Model Answers: Medium

1

The correct answer is **C** because:

- Although extensive root networks are a common adaptation of **xerophytes**, this diagram just depicts a cross section of a **leaf**, therefore it is **not** possible to ascertain anything about the nature of the root network (so 3 is wrong)
- There are **no** defensive spines visible in the diagram. There are **epidermal hairs** (which help trap humid air around the **stomata** to reduce water loss) that could be mistaken for defensive spines, however, as the primary role of defensive spines is to deter herbivory, to be effective they would need to face **outwards** (and the epidermal hairs are not)

2

The correct answer is **A** because:

- **Y** is a **companion cell** and **Z** is a **sieve tube element**
- Between the companion cells and the sieve-tube elements the movement of sucrose occurs via **diffusion** (through the **plasmodesmata** that link the companion cell to the sieve tube elements)
- It is possible to tell that **Z** is a sieve tube element due to its reduced cytoplasmic contents and pores at the end of the cell (which form the **sieve plate**)
- The pores at the end of the cells allow for pressure-driven mass flow (or translocation) of phloem sap

Hint: Active transport of sucrose occurs between the source cells and the companion cells, not the companion cells and the sieve tube elements – this is a common mistake!

Active Loading of Sucrose Recap:

Photosynthates, such as sucrose, are produced in the **mesophyll** cells (a type of **parenchyma** cell) of photosynthesising leaves. Sugars are actively transported from source cells into the **companion cells**, which are associated with the sieve-tube elements in the vascular bundles. This active transport of sugar into the companion cells occurs via a proton-sucrose **symporter**; the companion cells use an ATP-powered proton pump to create an **electrochemical gradient** outside of the cell. The cotransport of a proton with sucrose allows movement of sucrose against its concentration gradient into the companion cells.

3

The correct answer is **C** because:

- The **evaporation** of water from the leaf (i.e. transpiration) is the driving force of water movement in the xylem
- Transpiration is high during the day (due to higher **air temperatures** and the stomata being open) therefore there is a greater transpiration pull
- This transpiration pull is able to draw water up the xylem thanks to the **cohesive** properties of water
- At night the transpiration pull is reduced, therefore the water is under less tension and this lack of tension causes a slight widening of the xylem vessels
- As this occurs across all the vessels in the tree there is a measurable increase in tree diameter

Cohesion-Tension Theory Recap:

The movement of water up the xylem is possible due to the **dipolar** nature of water. Water forms hydrogen bonds with neighbouring water molecules creating cohesion. This results in a **continuous column** of water forming in the plant stem. Tension (a pulling force) is creating when the water evaporates out of the **stomata**. This movement of water out of the stomata results in the water column being pulled up the xylem towards the stomata, this is known as the transpiration pull. This pull will draw up the water and also put tension on the xylem, making it narrow and longer. This change in diameter of the xylem is measurable, for example the diameter of tree trunks will change according to transpiration rates.

4

The correct answer is **B** because:

- **Epidermal hairs** trap a boundary layer of humid air around the stomata
- **Sunken stomata** also help to ensure a boundary layer of humid air around the stomata
- A **reduced number of stomata** will lower the amount of water lost through transpiration, but it does not affect the water potential gradient of the stomata (i.e. although there are fewer stomata, water is still lost from them at a normal rate)
- **Rolled leaves** can help trap a boundary layer of humid air around the stomata (xerophytic marram grass famously uses this adaptation to reduce water loss)
- **Defensive spines** reduce the chance of tissue loss by discouraging herbivory, but they do not affect the water potential gradient

5

The correct answer is **D** because the volume of water lost by transpiration in 30 seconds = πr^2 x distance moved by the bubble

r (radius) is equal to half the diameter so **r = 0.3 mm**

So, to work out the distance moved in 15 seconds the formula is

$\pi(0.3^2 \times 14) = 3.96\ mm^3\ 30sec^{-1}$

Then to work out the rate in $mm^3\ min^{-1}$ **multiply** this number by **2**

6

The correct answer is **B** because:

- mass flow can occur in both directions (depending on what part of the plant is acting as a source and what part is acting as a sink)
- the flow in each sieve tube can only occur in one direction at a specific time though as the movement is driven by hydrostatic pressure
- if there are two opposing hydrostatic pressures pushing in opposite directions, they will essentially cancel each other out

A **source** is adding sucrose and other assimilates to the phloem (known as phloem loading). A **sink** is removing sucrose and other assimilates to the phloem (known as phloem unloading) where they will be used for growth, metabolism or stored for future use. In the summer, the leaves of a deciduous tree act as sources and roots act as sinks. A significant amount of the assimilates that are produced over the summer months are stored in the roots so that the tree has an energy store to get through winter and to facilitate the growth of new foliage in the spring

7

The correct answer is **C** because:

- The climate in a tropical rainforest is heavily influenced by the plants located there. High rates of transpiration from the plants in a rainforest leads to large amounts of water vapour entering the atmosphere, which, in turn leads to cloud formation and eventually rain (essentially the plants are responsible for creating much of the rain that is so characteristic of the **rain**forest).
- **A**, **B** and **D** all play an important role in transpiration and therefore will have a significant impact on the climate
- While **C** plays an important role in preventing the seasonal freezing of bodies water located at higher latitudes, it is of less significance to the climate of a tropical rainforest

8

The correct answer is **D** because:

- increasing **atmospheric humidity** would decrease the amount of water lost via **transpiration** due to the reduced diffusion gradient
- the reduction in transpiration would mean a **weaker transpiration pull** (as less water is being lost), therefore the flow of water through the xylem will be slower

Increasing **air temperature**, **light intensity** or **wind speed** would increase the rate of transpiration, therefore would **increase** the flow through the xylem

9

The correct answer is **C** because:

- 1 is incorrect as there is no cytoplasm in the xylem vessel elements so movement via the symplast pathway would not be possible (additionally water is transported in the xylem due to transpiration pull and root pressure rather than a water potential gradient)
- 2 is correct as water transported by both the symplast and apoplast pathways occurs down a water potential gradient
- 3 is correct as the Casparian strip blocks the apoplast pathway in the endodermis (which the water must pass to reach the xylem), therefore all water must have travelled via the symplast pathway at that point at least
- 4 is incorrect as plasmodesmata are narrow threads of cytoplasm that pass through the cell walls of adjacent plant cells. Therefore all water transported through plasmodesmata is travelling via the symplast pathway (not apoplast)

10

The correct answer is **C** because:

- all water must pass through the symplast pathway to reach the xylem due to the presence of the casparian strip
- the casparian strip is a band of **suberin** (an impermeable substance) and is found in the endodermal cell walls of plant roots
- the casparian strip blocks the movement of water through the **apoplast** pathway (the water is diverted from the cell wall to the cytoplasm where it then follows the **symplast** pathway)

The **apoplast pathway** is the movement of water via the **cell wall**

The **symplast pathway** is the movement of water via the **cytoplasm**

The **vacuolar pathway** is the movement of water via the **vacuole**