Activity 10A: Nutrition in plants

1. Describe how the raw materials for photosynthesis are brought to the chloroplasts.
2. Describe how the structure of leaves and location of leaves are adaptations for photosynthesis.
3. Explain how the cell layers in the typical angiosperm leaf are adaptations for the process of photosynthesis.
4. Explain chloroplast adaptations for the process of photosynthesis.
5. Explain why carnivorous plants can be considered to be both autotrophs and heterotrophs.
6. Explain why parasitic plants:
   - **a.** produce a large number of seeds
   - **b.** have haustoria
   - **c.** have very reduced or no vascular tissue, leaves or roots.
7. Compare and contrast the leaves of sun-adapted and shade-adapted plants.
8. Discuss diversity in the nutrition of three named groups of plants. In your answer:
   - describe the structures associated with nutrition in each group
   - explain the ways the structures carry out the processes of nutrition
   - discuss reasons the systems in these three groups differ.

Activity 10A answers: Nutrition in plants

1. Photosynthesis needs H_2O and CO_2 as raw materials. CO_2 *diffuses* into the leaf from the air, in response to its concentration gradient. CO_2 diffuses through the stomata and air spaces around the mesophyll cells, dissolving in the moisture around the cells, then passing through the membrane and into the underlying chloroplasts. H_2O enters the root hairs from the soil in *osmosis*, in response to its concentration gradient. H_2O moves from cell to cell inside the root to reach the xylem. Water is carried up the xylem to the leaves, mainly by transpiration pull. In the leaves, water exits the xylem to pass through the membranes of the mesophyll cells and into the underlying chloroplasts.
2. Leaves are adapted for photosynthesis by, e.g. being thin, having a large SA : Vol ratio, being positioned around the stem so that overlap is minimised.
3. Cell layers' adaptations include having a waxy cuticle to reduce water loss; epidermis (upper and lower) being one layer of transparent cells, to allow light to pass through; palisade mesophyll under the upper epidermis has large numbers of chloroplasts, to maximise photosynthesis; spongy mesophyll cells are loosely packed, providing air spaces to increase the rate of diffusion of CO_2 and O_2; guard cells are present in the epidermis (mainly lower), to form the stomata to allow entry of CO_2/exit of O_2 into/from the leaf; veins of xylem and phloem pass through the cell layers to bring H_2O (and minerals) to the leaf and remove glucose.
4. Chloroplasts are found in the cytoplasm under the membrane of the mesophyll cells. They contain stacks of (thylakoid) membranes called *grana* and a fluid matrix called the *stroma*. It is on/in the grana and stroma that photosynthesis occurs. The light-absorbing pigments (e.g. chlorophyll) are embedded in the membranes of the grana, which provide a large SA where the light-dependent reactions of photosynthesis occur, generating ATP and splitting H_2O. The fluid stroma provides the matrix for the light-independent reactions/Calvin cycle, which use(s) the ATP to fix CO_2 and to produce glucose.

5. Carnivorous plants are autotrophs, because they make their own food ('self feeders') in photosynthesis, and are also heterotrophs because they capture and digest insects. They are autotrophs because their leaves have chloroplasts in their cells, which carry out photosynthesis to produce glucose. However, the leaves also have adaptations to catch insects (e.g. pitchers, sticky hairs, hinge mechanisms), and enzymes to digest them. Insects are needed to provide essential nutrients (e.g. N), which are lacking in the environment where the plants live. In catching and digesting insects, the plants are acting like heterotrophs.

6. **a.** Parasitic plants produce large numbers of seeds to find a new host. Host plants are distributed throughout the community, so the more seeds produced by a plant, the greater the chances are that a seed will land on/by another host, germinate, and parasitise the host. In this way, members of the species spread and no host should become over-infested and killed.

   b. Haustoria are modified roots that digest their way into the host's stem and form a connection with the host's phloem and xylem. Haustoria are needed to obtain H_2O and minerals from the host's xylem and glucose from the host's phloem. If it did not obtain the water, minerals and glucose, the parasite would not survive, because it cannot photosynthesise.

   c. The vascular tissue, leaves and roots are greatly reduced or absent because the parasite does not need them, getting its food and water from the host. Leaves are not needed because the parasite does not need to photosynthesise, as it gets its glucose from the host. The roots are no longer needed as the parasite is anchored to the host by haustoria, and gets its water from the host's xylem. The haustoria tap directly into the host's xylem and phloem, reducing/removing the need for transport tissue.

7. *Comparisons* of the leaves could include the following.
   - Presence and location of the typical cell layers/structures are the same, e.g. epidermis, mesophyll cell layers, air spaces, cuticle and stomata.
   - Chloroplasts present in mesophyll cells, have the same internal structure to carry out photosynthesis.
   - Chemical reactions in photosynthesis are the same (light-dependent followed by light-independent).
   - Vascular tissue/veins/xylem and phloem are present in leaves to transport substances.

   Contrasts of the leaves could include the following.
   - Leaves of sun-adapted plants are typically smaller than those of shade-adapted plants.
   - Leaves of sun-adapted plants may be vertical, while those of shade-adapted plants are horizontal.
   - Leaves of sun-adapted plants are thicker than those of shade-adapted plants.
   - There is a thicker waxy cuticle in sun-adapted plants.
   - Leaves may be hairy in sun-adapted plants.
   - Chloroplasts are smaller in sun-adapted plants, with less thylakoid membranes in the grana. Chloroplasts are positioned more on the vertical than on the horizontal walls of the cells.
   - CAM photosynthesis is present in some sun-adapted plants.
   - Shade-adapted plants can change the orientation of their leaves as light intensity changes.

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- Shade-adapted plants have only one palisade cell layer; spongy cells have more chloroplasts than the palisade cells. Sun-adapted plants may have two or more palisade layers, and these have more chloroplasts than the spongy cells.

Correct terms should be used in all answers (e.g. stomata not 'holes', xylem not 'water tubes', phloem not 'food tubes').

8. Three clearly different taxonomic or functional groups (e.g. any three of sun-adapted plants, shade-adapted plants, carnivorous plants, parasitic plants) need to be selected.

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

- size, shape, thickness, position (vertical, horizontal) of leaves and location on stem
- location and internal structure of chloroplasts
- internal cell layers of leaves
- leaf specialisation (e.g. spines of cacti, pitchers of carnivorous plants)
- vascular tissue (xylem and phloem)
- root hairs
- haustoria.

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

- how leaves of carnivorous plants lure, trap and digest insects
- transport of raw materials and products of photosynthesis (osmosis, diffusion, transpiration pull, translocation)
- reducing water loss
- how the chloroplasts perform photosynthesis, photosynthetic pigments
- CAM photosynthesis
- how parasites find a new host and tap into its vascular tissue.

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

- habitat – e.g. shade plants show adaptations to permanent, low light intensities within forest; carnivorous plants to living in low-nutrient marshlands; cacti to living in deserts
- size – e.g. canopy trees have leaves high up the tree exposed to high light intensities, so these leaves are smaller than those lower down the tree that experience lower light intensities
- life cycle – e.g. changes in size, shape of leaves from juvenile plants living in lower light intensities (ground floor of forest) to adult plants living in higher light intensities (canopy of forest); need for parasites to find a new host, so large amounts of seeds produced.