1.1 Photosynthesis

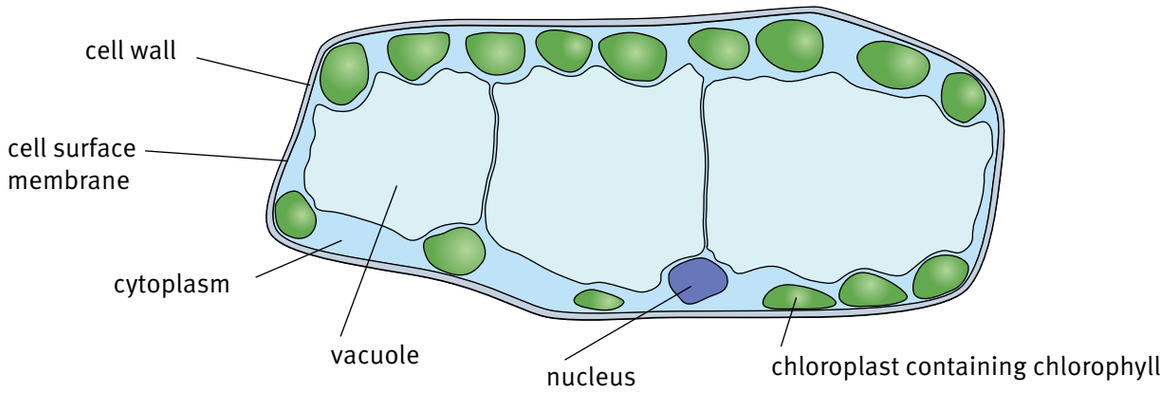
Photosynthesis is the way that plants make food. They use carbon dioxide and water to make glucose and oxygen.

Photosynthesis is a chemical reaction. We can summarise it using a word equation:

carbon dioxide + water → glucose + oxygen

Energy transfer

The photosynthesis reaction needs a supply of energy to make it happen. This energy comes from light. During photosynthesis, the plant's leaves absorb the energy of light. The energy is stored in the glucose that is made. The glucose is a store of chemical potential energy.



Photosynthesis happens inside the chloroplasts in a palisade cell like this one.

Questions

1 Think back to (remember) what you have already learnt about photosynthesis.
   a Where do plants get carbon dioxide from?
   b Where do plants get water from?
2 Explain why photosynthesis only takes place inside chloroplasts.

Storing carbohydrates

Glucose is a sugar. Sugars belong to a group of chemicals called **carbohydrates**.

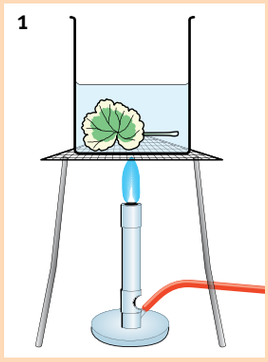
Plants usually make much more glucose than they need to use immediately. They store some of it to use later. But they do not store it as glucose. Glucose is soluble in water, which makes it difficult to store inside a cell.

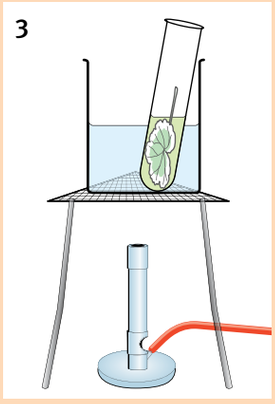
Instead, the plant changes some of the glucose into a different kind of carbohydrate – **starch**. A starch molecule is made of thousands of glucose molecules linked together in a long chain. Starch molecules are too big to dissolve in water. They stay as insoluble grains, inside the chloroplasts in the plant cell.

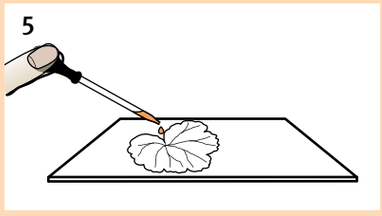
Activity 1.1
Testing a leaf for starch

You will remember that we can test for starch using iodine solution. But just adding iodine solution to a leaf won't work, because the starch is inside the leaf cells. Iodine solution can't get through the cell membranes of the leaf cells.

1 Boil some water in a beaker. Add a leaf to the boiling water. This will break down the cell membranes around the leaf cells.
2 Turn off your Bunsen burner or spirit burner. This is important because you are going to use ethanol in the next step, and ethanol is very flammable. Using forceps (tweezers), remove the leaf from the water. Be gentle – it will be very soft and easily torn.
3 Collect some ethanol in a test tube. Stand the test tube in the beaker of very hot water. Put the leaf into the ethanol. You will see the green colour (chlorophyll) coming out of the leaf, into the ethanol.
4 When you think most of the colour has come out, take the leaf out of the ethanol and dip it into the water to soften it. Spread the leaf out on a tile.
5 Now you can add iodine solution to the leaf. If the leaf contains any starch, it will turn blue-black.







