

SOLUTIONS

7.1: Structure of transport tissues

- B**
Mitochondria are located in the companion cell (B), where they provide ATP for active transport of sucrose into the sieve tube during translocation.
- B**
Protons move from Y to Z by active transport to create a proton gradient, which drives sucrose uptake into companion cells for translocation in the phloem.
- C**
Statement C is correct as the cellulose walls of xylem vessels are hydrophilic, allowing adhesion between water molecules and the vessel walls. This helps maintain a continuous water column for transport, essential for transpiration and cohesion-tension mechanisms.
- B**
In a leaf's vascular bundle, xylem is positioned closer to the upper epidermis, while phloem is located towards the lower epidermis. This arrangement facilitates efficient transport of water, minerals, and nutrients within the plant (option B).
- D**
To correctly represent 100 μm , the scale bar length is calculated using the ratio ($15 \text{ mm} / 250 \mu\text{m} = x \text{ mm} / 100 \mu\text{m}$). Solving gives $x = 6 \text{ mm}$. The mistake is in the xylem of the stem.
- A**
Phloem sieve tube elements lack nuclei and vacuoles but contain mitochondria for active transport in companion cells. The correct diagram is A, as it correctly labels the mitochondria, sieve plate, and thin cytoplasm.
- A**
Cell 1 is a companion cell, which supports the phloem sieve tube element (Cell 2) in transporting sugars and other nutrients. These structures are part of the phloem tissue, involved in translocation in plants.
- C**
The structure labeled "X" in the image is a phloem sieve tube element, identifiable by its perforated sieve plates, which allow the flow of nutrients between cells.
- D**
Lignin in xylem makes the vessels impermeable to water and, along with cellulose, strengthens the walls to prevent collapse under pressure.
- C**
In a sieve tube element, the cell wall and sieve plate are visible, but cytoplasm is minimal, and no mitochondria are present. This matches the structure shown in option C, which correctly labels the key features.
- B**
Both xylem and phloem use mass flow for transport: xylem for water and minerals, phloem for nutrients.
- B**
Pits in xylem vessel elements allow lateral movement of water into adjacent vessels. Options A, C, and D describe incorrect features for xylem vessels.
- A**
Lignin stains xylem, which supports the identification of Z as xylem and W as phloem. Xylem is typically located toward the center of the stem, while phloem is found toward the periphery.
- B**
Phloem sieve tube elements and companion cells are connected by plasmodesmata, allowing for the exchange of nutrients, signaling molecules, and other substances. This is essential for the transport of organic compounds, like sugars produced during photosynthesis, throughout the plant. In contrast, xylem vessel elements are dead, lignified cells that are stacked end-to-end, forming a continuous tube for efficient water transport. They don't require plasmodesmata because they're specialized for water transport and don't need cellular connections.

- 15. C**
The structure of phloem sieve tube elements and xylem vessel elements is closely related to their functions as transport system:
- Phloem sieve tube elements have perforated end walls (sieve plates) that allow dissolved solutes like sugar to move between cells, enabling the transport of organic compounds throughout the plant.
 - Xylem vessel elements have lignin in their cell walls, providing strength, waterproofing, and preventing collapse under transpiration pull, enabling the efficient transport of water and minerals from the roots to the rest of the plant.
- 16. A**
Phloem sieve tube elements are specialized cells that are part of the phloem tissue in plants, responsible for transporting sugars and other metabolic products throughout the plant. The correct match for the structure and function of phloem sieve tube elements is the one that states they have peripheral cytoplasm with no nucleus (A). This structure allows for a more efficient flow of sap as it provides as little resistance to flow as possible, which is essential for the function of phloem in the transportation of nutrients.
- 17. D**
In xylem vessel elements, adhesion plays a crucial role during transpiration, which is the process of water movement through a plant and its evaporation from aerial parts, such as leaves. Adhesion refers to the ability of water molecules to stick to the walls of the xylem vessels, which is facilitated by the surface tension of water and the narrowness of the tubes. When the vessel elements form a narrow tube (D), it enhances the adhesion of water molecules to the walls of the vessels, aiding in the upward movement of water against gravity.
- 18. D**
Mass flow is a mechanism that occurs in both plants and animals for the transport of fluids. In the given list, the artery and the vein are part of the circulatory system in animals and transport blood by mass flow due to the pumping action of the heart. The phloem sieve tube and the xylem vessel are part of the plant's vascular system; the phloem transports sugars and other metabolic products by mass flow from sources (where sugars are produced by photosynthesis) to sinks (where sugars are used or stored), while the xylem transports water and minerals from the roots throughout the plant also by mass flow, primarily driven by transpiration pull.
- 19. A**
A companion cell in phloem tissue is primarily responsible for maintaining the metabolic functions necessary for the active transport of sugars and other nutrients into or out of the sieve tube elements. It provides the energy required for loading and unloading materials due to its close association with sieve tube elements, facilitated by numerous plasmodesmata connecting the two cell types. This function is crucial for the efficient transport of photosynthates (like sugars) throughout the plant.
- 20. D**
It involves identifying cellular structures in an electron micrograph, focusing on plant cell anatomy. The structure labeled X is a companion cell, essential for the functioning of phloem sieve tubes in plants, illustrating the specialized cellular organization in plant vascular tissue.
- 21. A**
Identifying vascular tissues in plant organs typically involves recognizing phloem as the outer ring of cells in a vascular bundle and xylem towards the center. The diagrams likely depict cross-sectional views of stems, showing different vascular tissues.
- 22. C**
Xylem vessel elements are known for being part of the plant's vascular system, responsible for the transport of water and minerals. They are characterized by elongated cells with end walls that have broken down to form a continuous tube, facilitating the movement of water. These cells are typically dead at maturity, have thick, lignified walls, and are located throughout the plant, not just in roots but also in stems and leaves.
- 23. C**
The organ in the photomicrograph shows trichomes, which are extensions of the epidermis tissue, indicating the organ's identity.
- 24. A**
Lignin's properties, such as rigidity, impermeability to water, and strength to resist pressure, are crucial for maintaining the integrity of xylem vessels for water transport in tall plants like trees.
- 25. B**
Option B is the correct answer as 1, 4 and 6 are xylem vessels which contain lignified walls while 2, 3 and 5 are phloem vessels that transport organic solutes such as sucrose.

