

The pathway of water through a plant

Investigate, using a suitable stain, the pathway of water through the above-ground parts of a plant

For Cambridge IGCSE Biology 0610 (and 0970, which has the same content). Teacher answers start on a new page.

Name

Date

Aim

To show where water travels in the above-ground parts of a plant by placing cut stems in water containing a stain.

Background

Water enters a plant through the **root hairs**, crosses the root and moves into the **xylem**. The xylem vessels carry water up the stem to the leaves. Water evaporates from the leaves in **transpiration** and the loss pulls more water up the stem.

A coloured **stain** (dye) such as red food colouring or eosin is carried in the water. Where the stain is found shows the route that the water has taken, and how far it has gone in a given time shows the speed.

In a stem, the xylem is found in the **vascular bundles**, together with the phloem. In a transverse section, the vascular bundles form a ring of small areas near the outside. Only the xylem will be stained. A celery stalk is really a leaf stalk, but it carries water to the leaves in the same way as a stem.

Hypothesis

The stain will be found in the xylem in the vascular bundles of the stem, and will rise further in the stem the longer the stem is left, because water is pulled up the xylem as water is lost from the leaves.

Variables

Independent	Time that the stalk is left in the stained water
Dependent	Height reached by the stain above the surface of the stained water
Control	• Same type and length of celery stalk, each with leaves • Same volume and concentration of stain • Same light, temperature and air movement (all beakers under the same lamp) • Same fresh cut at the base of each stalk

Equipment

- 6 fresh celery stalks with leaves, cut to the same length (about 20 cm)
- 6 beakers (100 cm³)
- Water and red food colouring or eosin stain, and a dropping pipette
- Scalpel or sharp knife and white tile
- Paper towels
- Ruler graduated in mm
- Hand lens
- Lamp, to speed up transpiration
- Stop-clock
- Marker pen
- Eye protection

Risk assessment

Hazard	Risk	Precaution
Scalpel or knife	Cuts from the sharp blade.	Cut on a white tile, cutting away from the fingers, and put the blade down after use. Do not hold the stem in the hand while cutting.
Stain (food colouring or eosin)	Stains skin and clothes; may irritate eyes.	Wear eye protection. Wash off splashes at once and wipe up any spills.
Mains-powered lamp	Hot bulb, and water near electrical equipment.	Do not touch the lamp and keep it and its cable away from the water.

