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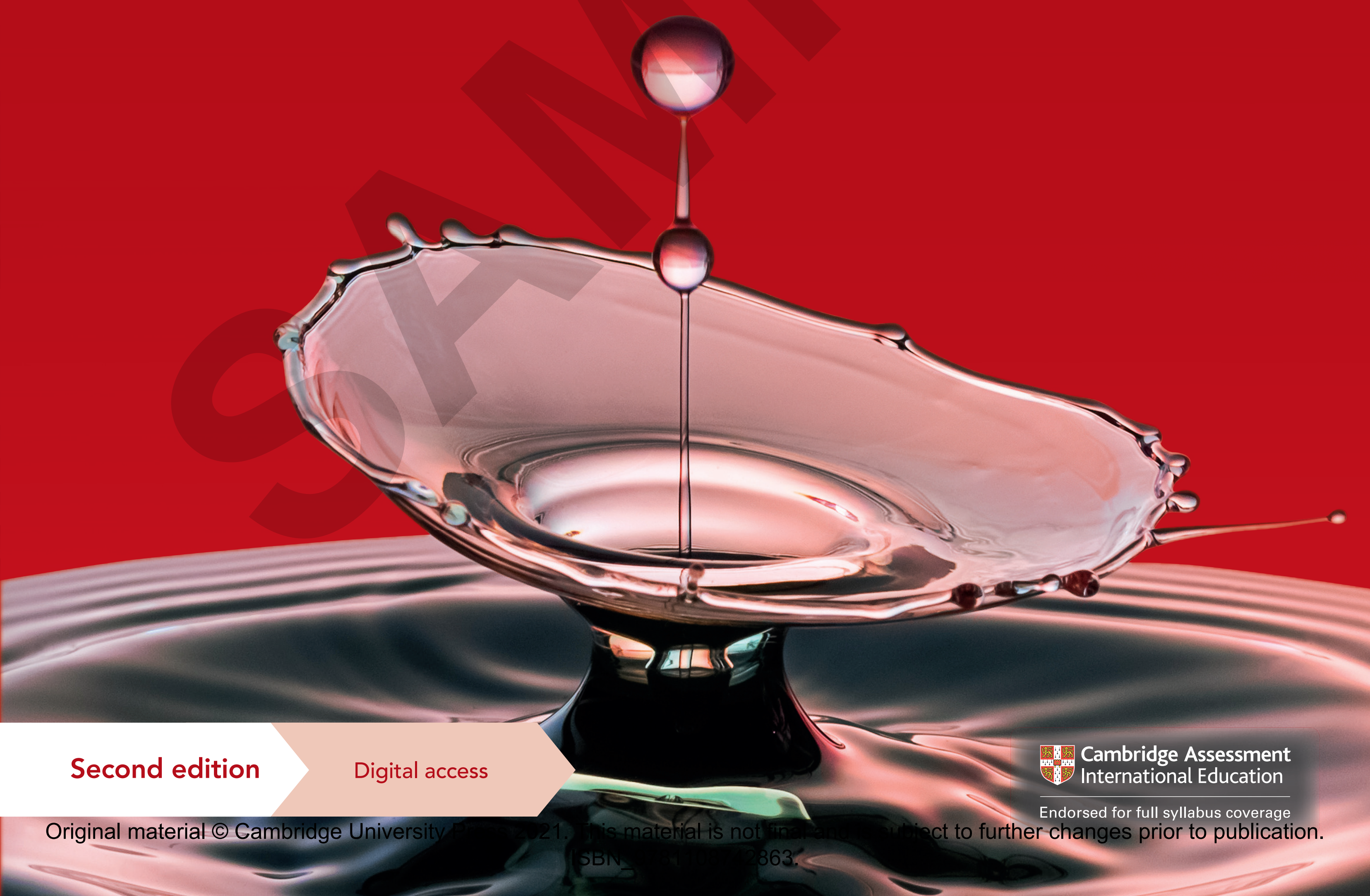
Cambridge Lower Secondary Science

LEARNER'S BOOK 9

Mary Jones, Diane Fellowes-Freeman & Michael Smyth



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How to use this book

This book contains lots of different features that will help your learning. These are explained below.

This list sets out what you will learn in each topic. You can use these points to identify the important topics for the lesson.

In this topic you will:

- discover that thermal energy always transfers from hotter places to colder places
- understand what is meant by heat dissipation.

This contains questions or activities to help find out what you know already about this topic.

Getting started

1 Thermal is a type of energy store. List as many other types of energy store as you can remember.
2 Choose two of your energy stores. Describe how the energy can be changed between these types of energy store.
3 Describe what is meant by dissipated energy.

Important words are highlighted in the text when they first appear in the book. You will find an explanation of the meaning of these words in the margin. You will also find definitions of all these words in the Glossary and Index at the back of this book.

Key words

chlorophyll light intensity photosynthesis

You will have the opportunity to practise and develop the new skills and knowledge that you learn in each topic. Activities will involve answering questions or completing tasks.

Activity 3.1.1

Densities of some regular objects

In this activity you will calculate the densities of some different materials, using the mass and volume of regular objects.

You need

- a balance
- a ruler that can measure in millimetres
- a calculator
- some regular shaped items made from different materials

Method

1 Measure the length, width and height of each object. You should measure to the nearest 0.1 cm.
2 Calculate the volume of each object in cm^3.
3 Measure the mass of each object in grams. Remember to check that the balance is reading 0.0 g before you place the material on the balance.

This provides an opportunity for you to practice and develop practical skills with a partner or in groups.

Think like a scientist

Densities of irregular objects

In this investigation, you will calculate the densities of irregular objects.

You need

- a balance
- measuring cylinders of various sizes
- water
- small irregular objects that will sink in water and will fit inside the measuring cylinders
- a calculator

Safety

Do not drop heavy objects into glass measuring cylinders; either use a plastic measuring cylinder, or hold the glass measuring cylinder at an angle, so that the object slides down slowly.

Method

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After completing an activity, this provides you with the opportunity to either assess your own work or another student's work.

Self-assessment

For each of these statements, decide on how confident you are. Give yourself 5 if you are very confident and 1 if you are not confident at all.

- I understand how to calculate the volume of a regular object.
- I understand how to calculate the volume of an irregular object.
- I know the equation for density.
- I can use density to predict whether an object will float or sink in water.

This contains questions that ask you to look back at what you have covered and encourages you to think about your learning.

The carbon cycle is a complicated diagram. What can you do to help you to remember it?

This list summarises the important topics that you have learned in the topic.

Summary checklist

I know:

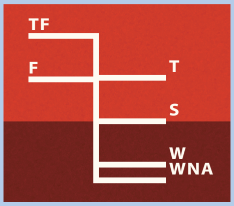
- [ ] what is meant by density
- [ ] the equation for density

At the end of each unit, there is a group project that you can carry out with other students. This will involve using some of the knowledge that you developed during the unit. Your project might involve creating or producing something, or you might all solve a problem together.

Project: Load lines

Background

Load lines, sometimes called Plimsoll lines, are painted on the sides of many ships. The picture shows an example of load lines.



The load lines are on the side of a ship, half way between the front and the back.

When cargo or passengers go onto a ship, the ship goes further down into the water. The load lines show how far down a ship can be in water and still be safe. The letters stand for different types of water and different conditions.

Your task

Find out what the letters on the load lines stand for.

Use a block of wood to model a ship. You will prepare different water conditions and test how your model floats in each. Your water conditions will model those shown on the load

These questions look back at some of the content you learned in each session in this unit. If you can answer these, you are ready to move on to the next unit

Check your progress

3.1 Which of these is the correct equation to calculate density?

Give **one** letter. [1]

A density = weight × volume

B density = $\frac{\text{mass}}{\text{volume}}$

C density = $\frac{\text{volume}}{\text{mass}}$

D density = $\frac{\text{weight}}{\text{volume}}$

3.2 Which statements are true about the density of air?

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1 Photosynthesis and the carbon cycle

1.1 Photosynthesis

In this topic you will:

- practise using the word equation for photosynthesis
- learn what photosynthesis is and why it is important

Getting started

Look at the pictures of the young maize (corn) plants. The plants on the left have been given light, but the ones on the right have not had light.

You may also be able to look at some actual plants that have been grown in the light and the dark.

With a partner, make a list of the differences you can see between the two sets of plants.

Suggest what has caused these differences.

Key words

chlorophyll light intensity photosynthesis

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How plants make food

Plants make food by **photosynthesis**. 'Photo' means 'light'. 'Synthesis' means 'making'. So, photosynthesis means 'making with light'.

Activity 1.1.1

Words beginning with photo-

Work in a team.

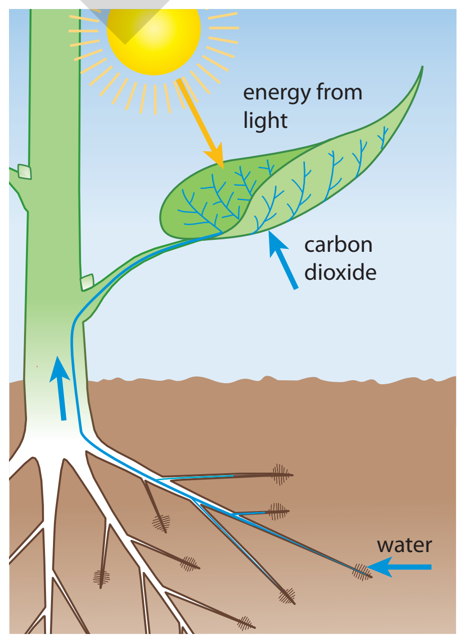
In two minutes, write down as many words as you can think of that start with 'photo'.

The winning team is the one which has thought of the most words – but only if they are all real words, and are spelt correctly.

What does each word have to do with light?

In photosynthesis, plants use:

- water, which they get from the soil
- carbon dioxide, which they get from the air
- energy, which they get from sunlight



The energy in sunlight is captured by a green pigment, called **chlorophyll**, which is inside some of the cells in the leaves of plants.

The plants use the energy to make the water and carbon dioxide combine together in a chemical reaction.

Two new substances are made in the reaction. These are glucose and oxygen.

You can write the word equation for photosynthesis like this:

water + carbon dioxide → glucose + oxygen

Photosynthesis happens in the leaves of a plant. You will find out more about this in the next topic.

