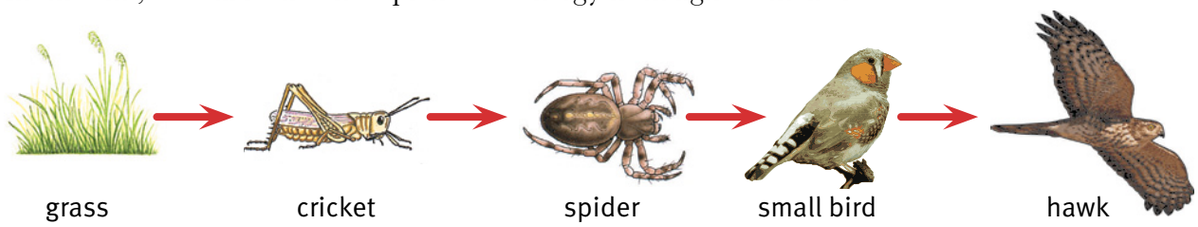
1.1 Photosynthesis

Where do you get your energy from?

Your energy comes from the food that you eat. Energy is passed from one organism to another along a food chain.

Every food chain begins with a plant. Plants capture energy from light, and transfer some of the energy into the food that they make. When we eat food, we get some of that energy.

In this unit, we will look at how plants use energy from light to make food.



The arrows in a food chain show the energy passing from one organism to another.

Making with light

'Photo' means to do with light. 'Synthesis' means 'making'. So 'photosynthesis' means 'making with light'. Photosynthesis is the way that plants make food, using energy from light.

This forest in New Zealand is a giant food factory.

Questions

1. Think of **two** more words that begin with 'photo'. What does each of your words mean?
2. In the food chain above, at which point does photosynthesis take place?

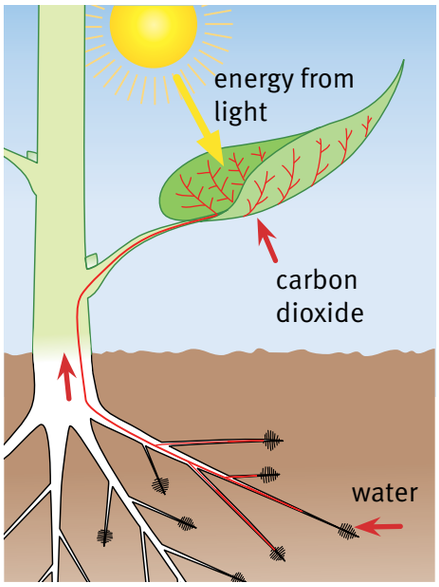
What else do plants need for photosynthesis?

- Plants use **water** in photosynthesis. They get the water from the soil.
- Plants use **carbon dioxide** in photosynthesis. They get the carbon dioxide from the air.

You already know that plants make food by photosynthesis. But they also make a very important gas – **oxygen**.

We can summarise photosynthesis like this:

Water and carbon dioxide are changed into food and oxygen, using energy from light.



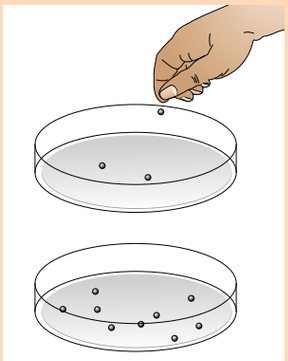
Biomass

Plants use the food that they make in photosynthesis to make new cells and tissues. Material that is made of living cells and tissues is called **biomass**.

Activity 1.1
Plants and light

SE

You are going to find out what happens to plants that do not get light.



1. Sow some small seeds on damp filter paper, in two identical dishes. Leave them in a warm place to germinate. Make sure that they do not dry out.
2. When the seeds have germinated, put one set into a dark cupboard, or into a closed cardboard box. Leave the other set in a light place. Keep giving them both a little water. Try to make sure that the temperature is the same for both sets of seedlings.
3. After two days, compare the appearance of the two sets of seedlings. You could also make labelled drawings of a seedling from each set.

Questions

A1 Explain why it was important to keep one set of seedlings in the light.
A2 Explain why it was important that the temperature was the same for both sets of seedlings.

Summary

- Photosynthesis is the way that plants make food, using energy from light.
- Some of the food that is made becomes new biomass in the plant.
- Plants use water and carbon dioxide in photosynthesis.
- Plants make food and oxygen by photosynthesis.

1.2 Leaves

In most plants, the leaves are the organs that carry out photosynthesis.

Leaves capture energy from light.