Method

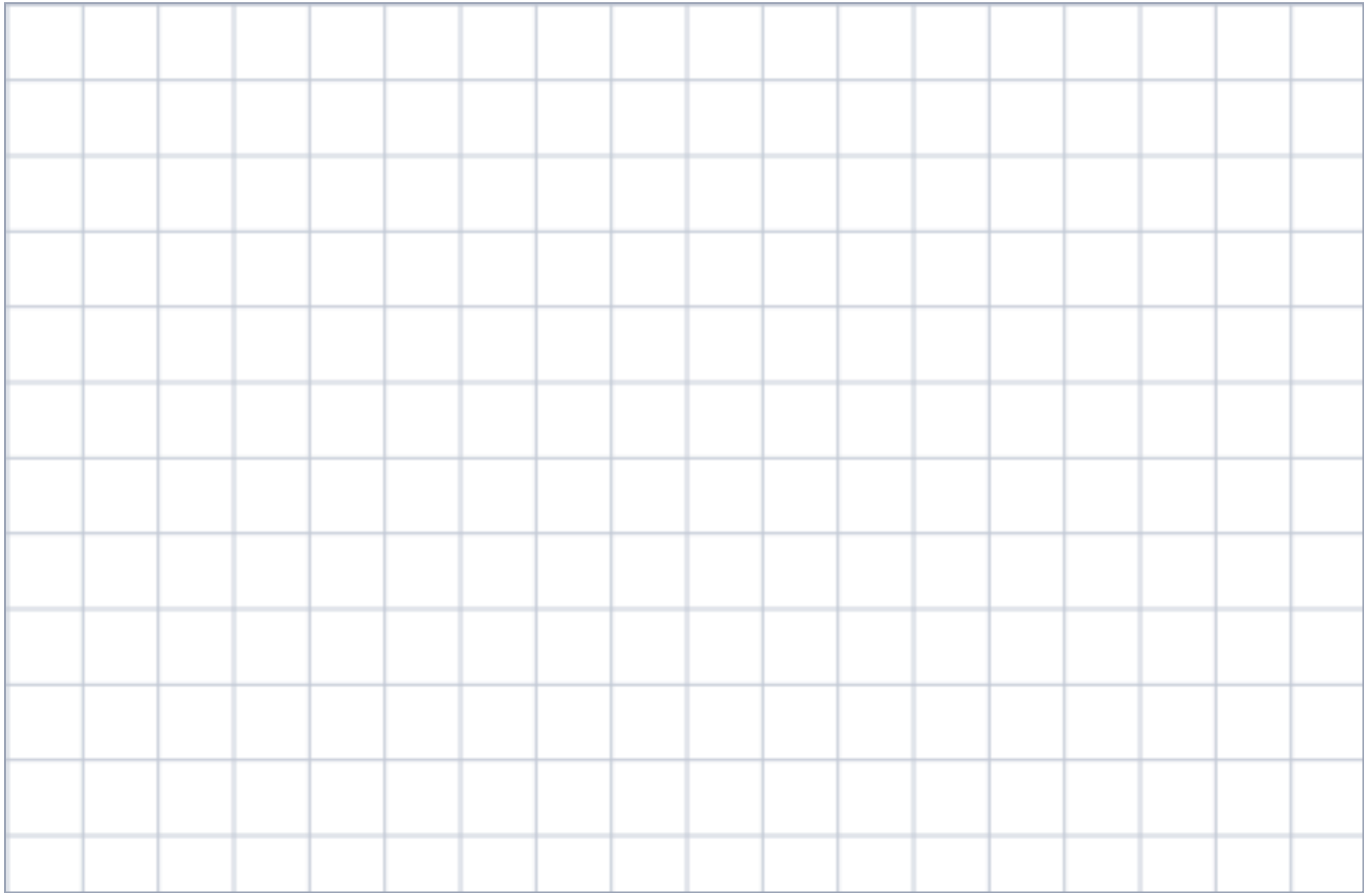
1. Put on eye protection. Label five beakers 10, 20, 30, 40 and 50 min, and a sixth beaker 'overnight'.
2. Put 50 cm³ of water in each beaker and add the same number of drops of stain (for example 10 drops) to each, so that the stain is the same strength in every beaker.
3. On a white tile, cut about 1 cm from the base of each celery stalk with a sharp scalpel, to give a fresh cut end. Stand each stalk in its beaker straight away.
4. Use a marker pen to mark each stalk at the surface of the stained water. Start the stop-clock.
5. Place all the beakers close together under the same lamp, so that all the stalks are in the same conditions.
6. After 10 minutes, take the stalk out of the 10 min beaker and blot the base dry with a paper towel.
7. On the tile, cut thin slices (transverse sections) across the stalk, starting at the water mark and working upwards, until you reach a slice with no stain.
8. Measure the distance from the water mark to the highest slice with stain, to the nearest mm. Record it in cm, to one decimal place.
9. Use a hand lens to look at a stained transverse section. Draw it and show which parts are stained.
10. Repeat steps 6 to 9 for the other stalks at 20, 30, 40 and 50 minutes.
11. Leave the sixth stalk overnight. Next lesson, look for stain in the veins of its leaves, and cut a thin longitudinal section of the stalk to see the stained xylem as lines.
12. Clear away, wash your hands and dispose of the plant material.

Results

Height reached by the stain in the celery stalks	
time in stain / min	height of stain above water level / cm
10	
20	
30	
40	
50	

Graph

Line graph. Plot the height of stain above water level / cm on the y-axis and the time in stain / min on the x-axis. Use more than half the grid in both directions, mark each point with a cross (×) and draw a single thin best-fit straight line. Use the gradient of the line (change in height ÷ change in time) to find the speed of water movement in cm per min.



Exam questions 10 questions · 26 marks

- 1** State the tissue in which the stain was found and where this tissue is found in the celery stalk. [2 marks]

- 2** Stain was seen in the veins of the leaves. Explain how it got there. [2 marks]

- 3** Describe how you would prepare a transverse section of the stem and observe where the stain is found. **[3 marks]**

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- 4** Give two variables that should be kept constant when comparing the stalks. **[2 marks]**

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- 5** Using Table 8.1, calculate the mean speed of the stain between 10 minutes and 30 minutes. Give your answer in cm per min. **[3 marks]**

Table 8.1	
time in stain / min	height of stain above water level / cm
10	1.8
20	3.6
30	5.2
40	7.1
50	8.8

Answer =

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- 6** Explain why the stain moves up the stalk. **[3 marks]**

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7 A fresh cut is made at the base of each stalk just before it is put into the stain. Explain why. **[2 marks]**

8 A second set of celery stalks with all the leaves removed was set up in the same way. Predict the height reached by the stain and explain your prediction. **[3 marks]**

9 Suggest three ways in which this investigation could be improved. **[3 marks]**

10 Describe the appearance of a transverse section of the stalk after the investigation and explain what it shows. **[3 marks]**

Teacher answers

Practical skill 8: The pathway of water through a plant. The example results are practice data, not real measurements.

