

STUDENT BOOK ANSWERS

Chapter 12 Plant systems for life

Question set 12.1

- The essential requirements of a large plant include carbon dioxide, water, light, oxygen and minerals. Photosynthesis and respiration are the processes that need these requirements.
- Sucrose moves through a plant via the vascular tissues and, in particular, the phloem. Sucrose is formed in the mesophyll layer of the leaf and then moves from these cells into the phloem via a concentration gradient. The concentration gradient is maintained because, as sucrose enters the phloem tube cells, it is moved away to other parts of the plant, thus ensuring that sucrose will move out of the leaf cells.

Xylem vessels	Phloem vessels
Thick-walled cells, joined end to end	Thin-walled cells, joined end to end
Cells are dead and are just a thoroughfare through which water moves	Cells are alive with cell organelles that control functions with the aid of companion cells
Water moves in one direction from roots up the plant.	Sucrose and other plant products move in both directions around the plant.
The wood of a plant is composed of xylem vessels and therefore is the main support structure of plants.	The phloem vessels are living cells arranged end to end that allow plant products to move through them.

- Dead cells such as xylem vessels provide an uninterrupted pathway through which water flows through a plant. Dead cells offer support and strength to the plant (particularly to trees), and allow leaves to receive the best exposure to necessary sunlight.

Experiment 12.1: Plant transport systems

Discussion

- Answer will be based on students' results. Most of the dye should be in the xylem vessels.
- There is an assumption that the dye has moved into the xylem only and has not diffused into other plant tissues.
- The transpiration stream
- Indian ink particles cannot pass through cell membranes.
- Xylem vessels
 - Lignin
 - To strengthen and keep the tube open

Question set 12.2

- 1 The main function of roots and stems in plants is to provide an uninterrupted pathway through which water travels up the plant. Both structures also provide support for the plant. The roots anchor the plant and the stem and ensure that it is upright and that leaves receive maximum exposure to sunlight. The roots are also the site of absorption of water into the plant. The stem is unable to provide this function.
- 2 The features of the xylem vessel that make it an effective water transporter include:
 - lignified walls that prevent the collapse of the vessel as water is 'sucked' up the plant via the transpiration stream
 - the narrowness of the vessels that allow the forces of adhesion and cohesion to work to their best advantage
 - the pits in the sides of the walls in some plants that aid the adhesion forces.
- 3 The forces that enable water to move through the xylem vessel and reach the top of the tallest tree are adhesion (the attraction that exists between water molecules and the molecules of the xylem vessel) and cohesion (the attraction that exists between individual water molecules).
- 4 The energy for transpiration comes from sunlight, which works to evaporate water from the leaves of the plant.

Question set 12.3

- 1 Stomata are small openings in leaves and some stems. The singular is stoma. Guard cells are pairs of cells surrounding and controlling the action of stomata.
- 2 Oxygen and carbon dioxide, water vapour
- 3 Gases move in and out of leaf cells by diffusion. In root cells, gases are also transferred by diffusion through the root hairs.
- 4 Oxygen is produced in photosynthesis and used in cellular respiration. Carbon dioxide is produced in cellular respiration and used in photosynthesis. Water vapour available in humid environments can enter the leaf via open stomata and water produced in photosynthesis can exit closed stomata as vapour during transpiration.
- 5
 - a If petroleum jelly were placed on a plant's leaves, the stomata would be clogged. The rate of transpiration would drop because water would not be able to evaporate out of the leaf, and similarly carbon dioxide would not be able to enter, thus also lowering the photosynthetic rate.
 - b The factors that would need to be controlled in order to test the predictions include maintaining the levels of water supplied to a plant and ensuring that the plants used were of similar size and contained the same number of leaves. Students should be able to design an experiment and then look at the factors that would need to be controlled.

Experiment 12.2: Leaf structure

Results and Discussion

- 1 Veins branch throughout the leaf, which means that most cells are very close to a vein. This ensures that all cells can be provided with the nutrients they require and also that wastes are removed from the cells at a fast enough rate.

