Xylem Tissue

A Level

Part A Function

Xylem tissue is used to transport [ ] from the [ ] to the [ ].

It also provides plants with [ ].

Items:

water (and minerals) | roots | structural support | carbon dioxide | sugars | light | stems and leaves | oxygen

Part B Structure

Xylem tissue includes xylem vessels (the main structures that transport [ ]), parenchyma cells (which can store water, nutrients, and tannins), as well as some other cell types and structures.

Xylem vessels are initially formed as columns of cells. These cells produce a strong polymer called [ ], which is deposited in the cell walls. The cells then die, leaving behind hollow tubes surrounded by the polymer.

Because the polymer is very strong and rigid, xylem vessels also provide the plant with [ ].

Items:

lignin | starch | structural support | water | chitin | keratin | carbon dioxide | light

Part C Transport mechanisms

Various mechanisms are involved in the movement of water into and through a plant. Match the mechanism to the description in the table below.

Mechanism	Description
	the evaporation of water out of the leaves (through stomata) which pulls water towards the leaves
	the attraction between water molecules that ensures that they are pulled upwards together
	the movement of water molecules from a region of higher water potential to a region of lower water potential through a partially permeable membrane (e.g. from the soil into the root hair cells)

Items:

cohesion **active transport** **translocation** **transpiration** **osmosis**

Part D Xylem statements

Which of the following statements are correct? Select all that apply.

- [ ] xylem is only found in the main stem of a plant
- [ ] xylem tissue is entirely non-living
- [ ] xylem transports water from the roots to the stems and leaves
- [ ] xylem tissue carries out photosynthesis
- [ ] xylem provides structural support to plants
- [ ] xylem vessels are non-living, but other parts of xylem tissue (e.g. parenchyma cells) are living
- [ ] xylem transports sugars from the leaves to the non-photosynthetic parts of the plant (e.g. the roots)
- [ ] xylem is found in the roots, stems, and leaves of a plant

Phloem Tissue

A Level

Part A Function

Phloem tissue is used to transport [ ] from the [ ] to the [ ].

This process is called [ ].

Items:

photosynthates (e.g. sugars and amino acids) | water | non-photosynthetic parts of the plant | transpiration | translocation | photosynthetic parts of the plant (e.g. leaves)

Part B Structure

The main vessels in phloem tissue formed by cells called [ ], which form a column. The cell walls between these cells form large holes and are referred to as [ ], which allows material to move between the cells easily. These cells also lose their nucleus, tonoplast, and some other organelles.

The vessels are surrounded by cells called [ ], which are connected to the vessel cells by [ ]. These cells provide energy and materials to the vessel cells.

Items:

stomata | lignin | sieve tube elements | gap junctions | sieve plates | companion cells | plasmodesmata

Part C The mass flow hypothesis

The mass flow hypothesis offers an explanation of how organic compounds (e.g. sugars) are translocated via phloem tissue.

The hypothesis states that in [ ] areas (e.g. leaves, where sugars are produced during photosynthesis), water potential is [ ] as the concentration of soluble sugars increases. This causes water to flow into these areas, increasing the hydrostatic pressure.

In [ ] areas (e.g. growing roots, where sugars are being used up during respiration), water potential is [ ] as the concentration of soluble sugars decreases. This causes water to flow out of these areas, decreasing the hydrostatic pressure.

The water will then flow through [ ] from the high pressure area to the low pressure area, taking soluble sugars with it.

Items:

increased **source** **xylem vessels** **sink** **decreased** **sieve tube elements**

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Xylem vs Phloem

A Level

Part A Tissue comparisons

In the table below, identify whether each statement applies to xylem, phloem, or both.

Statement	Tissue
found in roots, stems, and leaves	
responsible for translocation	
responsible for transpiration	
contains living cells	
main vessels are composed of lignified non-living tissue	
main vessels are composed of sieve tube elements	

Items:

xylem phloem both

Part B Vascular bundles

Xylem and phloem tissue are found together in "vascular bundles".

A student was investigating the vascular system in a flowering plant and observed a vascular bundle. They identified features of a mature sieve tube element.

The cross-sectional area of a typical xylem vessel is six times greater than the cross-sectional area of this mature sieve tube element.

The cross-sectional area of a typical xylem vessel is $170\,\mu\text{m}^2$

What is the cross-sectional diameter of this sieve tube element? Give your answer to the nearest integer.

(Assume that both cross-sectional areas are circular.)

Part C Radioactive tomatoes

Tomato plants were placed in sunlight in an atmosphere containing radioactively labelled carbon dioxide. After a period of time, radioactively labelled sugars were detected in the roots of the plants.

Drag the statements below into the correct chronological order on the right (with the first step at the top and the last step at the bottom). Only some of the statements will be needed.