Example results

Example results (practice data)	
time in stain / min	height of stain above water level / cm
10	1.8
20	3.6
30	5.2
40	7.1
50	8.8

Conclusion

The stain was found only in the xylem, which appeared as a ring of coloured spots (the vascular bundles) in the transverse section. The cortex and the phloem were not stained. This shows that water is carried up the stalk in the xylem. In the stalk left overnight the stain had reached the veins of the leaves. The height reached by the stain increased with time, from 1.8 cm after 10 minutes to 8.8 cm after 50 minutes, a mean speed of $8.8 \div 50 = 0.18$ cm per min (about 11 cm per hour). Water moves up because water evaporates from the leaves (transpiration), which pulls water up the xylem.

Errors and improvements

Error	Effect on the results	Improvement
The stalks are not all the same size or age.	Different numbers of leaves and xylem vessels change the speed of water uptake, so the results cannot be compared.	Use stalks of the same length, age and number of leaves from the same bunch.
Judging where the stain ends by eye is difficult because the stain fades.	The height measured is not accurate.	Cut thin sections close together and use a hand lens to find the last one with stain.
The cut end dries out, or air enters the xylem, before the stalk is put in the stain.	Air bubbles or dried cells block the xylem, so less water and stain are taken up.	Make a fresh cut just before standing the stalk in the stain, and put it in straight away.
Conditions such as light, temperature and air movement differ between beakers.	Transpiration rate differs, so the height reached by the stain differs for reasons other than time.	Keep all the beakers close together under the same lamp or fan.
Only one stalk is used for each time.	An unusual stalk could give a misleading result.	Use two or three stalks at each time and calculate a mean.

Mark scheme

One mark for each point unless a maximum is given. Words in brackets are not needed for the mark.

1. [2]

- xylem (1)
- in the vascular bundles / in a ring (1)

2. [2]

- stain was carried in the water (1)
- through the xylem, up the stem and into the leaves / veins (1)

3. [3]

- cut a thin slice (1)
- across the stalk / at right angles to its length (1)
- with a sharp blade / scalpel, on a tile, cutting away from the fingers (1)
- look at the section with a hand lens and note which parts are coloured (1)
- Max 3

4. [2]

- same size / type of stalk (1)
- same volume / concentration of stain (1)
- same light / temperature / air movement (1)
- Max 2

5. [3]

- $5.2 - 1.8 = 3.4$ (cm) (1)
- $3.4 \div 20$ (1)
- $= 0.17$ (cm per min) (1)

6. [3]

- water evaporates from the leaves / transpiration (1)
- this pulls water up the xylem (1)
- water molecules are attracted to each other so a continuous column / stream is pulled up (1)

7. [2]

- removes the dried / blocked end / air bubbles in the xylem (1)
- so that water and stain can enter the xylem (1)

8. [3]

- stain would rise less / more slowly (1)
- less transpiration because there are fewer leaves / less surface for evaporation (1)
- so less pull / less water taken up (1)

9. [3]

- repeat and calculate a mean (1)
- use more times / leave the stalks for longer (1)
- use the same type / size of stalk (1)
- keep conditions the same under a lamp / fan (1)
- use thin sections to find the end point (1)
- Max 3

10. [3]

- ring of small coloured spots / vascular bundles stained (1)
- only the xylem is coloured, the rest is unstained (1)
- so water travels in the xylem (1)

Exam tips

- Say xylem, not 'the veins' or 'the tubes'. Say that the stain is carried in the water, so it shows the route of the water.
- In a transverse section the stained xylem is seen as spots in a ring of vascular bundles. In a longitudinal section it is seen as coloured lines.
- A speed is a distance divided by a time. Show the working and give the unit, for example cm per min.
- Mention transpiration when you explain why the stain moves: loss of water from the leaves pulls the water and stain up.
- Safety: the cutting tool is the main hazard. Say that you cut on a tile, away from your fingers.