- 2 Leaves generally have a large surface area compared to their volume. A large surface area provides a greater surface to absorb sunlight and a large surface area compared to volume also means that carbon dioxide, for example, can enter the leaves more quickly to be distributed to all the leaf cells. This also means that substances such as water can evaporate from their large surface much more quickly.
- 3 This will depend on the specimen studied. For many plants the spongy palisade cell layer is where most photosynthesis takes place in the leaf. Usually this layer is found on the upper part of the leaf, below the epidermal layer. The best guide to the presence of chlorophyll is the green colouring.
- 4 This will depend on the specimen studied. In many plants the cuticle on the upper surface of the leaf is thicker than the lower surface because it is in direct contact with the Sun's rays. This in turn reduces water loss by the leaf.
- 5 Spongy mesophyll layer
- 6
 - a Carbon dioxide enters the leaf through open stomata and moves into the air spaces between the loosely packed spongy mesophyll cells. It then enters the cell membrane of the cells it comes in contact with and diffuses from one cell to the others.
 - b Oxygen moves in the opposite direction to carbon dioxide.
 - c The water and mineral ions would move from the xylem adjoining cells of the leaf.
- 7 Stomata in the epidermal layer allow gas exchange and transpiration to occur. This supplies carbon dioxide and water for photosynthesis. Cells within the leaf are packed with chloroplasts to utilise the Sun's energy, and are surrounded by air spaces. This allows for efficient gas exchange and a maximum rate of photosynthesis. Cells within the leaf are in close proximity to veins that bring the water for photosynthesis and take away the products of photosynthesis for use throughout the plant.

Question set 12.4

- 1 Carnivorous plants often lack nitrogen. They make up for the deficit by collecting and digesting insects. This provides them with the essential nitrogen required in the production of proteins and nucleic acids.
- 2 The energy for translocation comes originally from the Sun. Photosynthesis converts light energy into chemical energy in the form of sucrose. The sucrose is then broken down to release energy to allow translocation and other functions in the plant to occur.
- 3 The phloem is an ideal transport system for nutrients because it allows the movement of nutrients throughout the plant in both directions. The nutrients are dissolved in the cytoplasm of the cells of the phloem and move through sieve cells via openings at the ends of the each of the cells.
- 4 The main function of the leaf is to allow maximum levels of photosynthesis to occur. It absorbs sunlight via chloroplasts in its cells, it is the focal point for the passage of water and it allows carbon dioxide to enter via the stomata.
- 5 Substances that enter leaves and that are used for photosynthesis include carbon dioxide, water and sunlight (though sunlight is not strictly a substance, but an energy form).
- 6 Mineral ions in a plant go towards the construction and provision of various organelles and other plant structures; for example, ions are required in the production of chloroplasts and chlorophyll.
- 7 Deciduous plants are able to move any waste products to the dying leaves before they drop from the plant. In this way wastes and toxic substances are removed from the functioning organism, allowing it to function at its optimum level.

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- The epidermis comprises the upper and lower layers of transparent cells in the leaf that allow sunlight to pass through and produce the waxy cuticle. There are also stomata embedded in the layers.
 - The palisade mesophyll is the layer with the cells that are packed with chloroplasts that are best able to harness the energy of the Sun.
 - Stomata are the openings in leaves and some stems that allow the movement of gases into and out of the plant.
 - Spongy mesophyll contains cells with fewer chloroplasts; however, they occur immediately behind the stomata in the lower side of the leaf and allow the gas to diffuse freely within the spaces that occur between the cells.
 - Guard cells make up the stomata and control the opening and closing of the stoma or pore of the stomata. When they take in water they swell and open; when they lose water they become flaccid and close the pore.

Chapter review questions

- Oxygen, carbon dioxide, water and minerals
- Xylem and phloem
- Xylem and phloem tissue is arranged in vascular bundles. The phloem is towards the outside of a stem and xylem tissue is towards the inside.
- Factors that affect the transpiration rate of a plant include the following.
 - Humidity of the air around the leaves. The higher the relative humidity of the air surrounding the leaves, the lower the transpiration rate. This is also affected by whether the weather is windy or still. When it is windy, evaporated water will be moved away from the leaves, thus maintaining the gradient of water molecules around the leaf and ensuring that more water will evaporate.
 - The temperature of the ambient air and the availability of sunlight. Both will allow the stomata to open, thus allowing the evaporation of water.
- The leaves in upper canopies of the tropical rainforest, where there is high exposure to sunlight and water loss, are very small and often hang vertically. This limits the amount of sunlight that strikes them directly and points them towards the trunk of the tree, so that any water is directed down the trunk to the roots of the plant.
- The major difference between animal and plant transport is that almost all animals have transport systems based on muscular systems. The animal circulatory system uses the mechanical action of muscle tissue. Plants lack muscle tissue.
- Xylem allows the movement of water from the roots of the plant to the plant tip in an unbroken, narrow column known as the transpiration stream. The Sun shining on the leaves, the opening of the stomata and the evaporation of water from the leaves ensure the stream of water is constantly moving up through the plant. In order for this to occur, the xylem must be narrow, reinforced and located so that it leads to the leaves.

The phloem, transports sucrose and other substances to all parts of the plant; therefore, movement occurs in either direction. In order for this to occur successfully, energy is expended occasionally. The phloem is made up of sets of two cells that are joined via the cytoplasm they share. This ensures two things: the movement of substances to locations where they are needed, and the availability of energy when required. The living sieve cells and companion cells ensure that this occurs.

