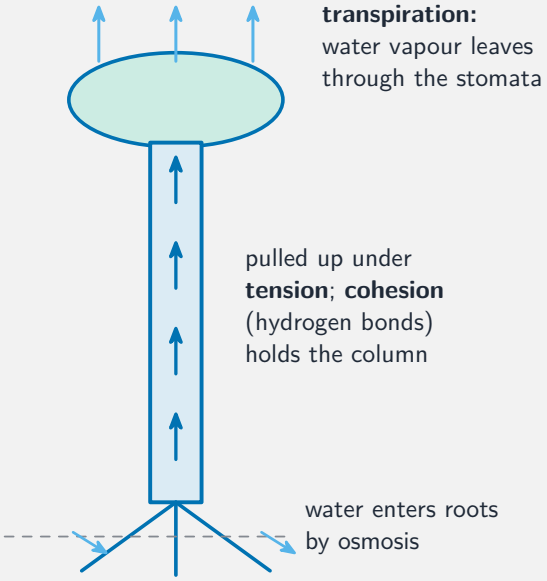
Water enters a root hair by **osmosis** 渗透 then crosses the root two ways:



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

- **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.

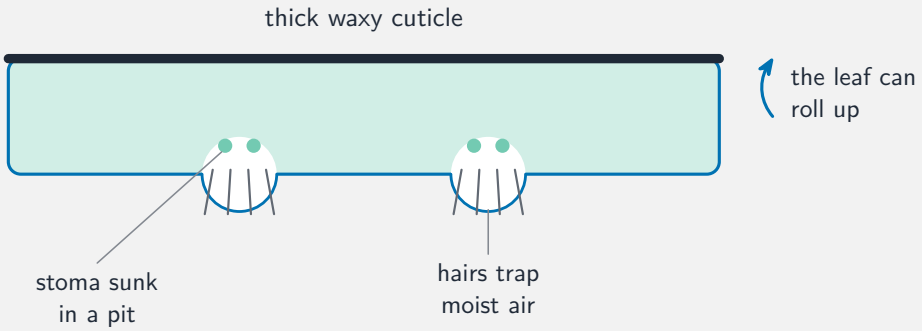
Transpiration and cohesion–tension



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** 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).

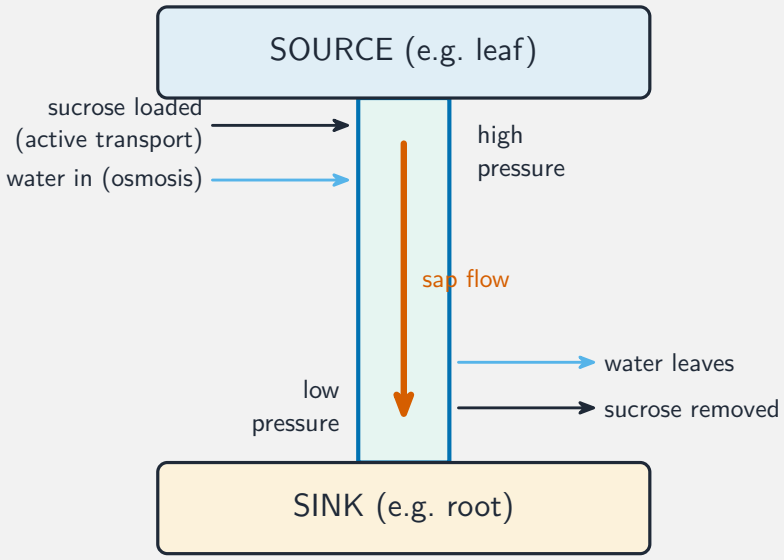
Xerophyte adaptations



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

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.



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]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **7.2 Transport mechanisms** past-paper sheet in the Library, or try these in **Practice mode**:

- 9700/11 N25 —Q28 (transpiration)
- 9700/12 N25 —Q30 (water transport)
- 9700/13 N25 —Q29 (translocation)
- 9700/24 N25 —Q6 (transport, calculation)

Solutions

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 = 60 mm × 2.0 mm^2 = 120 mm^3.
(b) rate = 120/10 = 12 $mm^3\,min^{-1}$.

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).