- 26. A**
Option A is correct as companion cells and phloem sieve tube elements both contain endoplasmic reticulum and xylem vessel elements and phloem sieve tube elements both do not contain any nucleus.
- 27. C**
Option C is the correct answer as xylem vessel elements contain lignified walls and pits. Phloem sieve tube cells contain cytoplasm, mitochondria and plasmodesmata.
- 28. C**
Option C is the correct answer as the only thing that is correct is that the material is circular. Spherical is a used for 3D materials which is not the case here and we cannot tell if the tubes are hollow from an upper cross section.
- 29. D**
Option D is the correct answer as no cell contents in P suggests that this is the xylem vessel elements since these are dead cells. Q is the phloem sieve tube elements that contains cytoplasm only and R is the companion cells next to the phloem sieve tube elements containing numerous mitochondria giving them a granular image.
- 30. B**
Option B is the correct answer as the plasmodesmata allow the sucrose to pass from the companion cells into the sieve tube cells. The mitochondria in the companion cells help in sucrose loading while the nucleus allows for the production of protein carriers that help to bring sucrose in. The thicker cell wall of the companion cells has no correlation to their function.
- 31. C**
Option C is the correct answer as phloem sieve tube cells contain the cytoplasm, mitochondria and plasmodesmata. Lignin is present in xylem cells only while chloroplasts are present in leaf cells.
- 32. B**
Option B is the correct answer as 1 refers to the parenchyma cells that store starch. 2 refers to the phloem vessels that transport sucrose and 3 refers to the xylem vessels that transport water and mineral ions and are identifiable as they lie below the phloem and have thick walls.
- 33. A**
Option A is the correct answer as the pits in xylem vessels allow water to flow from one tube to another. The lignin deposits prevent the collapse of the vessels when the column of water is under tension. The xylem tubes are continuous and are made of dead cells so they offer little resistance to the flow of water.
- 34. A**
Option A is the correct answer as adhesion, cohesion and mass flow caused by the pull generated from transpiration are responsible for the upward movement of water in the xylem.
- 35. B**
Option B is the correct answer as it shows the phloem vessels.
- 36. D**
Option D is the correct answer as both the phloem sieve tube elements and xylem vessel elements do not have any nucleus. Phloem sieve tube elements have cytoplasm and end walls which xylem vessels do not have.
- 37. C**
Option C is the correct answer as it represents the xylem vessel that lies inward than the phloem and in thick walled, hence takes up more stain and appears darker in colour.
- 38. B**
Option B is the correct answer as xylem vessels are remnants of dead cells that are lignified and contain pits as well.
- 39. C**
Option C is the correct answer as in the diagram on the edges there are these pits which indicate the sunken stomata and there is a significantly thick cuticle.
- 40. C**
Option C is the correct answer as since the palisade mesophyll layer is thicker the line should remain closer to the bottom layer and xylem is always above the phloem vessels.
- 41. A**
Option A is the correct answer as it shows the xylem vessels which are dead lignified cells. Options B, C and D show phloem.
- 42. A**
Option A is the correct answer as 1 shows the cortex, 2 shows the endodermis and 3 shows the phloem.

43. **C**
Option C is the correct answer as this section clearly shows a stem as the vascular bundles are visible underneath the epidermis.
44. **A**
Water flows from less negative to more negative water potential. Since cell 3 is the xylem vessel it has the less negative water potential than cell 1 making option A the correct answer.
45. **C**
Option A is incorrect as phloem sieve tube elements are not lignified. Option B is incorrect as water does not flow through the companion cells. Option D is incorrect as companion cells are not lignified and xylem vessels do not contain cytoplasm. Hence, option C is the correct answer as companion cells contain many plasmodesmata for cell communication, sieve tube elements contain cytoplasm to reduce resistance to flow and xylem vessels allow water to flow freely.
46. **C**
Option C is the correct answer as no cytoplasm means that more water can flow through at a time and there is less resistance to flow meaning that water than flow faster. Cellulose content of cell walls has no correlation with the cytoplasm in xylem cells.
47. **B**
Option B is the correct answer as transporting water is the main function of xylem vessels and 1, 4 and 6 represent the xylem vessels.
48. **D**
Option A is incorrect as companion cells help in the phloem's metabolism and regulation. Option B is incorrect as phloem cells are not lignified. Option C is incorrect as phloem sieve tube elements do not become narrower. Hence, option D is the correct answer as plasmodesmata allow for the movement of water and solutes across the cells walls of the phloem sieve tube elements.
49. **C**
Option C is the correct answer as phloem sieve tube elements contain plasmodesmata, mitochondria and cytoplasm.
50. **D**
Option D is the correct answer as 1 is the xylem, 2 is the phloem, 3 is the spongy mesophyll cell and 4 is a palisade mesophyll cell.
51. **C**
Option C is the correct answer as the material is circular in shape. Not all the areas are spherical some are irregularly shaped as well and from this picture it cannot be determined if the structure is a hollow tube or not.
52. **B**
Xylem vessels transport water and they are represented by 1, 4 and 6. Phloem vessels transport sucrose and are represented by 2, 3 and 5. Hence, option B is the correct answer.
53. **D**
Option D is the correct answer as 1 is the xylem, 2 is the phloem, 3 is the endodermis, 4 is the cortex and 5 is the epidermis.
54. **B**
Option B is the correct answer as the root hair has a diameter of 40 and the endodermis with the vascular tissue has a diameter of 11. Hence, 40 : 11 is the correct ratio.
55. **D**
Option D is the correct answer as both the sieve tube elements and the xylem vessels elements do not have a nucleus.
56. **C**
Option C is the correct answer as this photomicrograph Y shows a cross-section of the phloem vessels.
57. **C**
Option C is the correct answer as ATP is used to remove protons from the cytoplasm of the companion cell in order to establish a gradient for movement of sucrose.
58. **C**
Option C is the correct answer as 2 and 3 represent the phloem vessels which can transport sucrose and water.
59. **D**
Option D shows the correct drawing as the xylem vessels are thick lignified and have pointed ends not circular.

60. **D**
Option D is the correct answer as a sieve tube element has a thin layer of cytoplasm and has sieve plates on both edges.
61. **B**
Option B is the correct answer as the marking indicate that this is the sieve plate in the sieve tube elements.
62. **C**
Option C is the correct answer as R and S are phloem vessels and they contain proton pumps.
63. **D**
Xylem vessels transport water and they are represented by 1, 4 and 6. Phloem vessels transport sucrose and are represented by 2, 3 and 5. Hence, option D is the correct answer.
64. **B**
Statements 1 and 2 are correct as P has a more negative water potential than Q due to the curled shape and this means that more cells are plasmolyzed in P than in Q. Hence, option B is the correct answer.
65. **C**
Option C is the correct answer as phloem sieve tube elements have a cell membrane and cytoplasm but no nucleus or ribosomes.
66. **D**
Xylem vessels transport water and they are represented by 1, 4 and 6. Phloem vessels transport sucrose and are represented by 2, 3 and 5. Hence, option D is the correct answer.
67. **C**
Option C is the correct answer as phloem vessels transport the most amin acids and they are represented by 2, 3 and 5.
68. **B**
Option B is the correct answer as it represents the xylem vessels that are on the inner side of the vascular bundle.
69. **D**
Statements 2 and 4 are correct for both the apoplast and the symplast pathway as water enters the cytoplasm via mitosis and moves through the cell wall. Hence, option D is the correct answer.
70. **C**
Option C is the correct answer as 2 is the phloem in the root, 3 in the stem and 6 in the leaf.
71. **A**
Option A is the correct answer as 1 and 3 represent the xylem vessels which transport mineral ions.
72. **B**
Option B is the correct answer as 1 and 4 represent the xylem vessels which transport mineral ions.
73. **D**
Statement 1 is incorrect as water can pass through cellulose. Statements 2 and 3 are correct as lignin is impermeable to water and water cannot pass through the Casparian strip. Hence, option D is the correct answer.
74. **C**
Option A is incorrect as there are no sieve plates in xylem vessel elements. Option B is incorrect as xylem vessels do not contain cytoplasm. Option D is incorrect as there are no companion cells associated with xylem vessels. Hence, option C is the correct answer as xylem vessel elements are elongated cells with ends broken down and are located in vascular bundles in the stem and in the roots.
75. **C**
Option C is the correct answer as the mesophyll cell walls have a layer of moisture and this is the site of evaporation during transpiration.
76. **A**
Option A is the correct annotation as the epidermis can be seen as a darkly stained layer of cells and hollow vessels are xylem.
77. **A**
Option A is the correct answer as microvilli increase the surface area, cannot be resolved using a light microscope and more than one are present on a cell. Root hair cells contain vacuoles.
78. **A**
Option A is the correct answer as A represents the xylem vessel which transports water meaning it has the least negative water potential.