Questions

1 What are the reactants in photosynthesis?

2 What are the products in photosynthesis?

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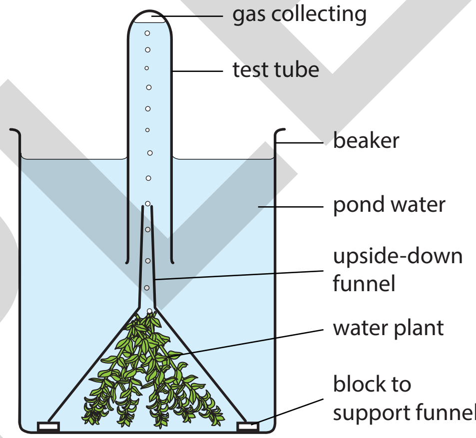
Think like a scientist

Collecting the gas produced in photosynthesis

You are going to use a plant that grows in water for this experiment. This makes it easy to collect the gas that it releases.

You will need:

- the apparatus shown in the diagram



If you don't have any pond water, you can use ordinary tap water.

You can use any plant that grows under water. You can often buy water plants in pet shops, because people like to put them into tanks with their pet fish.

Method

1. Set up the apparatus shown in the diagram.
2. Put the apparatus in a place where the water plant will get sunlight. Leave it for at least one day.
3. When plenty of gas has collected in the top of the test tube, put your hand into the beaker of water.

   Carefully remove the tube from the top of the funnel. Keep the opening of the tube under the water, or the gas will escape!
4. With the tube still upside down, put your thumb over the end of the tube, to keep the water and gas inside.
5. Take the tube out of the water, keeping your thumb over the end. Keep the tube upside down.
6. Ask someone else in your group to light a splint, and then blow it out so that it is glowing but not burning.
7. Very carefully, move your thumb just a little bit, so that the water runs out of the tube but the gas stays inside.
8. Test the gas with a glowing splint. (Try not to touch the wet sides of the test tube, or the splint will be extinguished!) If the gas contains a lot of oxygen, the splint will relight.

Questions

1. Explain why it was best to use a water plant in this experiment.
2. Explain why it was important to leave the apparatus where it would get plenty of sunlight.

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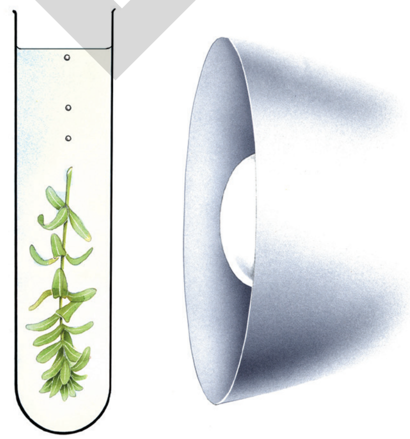
Think like a scientist

Investigating how light intensity affects the rate of photosynthesis

Like the previous experiment, this experiment uses a water plant. You are going to change the amount of light that falls onto the plant and see how this affects zthe number of bubbles it produces in one minute.

You will need:

- the apparatus shown in the diagram
- a beaker in which you can stand the test tube
- a ruler, for measuring the distance between the lamp and the test tube
- a timer



Safety

It is very important to keep electrical wires, plugs and the lamp away from the water.

Method

1 Set up your apparatus. Place the lamp close to the test tube. Leave the apparutus like that for about 5 minutes, to give the plant time to settle down and start to photosynthesise.

While you are waiting, read the rest of these instructions and then draw a results chart.

When you can see bubbles coming from the cut end of the plant stem, you can start your experiment.

2 Measure the distance between the lamp and the test tube, and write it down in your results chart.

3 Start the timer. Count how many bubbles the plant produces in one minute, and write this down.

4 Repeat step 3 two more times.

5 Now move the lamp a little bit further away from the test tube. Measure the new distance.

6 Repeats steps 3 and 4.

7 Repeat steps 5 and 6 for at least two more distances of the lamp, further from the test tube.

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Continued

Questions

1 Calculate the mean number of bubbles for each distance of the lamp from the test tube.

2 Plot a graph of your results.

- Put distance of lamp from the test tube on the horizontal axis. Remember to include units.
- Put mean number of bubbles per minute on the vertical axis.
- Plot your points as small, neat crosses.
- Draw a line to show the trend in your results.

3 Light intensity means the amount of light. Copy and complete this sentence:

As the distance of the lamp from the test tube increases, the light intensity ....

4 Now write a conclusion for your experiment, by copying and completing this sentence:

As the light intensity increases, the rate of photosynthesis ....

Peer assessment

Exchange your results chart with a partner (not the person who worked with you on your experiment!)

How well did they construct and complete their results chart?

Give them a mark, from 0 to 2, to show how well they did on each of the five statements below:

0 if they did not try, or were really bad at it

1 if you think they did quite well

2 if you think they did it really well

- They drew a results chart using a ruler and pencil, so that it was easy for you to read.
- They wrote a heading for the distance of the lamp from the plant, including units.
- They wrote a heading for the number of bubbles per minute.
- They marked small neat crosses in the correct positions to show the mean number of bubbles per minute.
- Overall, it was really easy to understand everything in the results chart.

If you gave your partner two marks for everything, the best possible score would be 10. How many marks did you give them out of 10? If it was less than 10, explain to them what they could do better.

If you were asked to draw another results chart in the future, how could you do it better?

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Activity 1.1.2

Photosynthesis and respiration

In Stage 8, you learnt about respiration.

Think about each of these questions on your own. Then turn and discuss them with your partner.

- What similarities are there between photosynthesis and respiration?
- What differences are there between photosynthesis and respiration?

Now share your ideas with the rest of the class.

Why is photosynthesis important?

Firstly, photosynthesis provides energy, in the form of chemical energy in nutrients, for all other organisms.

Plants use the energy in sunlight to make glucose and other carbohydrates. These carbohydrates contain some of the energy that was originally in the sunlight.

Think about what you have learnt about food chains. When animals eat food, they get some of the energy that was captured by plants. All the energy in all the food in the world comes from plants. A food chain shows us how this energy is passed along from one organism to another.

The second reason that photosynthesis is so important is that it provides oxygen for the Earth's atmosphere. Animals and plants, of course, need oxygen for respiration.

Oxygen is a waste product of photosynthesis. It is released from the leaves of plants and mixes with the other gases in the atmosphere. About 20% of the air around us is oxygen.

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When the Earth was first formed, about 4.6 billion years ago, there was almost no oxygen in the Earth's atmosphere. Scientists think that oxygen first began to collect in the air when bacteria first began to photosynthesise. (There were no plants at that time – they did not appear on Earth until about 4.7 million years ago.)
If photosynthesis had not ever begun on Earth, then no animals would ever have been able to live here.

Questions

3 The picture shows a lizard eating a grasshopper. Grasshoppers eat grass.

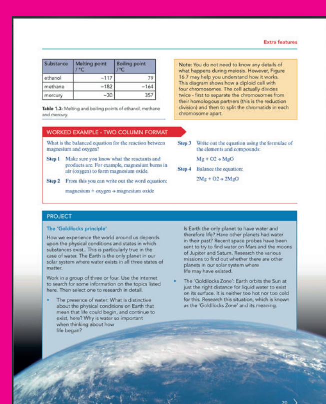
Explain how the lizard relies on photosynthesis to provide it with energy.

4 Explain one other reason (apart from food) why the lizard would not be able to survive if there were no plants on Earth.

Summary checklist

- [ ] I can how to write the word equation for photosynthesis
- [ ] I can how to explain why photosynthesis is important for all life on Earth

This image appears to be borrowed from the IGCSE Physics design sample, please change the Earth image to a different one and style in the same way as the screenshot from IGCSE. Would need to fade the background only and would be good to overlap summary box with the Earth part.



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1.2 More about photosynthesis

In this topic you will:

- find out where photosynthesis happens in plants
- learn why plants need magnesium and nitrate

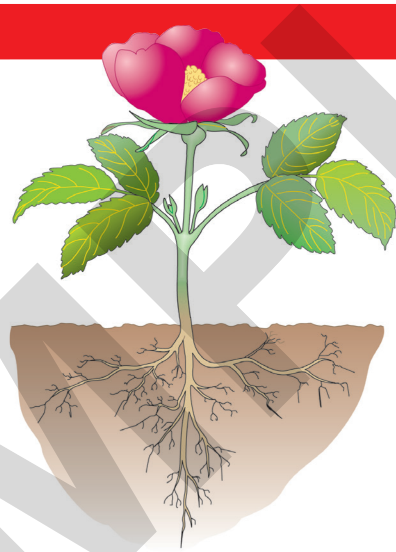
Getting started

Look at a complete plant – one that has stems, leaves, flowers and roots.

In which parts of the plants do you think photosynthesis happens?

Why do you think photosynthesis happens there?

Why do you think photosynthesis doesn't happen in other parts of the plant?



Key words

fertiliser

stomata (singular: stoma)

yield

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Chloroplasts and chlorophyll

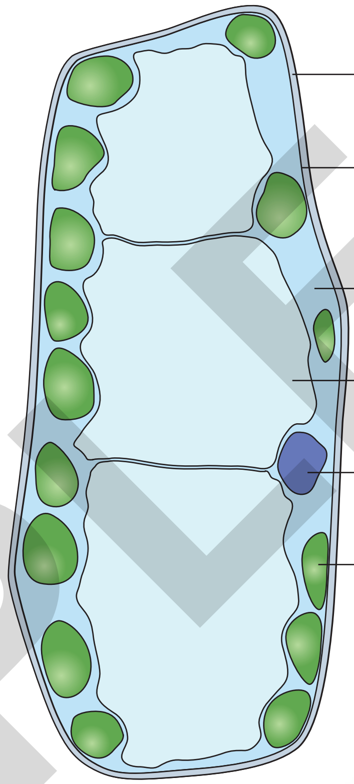
In the previous topic, you saw that chlorophyll is essential for photosynthesis. Chlorophyll captures energy from sunlight. The energy helps water and carbon dioxide to react together.

Chlorophyll is kept inside chloroplasts, inside plant cells.

This means that photosynthesis happens inside chloroplasts. Not all cells have chloroplasts, so not all plant cells can photosynthesise.

In most plants, the cells in the leaves have the most chloroplasts. Inside the cells in a leaf, carbon dioxide and water are made to react together, to produce carbohydrates and oxygen. We can think of the field of lettuces in the photograph as a giant carbohydrate factory.

