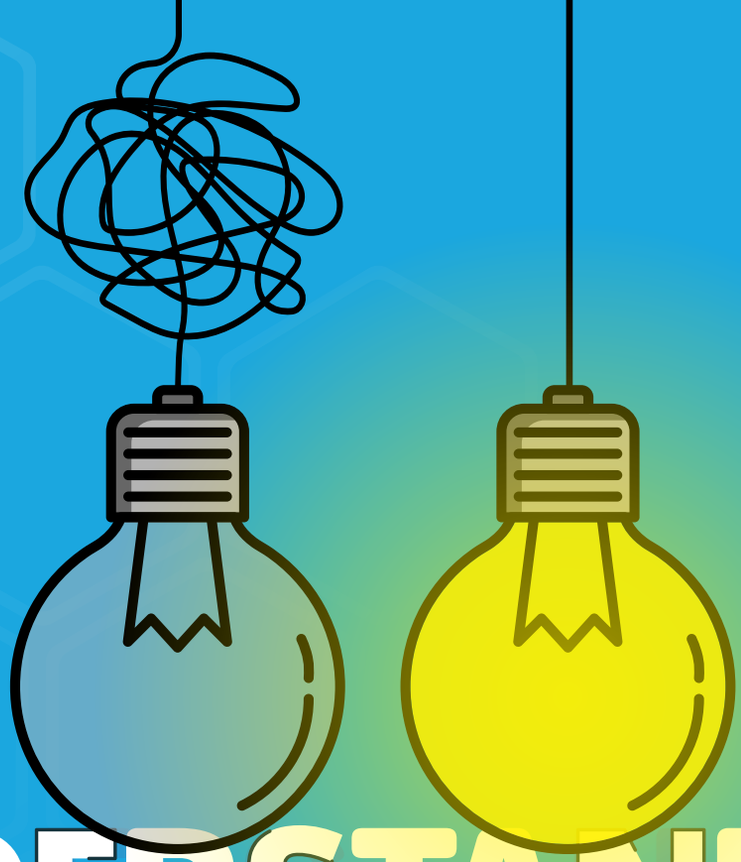


1 UNDERSTANDING SCIENCE

Master the Key Concepts

DR TONY SHERBORNE
and GEMMA YOUNG

Contents

MATTER

Chemical and physical

Acids & alkalis

ENERGY

Energy transfer

Wasted energy

Heat & temperature

ORGANISMS

Feeding relationships

Competition

Biotic & abiotic

ENERGY

Electric current

Resistance

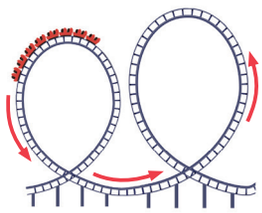
Answers are online: **masteryscience.com/pages/extras**

How can you improve your grades?

Riley learned the facts in his textbook. But he couldn't use his knowledge. When he saw unfamiliar questions in the test, he had no idea what they were about.

How can he improve?

Organise your knowledge



A rollercoaster designer looks at this design and knows it's impossible. Why is that?

Riley's teacher said that GCSEs are now testing real understanding, not memorisation. Examiners want to see students applying their knowledge. So they ask questions like this one – about real-life situations that students haven't seen before. We call these apply questions. The challenge for you is to work out which idea will solve the problem. It's called applying knowledge. This question is about the law of energy conservation (you can read about this on p107).

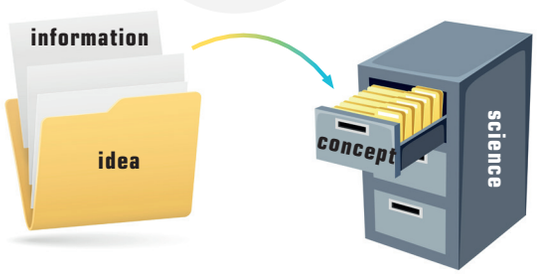
When you learn, you store new information in your memory. That's what knowledge is. But it turns out that not all knowledge is equally useful for solving problems.

Memorising facts leads to disorganised knowledge.

Riley's textbook presented science as a lot of separate details. He had little choice but to memorise all the information. Picture each item of information as a piece of paper. When Riley memorises the information, his memory ends up looking like a big pile of papers. This is called **disorganised knowledge**.

When he sees a question, he has to search through his knowledge to find the right information. But finding the right piece of paper in a big pile is difficult. That's why Riley couldn't solve apply questions: his knowledge is disorganised.

Organised knowledge



Understanding leads to organised knowledge.

Things would be different if Riley had a textbook like this one, which focusses on understanding. It helps you link the ideas together in your memory. This is called **organised knowledge.** Visualise organised knowledge as information stored in a filing cabinet. The information (paper) is organised into ideas (folders) with labels. And the ideas are organised into bigger concepts (drawers).

Now when you see a question, it's easy to find the right information. You just go to the right drawers and folder and pull out the right piece of paper. Organised knowledge is what you need to solve apply questions.

How understanding science works

How does this book give you organised knowledge?

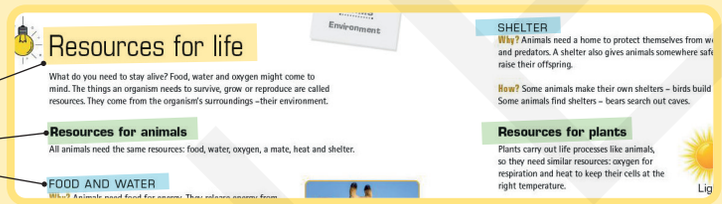
1. THE FIRST SPREAD IN EACH CHAPTER REVIEWS WHAT YOU KNOW

Your memory already contains information about science topics, from everyday life and primary school. The first job is to review and organise your existing knowledge. We call it 'activating knowledge'. This is what the first spread of most concepts is for.

2. EACH SPREAD IS ABOUT ONE IDEA

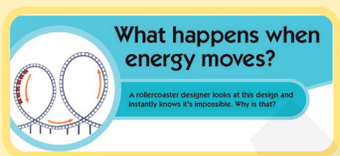
To help you connect information together (into folders):

- Each spread shows the main idea as a big heading.
- Linked ideas are broken down into small sections.

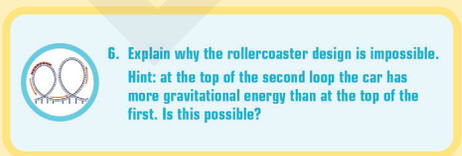


3. YOU GET PRACTICE AT APPLYING IDEAS

The spread explains the science idea behind a puzzle.



The final review question helps you to solve it and practise applying the idea.



Active reading strategies

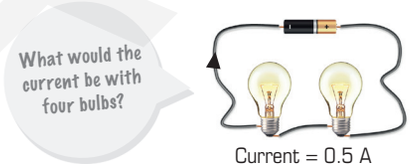
When you use a textbook, you're reading to learn. Here are some of the things good learners do before, during and after reading. They are called active reading strategies.

PREPARE YOUR MIND

The 'focus on' box describes what the main idea is all about so you can focus on the key information.

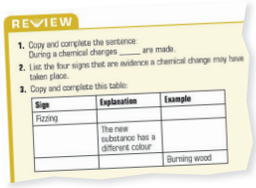
CHECK YOUR UNDERSTANDING

The questions in the margins are there to check your understanding. If you can't answer, try re-reading the text.



PROCESS THE INFORMATION

Each review question helps you process the information: summarise it, put it into a list or order, draw or interpret a diagram, or use what you have learnt in a new situation.

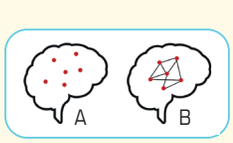


REVIEW

1. Which of these questions is an apply question?
   a) Name the force that keeps the Moon in orbit around the Sun.
   b) Which of these animals is a mammal: spider, shark, dog?
   c) Suggest why peach tree roots produce a poisonous substance.

2. Write these instructions in the correct order to show how to use active reading when reading a spread in this book.
   - Answer the review questions.
   - Think about what you already know.
   - Answer the questions in the margins.

3. These diagrams show two ways that information can be stored in your brain. Each dot shows one piece of information. Which shows organised knowledge? Explain your answer.



4. Describe the difference between disorganised and organised knowledge.

5. Explain why having organised knowledge will help you answer apply questions.

6. **Explain why answering these questions has helped you to remember the information on this page.**

What is alive?

"I'm Sophia. Some humans say that I'm not alive. But I can recognise people, have a conversation, and even draw you."

Can a robot like Sophia be alive?

TERMS

Organism

Life processes

There is actually no simple definition of life. But scientists think there is a set of jobs that all living things, or **organisms**, carry out. They are called **life processes**. Their names are easy to remember - they spell MRS GREN.

FOCUS ON

what processes all living organisms carry out.

Movement

Moving isn't just for animals. Plants do it too. This lily opens its petals in the daytime and closes them again at night.

Respiration

Everything you do requires energy. Your energy comes from food but your body has to break down the food to release energy. This is called respiration.

What's another example of sensitivity?

Sensitivity

A deer runs when it hears a loud noise. Organisms are always on the look out for threats, food or mates. Sensing what is going on around you, then taking action, is called sensitivity.

Growth

Animals start their lives small and then grow until they're adults. Plants can keep growing all their lives.

Reproduction

Humans usually have just one baby at a time, while insects can lay thousands of eggs in one go. All organisms need to replace themselves, or reproduce, otherwise there would soon be none left.

Excretion

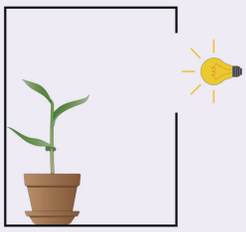
Excreting means getting rid of waste. Organisms produce unwanted products when they break down food. Many animals excrete carbon dioxide in their breath and other waste in urine.

Nutrition

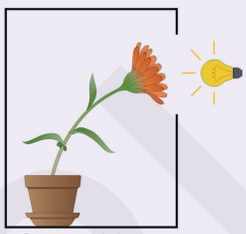
Nutrition means taking in food and using it for other life processes. Carbohydrate, fat and protein are nutrients for humans. Plants can make their own nutrients.

Question

A scientist put a young plant in a box with a light shining into it and left it for one month to see what would happen.
What life processes did she find evidence for when she returned?



▲ At start



▲ One month later

Answer

Movement	✓	The plant bent towards the light
Respiration	?	–
Sensitivity	✓	It sensed light and grew towards it
Growth	✓	It grew in size
Reproduction	✓	The flower contained seeds
Excretion	?	–
Nutrition	?	–

There was evidence for four life processes.

Why are seeds evidence for reproduction?

WRONG!

Seeds are not alive.

RIGHT!

Seeds are alive. They may not be doing much now but give them water and warmth and they will grow.

Grouping organisms

Organisms perform all the life processes – but they do them in different ways. Animals eat food, plants make their own and fungi break down other organisms for their nutrition. Scientists arrange organisms into groups based on how they carry out life processes.

ANIMALS

Eat food

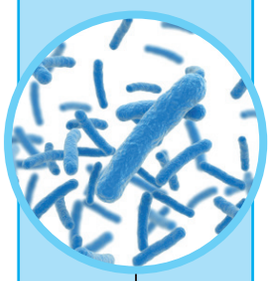
PLANTS

Make food

FUNGI

Break down dead organisms to get food

BACTERIA

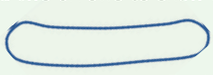


Absorb food

What group do mushrooms belong to?

REVIEW

1. Copy and complete: All living organisms carry out seven life processes. These are M_____, R_____, S_____, G_____, R_____, E_____, and N_____.
2. Write a sentence to describe what each life process means.
3. Copy this diagram of a bacteria. Add two arrows to show the direction of the food and waste.



Waste Food

4. If an organism stops carrying out respiration it dies. Explain why.
5. In the question and answer box, the scientist saw only four life processes. Does that mean the plant is not alive? Give a reason.