79. **C**
Option C is the correct answer as 1 is the epidermis, 2 is the phloem, 3 is the xylem and 4 is the cortex.
80. **C**
Option C is the correct answer as since the palisade mesophyll layer is thicker the line should remain closer to the bottom layer and xylem is always above the phloem vessels.
81. **B**
Option B is the correct answer as xylem will continue functioning since it contains dead cells while phloem will stop functioning as it consists of live cells.

7.2: Transport mechanisms

1. **D**
Leaves can act as sources when mature (exporting sucrose and amino acids) and as sinks when developing (importing nutrients), so they function as sources or sinks for both.
2. **B**
As amino acids are actively loaded into phloem sieve tubes, solute concentration rises, decreasing water potential. Water enters by osmosis, increasing the volume of sap in sieve tubes.
3. **A**
Sucrose and amino acids are transported in the phloem from source to sink by mass flow in both upward and downward directions. Cohesion-tension applies to water movement in the xylem. Thus, option A is correct.
4. **B**
Phloem transports sugars bidirectionally, moving from source (e.g., leaves) to sink (e.g., roots or growing tissues). Therefore, cell Z (sink) can be above or below cell Y (source).
5. **A**
Statement A is correct as the Casparian strip, made of suberin, blocks the apoplast pathway, forcing water and solutes into the symplast pathway through root cell membranes before entering the xylem.
6. **A**
Sucrose is transported by mass flow to sinks, which are areas of growth or storage. The root storage organ, growing leaf bud, and growing shoot tip are all sinks where sucrose is used or stored.
7. **A**
In the symplast pathway, solutes move through the cytoplasm of plant cells, and cell surface membranes regulate their selective absorption, ensuring controlled movement between cells.
8. **B**
Water molecules form hydrogen bonds with each other in a process called cohesion. This creates a continuous column of water that moves upward through the xylem vessels due to transpiration pull.
9. **B**
Lignin is deposited in the xylem vessel walls, making them impermeable to water and providing structural support for water transport.
10. **D**
The companion cell contains a nucleus, which controls metabolic activities and supports the sieve tube cell, which lacks a nucleus and relies on the companion cell for essential functions.
11. **B**
The Casparian strip blocks the apoplast pathway, forcing ions to be transported through the symplast pathway. However, since fluorescence is observed, the ions are only transported through the apoplast before reaching the Casparian strip.
12. **D**
Adhesion refers to the attraction between water molecules and xylem vessel walls, while cohesion refers to the attraction between water molecules due to hydrogen bonding. Both are essential for water transport in plants.
13. **B**
In phloem, sucrose moves from a source (high hydrostatic pressure and lower water potential) to a sink (lower hydrostatic pressure and higher water potential) through mass flow, driven by pressure differences between the source and sink.

14. **A**
Assimilates are moved into the phloem sieve tube through active transport to load sucrose, followed by facilitated diffusion and simple diffusion to move it down the concentration gradient. These processes ensure efficient translocation of nutrients.
15. **B**
In row B, the mesophyll cells have a low sucrose concentration (5), and the companion cells have a higher concentration (15) due to active transport. Sucrose then moves into the phloem sieve tube element, which has a slightly lower concentration (10) than the companion cells, ensuring continuous flow from source to sink.
16. **D**
The apoplast pathway occurs through cell walls, while the symplast pathway moves through the cytoplasm. In option D, the apoplast pathway correctly shows water being blocked by the Casparian strip, forcing water into the symplast pathway.
17. **A**
The symplast pathway involves water movement through the cytoplasm of cells via plasmodesmata. Water enters the root hair cell vacuoles (1) and moves through the cytoplasm of cells like the cortex and endodermis (4).
18. **B**
Structure 1 reduces the water vapor concentration gradient to slow down transpiration. Structure 2 reduces evaporation from the epidermis, while structure 3 traps a layer of moist air, maintaining humidity around the stomata to reduce water loss.
19. **D**
As carbohydrates are taken up by the sink, water potential in the phloem sieve tube element decreases, causing water to move in, which increases the volume of liquid.
20. **D**
The data show that in the absence of the Casparian strip (*sgn3* mutant), ammonium ion uptake into the xylem is similar to that in non-mutants, indicating that the Casparian strip has little effect on ammonium movement into the xylem.
21. **C**
The thick cuticle, sunken stomata, and curled leaves reduce water loss by transpiration, which helps the plant conserve water in dry environments.
22. **A**
Water movement from root hair cells to the atmosphere involves cohesion to pull water molecules up through the xylem, diffusion of water vapor through stomata, and evaporation from leaf surfaces into the atmosphere.
23. **B**
Statements 1, 2, and 3 are correct as they describe the apoplast and symplast pathways. However, statement 4 is incorrect because the Casparian strip blocks the apoplast pathway, forcing water into the symplast pathway. Hence, B is the right answer.
24. **C**
During transpiration water evaporates from the surface of mesophyll cells which are always lined with water to dissolve carbon dioxide so it can be taken up by the cells to perform photosynthesis. This evaporated water then transpires out of the stomatal pore.
25. **A**
Since this is a xerophytic leaf, we will assume that layer Y is the thick cuticle. Water potential in P is higher than R and S as it appears more turgid. R has lower water potential than P and S as it appears the least turgid. S has lower water potential than P but higher water potential than R as it has a turgidity between that of P and R.
26. **C**
Trichomes and leaf shape typically help increase humidity near the leaf surface, which can be essential for plant survival in a dry habitat by reducing water loss and increasing the chances of moisture retention. The leaf shape is circular and this means that it allows very little water vapors to escape into the external environment and therefore also increases internal humidity.
27. **A**
The correct statement that supports the theory of active loading of sucrose into companion cells is: A The pH decreases in the cell wall of the companion cells compared with the cytoplasm. Active loading of sucrose into companion cells typically involves the transport of protons (H⁺) out of the companion cells,

creating a lower pH in the cell wall compared to the cytoplasm. This proton pump creates a proton gradient that helps drive the uptake of sucrose into the companion cells against its concentration gradient.