- 8 Carbon dioxide enters the leaf via the stomata; oxygen may leave the leaf via the stomata. Carbon dioxide is required in the process of photosynthesis that occurs in the chloroplasts of the palisade and spongy mesophyll cells. It is also a product of cellular respiration that occurs either in the cytoplasm (anaerobic) or in the mitochondria (aerobic) of cells. Oxygen is produced as a by-product of photosynthesis and is also required in the aerobic respiration process that takes place in the mitochondria of the cells.
- 9 Gas exchange in leaves occurs through the process of passive diffusion. Being flat and thin maximises the surface area available for diffusion in comparison to the relatively small volume of each leaf.
- 10 Being thin and flat makes the leaves liable to sag, but their shape is maintained by the turgor of the living cells inside them. Maintaining their shape results in a large surface area being presented to the light, therefore maximising the photosynthetic rate.
- 11 As the concentration of sugar in the phloem increases, water moves from the xylem into the sieve cells by osmosis. This increases the volume of liquid in the sieve cells, causing the sugary solution to move.
- 12 The xylem needs to be close to the phloem because the water needed for movement of sieve tube contents comes from the xylem. Osmosis occurs efficiently over small distances.
- 13 If the water loss exceeds the uptake of water from the soil, the water content of the plant falls. Eventually, the guard cells will begin to lose their water and the stomata will close, preventing further water loss. A fall in the internal concentration of carbon dioxide can cause the stomata to open, allowing carbon dioxide to diffuse into the plant.
- 14 To limit water loss in very high temperatures, guard cells may close the stomata. While this reduces the loss of water it also cuts off the supply of carbon dioxide. This restricts the capacity of the leaf to carry out photosynthesis, thus restricting the growth of the plant overall during these environmental conditions.
- 15 Mosses and liverworts are small and do not have a vascular system. Because they don't have roots, stems and leaves, they can't transport water from the ground to the rest of the plant. Hence these plants need to have all tissues in close proximity to water and need to live in moist conditions.
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 - a A plant would be able to supply its own gaseous requirements when the rate of photosynthesis is equal to the rate of cellular respiration. In this way the amount of oxygen produced in photosynthesis would fuel the process of cellular respiration, and the amount of carbon dioxide produced in cellular respiration would drive photosynthesis.
 - b The plant would need to take in carbon dioxide and oxygen from the outside when it was growing, because growth requires the use of the products of photosynthesis.
 - c A plant kept in the dark will lose weight. The products of photosynthesis would be used in cellular respiration and if the plant was kept in the dark it would not be able to replace those products.
- 17 If stomata were open all the time, there could be more water lost from the plant than gained from the soil. In this case, the plant would wilt and eventually die. If stomata stayed shut all the time, diffusion of carbon dioxide would be severely restricted. In this case, the rate of photosynthesis would be lower compared to the rate of cellular respiration. The plant would lose weight and eventually die.
- 18 The phloem is under pressure so once the aphid pierces it, the sap will be forced into the aphid's digestive system.

- 19 a** Water is lost through leaf stomata by the process of transpiration. Transpiration requires the energy from the Sun to evaporate the water. This creates the transpirational pull that draws water into the roots.
- b** The energy for sugar transport comes from cellular respiration occurring in the mitochondria of the companion cells.
- 20** The absence of vascular tissue limits the size of mosses. The cells of a moss need to be almost in direct contact with their environment to ensure they are able to obtain all their requirements.
- 21** When transplanting plants, taking some of the local soil is useful as the soil may contain other features that help them survive in its new location, such as bacteria that assist the plant to obtain nitrogen.
- 22** Water enters the root from the soil by the process of osmosis. Mineral ions are taken up by the root by diffusion and active transport.
- 23** The adhesion and cohesion forces of water in xylem vessels allow movement of water. In xylem, the thickened, lignified walls normally prevent the water column from breaking. The narrow, thickened xylem vessels arise in dead xylem tissue. The process of water movement through the plant does not require the expenditure of plant energy; therefore, it can successfully occur in non-living cells. Phloem tissue, on the other hand, relies on energy expenditure. Cellular respiration must occur; this requires living cells and, specifically, mitochondria.
- 24** Costs include loss of water. Benefits include diffusion of carbon dioxide from the air for photosynthesis. Transpiration also cools plants and enables flow of mineral nutrients and water from roots to shoots.
- 25** The fungus is increasing the absorbing area of the root. The fungus is breaking down the surrounding soil humus into soluble nutrients, some of which are absorbed and used by the plant. These extra nutrients allow the plant to grow better than the other plants without the fungus.
- 26** Responses will vary.
- 27** Responses will vary.