6. **Can a robot like Sophia be alive? Give reasons for your opinion.**

What are you made of?

0.7 mm

This is what you looked like when your life began. You started out as a tiny structure called a cell.

How did that cell become you?

TERMS

- Microscope
- Cell theory
- Single-celled
- Multicellular

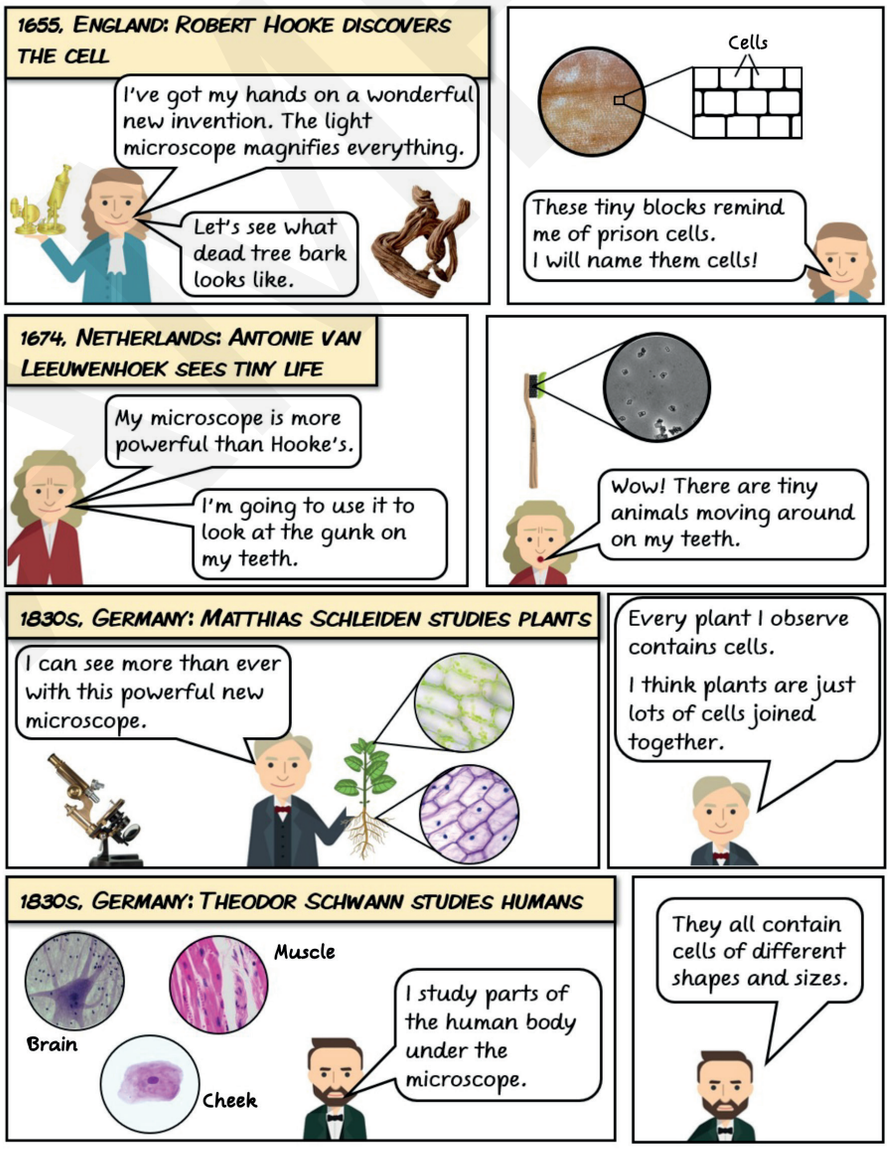
FOCUS ON

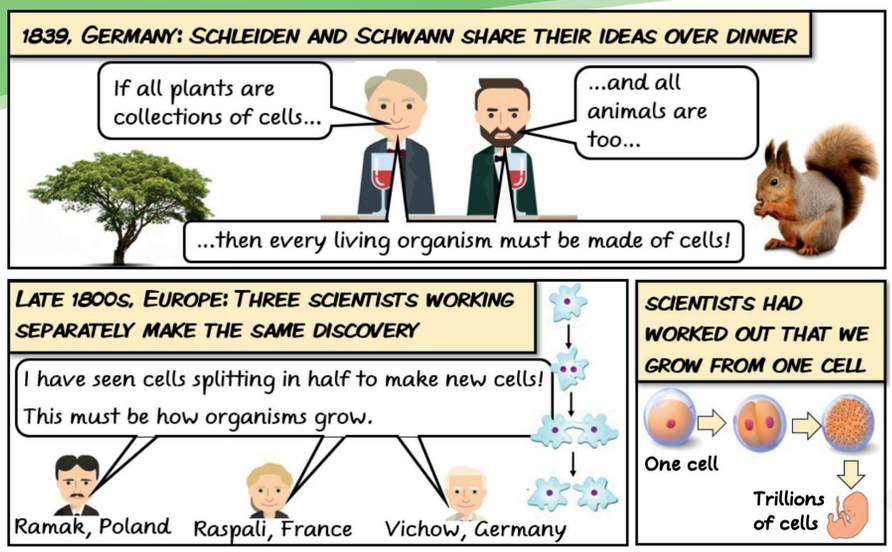
what each scientist did and what they found out.

What does a microscope do?

Cells make organisms

You may have seen cells under a microscope. But working out how cells relate to life was a hard puzzle to solve. It took scientists 200 years. Let's find out how they did it.





Why is it important scientists talk to each other?

The theory of cells

Here's what the scientists worked out:

1. All living things contain cells.
2. Cells split in half to make new cells.

These ideas about cells are called **cell theory**.

WRONG!
Bones don't contain cells.

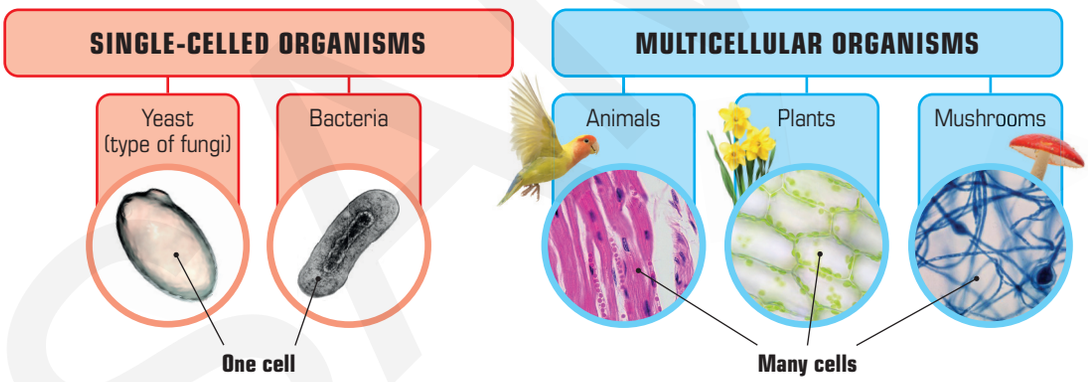
RIGHT!
All parts of your body are made up of cells – even bones.

Single-celled vs multicellular

Think of cells as building blocks, like LEGO® bricks. Bricks are small, but they can make a large structure if you connect lots of them together. Similarly, connecting trillions of cells together makes a large organism.

Some organisms are just one cell:

Others are made of many cells:



What type of organism are humans?

REVIEW

1. Describe what a cell is.
2. Why were microscopes important for discovering cells?
3. Copy and complete the table. Add a row for each scientist in the story. The first one has been done.

Scientist	What they did	What they discovered
Robert Hooke	Used a microscope to look at tree bark	Tree bark is made up of tiny compartments. Hooke called them cells.

4. A scientist uses a microscope to look at bacteria. Which diagram shows what they might see? Give a reason for your choice.

5. The text says that cells are like LEGO® bricks. List some ways cells are different from LEGO®.

6. **You started off life as a single cell. You are now made of trillions of cells joined together. Explain what happened for you to go from one cell to many.**

What's inside your cells?

Jo used to be a fast runner. But now she finds it an effort just to walk. Jo's doctor thinks her muscle cells are not working correctly.

Can you figure out where the problem is?

TERMS

- Cell membrane
- Cytoplasm
- Nucleus
- Ribosome
- Mitochondrion/ mitochondria

FOCUS ON

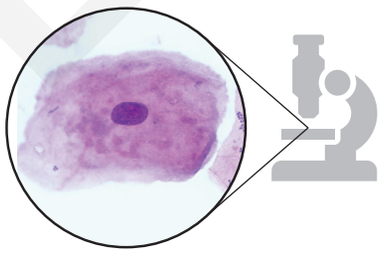
how each part of the cell helps it to carry out life processes.

Cell parts in animals

You may have seen a microscope image like this of a cell from your body. If you look closely, you might see that there are different parts visible inside it. The drawing below shows the parts more clearly.

Why do animal cells have parts like these? The different parts of the cell are needed to keep the cell alive. They carry out life processes, like removing waste, helping the cell grow, and supplying energy.

Look at the opposite page for a description of each part.



▲ Microscope image of an animal cell

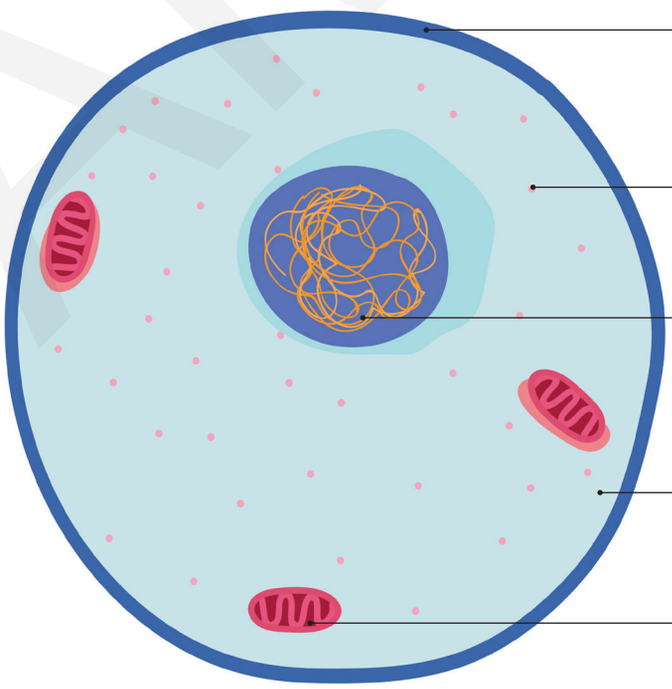
WRONG!

Cells are flat like the simplified picture.

RIGHT!

Real cells are 3D, like balloons, not pancakes.

What are the five main parts of an animal cell?



CELL MEMBRANE
lets substances in and out

RIBOSOME
makes proteins

NUCLEUS
controls the cell

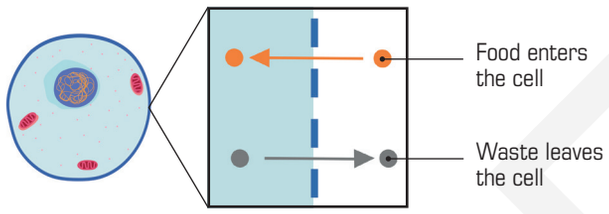
CYTOPLASM
stores useful substances

MITOCHONDRION
supplies energy

▲ Animal cell

Cell membrane

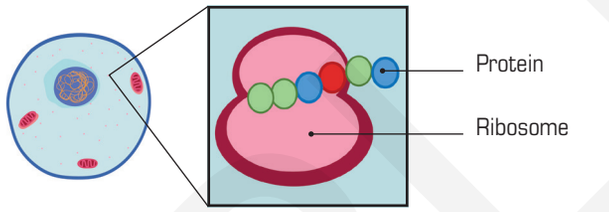
This is the cell's protective cover. It stops harmful substances getting in and stops the contents of the cell spilling out. But the cell membrane isn't a complete barrier. It's full of tiny holes that let in food and allow the waste out.



