Activity 11A: Internal transport in plants

1. Describe the *tissues* involved in vascular plants in the transport of:
   - **a.** water and minerals
   - **b.** sugars.
2. Describe the *processes* involved in the transport of the following in vascular plants:
   - **a.** water
   - **b.** minerals
   - **c.** sugars
   - **d.** gases.
3. Describe adaptations of the angiosperm leaf for the transport of essential materials.
4. Explain why mosses are said to be 'non-vascular' plants and how mosses obtain water and minerals.
5. Explain the role of transpiration in the movement of water in plants.
6. Discuss the need for, and the processes involved in, the transport of O_2 and CO_2 in plants.
7. Discuss the need for, and the processes involved in, the transport of water in plants.
8. Discuss diversity in transport in three named groups of plants. In your answer:
   - describe the structures associated with transport in each group
   - explain the ways the structures carry out the processes of transportation
   - discuss why the systems in these three groups are different.

Activity 11A answers: Internal transport in plants

1. **a.** Water and minerals are transported in the *xylem*. Mature xylem dies and becomes hollow, with a large lumen and lignified (bands or spirals) cell walls for strength. In *vessels*, the end walls break down, so a continuous tube is formed. In the more simple *tracheids*, the end walls remain, but are tapered and become pitted for passage of water.

   b. Sugars are transported in the phloem (sieve tubes). Mature phloem is living and consists of large *sieve tubes* and smaller, elongated *companion cells*. Sieve tubes have cytoplasm (but no nucleus) and the end walls (sieve plates) are perforated to allow the passage of sugars. Companion cells are alongside the sieve tubes and have cytoplasm, a nucleus and organelles, and are believed to control activity of the tubes.

2. **a.** Transport of water is by *osmosis*, from the soil into the root hairs, then from cell to cell (via the cell walls rather than the cytoplasm) to the xylem. Transport up the xylem to the leaves results from the cohesive and adhesive properties of water, root pressure, and (mainly) *transpiration pull*. Water leaves the xylem (leaf veins) by osmosis and passes into the chloroplasts of the mesophyll cells. The direction of movement is in response to a *concentration gradient* (i.e. from high water potential to low water potential).

   b. Transport of minerals is by facilitated *diffusion* (with the *concentration gradient*) or *active transport* (against the concentration gradient), from the soil into the root hairs, then from cell to cell to the xylem. Minerals are transported *in solution in the water* in the xylem to where needed in the plant.

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c. Sugars are transported from sugar sources to sugar sinks by *translocation* in the sieve tubes of the phloem. The method is not clearly understood, but it is *active transport* and possibly due to *pressure differences* between sources (high pressure) and sinks (low pressure).

d. Gases (e.g. O_2/CO_2) move by diffusion in response to their concentration gradient from high to low. Diffusion is through stomata into/out of leaves and through lenticels into/out of stems from the air.

3. Angiosperm leaves have *veins* of *xylem* and *phloem* that pass through the mesophyll cell layers. Water and minerals enter the leaf in the xylem and pass into individual cells for photosynthesis and other cell processes; sugars made in photosynthesis enter the phloem for transport out of the leaf. *Guard cells* are present in the epidermis (mainly the lower), and open and close *stomata*, which are the pores in the leaf that let gases in and out – CO_2, O_2, H_2O vapour. On the inside of the stomata are large *air spaces*, which are continuous with air spaces surrounding the mesophyll cells. These allow for rapid diffusion of the gases to and from the cells.

4. Mosses are non-vascular plants because they do not have vascular tissue (i.e. no xylem and phloem). They are small and live in damp areas, so can survive on the (slow) passage of substances by diffusion from cell to cell or by capillary action (water) up the side of the stem.

5. Transpiration is the loss of water from the leaves of the plant. As water is lost from the leaf, it draws more water up the xylem from the roots to replace it. Water vapour lost from the leaf is replaced by water from the xylem. As there are *strong attractive forces* (which provide cohesion) between water molecules, water forms a *continuous column* up the xylem. As a water molecule is lost from the xylem in the leaf, another water molecule is pulled up to take its place. The loss of water in transpiration therefore generates a *transpiration pull* to draw water up from the roots.

6. CO_2 is needed for photosynthesis, and O_2 is needed for respiration. Both enter the plant from the air in the process of diffusion – through stomata in the leaves and lenticels in the stem. Inside the plant, CO_2 diffuses into the cells and then into the chloroplasts, while O_2 diffuses into the cells and then into the mitochondria.

The pathway that the gases take is dependent on their *concentration gradient*. When CO_2 is used in photosynthesis, it will always have a lower gradient inside the leaf, the cells and chloroplasts, so will move in that direction. This also applies to O_2 used in respiration.

However, photosynthesis occurs only during daylight hours, while respiration occurs all the time. Therefore, during daylight, the O_2 produced in photosynthesis will also diffuse into the mitochondria for respiration (in response to its concentration gradient), and the CO_2 released in respiration will also diffuse into the chloroplasts for photosynthesis (in response to its concentration gradient). At night, without photosynthesis, the diffusion of the two gases is determined solely by the occurrence of respiration (O_2 diffuses in, and CO_2 out).

7. Water is one of the two raw materials for photosynthesis, and is needed for the production of glucose. It is required to keep cell membranes moist, so that the gases CO_2 and O_2 can dissolve and can then diffuse across membranes in the processes of respiration and photosynthesis. Water is needed to cool the leaf so that essential, enzyme-controlled reactions can occur / enzymes are not denatured by excess heat. Water enters the root hairs and moves across the cortex to the xylem in response to its concentration gradient

/ water potential. Transport up the xylem is mainly by transpiration pull acting on the column of water (water forms a column in the xylem from its cohesive and adhesive properties), though root pressure is a contributory factor. As water molecules are lost in transpiration, other water molecules are drawn up the xylem to replace them.

8. Three clearly different taxonomic (e.g. mosses, ferns, angiosperms) or functional groups need to be selected.

For *each* group, the *structures* associated with *transport* need to be *described fully and carefully using correct terms*, e.g.:

- location of the vascular tissue (roots, stem leaves), structure of xylem (tracheids, vessels) and phloem (sieve tube cells, companion cells)
- internal cell layers of leaves (e.g. air spaces in mesophyll, veins, stomata and guard cells, waxy cuticle)
- location and structure of root hairs.

For *each* group, *how* these structures perform their particular function needs to be *explained*, e.g.:

- processes associated with the transport of CO_2 and O_2 for both respiration and photosynthesis (diffusion, concentration gradients, time of day)
- processes associated with the transport of water from roots to leaves (osmosis, transpiration pull, cohesion and adhesion, root pressure, concentration gradient / water potential)
- processes involved with the transport of minerals from roots to the rest of the plant (diffusion, active transport, concentration gradients)
- processes involved in the transport of sugars made in photosynthesis to the rest of the the plant, storage of sugars (translocation, pressure differentials, active transport)
- opening and closing of stomata (turgor pressure, time of day).

For *each* group, reasons for *differences* between the groups need to be *explained*, e.g.:

- habitat – e.g. need for a damp environment for mosses, adaptations of angiosperms to a full terrestrial existence, xerophyte adaptations to conserve water
- size – e.g. mosses are small plants related to reliance on diffusion of materials in transport, and very large sizes of some angiosperms are related to the development of transport and support systems
- life cycle – e.g. the need of mosses and ferns for water for fertilisation places habitat restrictions on them.

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