Available items

- carbon dioxide diffused into the roots
- carbon dioxide entered the leaves
- the carbon dioxide was transported to the roots by translocation
- the carbon dioxide was transported to the roots by transpiration
- the carbon dioxide was converted into sugars in the roots
- the carbon dioxide was converted into sugars in the leaves
- the sugars were transported to the roots by translocation
- the sugars were transported to the roots by transpiration

Question elements adapted with permission from NSAA 2022 Specimen Paper Section 2 Q26 and Section 1 Q67

Plant Water Loss

A Level

Part A Stomata control

Which of the following statements correctly explain how the stomata are controlled? Select all that apply.

- [ ] when water levels are **high**, the guard cells become turgid, which causes each stoma to **open**
- [ ] when water levels are **high**, the guard cells become turgid, which causes each stoma to **close**
- [ ] when water levels are **low**, the guard cells become less turgid, which causes each stoma to **open**
- [ ] when water levels are **low**, the guard cells become less turgid, which causes each stoma to **close**

Part B Low water environments

What is the general name given to plants that are adapted to living in low water environments?

Which of the following adaptations are commonly found in these plants? Select all that apply.

- [ ] thick waxy cuticle
- [ ] very thin cuticle or no cuticle
- [ ] many stomata
- [ ] few stomata
- [ ] leaves with a large surface-area-to-volume ratio
- [ ] leaves with a small surface-area-to-volume ratio
- [ ] large root system
- [ ] small root system

Part C High water environments

What is the general name given to plants that are adapted to living in high water environments?

Which of the following adaptations are commonly found in these plants? Select all that apply.

- [ ] thick waxy cuticle
- [ ] very thin cuticle or no cuticle
- [ ] many stomata
- [ ] few stomata
- [ ] leaves with a large surface-area-to-volume ratio
- [ ] leaves with a small surface-area-to-volume ratio
- [ ] large root system
- [ ] small root system

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Transpiration and Water Potential

A Level

Water in a plant moves from a high water potential to a low (more negative) water potential. Water potential is measured in MPa.

Part A MPa values

For a particular plant, the water potential was measured in the soil, in the roots, in the leaves, and in the atmosphere. Match the MPa values to the locations in the table below, assuming that transpiration is occurring normally.

Measurement location	Water potential (MPa)
soil	
roots	
leaves	
atmosphere	

Items:

-75 -0.1 -1.5 -0.033

Part B Water transport

What is the name of the tissue responsible for transporting water from the roots to the leaves?

Part C Water loss

What is the name of the structures in leaves through which water is lost?

Adapted with permission from NSAA 2021 Section 2 Q50

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Capillary Action and Water Transport

A Level

An experiment was performed to investigate whether capillary action could account for the movement of water from roots to leaves in a plant.

Figure 1 shows apparatus used to model this effect using narrow glass capillary tubing. The inner diameter of the capillary tubing is $0.5\,\mathrm{mm}$.

The initial height of the water in the tubing was recorded as $0.2\,\mathrm{cm}$.

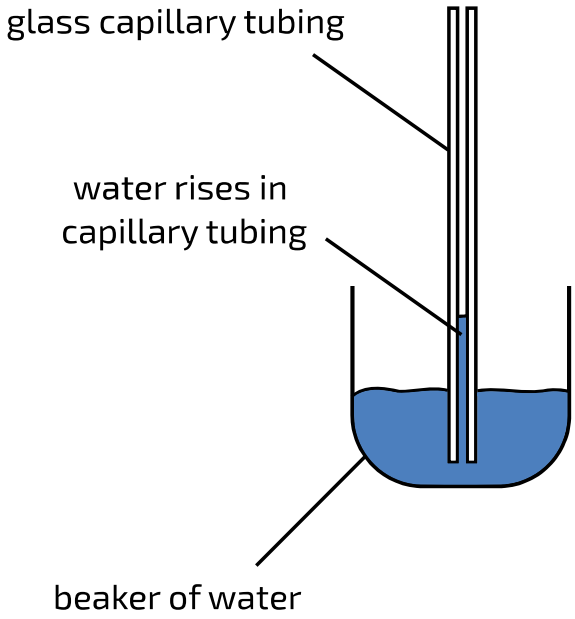

Figure 1: Capillary action experiment. A glass capillary tubing was placed in a beaker of water, and the initial height of water in the capillary tubing was recorded. Over time, the water in the capillary tubing rises as a result of capillary action.

Part A Rate of transport

After 2 minutes the height of the water was recorded as $1.8\,\mathrm{cm}$.

Calculate the rate of water movement in $\mathrm{mm^3\,min^{-1}}$. Give your answer to 3 significant figures.

Part B Transpiration processes

In the experiment above, the water would only travel upwards a certain distance and then stop. In plants, water continuously travels upwards.

This suggests that capillary action cannot fully account for water transport in plants.

Which of the following additional processes are occurring in plants but **not** in the experiment above?

- [ ] evaporation of water, pulling the water upwards
- [ ] cohesion between water molecules, allowing the water to be pulled upwards
- [ ] adhesion between the water molecules and the surface of the tube (xylem/capillary tubing)
- [ ] movement of water into the system

Adapted with permission from NSAA 2020 Section 2 Q51