- 28. A**
Transport mechanisms in plants, which include diffusion, the apoplast pathway, and the symplast pathway. It involves applying knowledge of these biological concepts to the specific context of sucrose movement from chloroplasts to the phloem. This application of knowledge and understanding of plant physiology is typically covered in A-Level biology, and while it is not the most challenging topic, it does require students to have a good grasp of plant biology and the mechanisms of molecule transport within plant tissues.
- 29. A**
Mechanism of sugar transport in plants, specifically how sucrose is loaded into the phloem sieve tube elements by companion cells. It requires knowledge of both active and passive transport processes in plant physiology.
- 30. B**
The component of plants used by the apoplast pathway as water is moved from the soil to the xylem is:
B cellulose
The apoplast pathway is a route that allows water and solutes to move through the cell walls and intercellular spaces of plant cells without passing through the living protoplast (the living part of the cell). The primary structural component involved in the apoplast pathway is cellulose, which is a major constituent of the plant cell walls. Cellulose forms a network within the cell walls, creating open spaces through which water and solutes can flow, facilitating their movement from the soil to the xylem.
- 31. D**
Water movement in plants occurs through two pathways: symplast and apoplast. The symplast pathway involves water movement through plasmodesmata, small channels connecting adjacent plant cells. In contrast, the apoplast pathway involves movement through non-living cell wall species, bypassing the living protoplast and plasmodesmata. The Casparian strip, a waxy barrier in the endodermis, blocks the apoplast pathway, forcing water and solutes to enter the symplast pathway.
- 32. D**
To determine the number of water molecules lost for a plant to synthesize one molecule of glucose, we can use the information provided, which states that 400 molecules of water are lost for each carbon dioxide molecule gained. The molecular formula for glucose is $C_6H_{12}O_6$, which means that it contains 6 carbon atoms. Since each molecule of glucose requires one molecule of carbon dioxide for each carbon atom, it needs 6 molecules of carbon dioxide.
Now, if for each molecule of carbon dioxide, 400 molecules of water are lost, then for 6 molecules of carbon dioxide (required for one molecule of glucose), you would lose $6 \times 400 = 2400$ molecules of water.
So, the correct answer is D 2400 water molecules are lost for a plant to synthesize one molecule of glucose.
- 33. D**
Sucrose is actively transported from source cells into companion cells and then into the sieve-tube elements. This reduces the water potential, which causes water to enter the phloem from the xylem. The resulting positive pressure forces the sucrose-water mixture down toward the roots, where sucrose is unloaded. Transpiration causes water to return to the leaves through the xylem vessels.
- 34. C**
The appropriate labels for the axes that would explain mass flow in phloem are:
C distance from source / m hydrostatic pressure / kPa
The x-axis should represent the distance from the source (where the sugars are loaded into the phloem) to the sink (where the sugars are unloaded from the phloem). This distance is a key factor in mass flow.
The y-axis should represent hydrostatic pressure (often called pressure potential), which is a significant driving force in the mass flow of sugars in the phloem.
So, option C correctly labels the x-axis and y-axis for explaining mass flow in the phloem.
- 35. D**
The correct matching based on plant cell wall components is: suberin is part of the Casparian strip (1), cellulose is a component of cell walls where water moves in the apoplast pathway (4), and lignin is found in the walls of xylem vessels (2).
- 36. C**
The apoplast pathway refers to the movement of water through the cell walls and the space outside of the plasma membranes, not crossing cell membranes. Arrows 2 and 4 indicate water movement in the cell walls outside of the plasma membrane, thus through the apoplast pathway. Arrow 6 indicates water movement into the xylem, which is also considered apoplastic since it's outside cells.

37. **A**
In the context of plant biology, a source is a part of the plant that produces or releases sugars, while a sink is a part of the plant that consumes or stores sugars. Root cells absorbing mineral ions are typically considered sinks because they often consume sugars for energy to power active transport mechanisms. Storage cells of a seed that is starting to grow would be a source because they release sugars to support growth.
38. **D**
The Casparian strip blocks the apoplast pathway in root anatomy, controlling water and solute movement.
39. **D**
Water moves through xylem vessels from roots to leaves primarily by the cohesion-tension mechanism. The continuous column of water is maintained by hydrogen bonding and adhesion to the vessel walls.
40. **C**
Water transport within xylem vessel elements primarily occurs through the cohesion-tension mechanism, a process driven by transpiration and the cohesive and adhesive properties of water molecules.
41. **C**
In a leaf cross-section, the structure responsible for mass flow by the use of proton pumps is typically associated with the phloem. Proton pumps create a hydrogen ion gradient that drives the active transport of sugars and other solutes into the phloem for distribution throughout the plant. Given that phloem cells are not always easily distinguished in an electron micrograph without labels, the correct answer is inferred based on the typical positioning of phloem in relation to other identifiable structures.
42. **B**
In a plant, the source (typically leaves) has a high sucrose concentration creating a low water potential, while the sink (such as tubers) has a low sucrose concentration resulting in a high water potential.
43. **D**
The key properties of water important for xylem transport are its ability to form hydrogen bonds with other water molecules and with polar molecules, aiding in water movement.
44. **C**
ATP is required for the active transport of protons out of the companion cell, which is indicated in step 1. This process creates a proton gradient that is used for the co-transport of sucrose into the companion cell, which is a passive process and does not require ATP directly. Step 3, the movement of sucrose into the sieve tube element, is also typically a passive process facilitated by the established concentration gradient.
45. **B**
Xerophytic adaptations like rolled leaves, hairy leaves, and sunken stomata reduce water loss by minimizing the water potential gradient between the leaf surface and the atmosphere.
46. **A**
Inhibiting mitochondrial activity in phloem cells affects the concentration of hydrogen ions in companion cells, the sucrose concentration in leaf cells, and the hydrostatic pressure gradient in the phloem.
47. **C**
The diagram shows the stages of a tulip bulb's growth, with the bulb acting as a source (providing nutrients) or a sink (storing nutrients) at different stages.
48. **D**
Sucrose moves through phloem sieve tubes by mass flow, a process driven by pressure differences along the phloem.
49. **C**
Option C is the correct answer as during transpiration water moves in the xylem and hydrogen bonds are formed with other water molecules and the cellulose in xylem wall which are essentially called adhesion and cohesion. No bonds are formed with suberin since it is present in the root cells not in the xylem vessel elements.
50. **A**
Statements 1 and 2 are correct as after entry into the root some heavy metals pass through the membrane of the vacuole to be stored in the vacuole. They must take an apoplastic pathway in the xylem but travel through the symplastic pathway in order to be stored in the vacuole. Hence, option A is the correct answer.
51. **B**
Option B is the correct answer as water moves from cell to cell via the intercellular spaces such as the cell walls in the apoplast pathway.