Questions

A1 Explain why the leaf needed to be boiled before testing with iodine solution.
A2 Suggest why it was useful to remove the green colour from the leaf, before testing it with iodine solution.
A3 Describe **two** things that you did in step 2 to reduce the risk of anyone being hurt.
A4 Explain why leaves often contain starch.

Summary

- Photosynthesis is the production of glucose and oxygen, by reacting water and carbon dioxide, using energy from light.
- Plants often change some of the glucose into starch, for storage.
- Before testing a leaf for starch, you need to boil it to break down the cell membranes.

1.2 Mineral salts for plants

Farmers and gardeners often add **fertilisers** to the soil where their crops are growing. The fertilisers provide mineral salts, which make the plants grow larger and healthier. Although fertilisers are expensive, the cost to farmers is outweighed by the extra money they can get for their crop.

This farmer in Indonesia is giving fertiliser to his growing rice plants.

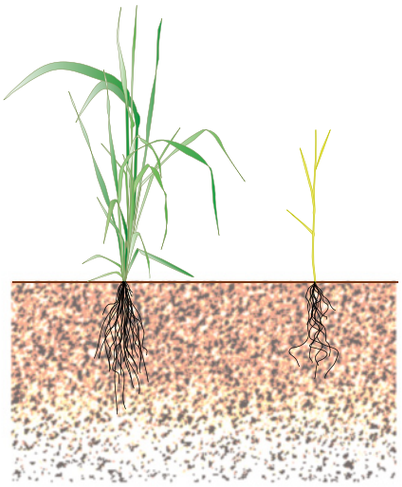
What are fertilisers?

Fertilisers contain **mineral salts**. These are substances that plants normally get from the soil. But often the soil does not contain enough of some kinds of mineral salts, which stops the plants growing as large and strong as they could.

Plants need many different kinds of mineral salts. Two of the most important ones are nitrate and magnesium.

Nitrate is needed so that the plant can make proteins. You'll remember that proteins are nutrients that living organisms need for making new cells. A plant that has not got enough nitrate can't make enough proteins, so it cannot make enough new cells to grow well.

Nitrate is also needed to make chlorophyll. If a plant does not have enough nitrate, it will become yellow instead of green.



Plants that are short of nitrate are stunted (small) and yellow.

Magnesium is also needed for making chlorophyll. So a shortage of magnesium makes plant leaves go yellow.

This tomato leaf is showing symptoms of magnesium deficiency.

Questions

A+I

1 Give **two** examples of mineral salts that are needed by plants.
2 Explain why a plant that does not have enough magnesium will not grow well.
3 Think about what you know about plant roots. How do plants absorb mineral salts from the soil?

Activity 1.2

Investigating the effect of fertilisers on plant growth

Duckweed is a tiny plant that grows on the surface of ponds and lakes. Each plant is made up of a leaf-like structure, often with tiny roots hanging down into the water.

If you add a single duckweed plant to some water, it will produce new plants as it grows. You can measure how fast the duckweed grows by counting how many plants there are after a certain period of time.

A frog surrounded by duckweed plants.

Plan an investigation to find out how fertiliser affects the rate of growth of duckweed. Your teacher will show you the plants and the fertiliser that you can use.

Think about these questions:

- What you will change in your experiment?
- How will you change this?
- What variables will you keep the same?
- What will you measure?
- When you will measure this?
- Will you do repeats in your experiment? If so, how many?

When your teacher has checked your plan, you can set up your experiment. You will have to be patient, as it may take several weeks before you have your results.

Record your results clearly. You may be able to draw a graph to display them.

Summary

- Plants need nitrate to make proteins, which are needed to make new cells for growth.
- Plants need magnesium to make chlorophyll.

1.3 Plants and water

Everyone knows that plants need water. If you grow plants in pots, you need to water them regularly.

Water for support

The photograph shows one reason why plants need water – it helps them to stand upright.

Plant cells contain a lot of water, especially inside their vacuoles. A plant cell that has plenty of water is strong and firm. When all the cells in a plant are like this, they press out against each other and make the whole plant firm and well-supported.

When a plant cell doesn't contain enough water, it becomes soft and floppy. When all the cells in a plant are like this, the plant collapses. We say that it has wilted.