On warm, sunny days, plants can make more carbohydrate than they need to use immediately. So they store some it for use later on – perhaps at night, or at a time of year when there is less sunlight. Plants store carbohydrates as starch. They store the starch inside the chloroplasts in their cells. One way to check whether a leaf has been photosynthesising is to test it for starch.



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Think like a scientist

Testing a leaf for starch

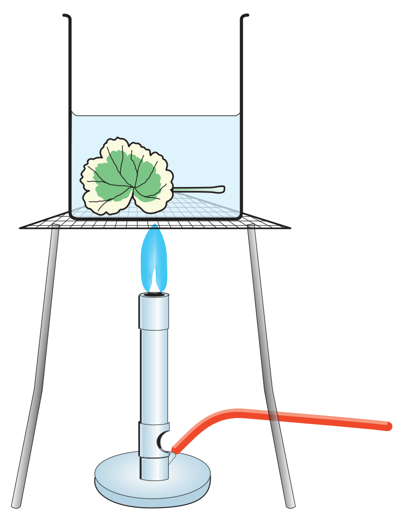
You are going to use a test you may already know – the iodine test for starch – to find out if a leaf has been photosynthesising.

You will need:

- a healthy plant that has been kept where it gets plenty of sunlight; if possible, use a plant whose leaves have some green parts and some white parts
- a burner (e.g. a Bunsen burner or a spirit burner)
- a tripod and gauze
- a medium sized beaker (e.g. 250 cm^3)
- a large test tube that can be safely heated
- some ethanol
- tongs or another way of handling a hot test tube
- forceps (tweezers)
- some iodine solution, with a dropper

Safety

- You will be using hot water, so make sure you keep safe. It is best to stand up while you work, so that if something is spilled you can easily move away.
- Be very careful to turn off the flame before you use any ethanol. Ethanol is very flammable (it catches light easily).



Method

1. Put some water into your beaker. Stand the beaker on the tripod and gauze and heat it until it starts to boil.
2. Take a healthy leaf from the plant. Carefully drop it into the boiling water.
3. After about two minutes, turn off the burner. This is really important, because you will use ethanol in the next step.
4. Collect some ethanol in the large test tube.
5. Use forceps to remove the leaf from the hot water. Carefully drop the leaf into the ethanol in the test tube.

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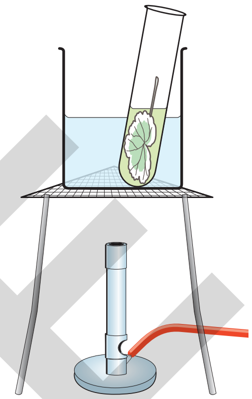
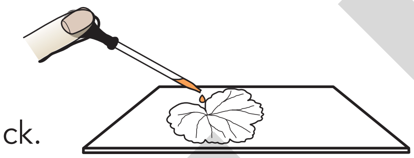
6 Stand the test tube in the hot water. This will safely heat up the ethanol. Watch what happens. You should see the green colour dissolve out of the leaf into the ethanol.



7 When you think most of the green colour has come out of the leaf, use forceps to gently take the leaf out of the tube. Be very careful – the leaf will be brittle. Dip it into the warm water to soften it.

8 Spread the leaf out onto a tile. Use the dropper to spread iodine solution over the leaf. If the leaf contains any starch, it will go blue-black.



Questions

1 Iodine solution cannot get through cell membranes. Boiling the leaf breaks the cell membranes apart.

  a In which part of a cell is starch stored?

  b Explain why it was important to boil the leaf before the starch test could work.

2 Suggest why it is a good idea to remove the green colour from the leaf, before you add iodine solution to it.

3 Did the leaf contain starch? If so, explain where the starch came from.

4 If your leaf had some green parts and some white parts, which parts contained starch? Can you explain why?

Inside a leaf

Photosynthesis happens inside chloroplasts, which are inside some of the cells in a leaf.

The diagram opposite shows a magnified view of the inside of a leaf.

On the diagram, you can see that chloroplasts are mostly inside the cells in the middle layers of the leaf. Leaves are very thin, so it is easy for sunlight to reach these cells.

Chloroplasts also need plenty of water and carbon dioxide, because these are used in photosynthesis. Water is brought to the cells in the leaf along the veins. You can read more about this in Unit 4.

Carbon dioxide diffuses into the leaf from the air. If you look at the diagram, you can see that there are tiny holes in the leaf, which allow gases to diffuse in and out. These holes are called **stomata** (singular: **stoma**). The gases can easily diffuse through the air spaces between the cells inside the leaf.

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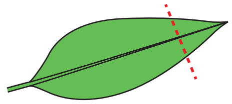
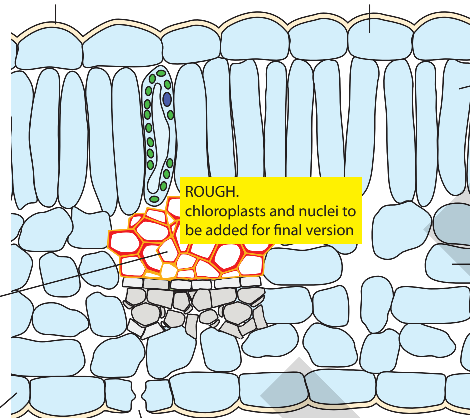
The diagram on the right shows what a leaf looks like if you cut it across, and then look at the cut edge.



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 1.2.1

Which surface of a leaf has most stomata?

Work with a partner for this activity.

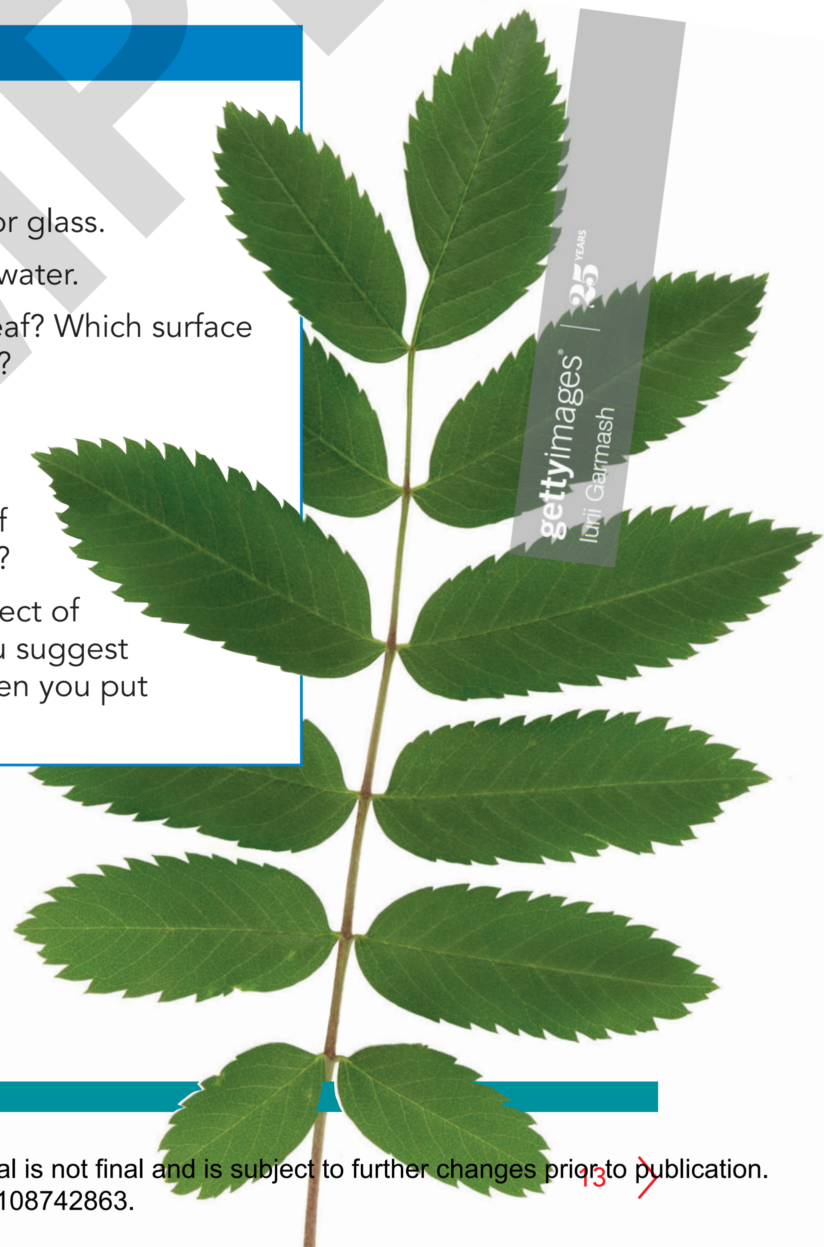
Put some warm (not hot) water into a beaker or glass.

Take a fresh leaf, and push it down under the water.

Can you see any bubbles coming out of the leaf? Which surface of the leaf do most of the bubbles come from?

Discuss these questions with your partner.

- What do you think the bubbles contain?
- If most bubbles came from one surface of the leaf, why do you think this happened?
- Think about what you know about the effect of increased temperature on gases. Can you suggest why the bubbles came out of the leaf when you put it into warm water?



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Questions

1 The cells inside a plant leaf use up carbon dioxide when they photosynthesise. Use what you have learnt about diffusion to explain how carbon dioxide diffuses into the leaf.

2 The cells inside a plant leaf produce oxygen when they photosynthesise. Suggest what happens to this oxygen.

Minerals and plant growth

The farmer in the picture is adding **fertiliser** to a field of wheat.

Farmers add fertiliser to their fields because it makes the crops grow larger and produce a higher yield. Yield is the quantity of crop that the farmer harvests.

Fertilisers contain minerals. Like the minerals that we need in our diet, plants need only quite small quantities of minerals. They get these minerals from the soil, through their roots. But sometimes the soil does not contain enough of certain minerals. This stops the plants growing to their full potential.

Two important minerals for plants are magnesium and nitrate.

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Magnesium is needed to make the green pigment, chlorophyll. If a plant does not have enough magnesium, its leaves look yellow instead of green. It cannot grow well, because it does not have much chlorophyll to absorb energy from sunlight, and so it cannot photosynthesise as much as it should.

Nitrate contains nitrogen atoms. These are needed so that the plant can convert carbohydrates to proteins. Proteins are essential for making new cells, so that the plant can grow well. Without enough nitrogen, leaves die and the plant stays small, like these maize (corn) plants. Nitrogen is also needed to make chlorophyll.

