CHAPTER 1

PHOTOSYNTHESIS AND TRANSPORT IN PLANTS

Look at how tall this Kapok tree is compared to the person standing next to it!

The tree grew from a tiny seed into a tall tree. Where did its gain in mass come from? How does it get its food and energy?

The roots of the tree absorb water from the soil. How does water from the soil reach the leaves that are high up on the tree?

WHAT WILL YOU LEARN IN THIS CHAPTER?

- Explore how carbon dioxide, water and light are needed for photosynthesis.
- Explore how photosynthesis produces biomass and oxygen.
- Describe how water and mineral salts are absorbed and transported in flowering plants.

1.1 PHOTOSYNTHESIS

Look at the piece of log in Figure 1.1. Where did it get its mass from?

The log was cut from a tree. The tree needed food and energy to grow and make new cells and tissues in order to gain mass. Matter that is made up of cells and tissues is called **biomass**.

In the past, people thought that plants obtained food from the soil. In the 1600s, a Belgian physician, Jan Baptist van Helmont carried out an experiment on plant growth (Figure 1.2).

Figure 1.1 The log has mass as it is made up of cells and tissues.

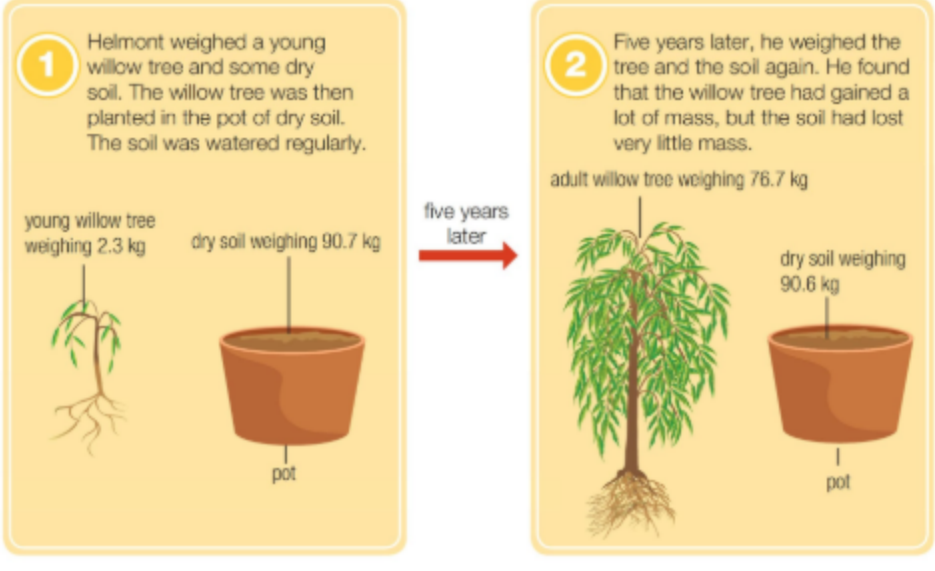

Figure 1.2 Helmont's experiment on plant growth

Helmont's experiment demonstrated that the gain in the mass of the willow tree did not come from the soil. However, he wrongly concluded that the gain in the mass of the willow tree came from the water it was given.

Today, we know that plants do not get food from the soil. Plants make food in the presence of light using carbon dioxide and water through a process called **photosynthesis**. The gain in mass as a plant grows comes from the food that the plant makes.

WHAT ARE NEEDED AND PRODUCED DURING PHOTOSYNTHESIS?

Figure 1.3 shows the substances needed and produced by the plants when they make food.