Chlorophyll

Most leaves are green. This is because they contain a green pigment called **chlorophyll**. (A pigment is a coloured substance.)

Chlorophyll is essential for photosynthesis. Chlorophyll captures energy from light. The leaf can then use this energy to make food.

Questions

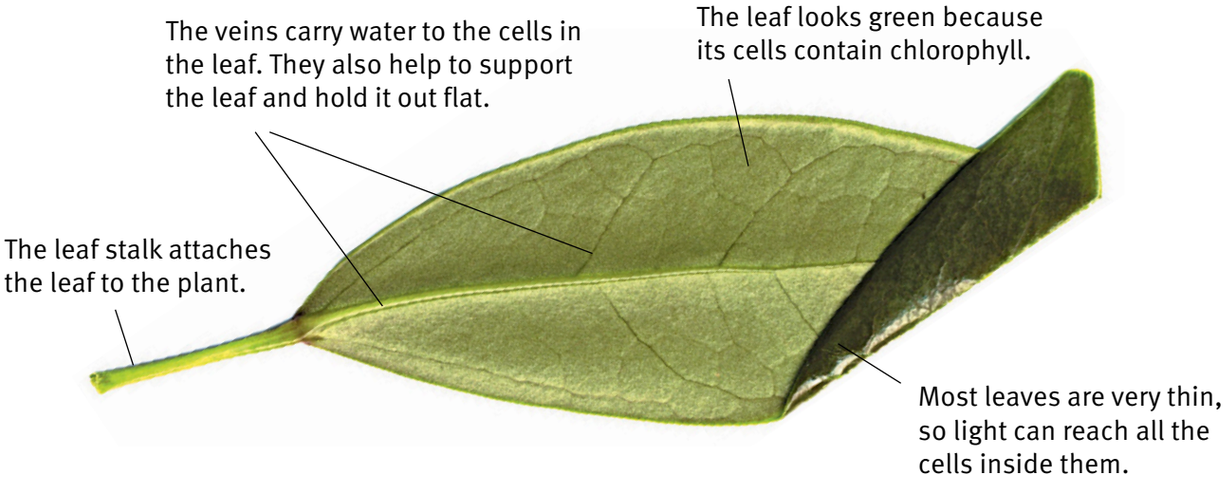
1 Think about what you know about the structure of cells. What is the name of the part of a plant cell – also beginning with 'chloro' – that contains chlorophyll?

A+I 2 Suggest why leaves are green, but roots are not.

A+I 3 Think back to Activity **1.1**, where you grew some seedlings in the dark. What happened to the chlorophyll in them?

The structure of a leaf

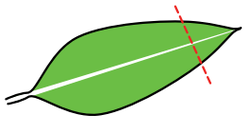
The picture shows the different parts of a leaf.



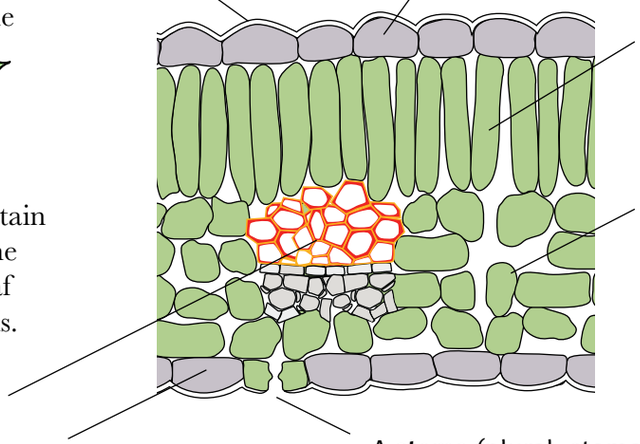
How a leaf is adapted for photosynthesis.

Inside a leaf

The diagram on the right shows what a leaf looks like if you cut it across, and then look at the cut edge.



Leaves are so thin that it is difficult to imagine they contain several layers of cells. It is the cells in the middle of the leaf that carry out photosynthesis.



Activity 1.2

Which surface has the most stomata?

SE

Take a fresh, green leaf. Push the leaf into some warm water. Watch carefully to see where air bubbles appear on the leaf surface.

Questions

A1 On which surface of the leaf did most bubbles appear?

A2 The bubbles contained gas that came out from inside the leaf. Which part of the leaf do you think the gas came from? (Look at the diagram of the inside of the leaf above.)

A3 Suggest how the gas got out of the leaf.

A4 Use what you know about the effect of heat on gases to explain why the gases came out of the leaf when it was put into warm water.