Why does the cell membrane need holes?

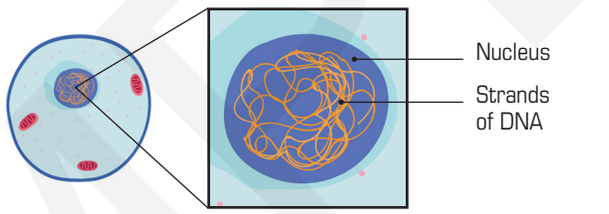
Ribosome

The job of a ribosome is to churn out new materials, called proteins, which the cell needs to grow and repair itself. There are many ribosomes in a cell, scattered throughout the cytoplasm.



Nucleus

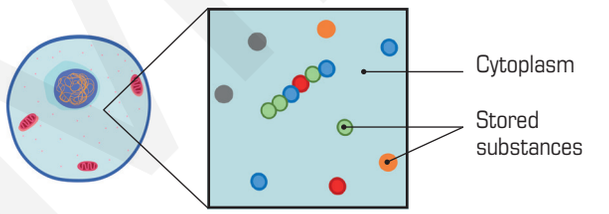
This is the control centre of the cell. It instructs the ribosomes how to make proteins. The instructions are written in a chemical code on long strands of a substance called DNA.



What does the nucleus contain?

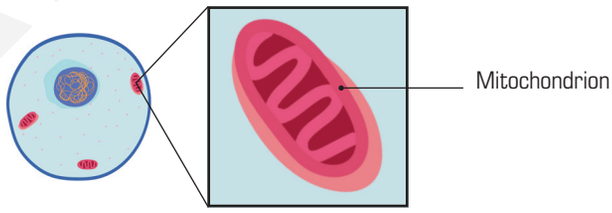
Cytoplasm

The cell is not empty. It's full of a watery liquid called cytoplasm. The cytoplasm stores substances that the cell needs and gives the cell its shape.



Mitochondrion

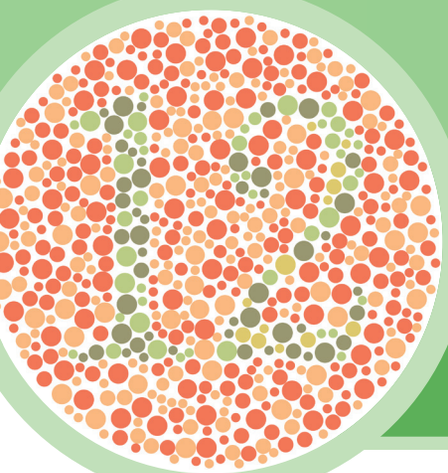
This part is in charge of respiration. A mitochondrion releases energy from food to keep the cell working. There are lots of mitochondria (the plural) scattered throughout the cytoplasm.



REVIEW

1. True or false?
   a) Humans are made up of animal cells.
   b) Mitochondria make proteins.
   c) Your skin is made of cells.
   d) Cells are flat.
2. Give the function of each part of an animal cell.
3. Some substances are too large to pass through the cell membrane. Draw a diagram to show this.
4. Which life process does each statement describe?
   a) Mitochondria release energy from food.
   b) Food enters the cell through the cell membrane.
   c) Waste leaves the cell through the cell membrane.
   d) Ribosomes make new cell parts.
   e) The nucleus makes the cell divide into two.
5. Explain why cells are made up of several parts.
6. **What cell part might not be working correctly in Jo's cells? Give a reason for your answer.**

How do your cells work?



There is a number in this image. Some people can't see it. This colour-blindness is the result of a small mistake in their DNA.

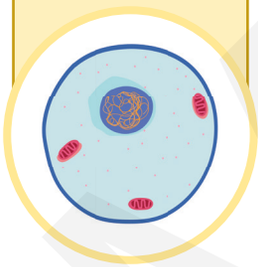
How does a small change in DNA lead to colour-blindness?

TERMS
Analogy

FOCUS ON
imagining what's going on inside a cell, like playing a movie in your mind.

A Cell is like a factory

CELL is like **FACTORY**



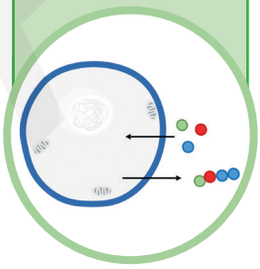
A drawing like this gives the idea there's not much happening in a cell. But it's quite the opposite. The parts of a cell are always busy making new proteins.

Instead, imagine the cell as a car factory. Inside, hundreds of robots are joining together the bits of a car.

When you imagine something as being like another thing, it's called an **analogy**. Scientists use analogies to make difficult ideas easier to grasp. Let's see how the factory analogy helps you to understand the parts of a cell.

Imagine things entering and leaving all over the cell membrane.

CELL MEMBRANE is like **WALLS**



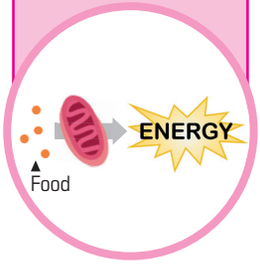
The cell membrane is full of tiny holes to let food enter…

…and finished proteins leave.

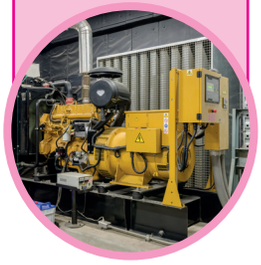
The factory walls are full of gates that let raw materials enter…

…and finished cars leave.

MITOCHONDRION is like **GENERATOR**

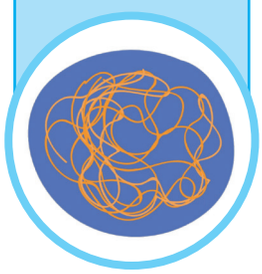


A mitochondrion releases energy from food for other cell parts to use.



A generator releases energy from fuel for other factory parts to use.

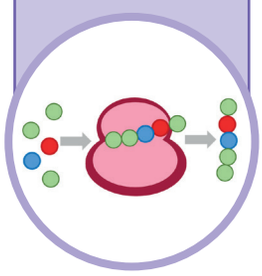
NUCLEUS is like **MANAGER**



Inside the nucleus is DNA. It gives instructions to the ribosomes to make proteins.

The manager gives instructions to the robots to make cars.

RIBOSOME is like **ROBOT**



A ribosome puts together all the bits of a protein.

A robot puts together all the bits of a car.

WRONG!

The cell is just like a factory.

RIGHT!

A cell is not exactly the same as a factory. In an analogy, some things are the same, others are different.

Question

What would happen to a cell if its mitochondria stopped working?

Answer

First, think about the factory.
A mitochondrion is like a generator.
What would happen if that stopped working?

If the generator stops working
↓
Then no more energy is released
↓
Therefore the robots stop working
↓
So no more cars can be made

Then think about the cell.
Work through the same steps with a mitochondrion.

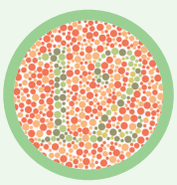
If the mitochondria stop working
↓
Then no more energy is released
↓
Therefore the ribosomes stop working
↓
So no more proteins can be made

A cell would be unable to make new proteins if its mitochondria stopped working.

Why can't a cell make proteins without mitochondria?

REVIEW

1. What is an analogy?
2. Copy and complete these sentences. The first one has been done for you.
   a) A mitochondrion is like the generator in a factory because it releases energy.
   b) The cell membrane is like the _____ of a factory because…
   c) The nucleus is like the _____ in a factory because…
   d) The ribosomes are like the _____ in a factory because…
3. Imagine you were shrunk so small that you could move inside a cell. Describe what you might see.
4. Write down or discuss with a partner how the factory analogy makes cells easier to understand.
5. Describe two ways that a cell is not like a tiny factory.
6. **How does a mistake in DNA lead to colour-blindness? Hint: People are colour-blind when they cannot make a certain protein.**



How are plants different?

In this field, one sunflower has grown a bigger flower than all the rest. How did it manage that? Keeping that huge flower up is an impressive feat. It doesn't have a skeleton like we do, only a thin stem.

How does the thin stem support the heavy flower?

TERMS

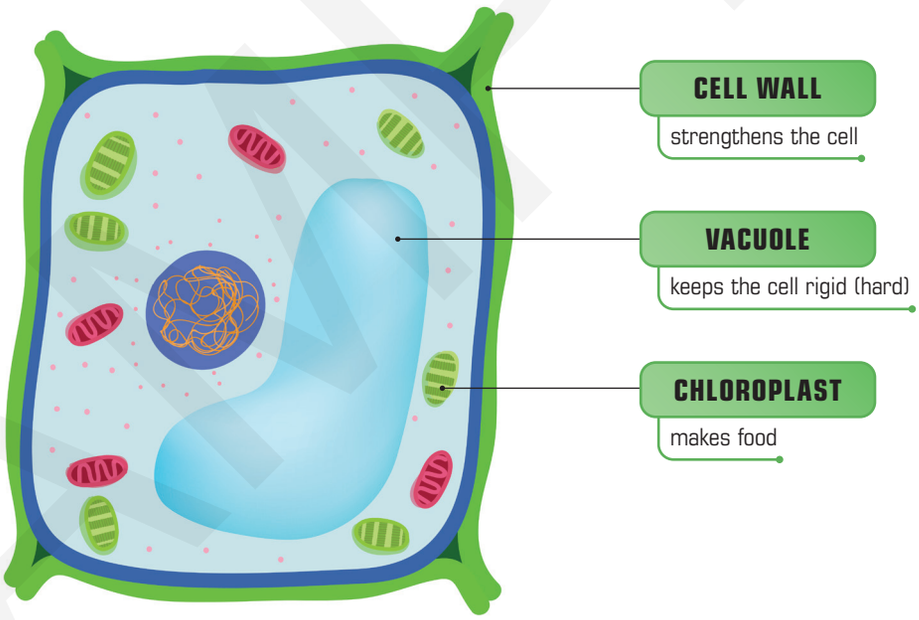
Cell wall
Vacuole
Chloroplast
Photosynthesis

FOCUS ON

the position, job and special features of each part.

Cell parts in plants

Here's what the inside of a plant cell looks like. Can you see how it's different from an animal cell?



▲ Plant cell

Name each part of the plant cell.

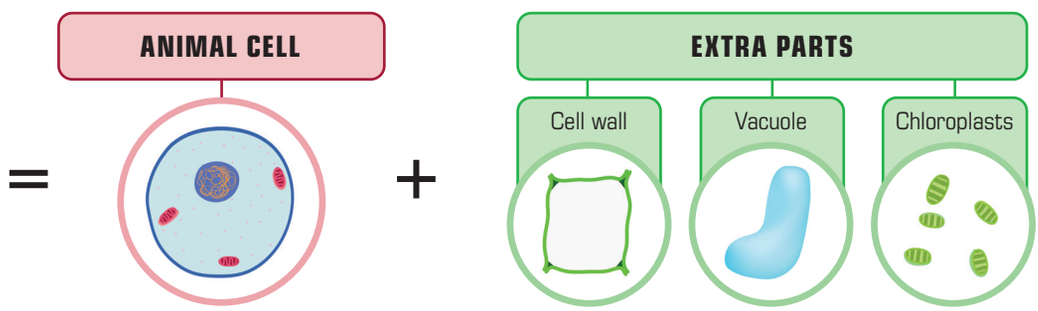
WRONG!

Plant cells don't have a cell membrane.

RIGHT!

Plant cells have both a cell membrane and a cell wall.

A plant cell is similar to an animal cell, but with extra parts.