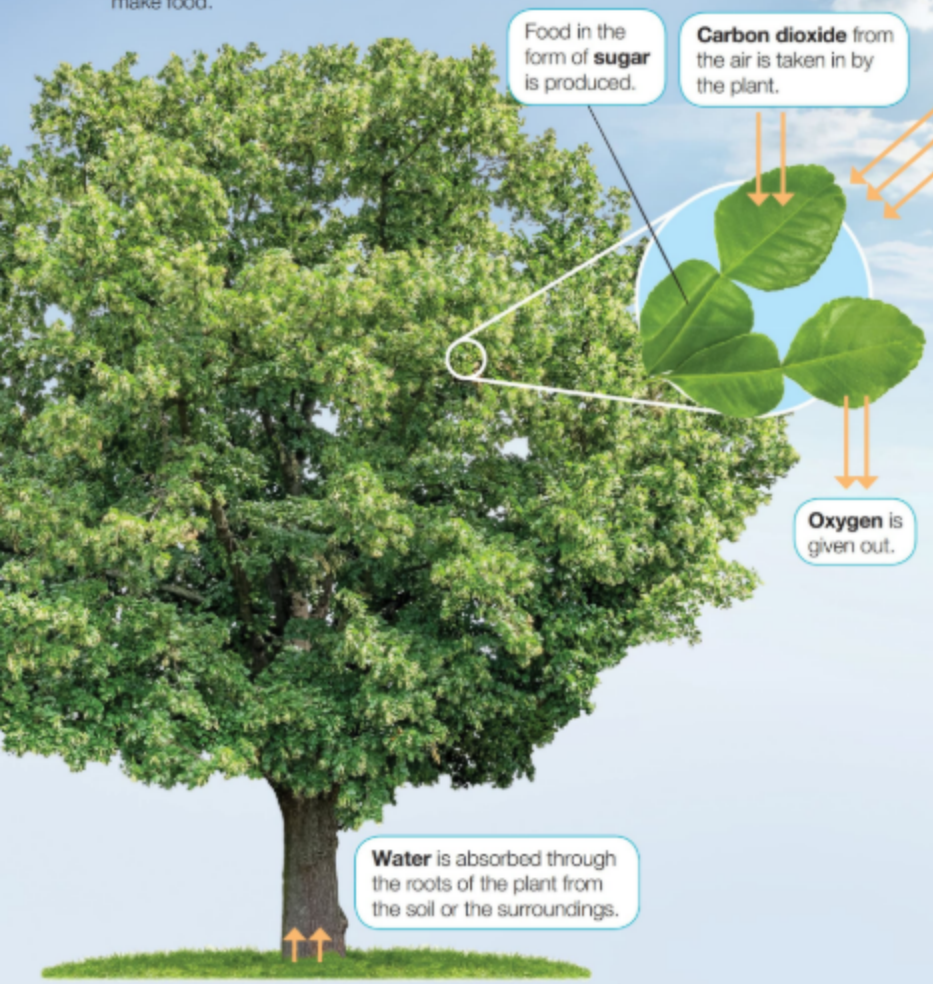

Figure 1.3 Plants make food during photosynthesis.

Carbon dioxide and water are converted into sugar and oxygen in the presence of light during photosynthesis. The process can be summarised using this word equation:

Carbon dioxide + Water $\xrightarrow{\text{presence of light}}$ Sugar + Oxygen

Most leaves are green because they contain a green pigment called chlorophyll that is able to capture sunlight. Light captured by the **chlorophyll** is used to make food during photosynthesis.

Science Bytes

'Photo' means light, while 'synthesis' means combining simpler or smaller parts to make something more complex.

Think About It

The leaves of this cactus have been reduced to spines. Does the cactus have chlorophyll? Can the cactus capture sunlight and carry out photosynthesis?

In pairs, share your answers.

Figure 1.4 A cactus has modified leaves known as spines.

How does carbon dioxide needed for photosynthesis enter the plants?

To find out, submerge a freshly plucked leaf in a basin of warm water. Do you see bubbles coming out from the underside of the leaf after some time?

Figure 1.5 Leaf submerged in warm water

There are many tiny openings called **stomata** [singular: stoma], usually found on the underside of a leaf. Gases enter and leave the plant through the stomata (Figure 1.6). That is why we see bubbles coming out from the underside of the leaf when it is soaked in warm water.

Carbon dioxide from the air enters the plant through the stomata. The carbon dioxide is used for photosynthesis. The oxygen produced during photosynthesis is used by the plant for an essential life process called respiration. Excess oxygen leaves through the stomata. Plants lose water in the form of water vapour through the stomata too.

Plants use the energy in the sugar produced to stay alive. The excess sugar made by plants is converted to **starch.** Plants store starch in different parts.

