# Water's climb

60 minutes • B3.2.7 and B3.2.8 • Chapters 1, 2, 3

**How evaporation, capillary action, tension and cohesion pull water up a plant, and how xylem vessels are built to carry it**

## BY THE END, STUDENTS CAN

- [ ] Explain how transpiration pulls water up from the roots: evaporation, capillary action in the leaf's cell walls, tension in the xylem and cohesion B3.2.7
- [ ] Explain how xylem vessels are built to carry water under tension B3.2.8

## TIMING

| | | | |
|---|---|---|---|
| 0-5 | 5 min | **Do now: a good drying day** | |
| 5-10 | 5 min | **Set up the dye** | |
| 10-25 | 15 min | **Pulled from the top** | |
| 25-45 | 20 min | **Every Cool Tree Climbs, then the vessel** | |
| 45-50 | 5 min | **How far has it climbed?** | |
| 50-60 | 10 min | **Exit** | |
| | 60 min | **One lesson** | |

## STARTER

**5** min

### Do now: a good drying day

On the board: why is a warm, dry, windy day good for drying washing and hard on a plant? Pairs write two reasons on a mini whiteboard. Keep them up: chapter 1 answers both.

## ON THE BOARD, FROM THE GUIDE

Open the guide on the projector at each chapter (the links work in this PDF). Every figure plays from its own buttons, and the lesson's slides have the same figures, step by step, in the order of this plan.

### 01 Water is pulled from the top

CHAPTER 01 IN THE SLIDES

**Step through the figure** (4 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. Water vapour **diffuses** out of the leaf through the stomata: transpiration.
2. Water **evaporates** from the wet cell walls. More creeps through the walls by **capillary action**, drawn out of the xylem.
3. The water in the xylem is under **tension**: its pressure is below zero. Cohesion keeps the column whole as it is pulled up.
4. As the column rises, water enters the **root hairs** from the soil to replace it.

**Play the animation, Water in a xylem vessel.** It loops; pause it on each moment below and ask what is happening (in the lesson slides it is a video).

1. Water **evaporates** from the wet cell walls in the leaf and escapes through a stoma.
2. Each molecule that leaves pulls on the next: **hydrogen bonds** hold the column together.
3. The whole column is pulled up from the roots, under **tension**.

> **Predict box:** An air bubble gets into one xylem vessel. What happens to the water in that vessel? Hands up or mini whiteboards first.
>
> **Answer C: Below the bubble it stops, because cohesion cannot pull across a gap**

> **Remember it:** Every Cool Tree Climbs (Evaporation, Capillary action, Tension, Cohesion).

## 02 Xylem vessels are built for the pull

CHAPTER 02 IN THE SLIDES

**Step through the figure** (4 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. Two xylem vessels side by side, each starting as a column of **living cells** with a nucleus and cytoplasm.
2. The cells thicken their walls with **lignin**, leaving gaps, the pits. In a young stem it goes on in rings or a spiral.
3. The cells die, their contents break down and the **end walls** go: an open tube.
4. Water flows up the **lumen** unimpeded, and sideways through the **pits** into the next vessel.

> **Predict box:** A plant cannot make lignin. On a hot, windy day, what happens to its xylem vessels? Hands up or mini whiteboards first.
>
> **Answer B: They are pulled inwards and collapse: the water in them is under tension**

## 03 A stem in section

CHAPTER 03 IN THE SLIDES

**Step through the figure** (2 steps, the arrow keys on a projector). Stop on each caption and ask what changed before you go on.

1. A light micrograph, drawn: a transverse section of a young stem, every cell in view. Lignified walls are pink, as the stain colours them.
2. Its plan diagram: one clean outline for each tissue, in the micrograph's proportions, no cells and no shading; ruled label lines, each tissue's main function, a title and a scale bar.

> **Predict box:** A cut stem stands for an hour in water with a red dye in it, then is cut across. Where is the red? Hands up or mini whiteboards first.
>
> **Answer D: In a ring of spots near the edge: the xylem of each bundle**

> **Remember it:** Eat Cake Pass Xmas Pudding (Epidermis, Cortex, Phloem, Xylem, Pith).

THE LESSON

**5** min

### Set up the dye

Stand fresh celery stalks, leaves on, in coloured water (Dye up the stalk, below): lesson 2 cuts them. Put out the stalk you set up yesterday, still whole.