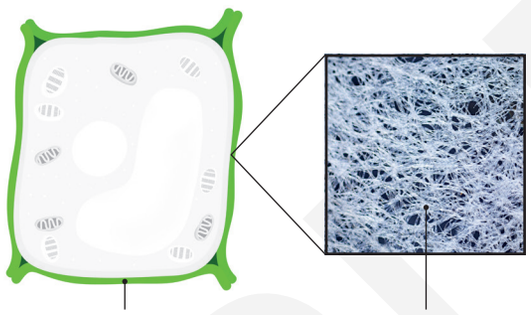
The extra parts make a plant cell bigger than an animal cell.

Here is what the extra parts of a plant cell do:

Cell wall

Plant cells have an extra layer around the cell membrane called the cell wall.
It's made from a tough material called cellulose, which strengthens the cell.

You can imagine the cell wall as a box around the cell. It gives the plant cell a cube-like shape.

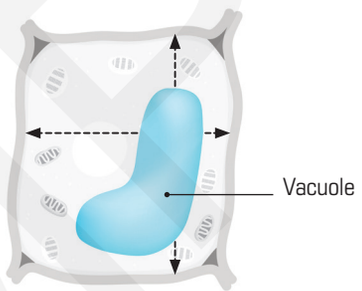


Why are plant cells stronger than animal cells?

Vacuole

The vacuole is a container full of watery liquid.
Its job is to keep the cell rigid. The liquid inside pushes outwards on the cytoplasm and cell wall.

If a plant gets too dry, the vacuoles start to empty. This makes the cells go floppy, and the plant starts to wilt.

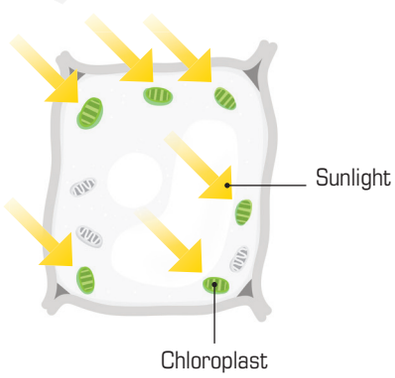


Imagine a cell going floppy when the vacuole loses water.

Chloroplasts

Plants don't eat food like animals do. They make their own. Inside plant cells are parts called chloroplasts, which contain the green substance chlorophyll. This is what makes plants green.

Chlorophyll has a superpower - it captures the energy in sunlight. The chloroplasts use this energy to combine water with carbon dioxide and make sugar - food for the plant.
This way of making food is called **photosynthesis**.



WRONG!
All plant cells have chloroplasts.

RIGHT!
Root cells don't have chloroplasts, because they don't receive light.

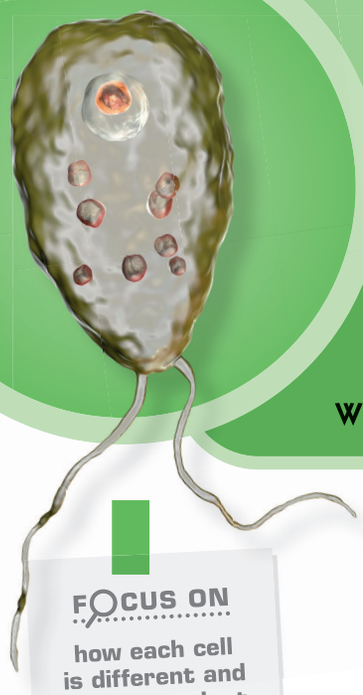
REVIEW

1. Name three parts of a plant cell that animal cells don't have.
2. Copy and complete this table.

Plant cell part	Property	Function
	Strong	
	Pushes outward	
	Absorbs light	

3. Draw a plant cell and label all its parts.
4. Complete the sentences:
   a) Plants don't eat food because…
   b) Plants don't need a skeleton for support because…
5. Explain why a plant dies if its chloroplasts stop working.
6. **Explain how one sunflower has grown a bigger flower than all the rest.**
   Hint: The taller the plant, the more light it gets.

How are other organisms different?



This is a brain-eater. If you get infected water up your nose, these creatures can devour your brain cells. To defeat invaders like these, scientists need to identify what kind of organism they are.

What type of organism is a brain-eater?

TERMS

Bacteria
Flagellum
Yeast
Protist
Virus

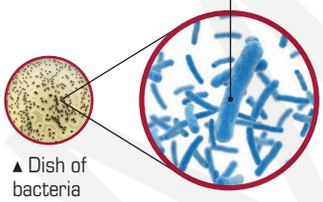
FOCUS ON

how each cell is different and similar to plant and animal cells.

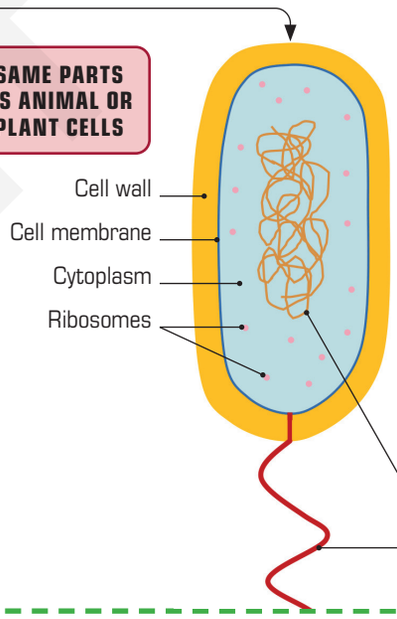
Single-celled organisms

Most organisms on Earth are not animals or plants. They're tiny microorganisms made of only one cell. Let's look at the different kinds of **single-celled organisms**.

Bacteria



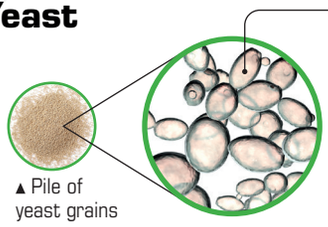
▲ Dish of bacteria



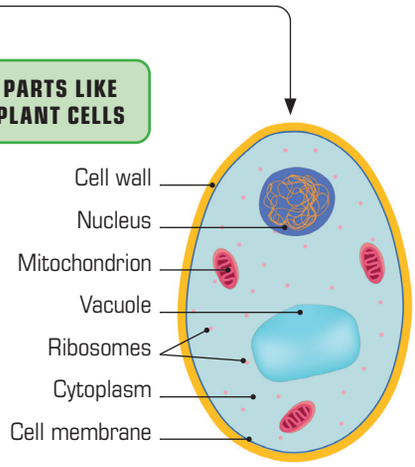
Why do bacteria need a flagellum?

Bacteria are everywhere. Your gut has lots of good ones, but bad ones can make you sick. Bacteria are single-celled organisms that lack a nucleus. The picture shows that a bacteria cell does contain DNA, but it's floating around in the cell. Bacteria also have an extra part called a **flagellum**.

Yeast



▲ Pile of yeast grains

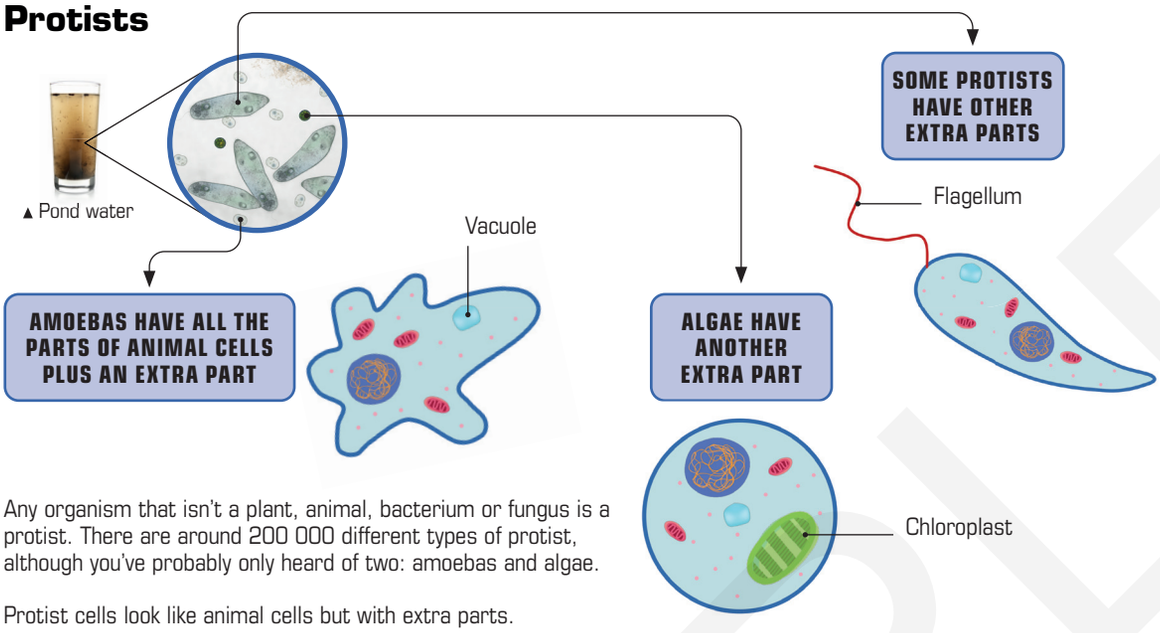


What process can plant cells perform that yeast cells can't?

Yeasts are fungi. They are the only kind that are single-celled. When yeasts respire, they produce bubbles of carbon dioxide. We use this superpower to make bread.

Yeast cells do have a nucleus and the picture shows they are similar to plant cells. However, yeast cells lack chloroplasts.

Protists

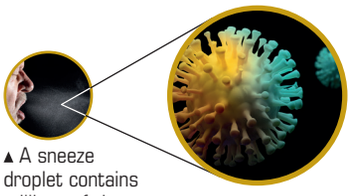


Any organism that isn't a plant, animal, bacterium or fungus is a protist. There are around 200 000 different types of protist, although you've probably only heard of two: amoebas and algae.

Protist cells look like animal cells but with extra parts.

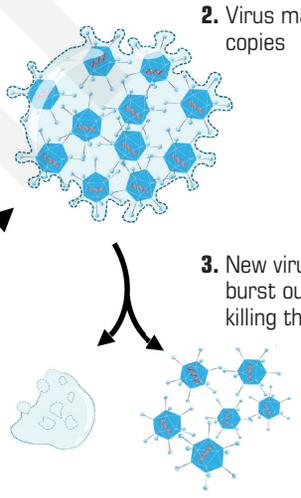
What do algae use chloroplasts for?

Viruses



▲ A sneeze droplet contains millions of viruses.

Viruses are a special group of microorganism. They're not made from cells at all. They're just packages of DNA strands, or a similar material called RNA. The strands carry the instructions to build new viruses.



You might be wondering how a virus can reproduce without cell parts. What it does is take over other cells. The diagram shows how.

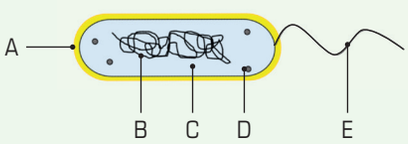
What one thing do viruses have in common with cells?

REVIEW

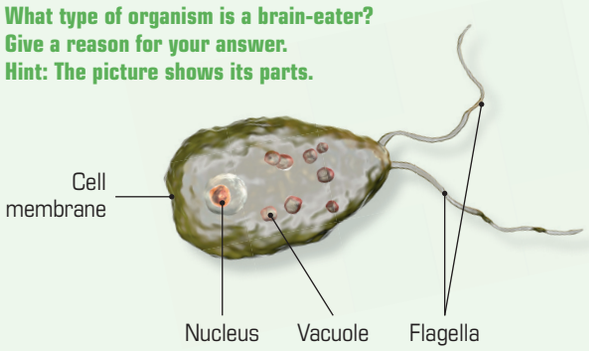
1. Copy and complete: Bacteria, _____ and most protists are _____-celled organisms. They are only made up of _____ cell.
2. Make a table to compare the cell parts in different single-celled organisms. The first row has been done for you. Add one row for each cell part: cell membrane, nucleus, cytoplasm, mitochondria, chloroplasts, ribosomes, vacuole.