- 52. D**
Option D is the correct answer as first protons are actively transported out of the companion cells into the cell wall. From there they move back into the cells and co-transport sucrose along with them. From there sucrose diffuses into the sieve tube via the plasmodesmata.
- 53. A**
Option A is the correct answer as water moves in a root via the apoplast pathway through the intercellular spaces and suberin is the molecule present in the Casparian strip.
- 54. A**
Option A is the correct answer as humidity affects the transpiration pull which allows water to be moved into the roots. The surface area is directly proportional to the rate of uptake of water and mineral ions. Oxygen concentration is dependent for the process of active transport which requires ATP produced from respiration. Temperature increases the kinetic energy resulting in faster diffusion and osmosis rates.
- 55. D**
Option D is the correct answer as movement of sucrose in the phloem sieve tube causes the water potential to decrease that results in an influx of water that causes the volume to increase.
- 56. D**
Option D is the correct answer as the movement of sucrose into the companion cells cause the pH of the companion cell wall to decrease due to the presence of hydrogen ions.
- 57. D**
Option D is the correct answer as an air bubble in the xylem interrupts the continuous column of water which results in a loss of adhesion.
- 58. C**
Option C is the correct answer as the sunken stomata on the leaf surface means that the rate of transpiration is reduced as a result of a reduced gradient.
- 59. A**
Option A is the correct answer as when amino acids are unloaded into a sink this results in an increase in water potential of the sieve tube and this causes the volume of solution to decrease as water moves out of it.
- 60. B**
Option B is the correct answer as water can pass through cellulose since it is fully permeable. It cannot however pass through lignified cell walls. Water cannot pass through cell walls that contain suberin.
- 61. B**
Option B is the correct answer as increased wind speed and temperature both causes an increase in the rate of transpiration that results in increased tension in the xylem vessels that causes the diameter of the tree trunk to decrease. Increased humidity decreases transpiration so the diameter does not decrease more.
- 62. D**
Option D is the correct answer as first protons are pumped actively out of the companion cell after which they reenter and bring sucrose molecules with them. The sucrose moves into the sieve tube element and this causes the water potential to decrease resulting in movement of water that causes the production of a high hydrostatic pressure.
- 63. B**
Option B is the correct answer as cohesion is described as the attraction of water molecules to one another.
- 64. D**
Only statement 3 is correct as the gas exchange in plants occurs via the stomata and since the stomata must be open for this to occur it is inevitable that water vapor will also diffuse through the stomata outside the leaves.
- 65. B**
Option B is the correct answer as Y is the source such as a leaf and Z is the sink such as a root. This means that W is the phloem that moves the sugars from source to sink that is from Y to Z. This makes X the xylem vessels since water moves through it.
- 66. A**
Option A is the correct answer as the rate is found by dividing 50 by the time taken. The fastest rate will be with the smallest denominator while the slowest rate will be with the largest one. Hence $50/166$ and $50/40$ give 0.3 and 1.3 respectively.

67. **C**
Option C is the correct answer as the proton pumps in the companion cells pump protons into the cell wall that results in protons bringing sucrose molecule inside the cells.
68. **D**
Option D is the correct answer as although the flow in phloem is bidirectional in each individual sieve tube the substances move in a single direction at a time via mass flow.
69. **C**
Option C is the correct answer as the distance the air bubble moves and the radius of the capillary tube can be used to find the volume of the cylinder. The time will allow for the hour units and the surface area of the leaves accounts for the m^2 units.
70. **B**
Statements 1 and 2 are correct as P has a more negative water potential than Q due to the curled shape and this means that more cells are plasmolyzed in P than in Q. Hence, option B is the correct answer.
71. **A**
Option A is the correct answer as cohesion between the molecules paired with the adhesion of the molecules to the walls of the xylem result in a continuous column of water.
72. **C**
Option C is the correct answer as ATP is required for the loading on sucrose into the companion cells from where they go into the sieve tubes. Hydrostatic pressure gradient is also required as that is what allows the mass flow of assimilates. Water potential gradient is not required as water is not moved through the sieve tubes.
73. **A**
Option A is the correct answer as removal of sucrose from the sieve tube element cause an increase in the water potential making it less negative and this causes water to flow out of it.
74. **D**
Option D is the correct answer as all the 3 factor cause an increase in the rate of transpiration that causes the diameter of the trunk to decrease.
75. **A**
Option A is the correct answer as at 16:00 hours both the water loss and absorption peak. The rate of water loss is greater that absorption from 8 to 20 and at night the rate of water absorption is greater due to the greater height of the graph.
76. **D**
Option D is the correct answer as the stem is cut under the water to prevent any air bubble from accumulating in the xylem vessel as they would break the continuous column of water.
77. **C**
Option C is the correct answer as first the hydrogen ions are actively transported out of the companion cells. Then when they diffuse back into the cell via co transported proteins sucrose is transported alongside them. From there the sucrose diffuses into the sieve tube cells via the plasmodesmata.
78. **A**
Option A is the correct answer as water can take the apoplast pathway through the cell walls of the cortex cells and then from there pass the Casparian strip into the endothermal cells form where it can go into the xylem vessels.
79. **B**
Option A is incorrect as the loading of amino acids is not mass flow. Option C is incorrect as movement of water across the root is not mass flow. Option D is incorrect as the movement of water vapor form the internal spaces of the leaf is due to transpiration. Hence, option B is the correct answer as the movement of sap in the phloem sieve tubes in the stem is an example of mass flow.
80. **B**
Option A is incorrect as co-transported proteins pump hydrogen ions into companion cells. Option C is incorrect as plasmodesmata move sucrose without the need of co-transported proteins. Option D is incorrect as sucrose moves through co-transported proteins via facilitated diffusion. Hence, option B is the correct answer as hydrogen ions diffuse into companion cells alongside sucrose molecules through the co-transported proteins.
81. **A**
Option A is the correct answer as increased temperature and increased light intensity both causes an increase in the rate of transpiration that contributes to the diameter of the trunk decreasing.