Farmers can test the soil in their fields to find out exactly which minerals are lacking in each part of the field. This tells the farmer where they need to add fertiliser, and where it is not needed.

Farmers who can afford the latest technology can use global positioning satellites (GPS) with their machinery.

The screen in the tractor cab shows the farmer exactly where he is in the field, as well as the results of the soil tests. The farmer can easily control how much fertiliser is added in each part of the field.

Questions

3 All organisms need protein, for growth. Compare the way in which plants obtain protein with the way that you and other animals obtain protein.

4 It can be difficult, even for an expert, to tell the difference between a plant that is short of magnesium, and one that is short of protein. Suggest why.

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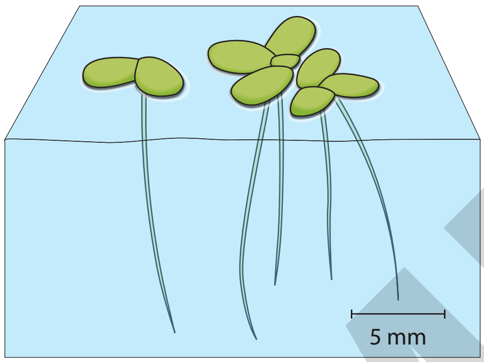
Think like a scientist

Planning an Investigation into the effect of fertilisers on plant growth

You are going to plan an experiment to find out how fertiliser affects the rate of growth of duckweed.

You may be able to do your experiment after you have planned it.

Duckweed is a tiny plant. There are lots of different species of duckweed, and they grow in most countries in the world. Some kinds of duckweed have just a single leaf, while others may have little groups of leaves. The leaves float on the water surface. All duckweed plants have roots that dangle down into the water.



- You could investigate effects of different kinds of fertiliser, or you could use just one kind and try different quantities of it.
- You could grow your duckweed in small containers – for example, Petri dishes.
- You could measure how much the duckweed grows by counting the number of leaves.

Part 1: Planning the investigation

1. Decide on a hypothesis that you will test.
2. How will you change your independent variable? How many different values will you use?
3. How will you measure your dependent variable? How many times will you measure it?
4. Which variables will you try to keep the same?
5. What equipment will you need?
6. What risks might there be in your experiment? How will you control the risks?
7. Predict the results you would expect to find and explain why you think this is what will happen.

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Continued

Part 2: Carrying out the investigation

Collect the equipment that you chose in your plan.

Make sure you have your step-by-step method to follow.

Questions

1 Scientists almost always find that they need to change something – even if it is only very small – when they carry out the experiment they have planned. Did you change anything in your plan? If so, explain what you changed, and why.

2 Write down a conclusion that you can make from your results. Do they support your hypothesis?

Summary checklist

- [ ] I can describe where photosynthesis happens
- [ ] I can explain why plants need magnesium and nitrate

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1.3 The carbon cycle

In this topic you will:

- find out how carbon atoms move between the air, living organisms and fossil fuels
- bring together what you know about respiration and photosynthesis, to think about how they affect the amount of carbon dioxide in the atmosphere

Getting started

Work with a partner.

Imagine one of you is a carbon atom. You are part of some carbon dioxide in the air.

Do you exist as an element, or are you part of a compound?

What happens to you when a plant uses you in photosynthesis? Do you change into something else, or are you still a carbon atom?

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Carbon and living organisms

Carbon is an element. The symbol for carbon is C.

Carbon is a non-metal. It occurs naturally in different forms. (You will find out more about carbon in Topic 2.4.)

Diamonds are made of carbon.

The 'lead' in a pencil is not lead at all - it is another form of the element carbon, called graphite.

Living organisms do not need diamonds or pencil leads, but they do need carbon. Organisms cannot use carbon in the form of an element. They can only use it when it is part of a compound.

Carbon is part of many different compounds that make up cells. Carbohydrates, proteins and fats are all compounds that contain carbon.

We rely on plants to make these substances. Plants take carbon dioxide from the air and use it in photosynthesis to make carbohydrates. Carbon dioxide is a compound that contains carbon atoms combined with oxygen atoms. (You will find out more about this in Unit 2.) The carbohydrates in plants contain carbon atoms that were originally part of the air.

Plants use the carbohydrates to make proteins and fats. All of these nutrients are compounds that contain carbon atoms.

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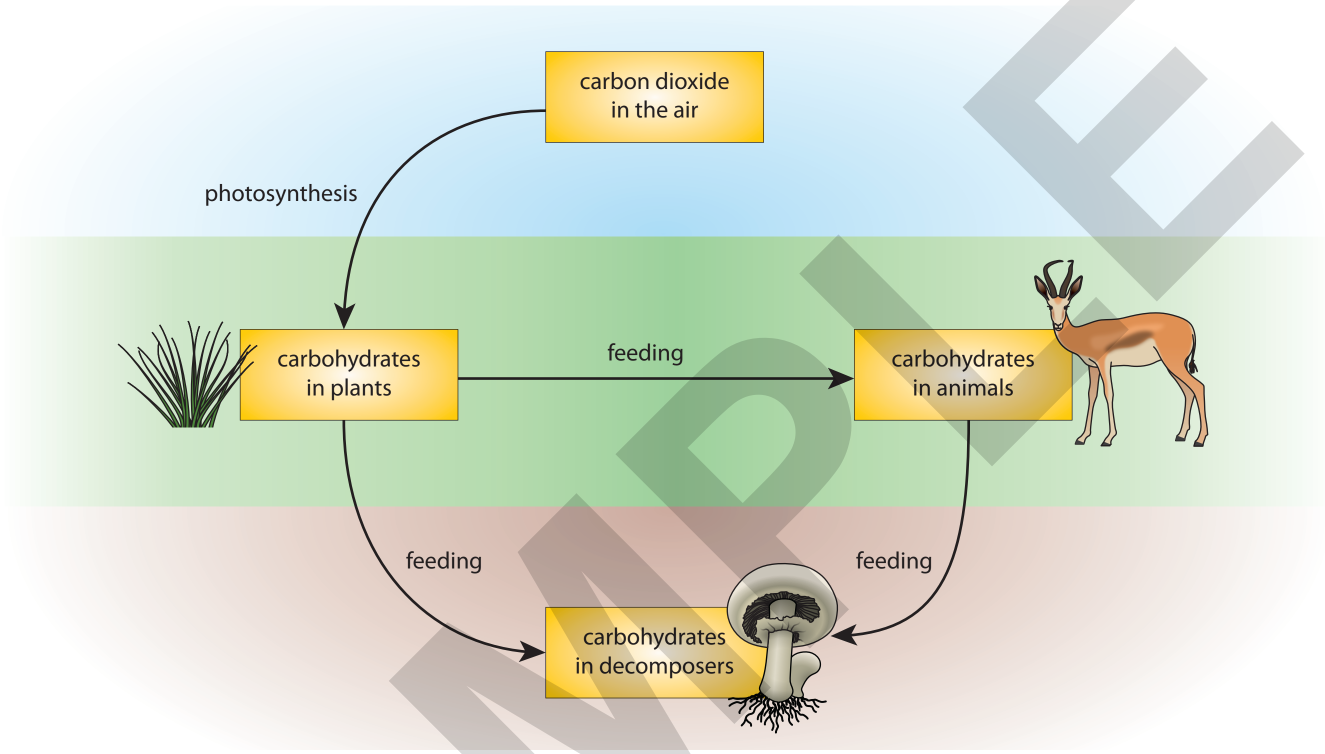
We are animals, so we get all of these carbon-containing nutrients when we eat plants or other animals. Decomposers get their carbon when they break down waste products from plants and animals.

We can show how carbon gets into the bodies of animals and decomposers using a flow diagram.



Questions

1 **a** Draw a food chain with one plant and three animals in it.

b The arrows in your food chain represent energy passing from one organism to the next. Do they also show how carbon atoms pass from one organism to the next? Explain your answer.

2 The human body contains atoms of many different elements. Carbon is one of the most common elements. Name three different compounds in your body that contain carbon atoms.

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Returning carbon dioxide to the air

A lot of the carbon dioxide that plants take from the air eventually goes back into the air again. This happens when plants and animal respire. You may remember the respiration equation:

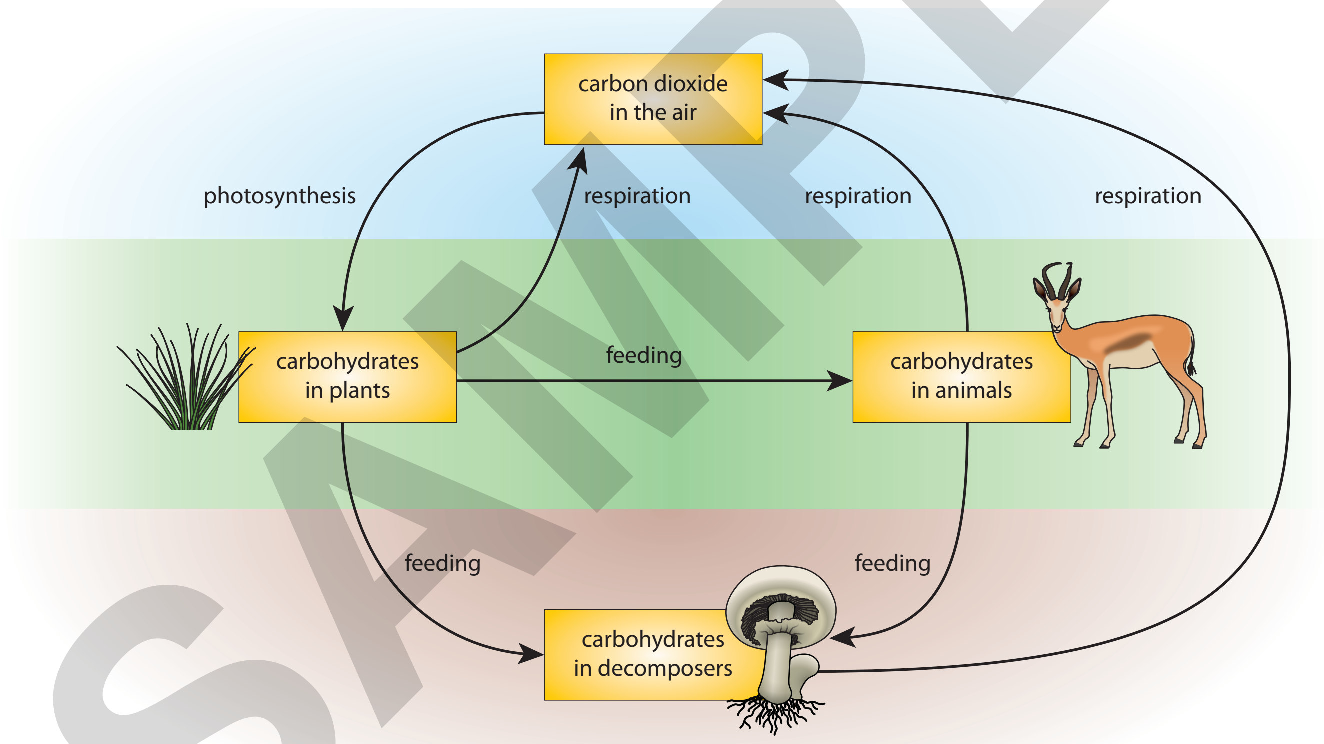
glucose + oxygen → carbon dioxide + water

When you breathe out, carbon dioxide that was produced in your cells, by respiration, goes into the air around you.