Part	Bacteria	Yeast	Protist
Cell wall	✓	✓	✗

3. The diagram shows a bacteria cell. Name each part A-E.



4. Give the name of a single-celled organism that makes its own food. Explain how it does this.
5. Imagine you see a single-celled organism under a powerful microscope. Explain how you could work out what type of organism it was.
6. **What type of organism is a brain-eater? Give a reason for your answer. Hint: The picture shows its parts.**



Mixed-up questions

Recall

1 mark for each question part

1. Copy and complete the statements.
a) We know cells exist because you can see them with a...
b) Waste leaves a cell through the...
c) Animals and plants are made up of many cells - they are...
d) To strengthen them, both bacteria and plant cells have a...
e) For movement, sperm cells have a...

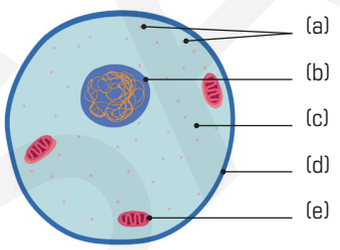
2. For each organism, say whether it is single-celled (S) or multicellular (M):

a) Amoeba	e) Bacterium
b) Flea	f) Moss
c) Worm	g) Yeast
d) Mushroom	h) Daffodil

3. Name three parts that a plant cell has, but an animal cell doesn't.

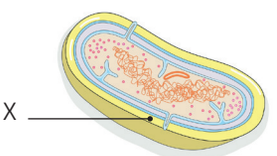
4. Name the plant or animal cell part that:
a) makes proteins.
b) carries out photosynthesis.
c) contains instructions to make proteins.
d) releases energy from food.
e) is full of liquid to keep a plant rigid.
f) controls what enters and leaves the cell.
g) gives the cell strength.

5. Name these parts of an animal cell.



6. This is a cell from your intestines. Describe the special feature it has.

7. Name the part of the bacteria cell labelled X.



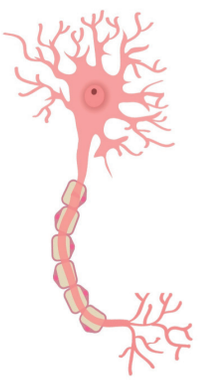
8. Copy the words below. Draw lines to match each cell to its function and special feature.

CELL	FUNCTION	SPECIAL FEATURE
a) Red blood	photosynthesis	no nucleus
b) Palisade	movement	an extension
c) Root hair	carry oxygen	contracts
d) Muscle	absorb water	many chloroplasts

9. Copy and complete the table. Put a tick or a cross in each box.

Cell part	Present in plant cell?	Present in bacteria cell?
a) Cell wall		
b) Cell membrane		
c) Nucleus		
d) Mitochondria		
e) Chloroplasts		
f) Cytoplasm		
g) Ribosomes		

10. This is a drawing of an animal cell.
a) Name the cell.
b) Say where it is found.
c) Describe one special feature it has and its function.



Hints
1.a) → p10 b) → p13 c) → p11 d) → p18 e) → p22
2. → p11 **3.** → p16 **4.** → p13 & 17 **5.** → p12 **6.** → p22 **7.** → p18
8. → a) & d)→ p23 b) → p25 b) → p24 **9.** → p18 **10.** → p22

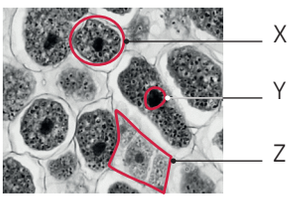
Describe & explain

2 marks for each question

1. This microscope image shows part of an organism.

a) Is it a multicellular or single-celled organism? Give a reason for your choice.

b) Which outline (X, Y or Z) shows one cell?

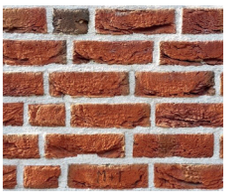


2. Describe two ways that bacteria cells are different to plant cells.

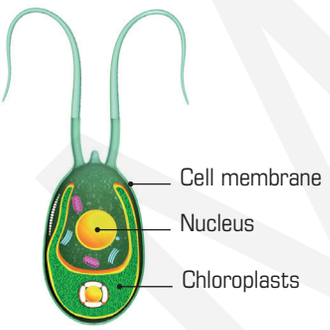
3. A website explains cells using the analogy that they are like bricks in a house.

a) What does the house represent in this analogy?

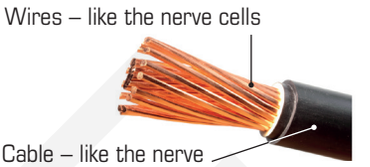
b) Describe one way that a cell is not a like a brick.



4. Here is a single-celled organism called *Chlamydomonas*. Some of its parts have been labelled. What type of organism is it? Give a reason for your answer.



5. This cable is a bunch of wires. A nerve is a bunch of nerve cells. Give two ways that nerve cells are like wires.



6.

▲ *Vibrio cholerae* is a bacteria cell.

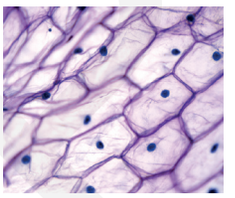
(images are not to scale)

▲ A sperm is an animal cell.

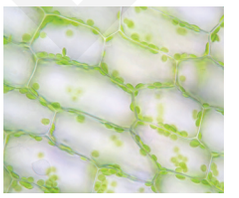
a) Which part does only the bacteria cell have?

b) Which parts do only the sperm cell have?

7. Here are two different types of plant cell.



▲ Root cells

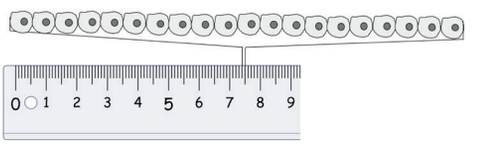


▲ Leaf cells

a) Describe how the cells are similar.

b) Describe how the cells are different.

8. A human cell is so small that 20 fit next to each other in 1 mm.



Calculate the width of a single human cell.

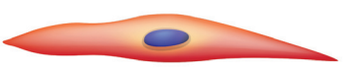
Hints
1.→ p11 **2.**→ p18 **3.**→ p14-15 **4.**→ p18-19
5.→ p22 **6.**→ p18/22 **7.**→ p24-25 **8.**→ p10

Apply

3 marks for each question

1. Explain why a cell dies if its ribosomes stop working.

2. This is a muscle cell from the stomach wall. It is relaxed.



a) Sketch the cell when it is contracted.

b) Food is squeezed when it moves through the stomach. Explain how the muscle cells changing shape helps the stomach squeeze the food.

3. Martha has not watered her pot plant for a while. Its stems have gone all floppy. Explain what has happened, using ideas about cells.

4. If an animal cell takes in too much water, it bursts. Explain why a plant cell does not burst if this happens.

Hints
1. → p14-15 **2.** → p23 **3.** → p17 **4.** → p17

SCORE YOURSELF: **Recall** ____/42 **Describe & Explain** ____/16 **Apply** ____/12

Can you undo a change?

You know it's important to recycle – to change rubbish back into its original material so it can be used again.

But why can you only recycle some plastics and not others?

FOCUS ON

the difference between a reversible and an irreversible change.

Reversible and irreversible change

Scientists use their knowledge to change things. They recycle materials, they make medicines and they even invent new ways of cooking food. But sometimes they need to change a material back to how it was, like recycling a bottle. It turns out that reversing a change can be easy or very hard.

Some changes are easy to reverse

Think about what's changing when you make an ice lolly. Liquid fruit juice turns into a solid lolly when you put it in the freezer. Is it easy or hard to reverse the change and get the liquid back?

It's easy! You simply warm up the lolly and it changes back into liquid juice. A change that is easy to reverse like this one is called a **reversible change**.

Solid ice lolly

Liquid fruit juice

Other examples of reversible changes include:

How can you reverse these changes?

Shaping a lump of clay into a pot

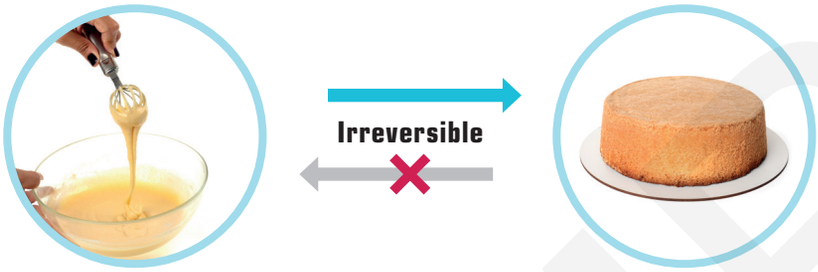
Melting chocolate

Mixing sand and gravel

Some changes are very hard to reverse

Now think about what's changing when you make a cake. You start with a runny mixture of flour, eggs, sugar and butter. Then when you bake it in the oven, it turns it into a solid cake. Is it easy or hard to reverse this change and get the runny mixture back?

It's very hard. You can't really unbake a cake. A change that is very hard to reverse like this one is called an **irreversible change**.



Liquid mixture

Solid cake

WRONG!

Irreversible means impossible to change back.

RIGHT!

Actually, almost all changes can be reversed, but some are just very difficult.

Other examples of irreversible changes include:

Frying an egg

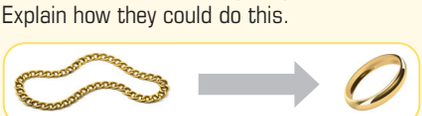
Firing clay

Burning wood

Why are these irreversible changes?

REVIEW

1. True or false?
   a) Heating a substance always causes a reversible change.
   b) A reversible change can alter how a substance looks.
   c) An irreversible change is one that is very hard to reverse.
2. Write one sentence to describe the difference between reversible and irreversible changes.
3. Write down if each change is reversible or irreversible:
   a) baking bread
   b) evaporating water
   c) mixing sand and salt
   d) melting wax
   e) burning a wax candle
4. Look at the picture that shows an ice lolly changing. Draw a similar picture to show the change when water boils.
5. A jeweller wants to change a gold necklace into a gold ring. Explain how they could do this.



6. **When plastic bottles are recycled, they are first heated to melt the plastic. Then the liquid plastic is cooled. It hardens into a new plastic object.**
   a) Is the melting of plastic a reversible or irreversible change?
   b) When some plastics are heated, they burn rather than melt. Is burning plastic a reversible or irreversible change?
   c) Why can't you recycle plastics that burn?

What is a physical change?

The instructions on the side of this Instant Snow Powder tin read:

'Experience the magic. Add water, then watch as the powder transforms into fluffy snow! Fool your friends, and re-use it over and over.'

How can this change really work again and again?

FOCUS ON

what changes during a physical change and what doesn't.

Physical change

This sculptor is turning a block of ice into a statue. This change is reversible. He can turn the statue back into an ice block simply by melting it and then re-freezing the water.

The reason it's easy to reverse is that the substance itself has not changed. It's still water whether it's in the liquid state or the solid state. When only the appearance of a substance changes, we call it a **physical change.**

Examples of physical change

Whenever a substance changes state it's a physical change.

WRONG!

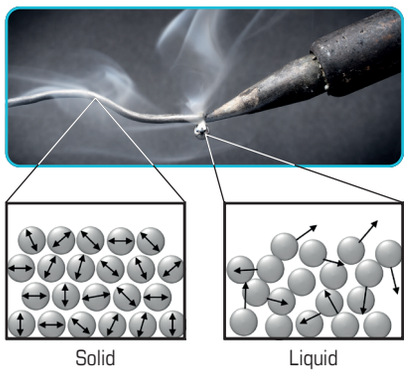
Ice, water vapour, clouds and steam are all different substances.

RIGHT!

They are all the same substance: water. So, changing from one state to another is a physical change.