- 82. A**
1 and 2 are correct as water moves from a higher to lower water potential and from a lower solute concentration to higher solute concentration since the more solute there is the less the water potential is. Hence, option A is the correct answer.
- 83. A**
Option A is the correct answer as capillary action, adhesion and hydrogen bonding all play an important role in the transport of water in the xylem vessel elements.
- 84. B**
The companion cells use the ATP to pump hydrogen ions out of the companion cell. Hence, option C is the correct answer.
- 85. A**
Option A is the correct answer as the fungi that grow inside the xylem vessels cause the break of the continuous water columns therefore affecting the cohesion between the molecules.
- 86. B**
Option B is the correct answer as ATP is required to move hydrogen ions out of the companion cells cytoplasm.
- 87. D**
A decrease in diameter indicates that the trees require more water for the leaves. Hence, we can look at the factors that increase the rate of transpiration. Light intensity, temperature and wind speed all increase the rate of transpiration and hence option D would cause the largest decrease in diameter.
- 88. B**
Option B is the correct answer as hydrostatic gradient causes the mass flow of sucrose from source to sink.
- 89. A**
Option A is the correct answer as when the sucrose is loaded into the phloem the water potential decreases and this causes water to move into the phloem via osmosis and this causes an increase in the hydrostatic pressure.
- 90. C**
Option C is the correct answer as an increase in humidity causes the water potential gradient to decrease as more water is outside than inside.
- 91. A**
Option A is the correct answer as capillarity, osmosis and transpiration all are responsible for maintaining the water potential gradient.
- 92. D**
As sucrose enters into the sieve tube the water potential becomes more negative and this causes the volume to increase as water moves into the tube via osmosis. Hence, option D is the correct answer.
- 93. D**
Option D is the correct answer as water moves through the symplastic pathway along a water potential gradient.
- 94. C**
Option C is the correct answer as sucrose molecules are carried into the companion cells as the hydrogen ions move through the co-transporter protein.
- 95. B**
Option B is the correct answer as it shows hydrogen bonding where the partially positive hydrogen bonds with the partially negative oxygen. They are also arranged in a line meaning that the water column in the xylem is continuous.
- 96. D**
Option A is incorrect as adding sucrose causes the water potential to decrease. Option B is incorrect as sucrose is not always polymerized into starch. Option C is incorrect as sucrose enters a sieve tube element using the plasmodesmata. Hence, option D is the correct answer as at the source sucrose is loaded into companion cells using a protein that also transports hydrogen ions.
- 97. B**
Option B is the correct answer as an increase in the cohesive tension forces causes the water molecules to move rapidly up the tree and this is due to a decrease in the diameter of the vessels causing a decrease in the circumference.

- 98. B**
Option A is incorrect as in the symplastic pathway water moves through the cytoplasm and plasmodesmata. Option C is incorrect as in the apoplastic pathway water moves using the cell wall. Option D is incorrect according to the reason for option C. Hence, option B is the correct answer as in the apoplastic pathway water moves across the root through cell walls and in the symplastic pathway water moves from cell to cell via the plasmodesmata.
- 99. D**
Option D is the correct answer as movement of sucrose into the sieve tube causes the water potential to decrease and as a result more water flows in causing an increase in the volume.
- 100. B**
Option A is incorrect as water moves from high to low potential. Option C is incorrect as water does not move from root to leaves just via adhesion. Option D is incorrect as the uptake of water due to the loss of water vapor is known as transpirational pull. Hence, option B is the correct answer as transpiration refers to the loss of water vapor from a plant to its environment down a water potential gradient.
- 101. C**
Option C is the correct answer as the salt in the soil once concentrated would cause the water potential of the soil to decrease and as a result water will be drawn out from the roots killing them.
- 102. C**
Option C is the correct answer as the casparian strip marks the start of the endodermis.
- 103. B**
Option B is the correct answer as the movement in phloem via mass flow is due to the hydrostatic gradient and it moves from the source to the sink.
- 104. A**
Option A is the correct answer as water might move via the apoplastic pathway using cell walls or just via osmosis down a water potential gradient in the cytoplasm.
- 105. B**
Option B is the correct answer as the casparian strip is found on the cell wall of the endodermis, is made from suberin and helps to stop the apoplast pathway.
- 106. C**
The apoplast pathway refers to movement of water through the cell walls. Hence, statements 1 and 4 represent the apoplastic pathway making option C the correct answer.
- 107. B**
Option B is the correct answer as the lowest concentration would be in the mesophyll cells since sucrose moves from there into the phloem. Then sieve tube element will have the highest concentration since they receive sucrose via the plasmodesmata and finally the companion cells will have the highest concentration since they receive sucrose directly via the loading mechanism.
- 108. D**
Xerophytic plants have adaptations to reduce transpiration as much as possible so option D is likely to be such a plant due to consistently low transpiration rates.
- 109. D**
Option D is the correct answer as the movement of sucrose makes the water potential more negative causing water to move into the phloem via osmosis and this results in an increase in volume.
- 110. C**
Option C is the correct answer as the apoplast pathway is blocked by the Casparian strip. Option A is incorrect as water moves through the cell walls in the apoplast pathway. Option B is incorrect as water moves through the cytoplasm in the symplastic pathway cell to cell. Option D is incorrect as the symplastic pathway cannot be blocked by the tonoplast.
- 111. B**
Option B is the correct answer as it shows the Casparian strip that blocks the apoplast pathway.
- 112. C**
Option C is the correct answer as loading of the sucrose causes the water potential to be more negative than the source and this causes water to flow into the phloem generating hydrostatic pressure. There is no lignification in the phloem.
- 113. C**
Option C is the correct answer as heating will cause the proteins in the companion cells to denature causing a halt in the movement of the phloem sap but movement will continue in the xylem since those cells are already dead.

- 114. D**
Option A is incorrect as sink is where the sucrose is deposited after transport. Option B is incorrect as loading sucrose causes a decrease in the water potential. Option C is incorrect as mass flow is faster than diffusion. Hence, option D is the correct answer as sucrose moves via the hydrostatic pressure from source to sink.
- 115. A**
Option A is the correct answer as unloading sucrose to a sink causes the water potential to be less negative and there is no lignification in the cells of the phloem.
- 116. A**
Option A is the correct answer as all the 3 statements are correct as in the apoplast pathway water does not move via the plasmodesmata and in the symplast pathway water does not move through intercellular spaces. The apoplast pathway may be blocked by the Casparian strip.
- 117. A**
Option A is the correct answer as all the 3 statements are correct since hydrogen bonding, cohesion and adhesion all play an important role in the upward movement of water in the xylem.
- 118. B**
When the shoot is removed that means no transpiration and hence no transpiration pull. Hence water will move via capillarity and root pressure. Hence, option B is the correct answer.
- 119. C**
Unloading the carbohydrate in the sink cause the water potential of the sieve tube to increase and as a result water moves out of it causing a decrease in volume. Hence, option C is the correct answer.
- 120. B**
Option B is the correct answer as in stage 2 it is acting as a source since food stores in it are used for the growth of roots and shoots until leaves can form. In stage 4 it is acting like a sink since the tuber has shrunk and the leaves can now photosynthesize so the tuber acts as a storage organ.
- 121. D**
Option D is the correct answer as $\text{cm}^3 \text{min}^{-1}$ are the correct units of measurement for a potometer.
- 122. B**
Option A is incorrect as on a humid day the water potential gradient decreases. Option C is incorrect as water evaporates from the cell walls of the mesophyll cells not from the guard cells. Option D is incorrect as water moves up xylem through mass flow not the apoplast pathway and the apoplast pathway does not involved osmosis. Hence, option B is the correct answer as water moves from the mesophyll cells via osmosis to their cell walls for evaporation.
- 123. D**
The trichomes trap a layer of moist layer near the surface of the leaves reducing the water potential gradient.
- 124. A**
Option A is the correct answer as the cohesive tension forces increase due to the narrowing of the xylem vessels which results in the diameter decreasing.
- 125. B**
Option B is the correct answer as cohesion refers to the hydrogen bonding between water molecules than allow movement of water in the xylem.
- 126. C**
Only increasing the temperature causes the rate of transpiration to increase. Increase in humidity, decrease in temperature and decrease in wind speed all lower the rate of transpiration. Hence, option C is the correct answer.
- 127. A**
Option A is the correct answer as cohesion, adhesion and good solvent properties are important for movement of water in xylem. High latent heat of vaporization is not an important property for the xylem.
- 128. A**
Option A is the correct answer as cohesion of water molecules through hydrogen bonding is important for the movement of water up the xylem.
- 129. A**
Option A is the correct answer as all the statements are correct. More mitochondria and more transporter proteins means that more ions can move in per unit time and the large surface area allows for rapid uptake.