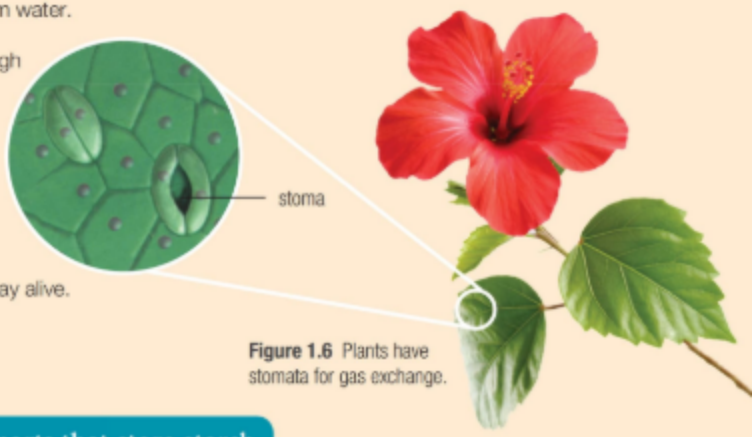

Figure 1.6 Plants have stomata for gas exchange.

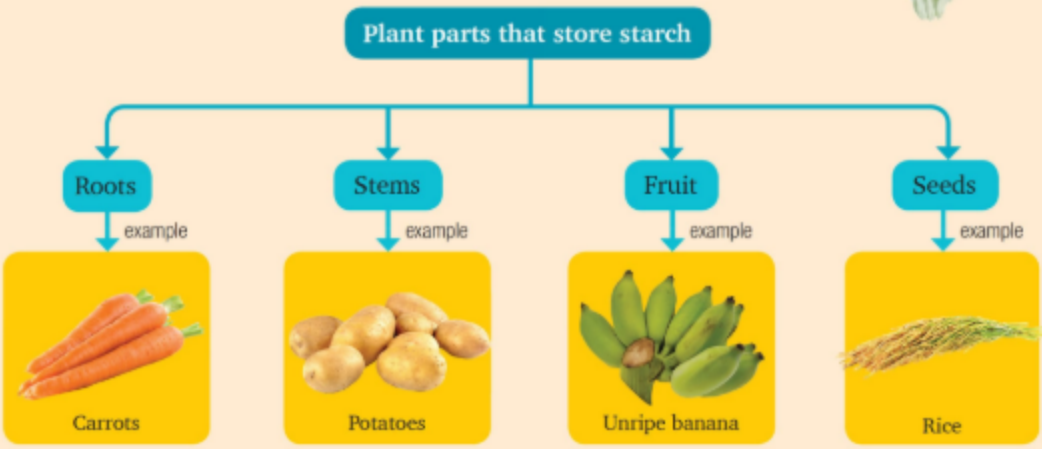

Figure 1.7 Chart showing parts of plants that store starch

Think About It

Plants take in carbon dioxide and give out oxygen during photosynthesis. How is this important to other organisms and the environment?

In pairs, share your answers.

HOW DO WE KNOW IF A LEAF HAS MADE FOOD?

If a leaf has made food, it will contain starch. We can use iodine solution to test and find out if starch is present in a leaf (Figure 1.8).

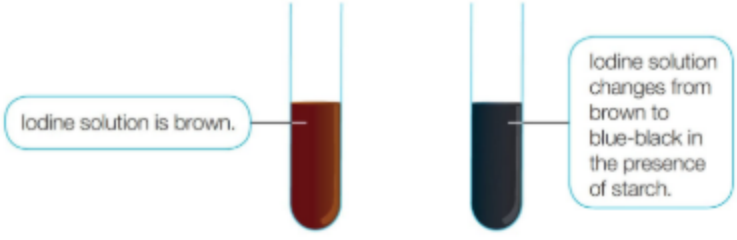

Figure 1.8 Using iodine solution to test for starch

The leaves in Figure 1.9 have been tested for starch using iodine solution. Which leaf has made food?

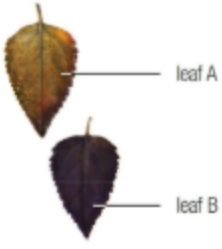

Figure 1.9 Leaves covered with iodine solution

Try It Out

A potted plant was kept in the dark for 48 hours. One of its leaves was then covered with black paper, which had cut-out holes (Figure 1.10).