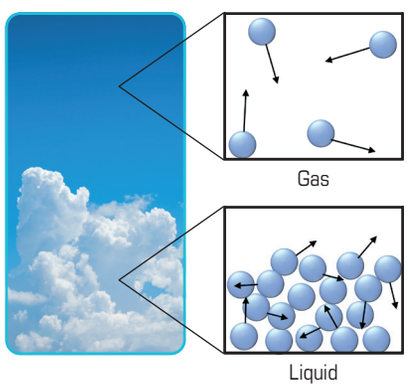
MELTING AND FREEZING

When you heat the metal lead it melts from the solid state to the liquid state. In the liquid state its particles move more, but they are still the same particles. This means melting is a physical change. Freezing is also a physical change - it's melting in reverse.



CONDENSING AND EVAPORATING

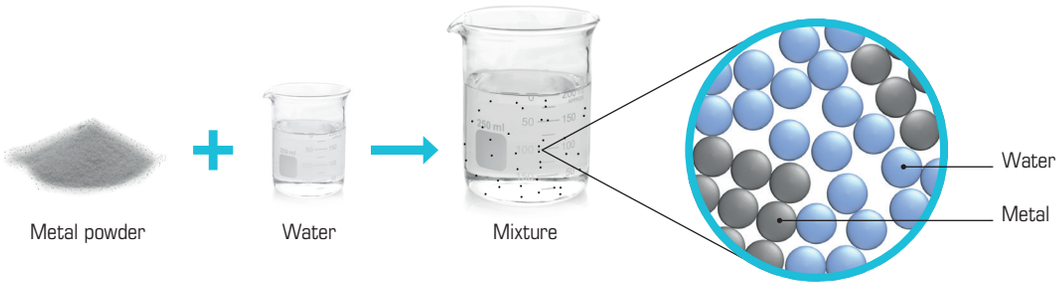
In a cloud, water vapour condenses from the gas state to the liquid state. The water particles move less, but they are still the same particles. It is another physical change. So is evaporating, which is condensing in reverse.



Making a mixture and dissolving are also physical changes.

MAKING A MIXTURE

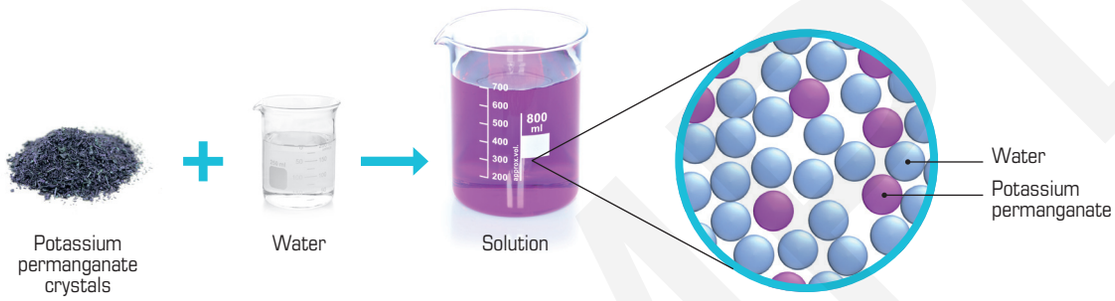
When you mix the metal powder and water, the two substances are still there at the end unchanged. So it's a physical change.



Why are these physical changes?

DISSOLVING

When you dissolve a crystal, the particles mix with water particles. But there are still the same two substances at the end. So it's a physical change.



Some physical changes are irreversible

You might think all physical changes are reversible. But in fact some are very hard to reverse.

When you chop a log you can't easily get it back again. So it's an irreversible change. But it is a physical change because breaking it into parts doesn't change the substance. It is still wood.

When you mix paints you can't easily separate them again. So it's an irreversible change. But it is a physical change because the paints themselves don't change when you mix them.

REVIEW

1. True or false?
   a) New substances are made during a physical change.
   b) Physical changes are always reversible.
   c) Water turning into steam is a physical change.
2. Write one sentence to describe what a physical change is.
3. Copy and complete this table.

Type of physical change	Example
Change in state	
Making a mixture	
	Mixing salt and water

4. Connie says, 'Melting wax isn't a physical change. It makes a new substance – liquid wax.'
   Explain why she is wrong.
5. If a piece of metal undergoes a physical change, which of these things could change?

Shape	Type of particles	Number of particles
Size	Colour	State of matter

6. **Adding water to the instant snow powder makes pretend snow. If you leave it uncovered for a while it will turn back into powder.**
   Explain why this is an example of a physical change.

What is a chemical change?

Take these two white powders and crush them together. The mixture will turn yellow.

What could have caused this?

TERMS

Precipitate

FOCUS ON

spotting the four signs of a chemical change.

Chemical change

Baking a cake is a different kind of change to melting or boiling. Heat from the oven turns the baking powder into bubbles of a gas called carbon dioxide. It's what makes cakes light and fluffy.
So, the original substance (baking powder) has changed into a new substance (carbon dioxide). We call this kind of change a **chemical change**. The word chemical means substance.

ORIGINAL SUBSTANCE → changes into → **NEW SUBSTANCE**

Baking powder

Carbon dioxide

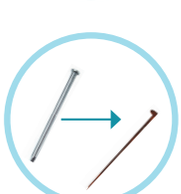
Once you've made a new substance it can be very hard to get back the original one. That's why chemical changes are often irreversible.

Examples of chemical changes

Many experiments that you do in science lessons are chemical changes.

CHEMICAL VOLCANO

Original substances: Vinegar and baking soda → **New substance:** A frothy mixture full of gas bubbles



RUSTING

Original substance: Shiny iron nail → **New substance:** Flaky, brown material called rust

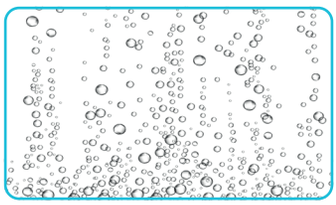
BURNING

Original substance: Wood → **New substance:** A greyish powder called ash

How can you tell that new substances have been made?

Evidence for chemical change

How do we know if a change makes a new substance or not? We look for evidence. Here are the signs that a chemical change is happening.



FIZZING

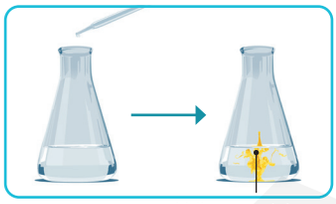
A chemical volcano makes bubbles of gas. The gas is a new substance. So, if you see fizzing, it's evidence of a chemical change. It's not proof because boiling, which is a physical change, also creates bubbles.

COLOUR CHANGE

If a metal rusts, the colour changes from grey to brown. The brown rust is a new substance. So, if you see a colour change, it's evidence of a chemical change. It's not proof because substances often glow a different colour when they are hot.

HEAT OR LIGHT

Burning wood is a chemical change which makes a flame. It's a combination of heat and light. So if you see heat or light, it's evidence of a chemical change. But it's not proof because an electric heater gives out heat and that's not a chemical change.



Yellow precipitate

A SOLID FORMING IN A SOLUTION

In this experiment, two colourless solutions are mixed and a yellow solid forms. The solid is a new substance, called a **precipitate**. So, if you see a precipitate form, it's evidence of a chemical change.

What other sign of a chemical change is there in this example?

Each sign is a piece of evidence. The more you have, the more likely a chemical change has happened.

REVIEW

1. Copy and complete the sentence:
During a chemical change _____ are made.

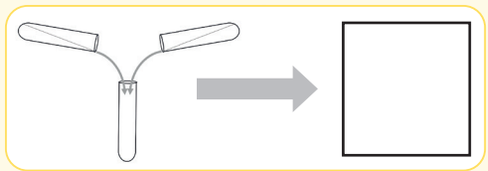
2. List the four signs that are evidence a chemical change may have taken place.

3. Copy and complete this table:

Sign	Explanation	Example
Fizzing		
	The new substance has a different colour	
		Burning wood

4. Kasey mixed a grey powder with a colourless liquid in a test tube. The mixture fizzed and the outside of the test tube felt warm. Do you think a chemical change happened? How sure are you? Explain why.

5. Rashin mixes two solutions in a test tube. A precipitate forms.



a) Copy the empty box and draw a diagram inside to show what happens.

b) Explain how you know that a chemical change took place.

6. Explain why the two white powders turn yellow when they are mixed together.

How do you make circuits?

When there's an emergency, an ambulance driver turns on the siren and flashing lights. You could make a simple circuit that does same thing.

What would you need and how would you connect it all together?

TERMS

Conductor

Insulator

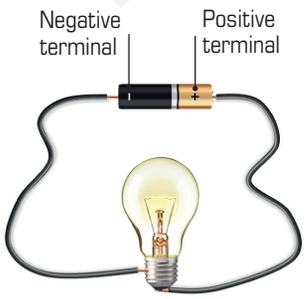
FOCUS ON

what the different parts of a circuit are.

Circuits

This bulb is not lit. There is no complete path, or **circuit**, for electricity to travel around.

To make a complete circuit, we connect a wire to both terminals of the battery and bulb.



WRONG!

Electricity can flow out of the end of a wire like liquid.

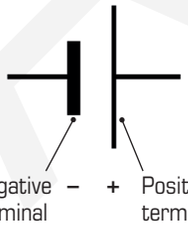
RIGHT!

Electricity can only flow through a complete circuit.

Circuit symbols

Drawing the parts of a circuit can be tricky. Scientists use symbols instead of pictures. Here are some common symbols:

▼ Battery

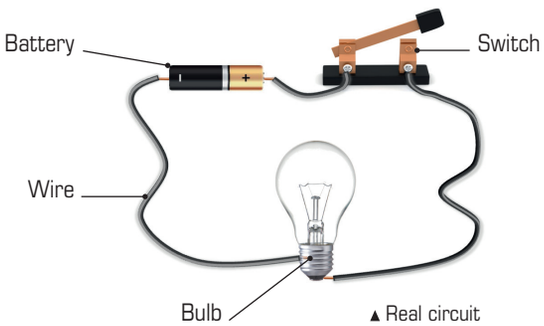


▼ Connecting wire

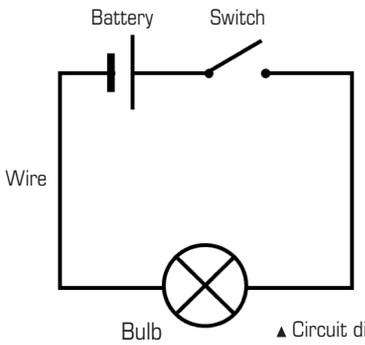
▼ Bulb

▼ Switch

We can use the symbols to turn a picture of a real circuit into a circuit diagram.



▲ Real circuit



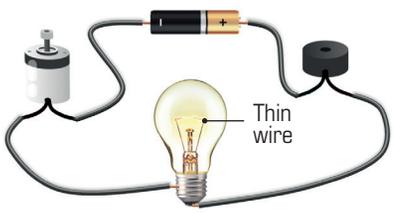
▲ Circuit diagram

Can you draw a circuit with two bulbs?

Devices

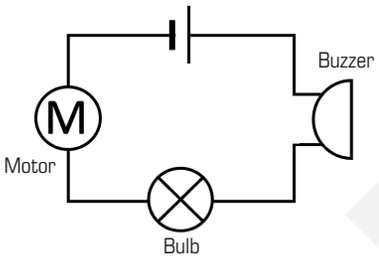
Devices are things like buzzers, bulbs and motors. They can go anywhere in a circuit and they can usually be connected either way round.

A motor rotates to provide movement.



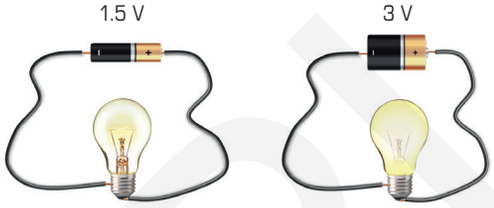
A thin wire inside a bulb gets hot and lights up.

A buzzer has a speaker that produces a sound.



Power source

A battery provides the force to move electricity around. The number on it is called voltage (V). The bigger the voltage, the harder the battery pushes. A 3 V battery makes a bulb brighter, a buzzer louder or a motor faster than a 1.5 V battery.