- 130. C**
Transpiration is a result of the gaseous exchange system of the plants that also allows the diffusion of water vapor. Hence, option C is the correct answer.
- 131. B**
Option A is incorrect as cohesion is between water molecules and adhesion is between the water molecules and the lignin. Option C is incorrect as adhesion does not push the walls outwards. Option D is incorrect as during the night water flow greatly decreases and cohesion maintains a column of water so it does not push on the xylem. Hence, option B is the correct answer as the tension developed by the moving column of water reduced the pressure causing the walls to narrow.
- 132. B**
Only increasing the temperature causes the rate of transpiration to increase. Increase in humidity, decrease in temperature and decrease in wind speed all lower the rate of transpiration. Hence, option B is the correct answer.
- 133. D**
Option D is the correct answer as statement 2 is correct only as in the apoplast pathway water does not move via the plasmodesmata and in the symplast pathway water does not move through intercellular spaces. The apoplast pathway may be blocked by the Casparian strip.
- 134. A**
Option A is the correct answer as the unloading of amino acids causes the water potential of the sieve tube to increase and this causes the volume of water to decrease as water moves out.
- 135. C**
Option C is the correct answer as the apoplast pathway may be blocked by the Casparian strip. In the apoplast pathway water does not move via the plasmodesmata and in the symplast pathway water does not move through intercellular spaces. The symplast pathway is not blocked by the tonoplast.
- 136. D**
Option D is the correct answer as the increase in temperature and the moving air removing the humidity around the plant would cause a sudden increase in the rate of transpiration causing the decrease in the mass.
- 137. A**
Since the liquid in the style has a low water potential it cannot be in the xylem and must be in the phloem sieve tube element. This sap has low water potential due to large quantity of dissolved solutes in it. Hence, option A is the correct answer.
- 138. A**
Option A is the correct answer as the unloading of sucrose causes the water potential of the sieve tube to increase and this causes the volume of water to decrease as water moves out.
- 139. A**
Water can pass through cellulose and lignified cell walls (statements 1 and 2), but suberin is a waterproof substance, preventing water movement (statement 3). Hence, all three statements are correct, making A the right answer.
- 140. A**
The water potential of the root hair cell must be more negative in order for water to move into it. Hence, option A is the correct answer as it is the only option with a more negative water potential.
- 141. B**
Option B is the correct answer as this sieve tube element receives sucrose from the leaf cells and loads them into the root cells.
- 142. D**
Option D is the correct answer as large number of mitochondria and protein carrier has no role in water absorption since it is a passive process and can pass directly through the cell membrane. The large surface area to volume ratio allows for rapid absorption of water.
- 143. A**
Option A is the correct answer as unloading into the sink causes the water potential of the sieve tube element to increase and there is no lignification on these cells.
- 144. A**
Option A is the correct answer as hydrogen bonding between water molecules, cohesion and adhesion all play an important role in the transport of water in the xylem.
- 145. B**
Option B is the correct answer as the rate of transpiration decreases with increase in the humidity.

- 146. D**
Option D is the correct answer as addition of amino acids in the sieve tube causes the water potential to decrease and this results in water moving into the sieve tube resulting in an increase in volume.
- 147. D**
Option D is the correct answer as loading a carbohydrate into the sieve tube causes the water potential to decrease resulting in an increase in volume and water flows into it.
- 148. B**
Option B is the correct answer as the increase in cohesive tension forces generates a negative pressure that causes the diameter of the xylem vessels to decrease.
- 149. D**
Option D is the correct answer as sucrose moves into the companion cells via passive diffusion alongside hydrogen ions.
- 150. C**
Option A is incorrect as sucrose moves into the sieve tube elements through plasmodesmata. Option B is incorrect as sucrose moves from the mesophyll cells into the companion cells with the help of protons. Option D is incorrect as mass flow does not cause sucrose to move into the sieve tube elements. Hence, option C is the correct answer as the entry of sucrose causes the water potential to decrease or become more negative.
- 151. C**
Option C is the correct answer since the water leaves the cell not the cell wall meaning it travels via the symplast pathway.
- 152. B**
Option B is the correct answer as statements 1, 2 and 4 are correct as the loss is mainly due to transpiration, most stomata close in both leaves after 1 hour since the loss of mass levels and the thicker cuticle in leaf 1 prevents water loss. Leaf 2 has a larger area than leaf 1 which leads to more water loss.
- 153. C**
Transpiration is a loss of water vapor from the aerial parts of the plant to the atmosphere. Hence, option C is the correct answer.
- 154. D**
Movement of sucrose into the phloem sieve tube causes the water potential to decrease that results in more water moving into it causing an increase in the volume. Hence, option D is the correct answer.
- 155. B**
Option B is the correct answer as statements 1 and 2 are correct. When the temperature rises the accumulation of molecules in the air spaces sets up a steep concentration gradient and the increased temperature results in greater kinetic energy resulting in faster diffusion. Increased hydrogen bonding would mean that the molecules would move slowly since they are attracted to one another.
- 156. A**
Option A is the correct answer as in the apoplast pathway water moves through the plant cell walls.
- 157. A**
Option A is the correct answer as when the sucrose leaves the phloem sieve tube its water potential increases and this results in water moving out of it resulting in a decrease in volume.
- 158. D**
Option D is the correct answer as the differences in water potential cause the water to travel via the symplast and the vacuolar pathway whereas the pull transmitted by the cohesive forces causes the water to travel via the cell walls in the apoplast pathway
- 159. A**
Option A is the correct answer as the removal of sucrose from the sieve tube causes the water potential to increase or become less negative and this results in water moving out and the volume decreases.
- 160. B**
Option B is the correct answer as statements 1 and 3 support the cohesion tension theory. When the transpiration rate is maximum the tension results in a negative pressure that causes the tubes to become narrow and evaporation of water from a pot results in transpiration pull that draws water up from the soil just like in plants.
- 161. D**
Option D is the correct answer as the Casparian strip stops water from moving back into the cortex from the xylem.