Water for transport

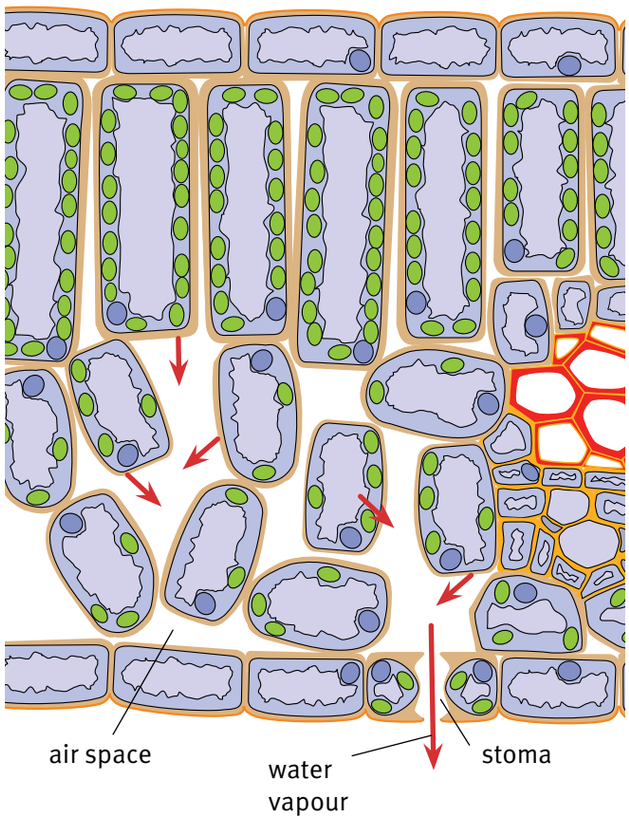
You may remember that plants contain long tubes, called xylem, which transport water from the roots up to the leaves. There are mineral salts dissolved in the water, and this is how they are transported around the plant.

Water for cooling

When the water in the xylem gets into the leaves, it spreads out through each leaf. Some of it evaporates into the air spaces inside the leaf.

When water evaporates, it absorbs heat energy. This cools down the surroundings. The water evaporating inside a plant leaf helps to keep the plant cool. This is really important for plants that live in very hot environments.

The plant on the left has not been watered for three days. The photograph on the right shows the same plant a few hours after it was watered.

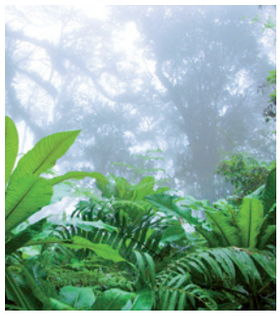


Most of the water that is taken up by a plant's roots is eventually lost from its leaves in the form of water vapour.

Water for photosynthesis

Water is one of the reactants in photosynthesis. Water combines with carbon dioxide, inside chloroplasts, to make glucose and oxygen.

In fact, only a very small proportion of the water taken up by a plant's roots is used in photosynthesis.



Water vapour diffusing out of plant leaves helps to keep the air moist.

Questions

1 Explain why a plant wilts if it is short of (lacks) water.
2 How does water help a plant to keep cool?
3 Water from the soil is absorbed by a plant. Eventually, it ends up in the air as water vapour. List the parts of the plant that it passes through on this journey.

Activity 1.3

Water loss from plants

1 Collect two very similar potted plants. Make sure both of them have moist soil. Cover the two pots with plastic bags as shown in the diagrams.
2 Measure the mass of each plant in its pot, using a top pan balance. Record this mass.
3 Each day for the next week, measure the mass of each plant in its pot again. Try to do this at about the same time each day. Record all of your readings in a results table.
4 When you have finished all your measurements, look carefully at the inside of the plastic bag covering the plant. You may find little droplets of liquid. To check if these are water, touch one of them with some blue cobalt chloride paper. If the liquid is water, the paper will go pink.
5 Draw a line graph to display your results. You could draw two lines on the same graph – one for each plant.

Questions

A1 What was the variable that you changed in this experiment?
A2 What variables did you keep the same?
A3 Compare the change in the mass in the two plants in their pots.
A4 Explain why the droplets of water formed on the inside of the plastic bag.
A5 Explain the reasons for the differences between the results for the two plants.

Summary

- Plants need water for support, cooling, transport and photosynthesis.
- Most of the water taken up by the roots eventually diffuses out of the plant's leaves, as water vapour.

1.4 Flowers

The photograph shows wild flowers growing. Many flowers are brightly coloured like this. Why are flowers so colourful?