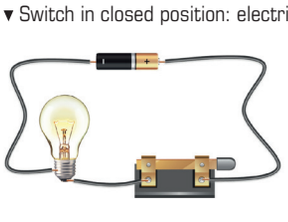


Why is one bulb brighter than the other?

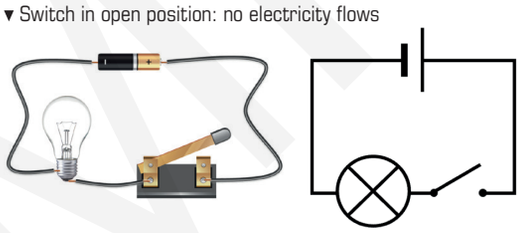
Switch

A switch starts and stops electricity. It has two different positions, closed and open, so it can be used to turn devices on and off.

▼ Switch in closed position: electricity flows

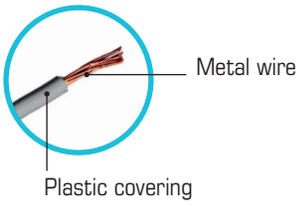


▼ Switch in open position: no electricity flows



Connecting wires

Metal wires connect the parts of a circuit. They're metal because metals are **conductors**. This means electricity passes through the material easily. The wires are covered in plastic. Electricity does not pass easily through plastics. They are **insulators**. Insulated wires stop you getting an electric shock.



What is the difference between a conductor and an insulator?

REVIEW

1. Give the terms for each of the definitions below.

a) A complete path for electricity to move around.

b) A device that makes a noise when electricity goes through it.

c) A power source.

d) They connect the different parts of a circuit.

2. Why doesn't this bulb light up?

3. Copy and complete this table.

Name	Symbol	Function
Bulb		
Switch		
Battery		
Wire		

4. Suki builds a circuit with 2 batteries and 2 bulbs. Draw a circuit diagram of her circuit.

5. You build a circuit with one battery and one bulb. Describe how you could change the circuit to make the bulb brighter.

6. Draw a diagram of a circuit that lights up and makes a noise when you press a switch.

What is electricity?

When you touch a lightstick at both ends, it lights up as if by magic.

How do you think it works?

TERMS

Amp

Ammeter

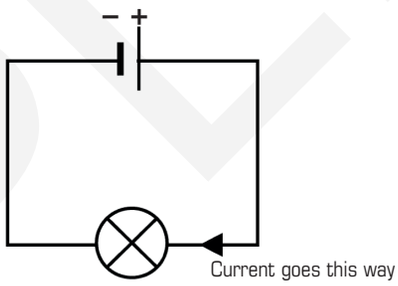
FOCUS ON

how to imagine current like a rope.

Current

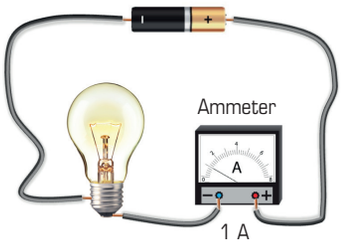
Current is the name for the flow of electricity around a circuit. The voltage from the battery is what makes current flow.

We show current as moving from the positive terminal of the battery to the negative terminal.



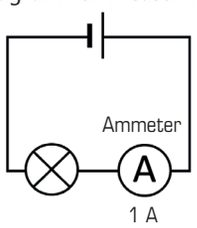
We measure the size of the current with a device called an **ammeter**.

The current here is 1 **Amp**. Amp is short for Ampere, the unit of current. Amp is usually just written as A. So the current here is 1 A.



This is the symbol for an ammeter:

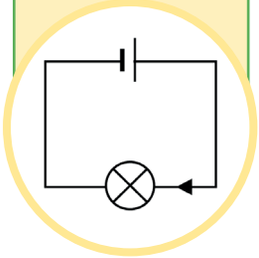
A circuit diagram for measuring current looks like this:



Can you draw a circuit where the ammeter is in between two bulbs?

What does the arrow represent in each drawing?

CURRENT is like **A LOOP OF ROPE**

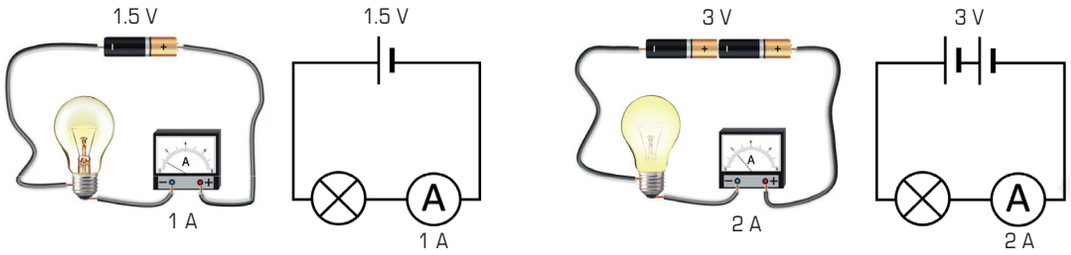


We can understand how current flows with an analogy.

Imagine current is like a loop of rope. Your hands are like a battery. When you give the rope a push (like voltage), you make the rope move around (like current).

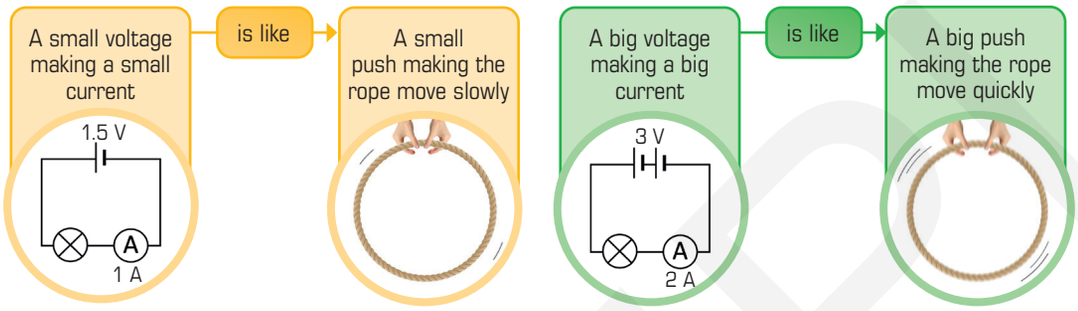
Higher voltage means more current

One way to make more current and a brighter bulb is to use a battery with a higher voltage. Joining several batteries together has the same effect.



What happens when current increases?

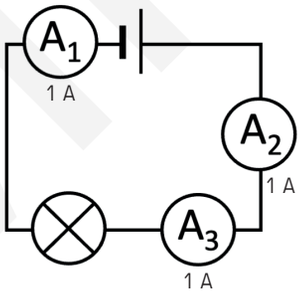
Why does a bigger voltage produce more current? Picture the loop of rope.



Current is the same everywhere

Some people think current is used up. But that's wrong. Look at this circuit. Wherever you put the ammeter, it measures 1 A.

To see why current is the same everywhere, picture it as a loop of rope. There's just one piece of rope, so it all has to move at the same speed. If it didn't, the rope would start to bunch up.



WRONG!
Current gets smaller as it goes around a circuit.

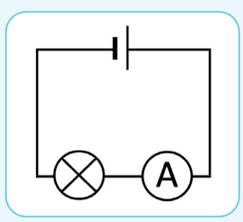
RIGHT!
Current is the same everywhere in a circuit.

REVIEW

1. Describe what current is.

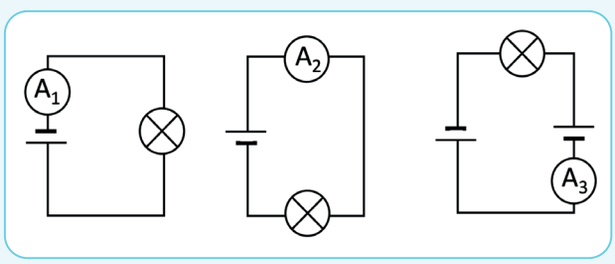
2. True or false?
a) Current is pushed around a circuit by a bulb.
b) The unit for current is the Amp.
c) Current decreases as it goes around a circuit.

3. This diagram shows a simple circuit. Draw and name the part which:
a) Measures current.
b) Varies the amount of current.
c) Turns on when there is a current.

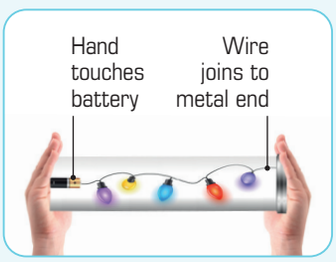


4. Imagine a second pair of hands pushes the rope. This is like adding another battery to a circuit. Use the loop of rope to explain why a second battery has to be the correct way round for current to flow.

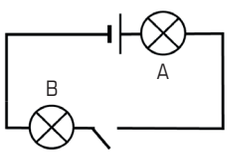
5. In which ammeter (A_1, A_2, or A_3) is the current highest? Give a reason for your answer.



6. This diagram shows what is inside the lightstick.
How does it work?
Hint: Current can flow through your body.



What is current really?



Three students discuss what will happen in this circuit at the instant the switch is closed.

Leo: "Bulb A will light first, because the current starts at the battery."

Keira: "Bulb B will light first, because it's closer to the switch."

Felix: "Both bulbs will light at exactly the same time."

Who is correct and why?

FOCUS ON

imagining the moving electrons inside a wire.

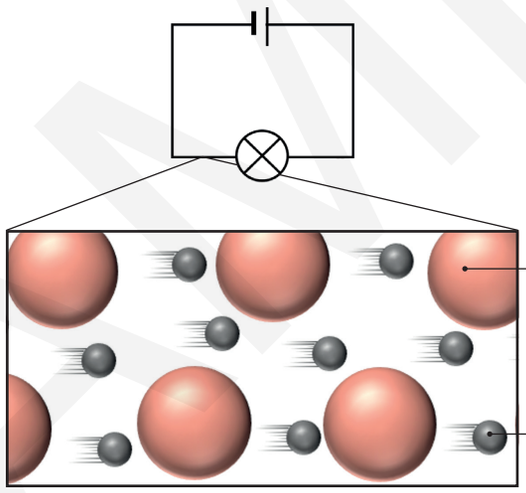
TERMS

Electron

Moving electrons

You know that current means something moving around a circuit. If we could zoom into a wire, we would see what is really moving.

Which part of a wire can move?



The wire is made of microscopic particles called atoms. As the wire is in the solid state, these atoms are unable to move around.

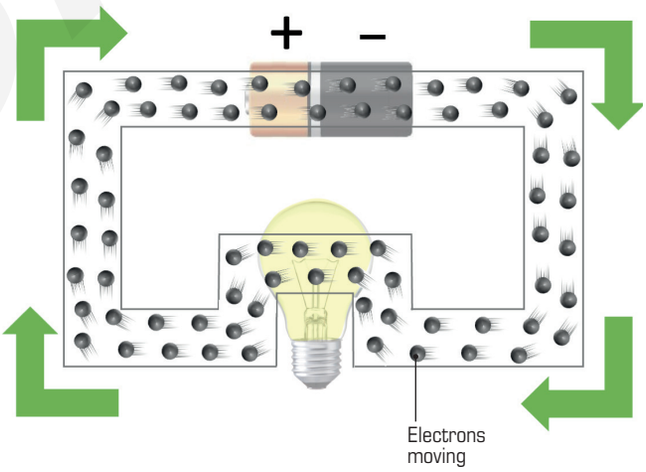
Between the atoms are even tinier particles called **electrons**. The electrons are free to move in any direction.

WRONG!

It takes time for current to reach the bulb.

RIGHT!

Electrons start moving all together so the bulb lights immediately.