The plant was exposed to strong sunlight for several hours. The leaf covered with black paper was then plucked off and tested for starch using iodine solution.

Shade the part(s) of the leaf that would turn blue-black in the outline of the leaf shown in Figure 1.11.

Figure 1.10 Leaf covered with black paper that has cut-out holes

Figure 1.11 Outline of leaf

Think About It

Do plants with non-green leaves carry out photosynthesis? Explain your answer.

Figure 1.12 Some plants have non-green leaves.

Plants make use of light energy from the Sun to make food during photosynthesis. The food produced by plants becomes the energy source for animals, which feed on the plants directly or indirectly. Thus, the energy stored in plants and animals is derived from the Sun.

Key Points

- Matter that is made up of cells and tissues is called biomass.
- Photosynthesis is the process by which plants use carbon dioxide and water in the presence of light to make food.
- The gain in mass as plants grow comes from the food that the plants make.
- Plants make food in the form of sugar during photosynthesis. Oxygen is also produced during photosynthesis.
- The leaves and some parts of a plant contain a green pigment called chlorophyll to capture sunlight.
- Carbon dioxide, which is needed for photosynthesis, enters a plant through the stomata. Stomata are usually found on the underside of leaves.
- Excess oxygen produced during photosynthesis leaves the plant through the stomata.
- Excess sugar produced during photosynthesis is stored in different parts of a plant as starch.

1.2 ABSORPTION AND TRANSPORT OF WATER AND MINERAL SALTS

HOW ARE WATER AND MINERAL SALTS ABSORBED BY FLOWERING PLANTS?

Look at the root of the seedling in Figure 1.13. What do you think is the function of the tiny hairs growing out from the root?

Figure 1.13 Close-up view of the root of a seedling

Besides holding the plants firmly to the ground, another function of **roots** is to **absorb** water and dissolved **mineral salts** from the soil or surroundings. The tiny hairs on the root are **root hairs**. The numerous root hairs greatly increase the surface area in contact with the water in the soil (Figure 1.14). Thus, water can be absorbed into the root much more quickly.