**15** min

### Pulled from the top

Chapter 1's figure, a step at a time: vapour out through the stomata, evaporation from the wet walls, capillary action, tension in the xylem, water in at the root hairs. Then the water film: make the air humid, then dry, and watch the column. Take the air bubble predict box before anyone switches the bubble on.

**20** min

### Every Cool Tree Climbs, then the vessel

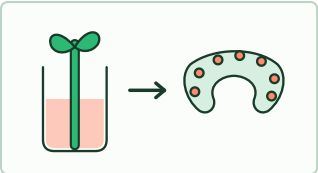
Turn over chapter 1's Remember it tiles from memory. Then chapter 2's figure, from living cells to an open tube. Pairs match each adaptation to its job: no contents, end walls gone, lignin, pits. Finish on the lignin predict box: what would a hot, windy day do to a plant that could not make lignin?

**5** min

### How far has it climbed?

Yesterday's stalk, from the outside: in a day the dye has climbed to the leaves and tinted their veins. Measure the climb from the water line, and ask what the leaves have to do with it. Nobody cuts it yet: that comes straight after chapter 3's predict box, in lesson 2.

ACTIVITIES



DEMO

### Dye up the stalk

Stand celery stalks, leaves on, in water coloured with red or blue food colouring, somewhere warm and bright. They need a day: set one up the day before lesson 1 and more during it. In lesson 1, look at the older one from the outside only: by then the dye has reached the leaves and tinted their veins, so measure how far it has climbed. Keep every stalk whole until lesson 2, so nobody sees inside one before chapter 3's predict box. Straight after it, cut a stalk across a few centimetres above the water and look with a hand lens: the dye shows as coloured dots near the edge, each the xylem of one bundle. White carnations show it in their petals within a few hours, and more strongly by the next day. A celery stalk is a leaf stalk, not a stem, but its bundles also sit near the edge.

**Needs:** fresh celery with its leaves, red or blue food colouring, beakers, a ruler, a sharp knife and a cutting board (for the teacher), hand lenses.

PLENARY

**10** min

### Exit

Four linked sentences on how water gets from the soil to the air, using evaporation, capillary action, tension and cohesion. Underline the word that names the pull.

WHAT STUDENTS GET WRONG

**"The roots pump water up the xylem."** The main force is the pull from the leaves. Root pressure is real but small (lesson 3).

**"Capillary action lifts water up a tree."** In a tube as wide as a typical vessel it lifts water less than a metre. The capillary action that matters is in the leaf's cell walls.

**"Xylem vessels are living cells."** They are dead when they carry water: living cells build them, then die.

**"Lignin is there to waterproof the vessel."** Its job here is strength: it stops the vessel caving in under tension.

STRETCH AND SUPPORT

**Support:** chapter 1's four captions as a cut-up strip to put in order, from the leaf down.

**Stretch:** why might there be a limit to how tall a tree can grow? (The higher the leaves, the stronger the tension needed to lift water to them, and the more likely an air bubble breaks a column.)

IN THE GUIDE

- 1 Water is pulled from the top
- 2 Xylem vessels are built for the pull
- 3 A stem in section
- All The whole guide, with the figures that play
- PPTX This lesson's slides, in the order of this plan

EXAM PRACTICE

### Check yourself

Set it for homework: a fresh paper of exam-bank questions on B3.2 at standard level each time, marked as students go and saved to their Exam practice when they are signed in.

biologybybradford.com/exam-maker/sit?topics=B3.2&level=SL&paper=quiz&marks=15&src=ep

PRACTISE AND REVISE

BUILD FOR YOUR CLASS

- Tarsia puzzle, dominoes and picture reveal on B3.2, built from its key terms and ready to print
- A pub quiz with rounds on B3.2, to present or run with no projector
- An escape room built from the question bank on B3.2

ALREADY ON THE SITE FOR B3.2

- Quiz: Transport
- Revision map: B3.2 Transport, to fill in
- Exam questions: B3.2 in the exam maker, a paper with its markscheme

CARD SETS ON SPLYCR

Open a set to host it as a class game, or make a copy to edit.

- B3.2 Transport: Humans
- B2.2–B3.2 Organelles, Gas Exchange & Transport
- B3.2–C2.2 Plant Transport, Respiration & Neural Signalling

**How this was made.** The course structure, the activities and the teaching choices come from my own classroom, my presentations and my years of teaching IB and AP Biology. I use Claude, an AI, to help write and build the interactive guides, lesson plans, slides and practice questions, and to draw the diagrams and code the interactives. I direct the work and review it against the IB and AP specifications before it goes live.