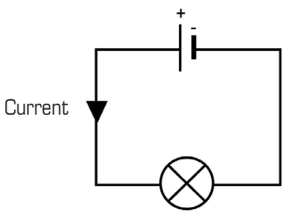
When you connect a battery, it creates electric forces. The negative terminal repels the electrons and the positive terminal attracts the electrons. The forces push all the electrons in the circuit around in the direction of the positive terminal. The electrons all move together like the loop of rope.

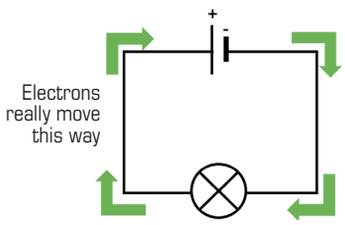
So, current is really a movement of electrons - through the battery, through the wires and through the devices.

The direction of the current

When scientists discovered electricity, they thought current moved from the positive to the negative terminal of the battery. Even through this is wrong, we still show the current going this way.

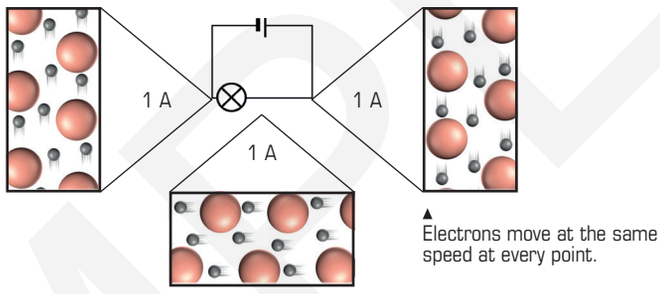
It was only later that scientists discovered that current is made of electrons. Then they realised that the electrons actually move from the negative to the positive terminal.





Why current is the same everywhere

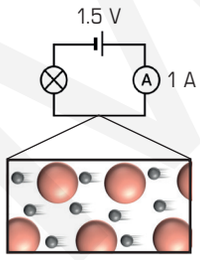
We have seen that current is the same everywhere in a circuit. Now we can explain why. Electrons all around the circuit move at the same speed. They have to. Otherwise, electrons would pile up somewhere.



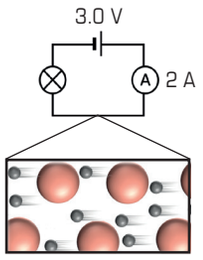
Electrons move at the same speed at every point.

Why higher voltage means more current

We also saw that using a battery with a higher voltage makes more current. We can explain this in terms of electrons. The higher the voltage, the stronger the push on the electrons. When electrons move faster around the circuit, it means there's more current.



Electrons move more slowly - less current



Electrons move faster - more current

What happens to the electrons if a 9 V battery is used?

REVIEW

1. Copy and complete the sentences:

a) Inside wires are tiny _____ that can move.

b) Electrons are pushed around a circuit by the _____.

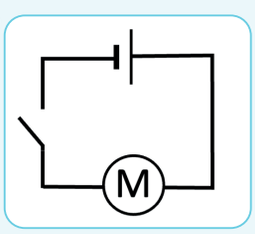
c) Electrons move from the _____ terminal of a battery to the _____ terminal.

2. Rewrite each sentence so it is correct:

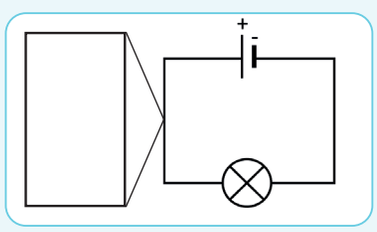
a) Electrons move more slowly when they go through a bulb.

b) The higher the voltage, the greater the number of electrons in the wire.

3. Describe what happens to the electrons in this circuit when the switch is closed.

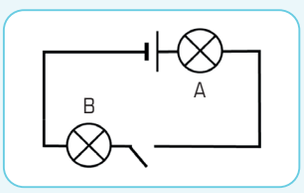


4. Copy this diagram. Draw the atoms and electrons in the box. Add arrows to show which direction the electrons are moving.



5. Oakley has a wrong idea: 'If you disconnect one of the wires in a circuit, electrons spill out of the end.' Explain what really happens.

6. When the switch is closed, which bulb lights first? Give a reason for your answer.



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"Brilliantly thought out and produced."
David Beauchamp, Stafford Grammar School

"I really like the challenge provided, the storyline, the abundance of questions, the images.
Possibly the best KS3 science textbook around."
Hugh Gough, Oakfield Academy

"This is not an ordinary textbook. It's designed to guide pupils to understanding by combining easy-to-read text, great diagrams, and checking understanding before moving on to the next section!"
NIck Chapman, Town Close House Preparatory School

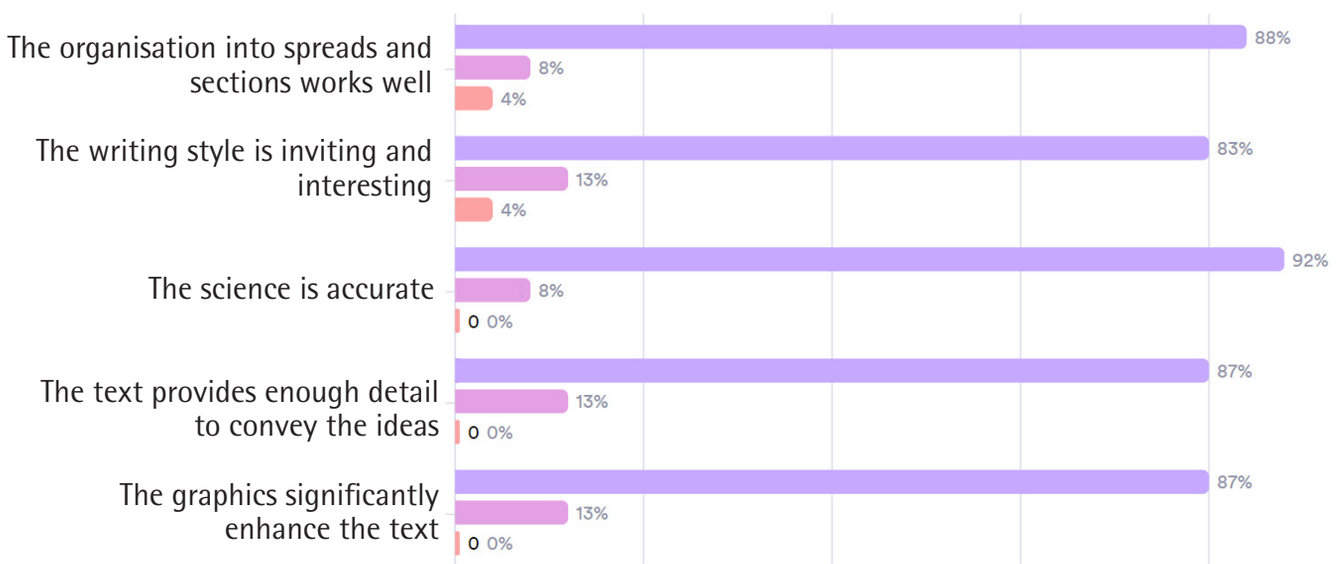
"Text and pictures are cleverly combined for strong and supportive dual coding process. Active reading strategies, used throughout the book, reinforce deep knowledge assimilation."
Caroline Neuberg, Fulneck School

"I really liked how it follows current pedagogical research (retrieval, discussion, practice, check understanding, fill in gaps)."
Philip Burrage, International School of Luxembourg

"Really, really like it. The sequencing of knowledge is superb and great for low to mid ability pupils. The tasks clearly build on the key concepts. There is a variety of methods which enables pupils to develop their understanding which is supported with excellent graphics and text. It is one of the best text books I have seen."
Beverley Webber, Bishop Hedley High

Evidence from trials

How did Understanding Science help with learning?



79% of teachers said students enjoyed learning with the book.

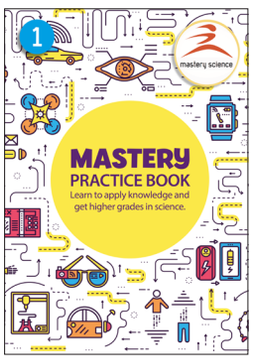
It helped 82% of teachers clarify the amount of detail and depth to teach for every concept.

Get more from **Mastery Science**

mastery science

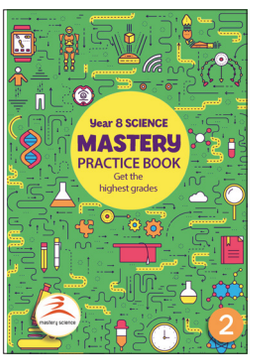
Visit masteryscience.com for details.

Year 7 Apply Practice Book



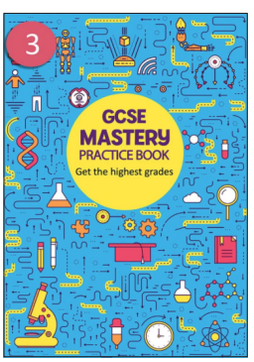
Get a flying start to secondary science. This book will give you confidence to tackle difficult exam questions by teaching you powerful strategies to apply knowledge, clear worked examples and masses of challenging practice.

Year 8 Apply Practice Book



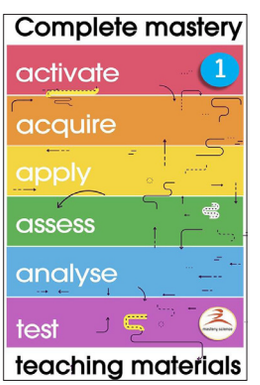
Building on 'Detect, Recall, Solve' from year 7, this book teaches the problem-solving process in more detail. It's apply problems, worked examples and 'your turns' cover all the year 8 concepts from the 5-year plan.

GCSE/year 9 Apply Practice Book



40 types of problems to develop students' problem solving abilities, and prepare them for the demands of apply questions at GCSE. Covers 24 key concepts taught in year 9/at the beginning of GCSE.

Year 7&8 Complete Mastery Course



A comprehensive teaching and assessment programme to give students a strong KS3 foundation in all the concepts and skills over two years, ready for GCSE. It supports students to: activate prior knowledge, acquire deep understanding, apply ideas, assess understanding, analyse information and test knowledge and skill - in short, it gives you a pathway to mastery!

Blueprint

A 'backwards designed' curriculum framework to ensure that students build expert knowledge they can apply in GCSE, not disconnected knowledge. 13 big ideas break down into key concepts, each its own vertical progression for students to revisit ideas in ever greater depth. The free year 7 & 8 planners set out clear yearly teaching objectives for knowledge, understanding, enquiry skills, application and analysis, to help you create coherent schemes of work.

UNDERSTANDING SCIENCE 1

Master the Key Concepts

DR TONY SHERBORNE
and GEMMA YOUNG

UNDERSTANDING SCIENCE

Understanding Science is more than a textbook. It's a step-by-step guide to mastering the difficult concepts in science. Based firmly on research, Understanding Science will give students deep knowledge that they can apply to get high grades.

- Starts by going over previously taught concepts.
- Gives crystal-clear explanations and visuals.
- Works through examples on how to use the concepts.
- Shows how to avoid misconceptions.
- Helps students fully process the ideas using questions.
- Provides strategies for learning by reading.

Understanding Science covers all the Key Concepts in year 7:

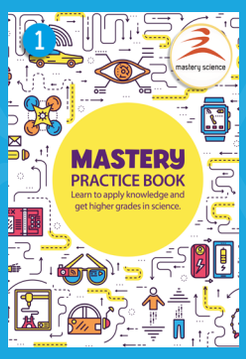
GENES
Sexual & Asexual
Menstrual Cycle
Embryo Development

ENERGY
Energy Transfer
Wasted Energy
Heat & Temperature
Electric Current
Resistance

MATTER
Particle Model
Mixtures
Solutions
Chemical & Physical
Acids & Alkalis

ORGANISMS
Cell Structure
Specialised Cells
Feeding Relationships
Competition
Abiotic & Biotic

FORCES
Balanced & Unbalanced
Friction
Density



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