Flowers are brightly coloured to attract insects and birds. They do this because the insects and birds help plants to reproduce. Flowers are the reproductive organs of plants.

Brightly coloured wild flowers.

The parts of a flower

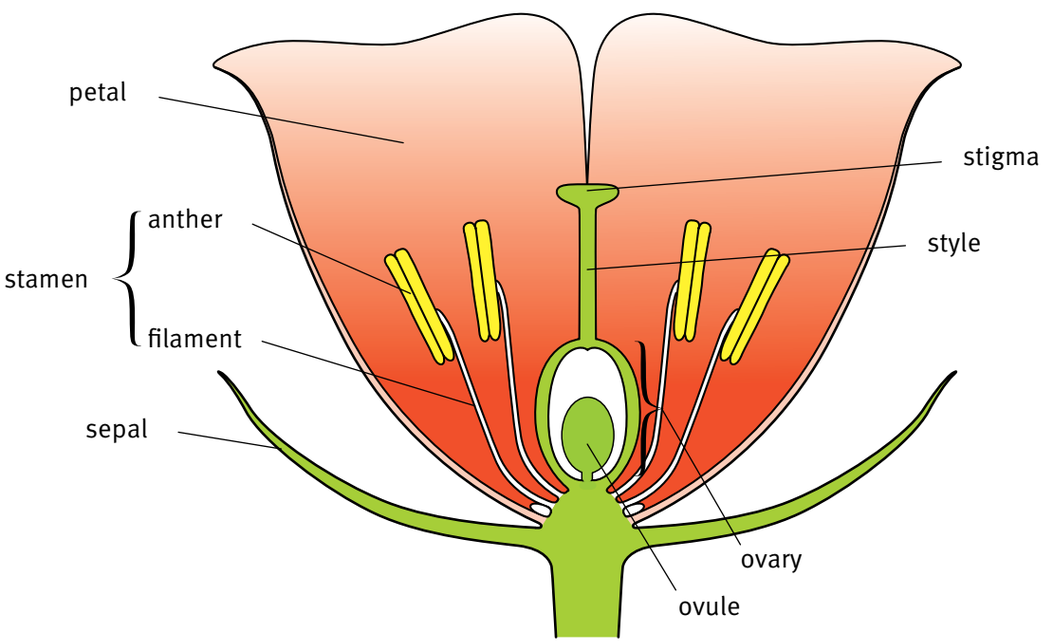
Flowers come in all sorts of different shapes and sizes. But you can usually find the same parts in most flowers that you look at.

The **petals** are usually the most colourful part of the flower. They attract insects or birds to the flower. Some flowers produce scents (smells), which also help to attract insects.

The insects or birds feed on sweet, sugary **nectar** produced at the base of the petals. They may also eat some of the **pollen**, produced in the **anthers**. The pollen contains the male gametes of the flower.

The female gametes are inside the **ovules**, which are inside the **ovaries**.

Unlike animals, many plants produce both male gametes and female gametes.



The structure of a flower.

A+I

Questions

1 Many people use the word 'flower' when they really mean 'plant'. Explain the difference between a plant and a flower.
2 Insects can often smell flowers from hundreds of metres away. Suggest how the scent from the flowers spreads out into the air around them.

Not all flowers produce smells that we like. This flower is a stapelia. It has a scent like rotting meat, and attracts flies.

Activity 1.4
Investigating flower structure

You are going to take a flower apart and stick the various parts into your notebook.

1 Look carefully at your flower.
- How many sepals does it have?
- Carefully remove each of the sepals, and stick them in a neat row in your book. Write a label to remind you what they are.
- How many petals does your flower have? What colour are they?
- Some petals have guidelines, to direct insects to where they can find nectar at the base of the petals. Does your flower have guidelines?
- Carefully remove each of the petals, and stick them into your book.

3 Now look at the stamens. These are the male parts of the flower.
- How many stamens does your flower have? Can you see any pollen at the top of them?
- Remove them carefully and stick them into your book. On one of them, label the anther and filament.

4 Now you should only have the stigmas, styles and ovaries left. These are the female parts of the flower.
- How many does your flower have?
- Carefully cut an ovary open. What can you see inside it?
- Stick the stigmas, styles and ovaries into your book, and label them.

Summary
- Flowers are the reproductive organs of plants.
- The male parts of a flower are the stamens. Pollen contains the male gametes.
- The female parts of a flower are the ovaries, style and stigma. Ovules contain the female gametes.
- Petals have bright colours and strong scents to attract insects and birds.

1.5 Pollination

Flowers are organs where sexual reproduction takes place. You will remember that sexual reproduction involves gametes (sex cells).