- 162. A**
Option A is the correct answer as protons are moved into the companion cells and co-transport sucrose via active transport using transport proteins. Sucrose moves into the sieve tube element via the plasmodesmata using diffusion.
- 163. D**
Movement of sucrose into the sieve tubes causes the water potential to become more negative that results in the volume of liquid in the sieve tube increasing as water moves in. Hence, option D is the correct answer.
- 164. C**
Options A, B and D are incorrect since they are all correct. Hence, option C is the correct answer as water moves from the high water potential of the xylem vessel to the lower water potential of a mesophyll cell.
- 165. A**
Removal of carbohydrates from the sieve tube causes the water potential to become less negative and this results in water moving out of it that results in the volume decreasing.
- 166. C**
Option C is the correct answer as the plasmodesmata serves as a barrier to allow for the movement of substances between cells via the symplast pathway.
- 167. D**
Option D is the correct answer as water evaporates from the cell walls of the spongy mesophyll cells during transpiration.
- 168. A**
Option A is the correct answer as first active loading of sucrose occurs which results in an increased hydrostatic pressure that results in the mass flow of sucrose and finally the unloading of sucrose at the sink.
- 169. D**
Option A is incorrect as transport does not occur in companion cells. Option B is incorrect as xylem vessels do not have any nuclei or cytoplasm. Option C is incorrect as xylem vessel elements are continuous. Hence, option D is the correct answer as companion cells have numerous mitochondria that allow it to actively transport sucrose and xylem vessels have no cytoplasm in order to enable mass flow.
- 170. D**
Option D is the correct answer as taking amino acids out of the sink results in the water potential of the sieve tubes decreasing and this results in an increase in volume as water flows into the sieve tubes.
- 171. A**
Option A is the correct answer as the removal of amino acids from the sieve tube causes the water potential to become higher and this results in water moving out of the tubes resulting in a decrease in volume.
- 172. D**
Option D is correct as the plateau is due to cells becoming turgid and this means that the amount of water that enters the cells is the same as the amount that leaves them. The water potential of the cells become less negative as water moves in.
- 173. C**
Option C is the correct answer as the cohesion of water molecules allows it to have high surface tension while hydrogen bonding makes it an excellent solvent and adhesion allows it to move up the xylem vessels.
- 174. A**
Option A is the correct answer as adhesion is responsible for holding water molecules on the surface of cell walls.
- 175. C**
Option C is the correct answer as the movement of ions into the root hair cells is accomplished via active transport using energy and these ions are transported in the xylem.
- 176. B**
Option B is the correct answer as in leaves sucrose enters the phloem via active transport which makes the water potential of it more negative and in the roots sucrose is used or polymerized into starch and the water potential of the phloem becomes less negative.
- 177. B**
Option B is the correct answer as sucrose is a non-reducing sugar meaning that before hydrolysis Benedict's will give a blue color and after hydrolysis it will give a red color. Since there is no starch present in the sieve tube the iodine test will give orange color.

178. **D**

Option D is the correct answer as sucrose can move either by the symplast or the apoplast pathway to get to the phloem but not mass flow.

7.3: Multiple topics

1. **A**

Monomers (e.g., glucose) and disaccharides (e.g., sucrose) are cotransported into companion cells for phloem loading, enabling sucrose translocation in plants.

2. **A**

Option A is the correct answer as unloading from the phloem sieve tube causes its water potential to be higher than the sink and lignified cell walls are absent there.

3. **A**

Option A is the correct answer as water is transported in the xylem vessels via cohesion-tension and mass flow.

4. **A**

Option A is the correct answer as these labels are the correct ones that can be seen clearly in a cross section.

5. **B**

Option B is the correct answer as many mitochondria means that more ATP is available for active transport of the ions and protein carriers means that more ions can be transported per unit time.

6. **B**

Option B is the correct answer as the cells in P are turgid meaning that they have a less negative water potential than Q and cells may be plasmolyzed in Q since it is rolled up. There is no net diffusion of water into X in either P or Q since this is probably a structural feature that causes the cell to roll up or relax.

7. **D**

Option D is the correct answer as DNA replication requires ATP but osmosis and facilitated diffusion are both passive processes.

8. **D**

Option D is the correct answer as since the plants were in the same room they were subjected to the same conditions except the fact that the surface area of their leaves might be different and that might lead to differences in transpiration.

9. **C**

Option C is the correct answer as the sunken stomata, thick cuticle and trichomes are features of xerophytic plants.

10. **B**

Option B is the correct answer as the only feature of transport that is similar in both the xylem and phloem is that the transport occurs via mass flow.

11. **A**

Statements 1 and 2 are correct since the ions can pass through the tonoplast as they accumulate in the vacuoles and they can take the symplast or the apoplast pathway but due to the presence of the Casparian strip at the endodermis they must take the apoplast pathway. Statement 3 is incorrect as they travel in the xylem via mass flow. Hence, option A is the correct answer.

12. **D**

Option D is the correct answer as 1, 4 and 6 transport water and 2, 3 and 5 transport sucrose as they are the phloem vessels.

13. **A**

Option A is the correct answer as companion cells, sieve tube elements and root hair cells all have plasmodesmata.

14. **C**

Option C is the correct answer as the reason the diameter of the trunk decrease is due to the pressure created by the tension due to the water molecules being held in the xylem.

15. **B**

Option B is the correct answer as more stomata, fewer trichomes and thinner cuticle all result in leaf 2 having a lower mass due to losing more water.

16. **A**
Option A is the correct answer as mass flow, osmosis and active transport are all involved in the transport of sucrose.
17. **C**
Option C is the correct answer as leaf X must have modification to reduce water loss through transpiration. Hence it must have sunken stomata and the ability to roll the leaf.
18. **B**
Option B is the correct answer as the loss of mass in both the leaves is due to transpiration and the stomata in both the leaves close as the mass loss levels out. Statement 3 is incorrect as if leaf 1 had a larger surface area it would lose more mass.
19. **B**
Option B is the correct answer as the lack of oxygen in the waterlogged soil would mean that ATP cannot be generated for the movement of ions and root pressure will decrease.
20. **A**
Option B is incorrect as if the leaf is thinner it will lose more water. Options C and D are incorrect as leaf 2 does not have trichomes or sunken stomata since it loses more water. Hence, option A is the correct answer as leaf 1 has a thicker cuticle than leaf 2 that causes it to lose less water.