Summary

- Leaves are adapted to carry out photosynthesis.
- Leaves are green because they contain the green pigment chlorophyll, which absorbs energy from light.
- Leaves have tiny holes in their lower surfaces, called stomata, which allow carbon dioxide to get into the leaf from the air.

1.3 Investigating photosynthesis

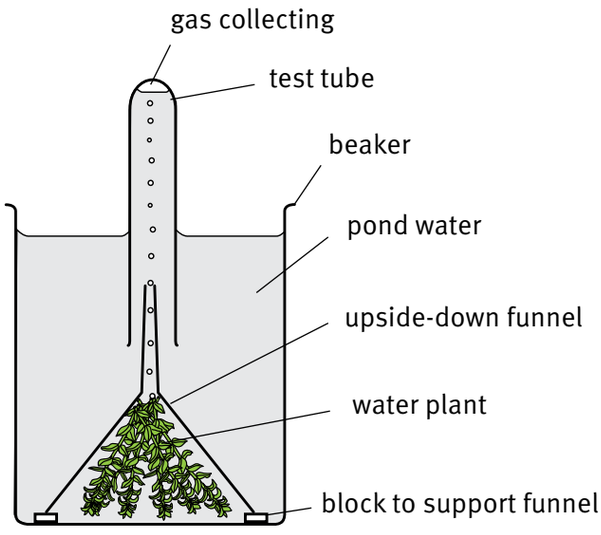
How can we tell if a leaf is photosynthesising? One of the simplest ways is to check if it is giving off (releasing) oxygen gas. This is easiest to do if the leaf is under water, because the oxygen gas makes bubbles.

Activity 1.3A

Collecting the gas produced in photosynthesis

SE

The diagram shows the apparatus you need to set up for this experiment.



You can use any plant that grows under water. You can usually get pond weed at a pet shop, because people buy it to put into fish tanks. If you live near the sea, you can use seaweed instead.

Leave the apparatus in a place where the plant will get plenty of light. If it is very warm and sunny, you may see the gas collecting quickly. If it is colder and not so bright, you may need to leave it for a day to give time for the gas to collect.

When you have collected about half a test tube of gas, you can test it to see if it is oxygen, like this:

1. Put your hand into the water in the beaker, and hold the test tube near its opening. Put your thumb over the opening, taking care to keep the test tube under water.
2. Keeping the tube open end downwards, take it out of the water.
3. Get a partner to light a wooden splint, then blow it out so that it is just glowing.
4. Now gently take off your thumb, to let the water fall out of the tube.
5. When all the water has fallen out, quickly but carefully put the glowing splint into the tube. Try not to touch the wet sides, or you will put it out!
6. If the gas is oxygen, it will make the glowing splint burst into flame.

Questions

A1 Explain why you needed to use a water plant for this experiment.
A2 Explain why you needed to leave the apparatus in a light place.

Activity 1.3B

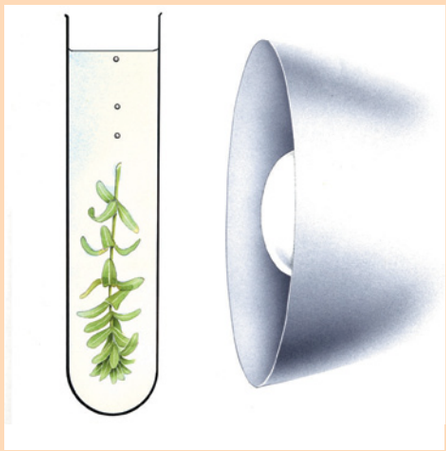
Investigating the rate of photosynthesis

SE

You are going to plan and carry out an experiment to investigate this question:

Is there a correlation between light intensity and the rate of photosynthesis?

A **correlation** is a relationship. If there is a correlation between light intensity and photosynthesis, then we would expect that changing the light intensity will result in a change in the rate of photosynthesis.