In humans, the male gametes are the sperm cells. They can swim to find an egg.

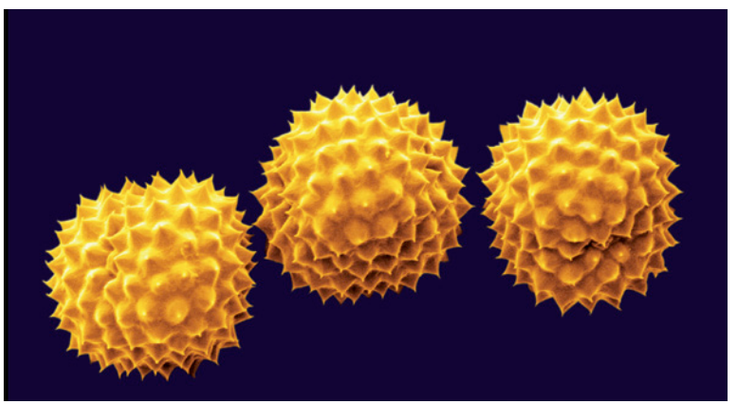
Flowers do not have swimming sperm cells. Their male gametes are simply nuclei inside their pollen grains. They cannot swim.

So flowers have to use another method of getting their male gametes to their female gametes. Many of them use insects or birds. Some use the wind.

The yellow powder falling from these catkins contains thousands of lightweight pollen grains. Catkins are made of lots of tiny flowers.

Pollen grains

Pollen grains are made in the anthers of flowers. Pollen grains contain the male gametes.



These spiky pollen grains are from a ragweed plant. Their spikes help them to stick to insects' bodies (magnification ×1600).

Activity 1.5
Looking at pollen grains

1. Collect a microscope and set it up with the low power objective lens over the stage.
2. Collect a clean microscope slide. Carefully tap a little pollen from a flower onto the centre of the slide.
3. Place the slide on the stage of the microscope. Focus on the pollen. Make a drawing of one or two pollen grains.
4. Repeat steps **2** and **3** using pollen from a different kind of flower.
5. Describe any differences that you can see between the two types of pollen.

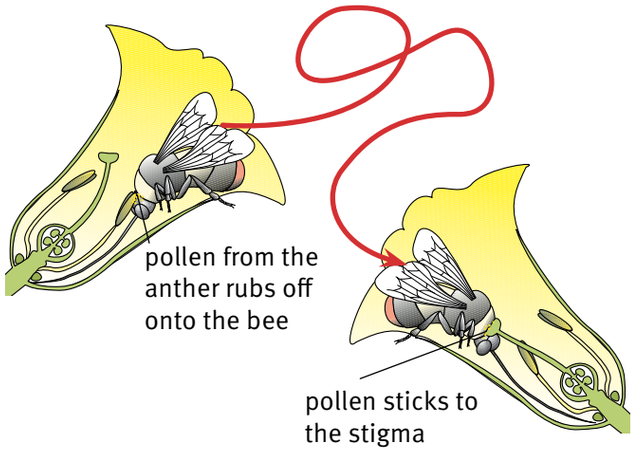
Transferring pollen grains

To help the male gametes get close to the female gametes, pollen grains must be carried from the anthers (where they are made) to the **stigma** of a flower.

Insects often help with this. When the insect comes to a flower to collect nectar, pollen gets stuck onto its body. When the insect goes to another flower, some of the pollen rubs off onto the stigma.

The transfer of pollen from an anther to a stigma is called **pollination**.

Many flowers are pollinated by insects or birds. Some, for example grasses, are pollinated by the wind. The wind blows pollen off the anthers. Just by luck, some of the pollen may land on the stigmas of other flowers.



Insects can transfer pollen from an anther to a stigma.

This Cape sugarbird is collecting nectar. When it flies to another flower, it may carry pollen with it on its feathers.

Questions

1 Where are the female gametes found in a flower?
2 Where are the male gametes found in a flower?
3 Explain why plants need help to get their male gametes to their female gametes.
4 A+I The table shows two differences between insect-pollinated and wind-pollinated flowers. Suggest reasons for these differences.

Insect-pollinated flowers	Wind-pollinated flowers
brightly coloured	not brightly coloured
have spiky or sticky pollen	have smooth pollen

Summary

- The male gametes of a flower are inside the pollen grains. The female gametes are inside the ovules.
- The male gametes cannot move by themselves, so flowers make use of insects, birds or the wind to move their pollen grains.
- The transfer of pollen from an anther to a stigma is called pollination.