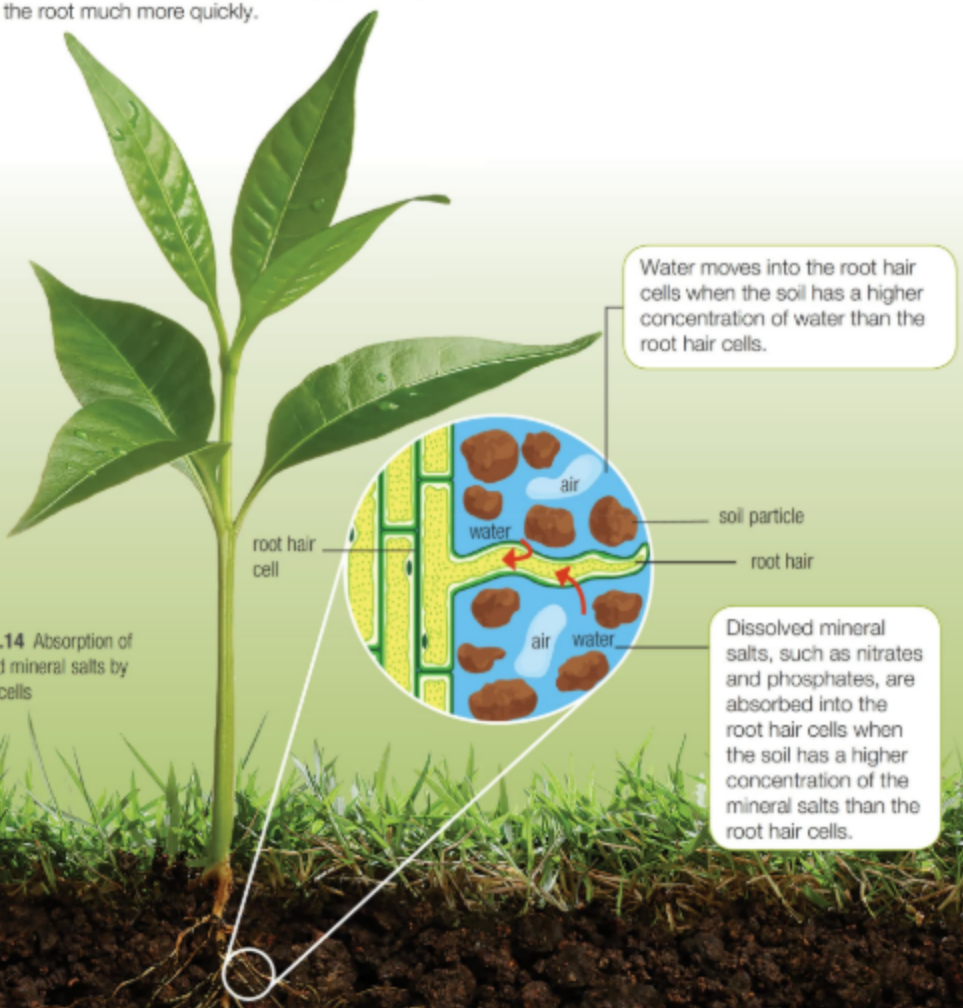

Figure 1.14 Absorption of water and mineral salts by root hair cells

Try It Out

There are many interesting types of roots around us. Some grow in air or water instead of soil.

Figure 1.15 The roots of this strangler fig are 'strangling' the trunk of another tree.

Figure 1.16 Some parts of the roots of these mangrove trees are underground, some parts are submerged in water, and some parts are in the air.

Observe some unusual roots around you. Take photographs or make sketches of these unusual roots. Find out the names of the plants the roots belong to and why they have such unusual characteristics.

Share your findings with the class.

Science Bytes

Some roots store food made by the plants. Such roots are called storage roots. Many storage roots are commonly eaten by us as food. Have you eaten any of these roots?

▲ Tapioca (cassava)

▲ Beetroot

▲ Sweet potato

▲ Radish

▲ Turnip

Figure 1.17 Examples of storage roots

HOW ARE WATER AND MINERAL SALTS TRANSPORTED BY FLOWERING PLANTS?

How do the water and mineral salts absorbed by the roots of the tall Kapok tree on page 1 reach the leaves at the top of the tree?

In a road transport system, vehicles carry or transport passengers and goods along the roads from one place to another. Similarly, a plant with vascular tissues, such as a flowering plant, has a transport system to transport materials around the plant.

The **transport system** of a flowering plant is made up of two networks of vessels — phloem and xylem. The **phloem** transports food made in the leaves during photosynthesis to the other parts of the plant. The **xylem** transports water and mineral salts from the roots to the other parts of the plant. The networks of vessels are often found side by side, forming vascular bundles (Figure 1.18).