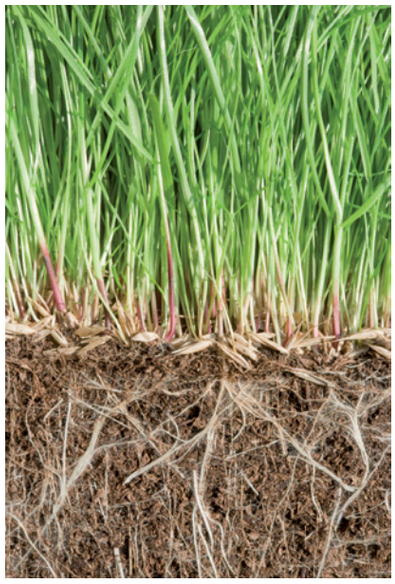
1 Write out your plan for your experiment.
Here are some ideas you can use.
   - You can use a water plant like the one that you used for Activity **1.3A**.
   - To measure the rate of photosynthesis, you can measure how much gas the plant gives off in a certain length of time. For example, you can measure the depth of gas that collects in the test tube in one hour. For a quicker experiment, you can count how many bubbles the weed gives off in one minute. If you do that, then you don't need a funnel or test tube to collect the gas.
   - To give the plant a high light intensity, you can place a lamp close to the plant. For a lower light intensity, place the lamp further away.
   - Think carefully about all the variables that you must keep the same in your experiment.
   - Decide whether you should do several repeats for each light intensity, so you can calculate a mean for each one.
2 Predict the results you expect to get, and explain why.
3 Check your plan with your teacher before you begin.
4 Now carry out your experiment. Make changes to your plan if you think you can improve it.
5 Record and display your results so someone else can easily understand them.
6 Write down a short conclusion to your experiment, and compare your results with your predictions.

Summary

- A good way to find out if a water plant is photosynthesising is to see if it gives off bubbles of oxygen.
- If photosynthesis is happening at a faster rate, then more oxygen is given off per minute.

1.4 Roots

Roots are usually underground, so we often do not notice them. But, for many plants, the roots take up just as much space as the above-ground parts of the plant.



For a plant, its roots are just as important as its leaves.

Functions of roots

The roots of a plant have several functions.

- Roots absorb water and minerals from the soil. These are then transported to all the other parts of the plant.
- Roots anchor the plant firmly in the ground, so it is not pulled out when the wind blows strongly, or when an animal pulls on the leaves.
- Some plants store food in their roots.
- When conditions are difficult – for example, in a cold winter, or a dry summer – some plants allow their above-ground parts to die. Only the underground roots continue to live. New shoots (above-ground parts) grow from the roots when conditions become better.

Activity 1.4A

Roots for food

We make use of many roots that store food. The plant stores the food for its own use, but we can also eat this food.

Choose **two** different roots that humans eat as food.

For each root, find out what the complete plant looks like.

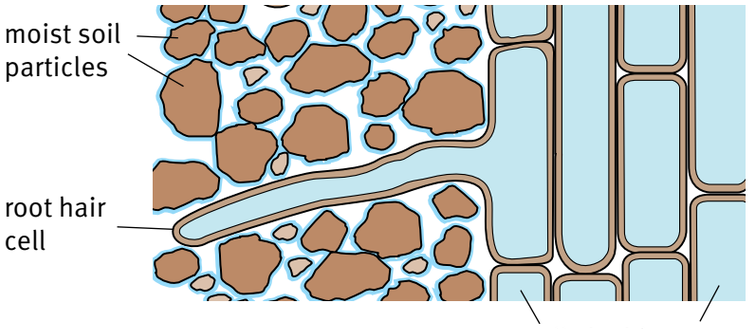
Make a labelled drawing of the plant. Describe how we use the root for food.

Roots are good sources of food for humans.

How roots absorb water and minerals

Soil is made up of tiny rock particles. There is usually water in the spaces between the particles. There are minerals dissolved in the water.

You may remember that special cells called **root hairs** grow out of the surface of roots. Root hair cells provide a really big surface through which water and minerals can be absorbed.



A root hair cell.

This photograph of a root was taken using a microscope. You can see that it is covered with thousands of tiny root hairs.

Questions

A+I
1 Explain how the absorption of water by roots helps photosynthesis to take place.

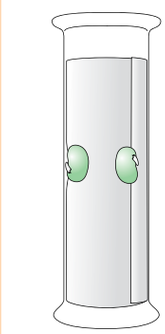
A+I
2 Suggest why most plants die very quickly if their roots are cut off.

3 Explain how root hairs help plants to absorb a lot of water in a short time.

Activity 1.4B

Which way up?

SE
1 Take a tall glass jar. Roll up a piece of strong absorbent paper so that it fits inside the jar. Add a little water and allow it to soak into the paper.
2 Take three soaked bean seeds. Carefully put them between the paper and the side of the jar. Place each one a different way up.
3 Put the jar in a warm place. Check it each day to see if it needs more water – it is important to keep the seeds moist but not too wet.
4 When all of the seeds have grown roots, make drawings of them.