All organisms respire. Plants respire all the time. At night, when they cannot photosynthesise, they give out carbon dioxide, just as we do.

Decomposers respire, too. As they break down waste products from plants and animals, they release carbon dioxide into the air.

We can add this information to the flow diagram.



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Think like a scientist

How do plants and animals affect carbon dioxide concentration?

In this investigation, you are going to think about two processes that you have learnt about – respiration and photosynthesis – and how they affect the concentration of carbon dioxide.

You will need:

- six clean test tubes, and a beaker or rack to stand them in
- rubber bungs to fit the tubes
- small pieces of perforated metal (e.g. zinc gauze), to make platforms inside the tubes (see the diagram)
- some small pieces of water plant
- some small animals, such as maggots (fly larvae) or woodlice
- blunt forceps (tweezers) for handling the plants and small animals
- some black paper and sticky tape
- some hydrogencarbonate indicator solution

Hydrogencarbonate indicator solution is a liquid that changes colour depending on the concentration of carbon dioxide. The colours are:

- purple when there is no carbon dioxide
- red when there is a low concentration of carbon dioxide
- yellow when there is a higher concentration of carbon dioxide

Safety

The animals did not volunteer to be part of your experiment. Treat them with care. After the experiment is finished, put the animals back into their container, or a safe place outside.

Method

1. Label the tubes A, B, C, D, E and F.
2. Use the pieces of perforated metal to make small platforms that can fit inside the tubes. The platforms will stop the animals from falling into the liquid.
3. Take the platforms out of the tubes. Pour about 3 cm depth of hydrogencarbonate indicator into each tube.
4. Put a piece of water plant into the indicator in tubes A, B, E and F.
5. Put the platforms back into the tubes. Try to make them level, with each one at approximately the same position in each tube.

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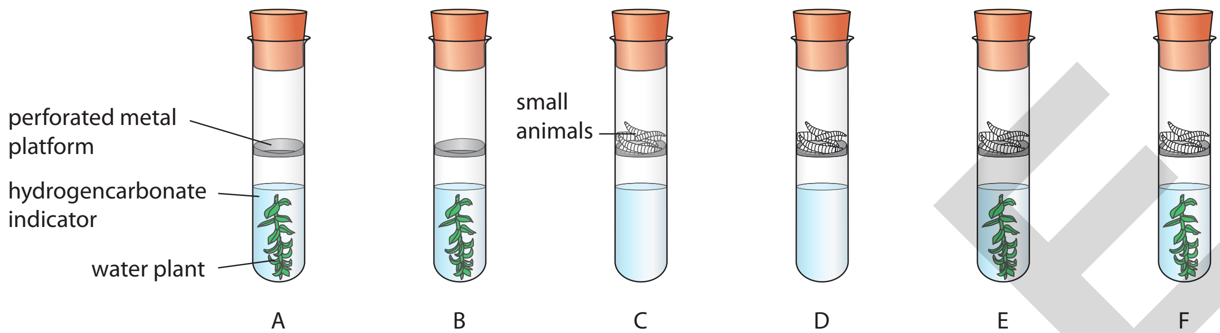
6 Carefully place animals on the platforms in tubes C, D, E and F.



Tube A: water plant ______

Tube B: water plant ______

Tube C: maggots ______

Tube D: maggots ______

Tube E: water plant and maggots ______

Tube F: water plant and maggots ______

7 Record the colour of the hydrogencarbonate indicator in each tube.

8 Now wrap black paper around tubes A, C and E, so that no light can get in.

9 Leave all the tubes in the same place for at least 30 minutes. (It is even better if you can set your experiment up in the morning, and then check it in the afternoon.) While you are waiting:

- write down your prediction of the results you expect to find.
- draw a results chart, ready to fill in.

10 Return to your tubes and take off the black paper. Record the colour of the indicator in each tube.

Questions

1 Use the colours of the indicator to record how much carbon dioxide is present in each of the six tubes.

2 All organisms respire all the time. In which tubes were organisms respiring?

3 Plants also photosynthesise when they have light. In which tubes were plants photosynthesising?

4 In the light, plants photosynthesise faster than they respire.

a In which tubes would you expect carbon dioxide to be used up?

b In which tubes would you expect carbon dioxide to be given out?

5 Use your answers to the questions above to explain your results. (If your results do not match what you expect, try to suggest why they do not.)

6 Suggest why you were asked to put a little platform into each tube, even if there were no animals to put onto it.

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Self assessment

The instructions for this experiment are quite long.

How carefully did you follow the instructions?

How fully do you feel you understand why the indicator changed to different colours in the different tubes?

Fossil fuels and combustion

There is one more very important set of processes to add to the diagram showing how carbon moves from the air, through organisms, and back to the air again.

When organisms die, they are not always broken down quickly by decomposers. Sometimes, their bodies fall into places where there is no oxygen, such as a peat bog, or deep in the ocean. In these places, the decomposers cannot respire, because there is not enough oxygen for them. Instead, the organisms' bodies get gradually buried, as more and more sediment builds up on top of them. High pressure and heat change their remains into fossil fuels, including coal, oil or natural gas.

Changing dead organisms to fossil fuels takes a very long time. Most of the fossil fuels that we use on Earth today were formed hundreds of millions of years ago.

Oil and natural gas formed when tiny marine organisms died and fell to the sea bed. This oil rig, in the sea off West Africa, has pipes that go deep into the sea bed where deposits of liquid oil are present. The oil is brought up through the pipes, and taken ashore to be used as fuel.

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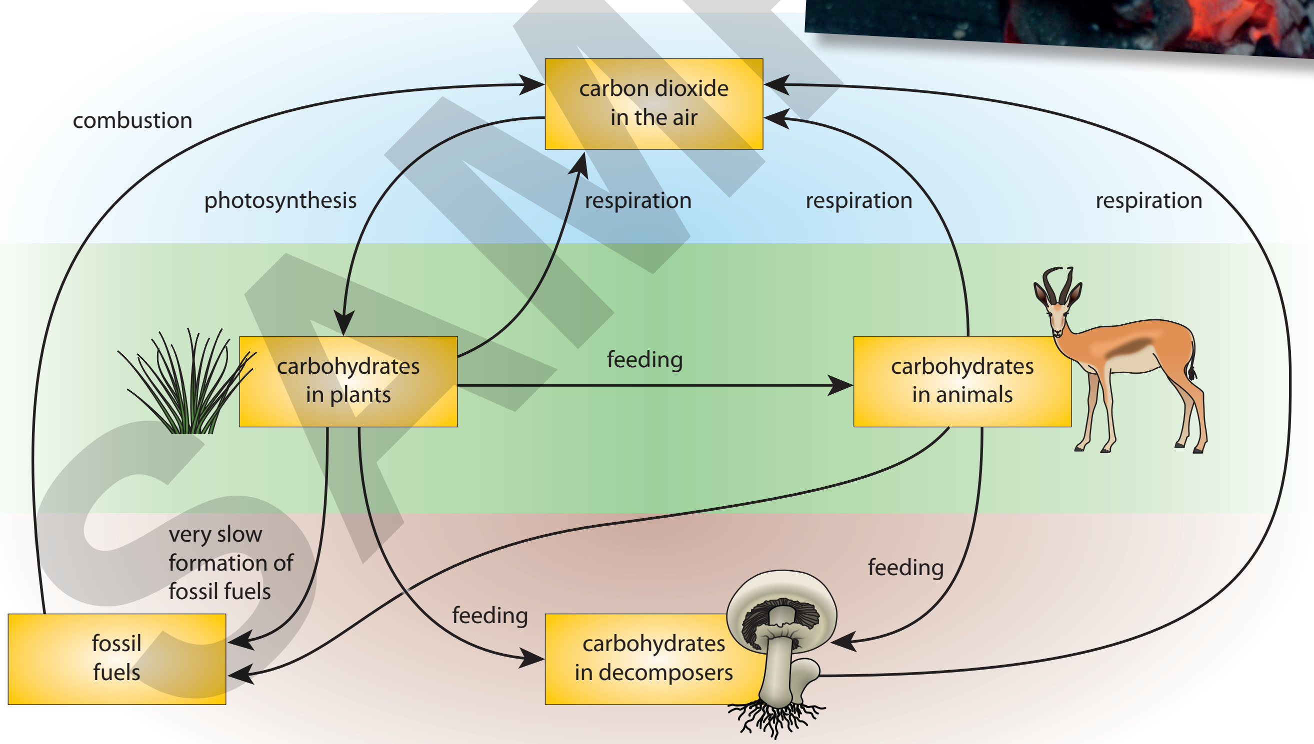
Coal was formed from the remains of plants that grew in huge swamps. Their remains were buried over millions of years, slowly turning into coal. Coal is dug out of the ground and then used as a fuel for cooking or heating homes, but most of it is used in power stations to generate electricity.

Fossil fuels contain carbon. This came from the carbohydrates, fats and proteins in the dead organisms. When we burn a fossil fuel, the carbon in it combines with oxygen from the air and forms carbon dioxide. This is called combustion.

We can add the formation and combustion of fossil fuels to the flow diagram. The completed diagram is called the **carbon cycle**.