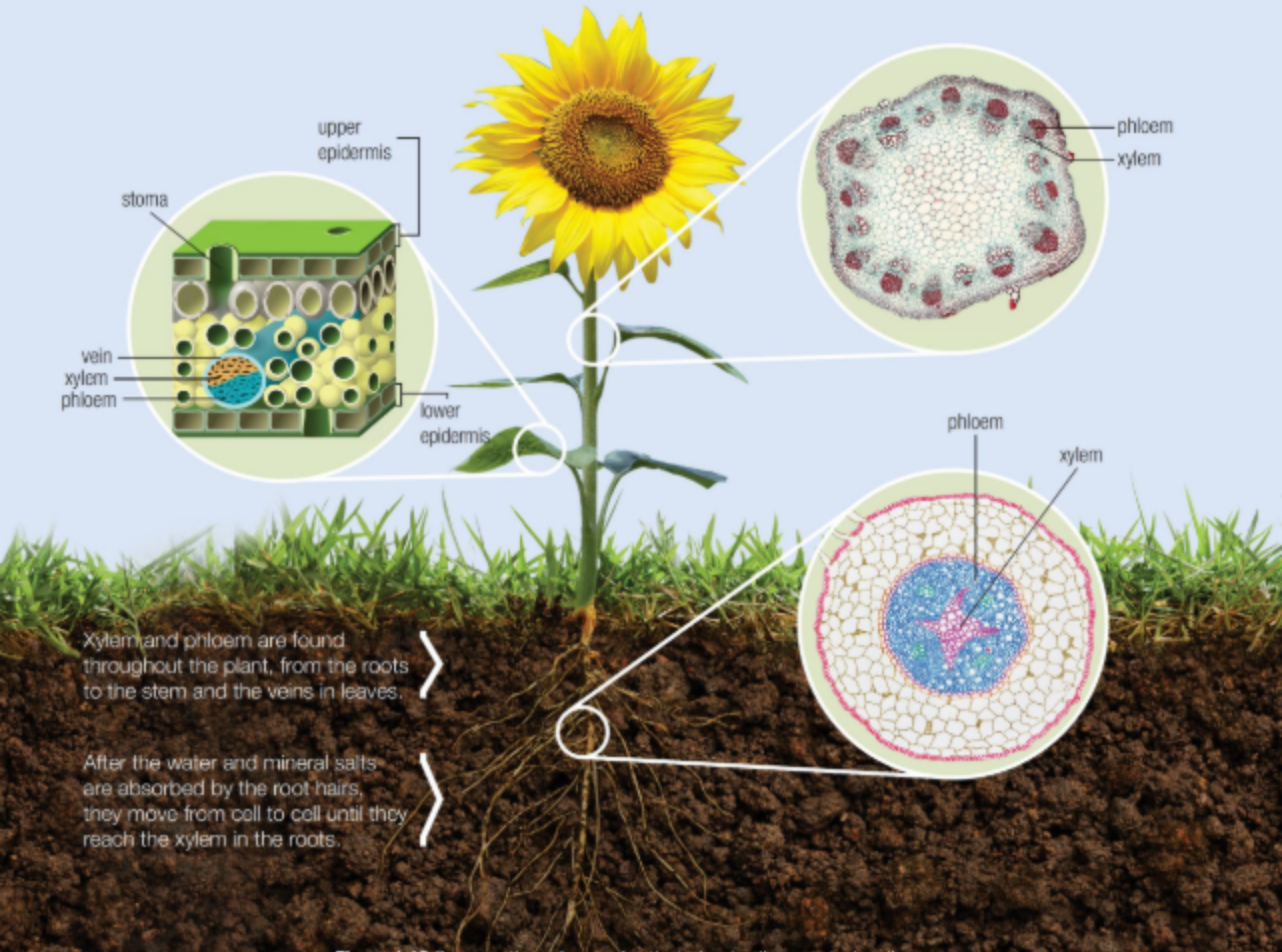

Figure 1.18 Cross-sections of parts of a plant, showing the vascular bundles

Try It Out

Observe a leaf. Do you see veins on it?

Figure 1.19 The veins on the leaf of a hibiscus have a net-like pattern.

Figure 1.20 The veins on the leaf of a bamboo are parallel and run alongside one another.

Compare different types of leaves, such as a hibiscus leaf and a grass leaf. Do the veins of the leaves have the same pattern?

Xylem vessels are made up of dead cells with thick and stiff walls at the side. The cells have lost their end walls. Thus, the cells join end to end to form a continuous tube, like a water pipe.

Water and dissolved mineral salts move up the xylem vessel (Figure 1.21). Why do water and mineral salts move up against gravity instead of flowing down?

Water and mineral salts are pulled up by the xylem vessels because of transpiration (Figure 1.22).

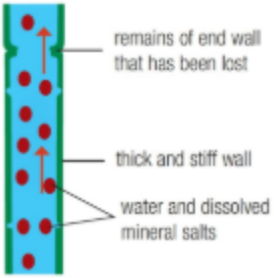

Figure 1.21 Direction of movement of water and mineral salts moving up a xylem vessel

Figure 1.22 Water and mineral salts move upwards due to transpiration.

Think About It

Compare these leaves from two different plants.

Figure 1.23 Large leaves of a yam plant

Figure 1.24 Small leaves of a bougainvillea plant

In which plant do transpiration and transport of water take place more quickly if the other conditions are the same?

In pairs, share your answers.

Try It Out

1. Prepare three transparent containers half-filled with water. Colour the water in each container using different colours of food dye.
2. Place a celery stalk in each container.
3. Predict what you will observe if you leave the set-up for a few hours. Explain your prediction.
4. Leave the set-up for a few hours and observe the celery stalks. What do you observe?
5. Wash the celery stalks and cut across each stalk carefully. What do you observe on the cross-section of the celery stalks? Can you identify the xylem vessels?