Questions

A1 What do you notice about the directions the roots have grown in?
A2 Suggest how this would help a bean plant to survive.

Summary

- Roots absorb water and minerals from the spaces between soil particles.
- Roots anchor a plant in the ground.
- Roots can store food for the plant.
- Roots can sometimes survive harsh conditions that kill the above-ground parts of the plant.

1.5 Transporting water and minerals

We have seen that the roots of a plant absorb water and minerals. How are these transported from the roots to all the other parts of the plant?

Activity 1.5A

Transport in a celery stalk

SE

1 Collect a stalk of celery. If possible, choose one that has some leaves at the top.
2 Put some water containing a coloured dye into a beaker. Stand the celery stalk in the dye. Make sure you stand the stalk the right way up.
3 Every now and then, look at the stalk. You should be able to see the coloured dye moving up inside it. (This can sometimes happen very quickly and sometimes very slowly, so be prepared!)
4 When the dye has reached the top of the stalk, take the stalk out of the dye and wash it in clean water.
5 Carefully cut across the stalk. Look at the cut end using a hand lens. Make a drawing of what you can see.

Questions

A1 Suggest why it is important to wash the celery stalk before cutting across it.
A2 Flowering plants, such as celery plants, contain long tubes called xylem vessels. (You pronounce the 'x' in xylem as though it is a 'z'.) These vessels transport water and substances dissolved in the water. Use your results to describe where the xylem vessels are in a celery stalk.

Activity 1.5B

How does temperature affect the rate at which water is transported in a celery stalk?

SE

You are going to plan and carry out an experiment to try to answer the question in the title.

Think about the following questions.

- What variable will I change? How will I change it?
- What will I measure? How will I measure it? When will I measure it?
- What variables will I try to keep the same? How will I keep them the same?
- Are there any safety risks in my experiment? If so, how can I keep safe?
- How will I record my results? Can I draw a graph? If so, what will I put on the graph axes?
- What do I think the results will be? Why?

When you have written your plan, check it with your teacher.

After you have done your experiment, identify the trends and patterns you can see. Compare your results with your predictions.

Xylem vessels

When you did Activity **1.5A**, you saw that the coloured dye did not soak into all of the celery stalk. It stayed inside the **xylem** vessels.

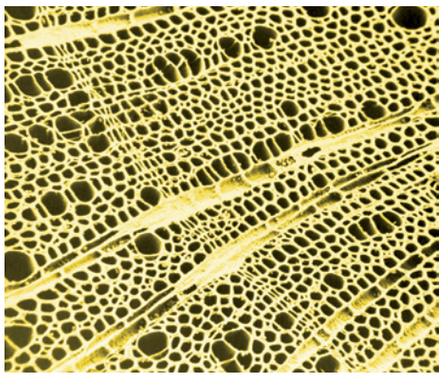
Xylem vessels are long, hollow tubes that carry water and minerals from the roots of the plant to its leaves. In a tree, the xylem vessels reach all the way up the trunk and to the very tips of the branches. The xylem vessels continue inside the leaves.

Xylem vessels are very tiny. The spots that you saw in the celery stalk each contain several xylem vessels.

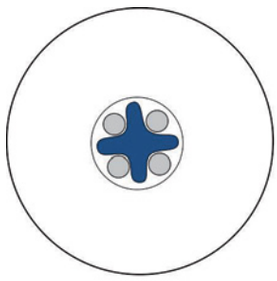
The diagrams show where the xylem vessels are in a root, a stem and a leaf. The dark blue areas show where xylem vessels are found.

Xylem vessels have very strong, hard walls. This means that they help to support the plant, as well as transporting water and minerals.

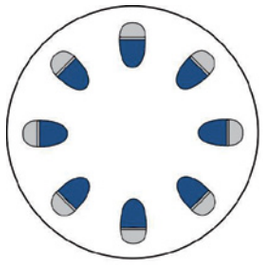
The wood in a tree trunk is made up of xylem vessels. If you are working at a wooden desk, you may be able to see the xylem vessels that make up the wood.



This is a piece of wood seen with a powerful microscope. Each hole is the cut end of a xylem vessel.



The position of xylem vessels in a root.



The positions of xylem vessels in a stem.

The positions of xylem vessels in a leaf. In a leaf, the xylem vessels are inside the veins.

Summary

- Water and minerals are transported from a plant's roots to its leaves inside long, hollow tubes called xylem vessels.
- The veins in a leaf contain xylem vessels.
- Wood is made up of xylem vessels.