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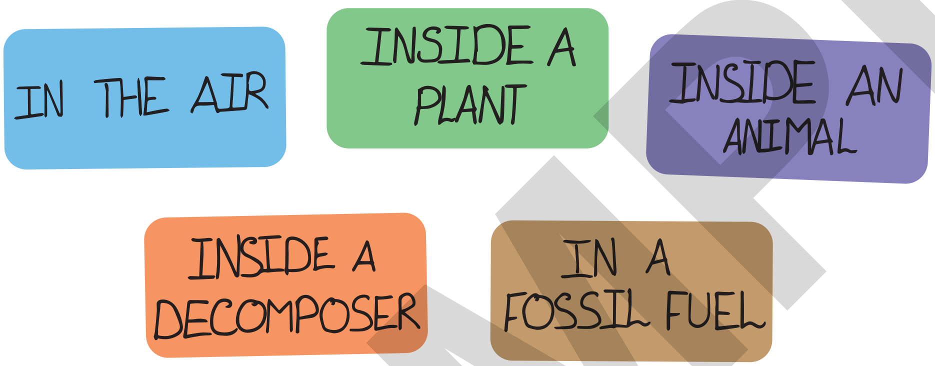
It's important to remember that fossil fuels are not the same as fossils. A fossil is the remains of an organism, or traces of it (such as its burrows) that have turned to rock. We can still see the shape of the organism in a fossil. But fossil fuels do not look like organisms at all, and oil and gas are not even rocks. Fossil fuels are given this name because – like fossils – they were formed a very long time ago and buried underground.

Activity 1.3.1

Modelling the carbon cycle

In this activity, you will play the part of a carbon atom in the carbon cycle.

First, make some big labels and stick them in five different places in the room. You only need one set of labels for the whole class.



Now write the following numbers and what they mean on the board, where everyone will be able to see them from every part of the room:

1 photosynthesis
2 respiration
3 feeding
4 formation of fossil fuels
5 decomposition
6 combustion

Divide everyone except one person (who could be your teacher) between the five places. Each person is a carbon atom.

The one person who is not a carbon atom now holds a die. They roll it, and call out the number. All the carbon atoms who are affected by the process linked to this number, move to

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the correct place. For example, if the number is 1, then all the carbon atoms in the air move into a green plant, as a result of photosynthesis. If the number is 3, then all the carbon atoms in a green plant move into an animal.

You can keep a record of how many carbon atoms are in each place, after each roll of the die.

Questions

1 In this model, all the carbon atoms in one place move to another place at the same time. Is that what happens in the real carbon cycle? If not, how could you modify your model to make it a better representation? If you can, try out your suggestion on your model.

2 Predict what would happen to the carbon atoms if one of the processes stopped completely – for example, combustion. If you can, try it out on your model.

The carbon cycle is a complicated diagram.
What can you do to help you to remember it?

Questions

3 If you drew a carbon cycle to show what was happening before humans were present on Earth, how would it differ from the carbon cycle diagram above?

4 Explain why fossil fuels are non-renewable resources.

Summary checklist

- [ ] I can describe the carbon cycle, including photosynthesis, respiration, feeding, decomposition and combustion
- [ ] I can explain how these processes affect the concentration of carbon dioxide in the air

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1.4 Climate change

need topic opener image
TS - please advise which image to use

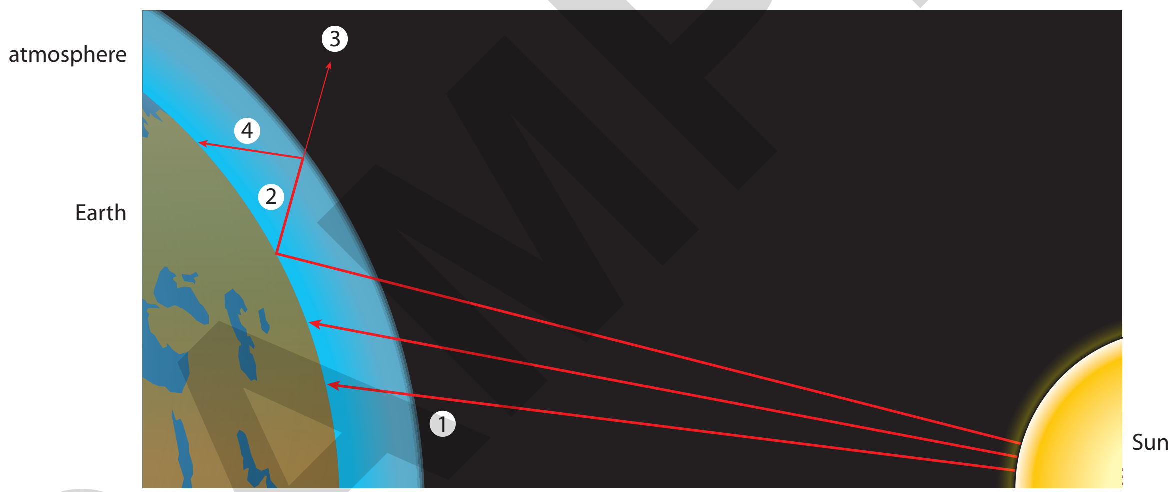
In this topic you will:

- find out how the Earth's climate has changed in the past
- learn what happened when an asteroid collided with Earth
- consider how the increase in carbon dioxide in the atmosphere affects climate today and also in the future

Getting started

In Stage 8, you learnt how carbon dioxide concentration in the atmosphere has been steadily increasing. Carbon dioxide is a greenhouse gas, which traps heat energy in the atmosphere and keeps the Earth warm.

Look at this diagram. It is similar, but not identical, to one that you may remember.



With a partner, match each of these statements to one of the numbers on the diagram.

A Some of the reflected energy passes back out through the atmosphere and is lost to space.

B Energy from the Sun passes through the atmosphere and warms the surface of the ground.

C Some of the reflected energy is blocked by carbon dioxide in the atmosphere, so it stays close to the Earth.

D Some of the energy that reaches the ground is reflected.

Key words

slush mass extinction meteorites meteoroids meteors

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Greenhouse gases

Carbon dioxide and methane are 'greenhouse gases'. In stage 8, you learnt how carbon dioxide helps to keep the Earth warm. Without any carbon dioxide in the atmosphere at all, the Earth would be a frozen place, unable to support life. But at the moment, we have too much carbon dioxide in the atmosphere.

Look back at the carbon cycle diagram in Topic 1.3. You can see that some carbon from the atmosphere ends up in fossil fuels. It takes a long time to form fossil fuels, and they can then stay buried in the ground for millions of years. But if we extract them and burn them, we release the carbon in them back into the air, in the form of carbon dioxide.

Carbon dioxide levels in the atmosphere are increasing. This is affecting the climate on Earth.

Climate change in the past

Climate is the long-term pattern of temperatures, wind and rainfall on Earth. The Earth's climate has been very different in the past compared to the climate today. Here are some examples of changes that we know about.

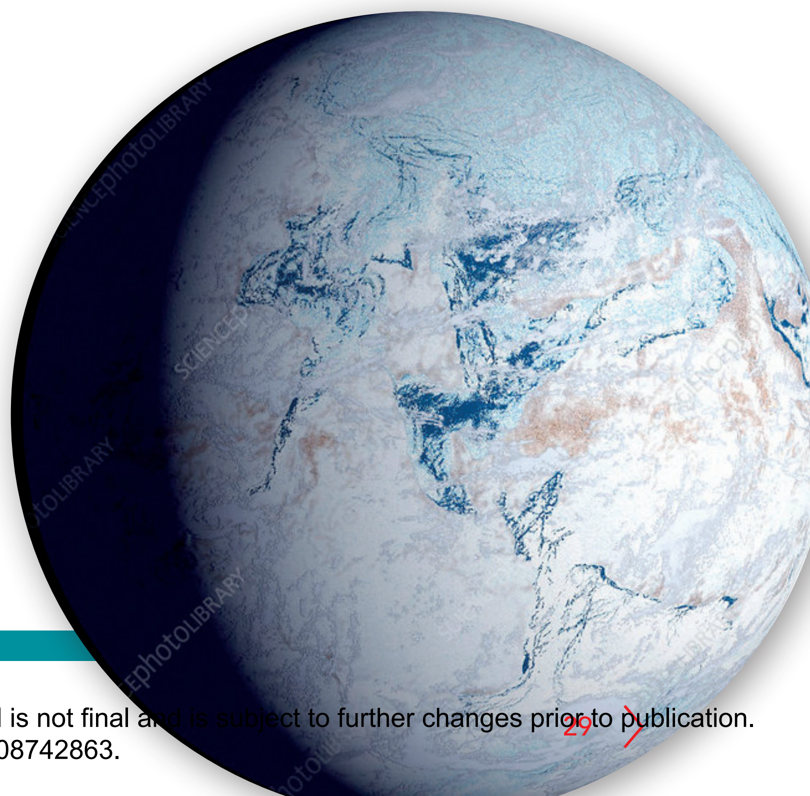
Ice ages

About 2 billion years ago, the Earth experienced the first ice age that we know about. Since then, the Earth has cycled between relatively warm periods and relatively cold ones. In the warm periods, there was no ice at all, even at the poles. In the colder periods, called ice ages, there was ice at the poles.

Snowball Earth

On at least one occasion, perhaps about 650 million years ago, the whole Earth was covered with ice and snow. Scientists call this 'snowball Earth', or sometimes 'slushball Earth', because they are not sure whether everything was completely frozen. (**Slush** is melting ice.) Scientists still do not completely understand what caused this to happen.

This is what the Earth may have looked like, 650 million years ago. At that time, the continents were not in the same positions as now.



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Asteroids colliding with each other

470 million years ago, scientists think that two asteroids collided with one another when they were in space, somewhere in-between Earth and Mars.

The collision produced huge quantities of dust. The dust reduced the amount of light and heat from the Sun reaching the Earth's surface. This triggered an ice age. The Earth became much colder – the ice caps spread much further from the poles and sea level fell.

Asteroids colliding with Earth

67 million years ago, an asteroid collided with Earth. Researchers have identified an area on the coast of Mexico where the asteroid impact took place. There was huge devastation close to where the asteroid fell. It would have been like a massive bomb exploding, with shock waves and very high temperatures spreading out from the crater.

But the collision affected the whole planet, not just the surrounding area, because it threw huge quantities of rock and dust into the air. It would also have created a massive tsunami (a huge sea wave), which could have spread across all of the Earth's oceans.