Did you observe that the leaves of the celery in the activity above were coloured by the food dye after some time? Were all parts or only some parts of the leaves and stalk of the celery coloured by the food dye?

The coloured water was drawn up the celery stalks to the leaves through the xylem vessels as transpiration took place. As a result, the veins of the leaves were stained with the colour from the food dye.

Figure 1.25 Celery stalk placed in the coloured water

Did you observe the parts of the celery stalks that were stained with the colours when you cut across the stalks? These parts are the xylem vessels, which transported the coloured water up the stalk to the leaves.

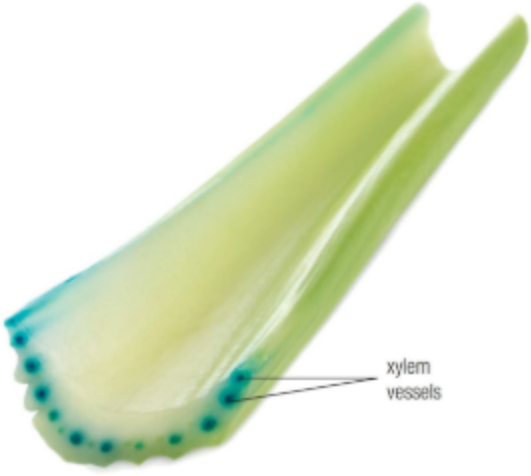

Figure 1.26 Cross-section of a celery stalk showing stained xylem vessels

Roots absorb water and dissolved mineral salts from the soil or surroundings. The water and mineral salts are then drawn up to the leaves through the xylem as transpiration takes place. This is how water absorbed by the roots at the bottom of a tall tree can reach the top of the tree.

Key Points

- Roots have numerous tiny root hairs to absorb water and dissolved mineral salts quickly from the soil or surroundings.
- A plant with vascular tissues, such as a flowering plant, has a transport system made up of xylem and phloem vessels.
- The phloem vessel transports food made by the leaves to the other parts of the plant.
- The xylem vessel transports water and dissolved mineral salts from the roots to the other parts of the plant.
- Water and dissolved mineral salts that are absorbed by the roots are drawn up through the xylem vessels to the stem and the leaves as transpiration takes place.

REVIEW QUESTIONS

1. A tiny seed gains a lot of mass as it grows into a tall tree. Where does the gain in mass come from?

2. **a** What is photosynthesis?
   b What do plants need for photosynthesis?
   c What are the products of photosynthesis?

3. **a** Describe briefly how you can test a leaf for starch.
   b What can you conclude if starch is present in the leaf?

4. Correct the following misconceptions.
   a Plants take in food from the soil.
   b Only the leaves of plants can carry out photosynthesis.
   c Only plants with green leaves contain chlorophyll.
   d Plants make food in the form of starch during photosynthesis.
   e The roots of plants are organs for feeding.

5. How do root hairs help the plant to absorb water and mineral salts quickly from the soil?

6. How are water and dissolved mineral salts transported from the roots to the leaves of a flowering plant?

7. Figures 1.27 to 1.29 show the cross-sections of different parts of a plant. Identify parts A, B and C. State the function of each part.

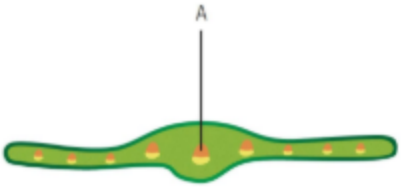

Figure 1.27 Cross-section of a leaf

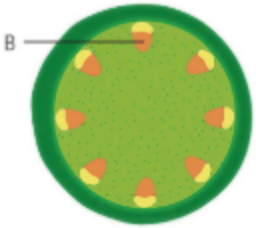

Figure 1.28 Cross-section of a stem

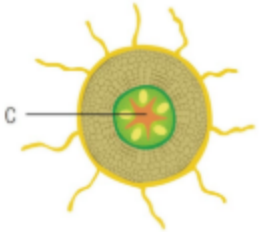

Figure 1.29 Cross-section of a root

THINK-TANK

1. Haze is a phenomenon in which dust, smoke and suspended fine particles remain in the air. Suggest how hazy skies affect the growth of plants.

2. What kinds of roots do desert plants have in order to absorb as much water as possible from their surroundings?