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The dust in the air meant that less light reached the Earth's surface. Plants could not photosynthesise, so animals had less food. As well as the disruption to food chains, the Earth became much colder, because less heat from the Sun could reach the surface.

Most scientists think that these changes in climate, caused by the asteroid impact, explain why dinosaurs became extinct around this time. Not only the dinosaurs, but also many other species on Earth, were destroyed as a result of the climate change following the asteroid collision. The asteroid caused a **mass extinction**. Up to 75% of all the species on Earth that were alive at that time are thought to have become extinct because of the asteroid collision.

There are about 175 known asteroid impact craters around the world. The crater shown in the picture is in the USA. The crater is more than 1 km wide and 170 m deep. It is estimated that the asteroid collision that formed this crater happened 50 000 years ago.

Could other objects collide with Earth?

Objects in space that are smaller than an asteroid are called **meteoroids**. When meteoroids enter Earth's atmosphere they are called **meteors**. Some people call meteors shooting stars as they appear like stars moving very fast across the sky. They usually present little risk as they burn in the atmosphere due to heat from friction. Some large ones can create shockwaves; in 2013 a meteor exploded over Russia and shattered windows. The parts of meteoroids that do collide with Earth are called **meteorites**. Around 500 of these reach Earth's surface each year.

If an object is large enough, it can cause local damage, or even damage that affects the whole planet.

In 1998, scientists started making detailed observations of objects that could possibly cause damage to Earth. When assessing the possible risk to Earth, scientists look at:

- the mass or diameter of the asteroid
- the closest possible approach to Earth.

An asteroid passing further from Earth may be a greater risk than one passing closer if its mass is greater.

The picture shows as asteroid, called 2006 DP_{14}, that passed 2 400 000 km from Earth in 2014. This asteroid measures 200 m × 400 m so is considered a potential risk. An asteroid such as 2006 DP_{14} colliding with Earth would cause an explosion equivalent to about 20 million tonnes of explosives.

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Questions

1 You learnt about asteroids in Stage 8. Describe what an asteroid is, and where asteroids are found.

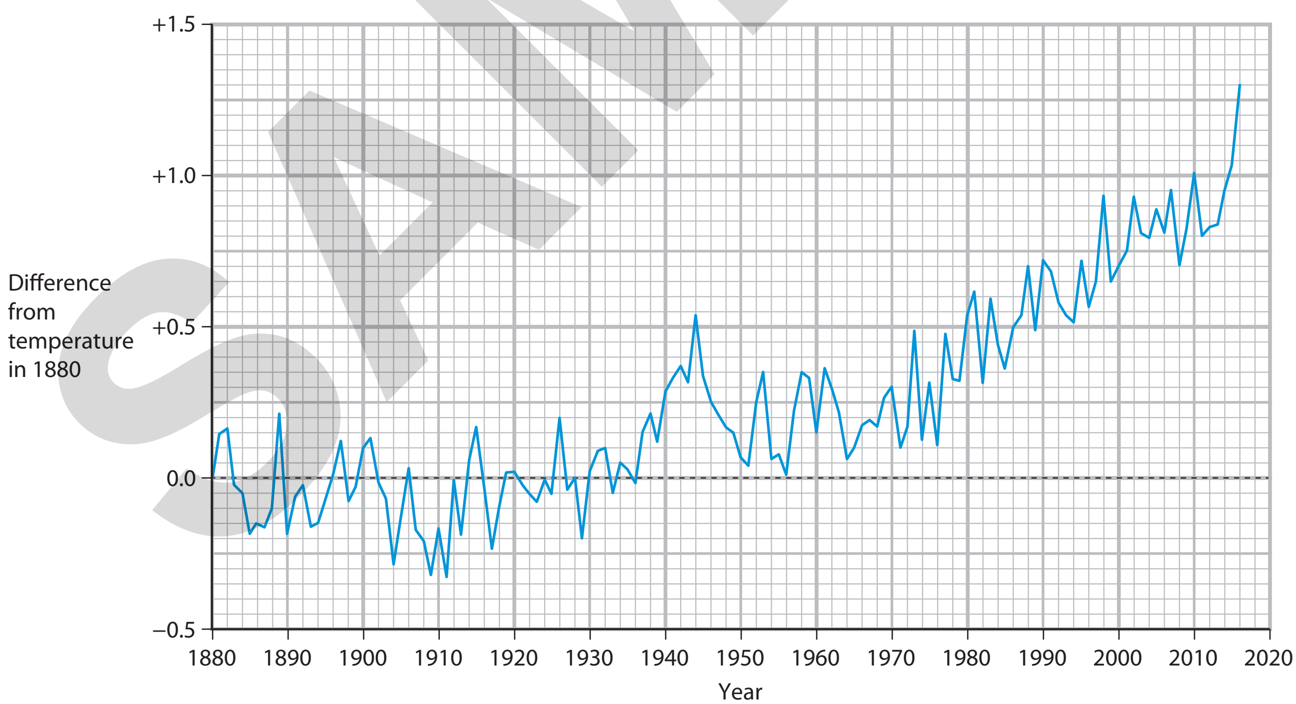
2 Outline **three** different ways in which the asteroid collision 67 million years ago would have made it difficult for plants and animals to survive.

Climate change today and in the future

For the last 2000 years or so, our climate has been fairly stable. People living in different places have become used to having more rain at some times of year than at other times, or temperatures that change in a predictable way during one year. Knowing this helps people to choose the best crops to grow, and to know when they should sow seed and collect the harvest.

Now, however, the mean temperatures on Earth are increasing. This is caused by an increase in carbon dioxide concentration in the atmosphere. Remember that carbon dioxide is a greenhouse gas, which traps heat energy close to the Earth's surface. When carbon dioxide concentrations increase, more heat is trapped.

The graph shows how the Earth's mean temperature changed between 1880 and 2016. Notice that the *y*-axis on the graph does not show the actual temperature – it shows how much it differs from the temperature in 1880.



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Questions

3 Look at the graph. How much higher was the mean temperature in 2016 than in 1880?

4 Describe the trend in the graph between:
- 1880 and 1910 and
- 1910 and 2016.

Impacts of climate change

More extreme weather events

We are already feeling the effects of this increase in temperature. The higher temperatures mean that there is more energy in the atmosphere. This increases the chance of extreme weather events, such as hurricanes and typhoons. Many scientists think that we are already seeing an increase in the number of storms, and in their severity. It is difficult to be certain, because there has always been a lot of variation each year in the number of big storms.

Tropical cyclone Idai hit the east coast of southern Africa in 2019. It was one of the worst storms ever to affect Africa and killed more than 1300 people. Severe flooding destroyed homes and fields, damaging people's livelihoods. Was this a result of climate change? We cannot say, because storms like this can happen anyway. However, there seem to be more of them now, and they are more violent.

Less predictable rainfall

The changing climate is also making it more difficult for people in some parts of the world to grow crops. Rains may come late, or might not come at all. Or rain may fall when it doesn't normally fall – or fall much more heavily, causing flooding.

Monsoon rains are usually welcomed, but not when they are so heavy that they cause severe flooding. In 2019, the monsoon rains in Pakistan, India, Nepal and Bangladesh came later and were heavier than usual. Millions of people in these countries were affected by floods.

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When rains fail, people may lose their harvests. Long droughts also increase the risk of wildfires. All of these changes affect not only people, but also plants and animals.

This wildfire in Australia followed a long period of drought.

Rising sea levels

The increase in the Earth's mean temperature affects sea level. Water expands as it is heated, so if the sea temperature increases, sea level rises. Melting ice caps and glaciers add extra water to the oceans.

This glacier is getting smaller (retreating) as temperatures increase. You can see that the ice used to reach much higher up the sides of the valley.

Sea level has been rising at a rate of about 3 mm per year. Scientists estimate that more than 600 million people are at risk from flooding caused by sea level rise by the end of this century. Many megacities are built on the coast – such as Shanghai, Mumbai and Los Angeles – and these are especially vulnerable to sea level rise.

Questions

5 Calculate by how much sea level is predicted to rise by the end of this century.

6 Explain why sea level is predicted to rise.

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Think like a scientist

How do rising temperatures affect sea level?

In this experiment, you will investigate how rising temperature can affect sea level.

Experiment 1

You will need:

two large measuring cylinders, a funnel big enough to hold 10 ice cubes, 20 ice cubes, all the same size

Method

1 Put 10 ice cubes into one of the measuring cylinders. Add water so that the cylinder is about three quarters full. Record this level.

2 Add water to the second measuring cylinder to exactly the same level as in the first one.

3 Place the funnel in the second measuring cylinder. Put 10 ice cubes into the funnel.

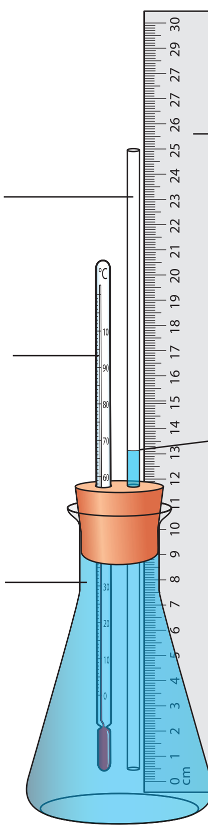
4 Leave both cylinders at room temperature, until the ice melts.

5 When the ice has melted, record the new levels in both measuring cylinders.

Experiment 2

You will need:

- the apparatus shown in the diagram – make sure that the water is really cold
- a lamp



Method

1 Read the temperature on the thermometer, and the level of the water in the glass tubing. Record them in a results chart.

2 Place a lamp close to the conical flask and switch it on. The lamp will gently warm the water in the flask.

3 Approximately every five minutes (the exact timing does not matter), record the temperature and the level of the water in the glass tubing. Keep going until you have at least 10 readings.

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Continued

Method

4 Draw a graph to display your results. Put temperature on the horizontal axis and height of water in the glass tube on the vertical axis. (Remember to include the units when you label the axes.)

Questions

1 Which of these changes increased the level of the 'ocean' in your experiment?
- melting ice in the sea
- melting ice on the land
- increasing water temperature

2 How do your results relate to what might happen to sea level as a result of climate change?

Activity 1.4.1

The carbon cycle and climate change

Work in a group of three or four.

Look at the complete diagram of the carbon cycle in Topic 1.3.

Which activities *increase* the quantity of carbon dioxide in the atmosphere?

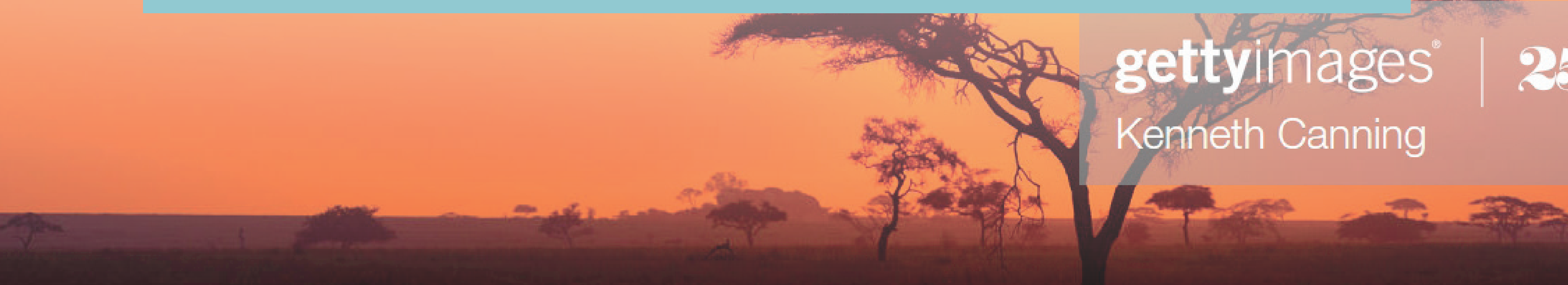
Which activities *decrease* the quantity of carbon dioxide in the atmosphere?

Use your answers to those two questions to suggest what we can do to help to slow down climate change. Write a list.

With the other groups in your class, build up a list of suggestions. For each one:
- explain why it would help
- explain why it might be difficult to make it happen.

Summary checklist

- [ ] I can some examples of how the Earth's climate has changed in the past
- [ ] I can how an asteroid collision is believed to have caused climate change and mass extinctions
- [ ] I can that scientists predict climate change will affect the Earth in future, including rising sea level, more flooding, more droughts and more extreme weather events



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Project: What happened to the dinosaurs?

You are going to work in a group to contribute to a display about the extinction of the dinosaurs.

Choose one or more of these issues to research. Try to make sure that each group researches a different issue.

Issues to research

- Who first came up with the idea that there was an asteroid impact that killed the dinosaurs? When did they put forward this theory, and what was their evidence?
- What do scientists think could have happened as a result of the asteroid impact? What is their evidence?
- Scientists think that other events may have contributed to the extinction of the dinosaurs. What are these events, and what is the evidence for them?
- How have the early theories changed over time? Why have they changed?
- Are dinosaurs really extinct? Some biologists think that a very familiar group of animals that live on Earth today are really dinosaurs. What are they, and why do biologists think this?

Doing your research

Use the internet to find information.

Before you begin, discuss in your group how will you choose the most trustworthy web sites.

Here are some possible search terms you could try:

- dinosaur extinction event
- asteroid in the Cretaceous
- Luis Walter Alvarez
- asteroid impact
- living dinosaurs

Making the display

Work with the rest of the class to decide how the display will be made. For example, each group could produce a poster containing the results of their research. The posters could be displayed on the wall together. Alternatively, you could work together to create a multimedia class presentation.

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Check your progress

1.1 Choose the correct word from the list to match each description. You can use each word once, more than once or not at all.

air carbon dioxide chlorophyll chloroplast
oxygen soil stomata veins

a This gas is used by plants in photosynthesis. [1]

b This gas is made by plants in photosynthesis. [1]

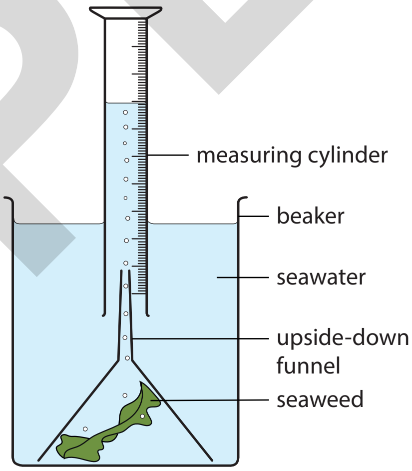
c Plants get their water for photosynthesis from here. [1]

d This green pigment absorbs energy from sunlight. [1]

e These tiny holes in a leaf allow gases to diffuse in and out. [1]

1.2 Marcus did an experiment to compare the rate of photosynthesis of two types of seaweed.

The diagram shows the apparatus he used.

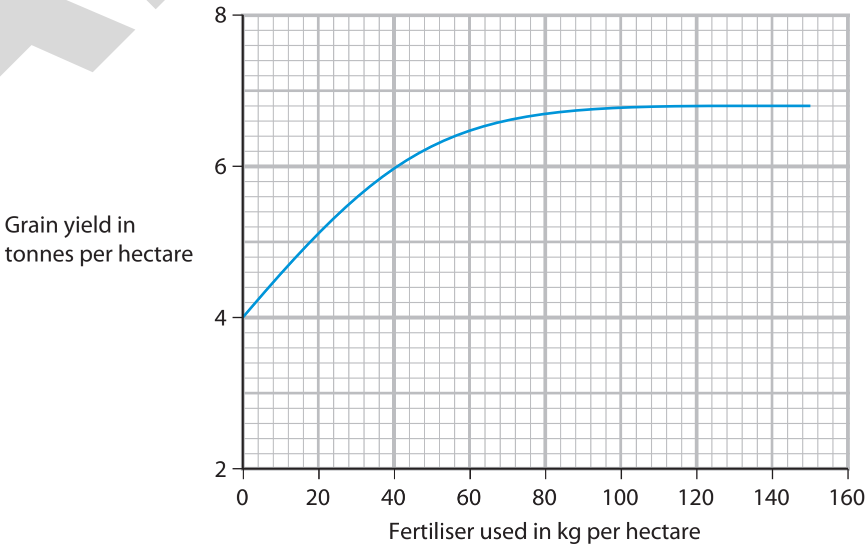


a What variable should Marcus change in his experiment? [1]

b List **three** variables that Marcus should keep the same. [3]

c What should Marcus measure during his experiment? [2]

1.3 A farmer carried out an experiment to find out how adding different amounts of nitrate-containing fertiliser affected the amount of grain that she harvested from her wheat crop. The graph shows the results.



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a What yield of grain did the farmer get if she did not add any fertiliser? **[1]**

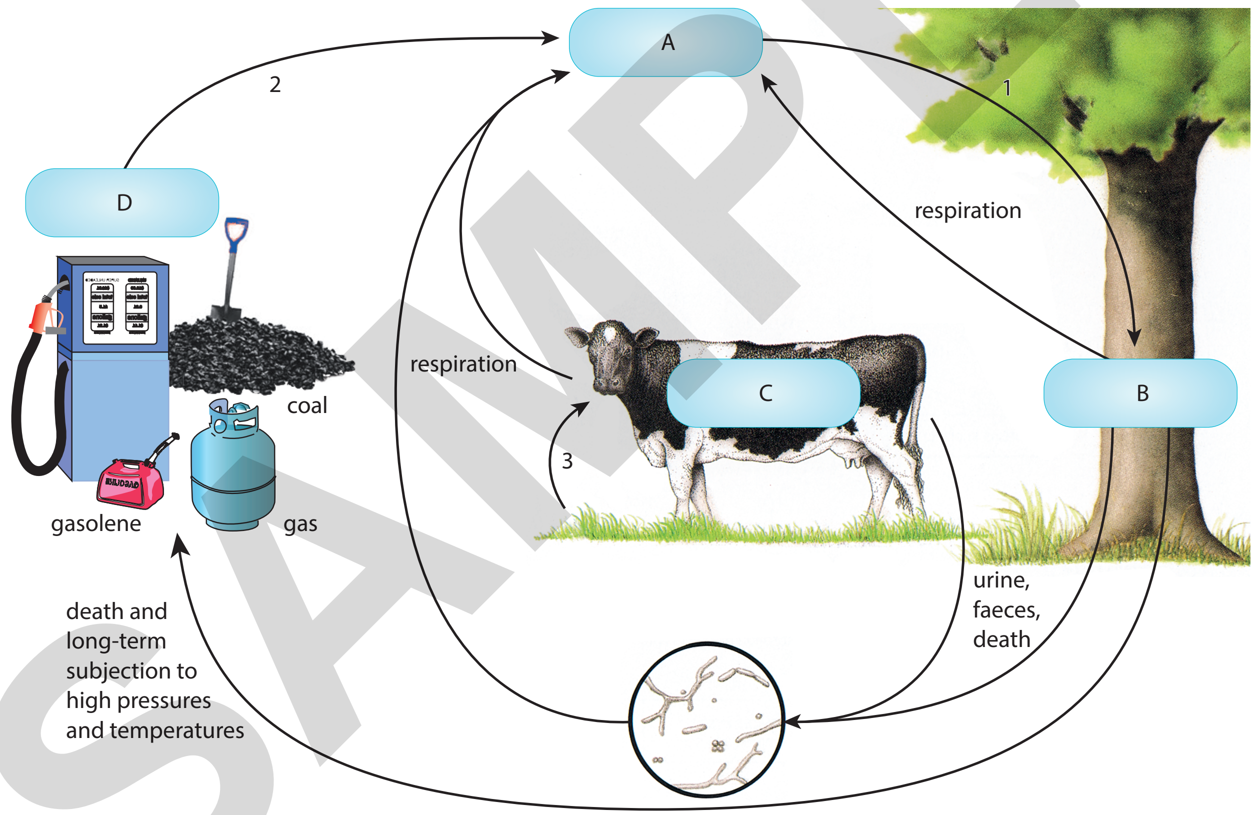
b The farmer decided that there was no need to add more than about 60 kg of fertiliser per hectare. Explain how the results of the experiment support her decision. (Remember that fertiliser is expensive.) **[2]**

c Explain why the yield of grain increases when nitrate-containing fertiliser is added. **[2]**

d Suggest why the results of this experiment might be different if it was repeated in a different place. **[2]**

e Name **one** mineral, other than nitrate, that plants need for healthy growth. Explain why they need this mineral. **[2]**

1.4 The diagram shows the carbon cycle.



a Match each of these labels to the correct **letter** on the diagram.

i carbon in fossil fuels

ii carbon compounds in plants

iii carbon dioxide in the air

iv carbon compounds in animals **[3]**

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