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Cambridge Lower Secondary Science

LEARNER'S BOOK 8

Mary Jones, Diane Fellowes-Freeman & Michael Smyth

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Contents

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1 Respiration

1.1 The human respiratory system

In this topic you will:

- learn the names of the different parts of the human respiratory system
- observe carefully, and record your observations, as the structure of lungs is demonstrated

Getting started

Respiration is one of the characteristics of living things.

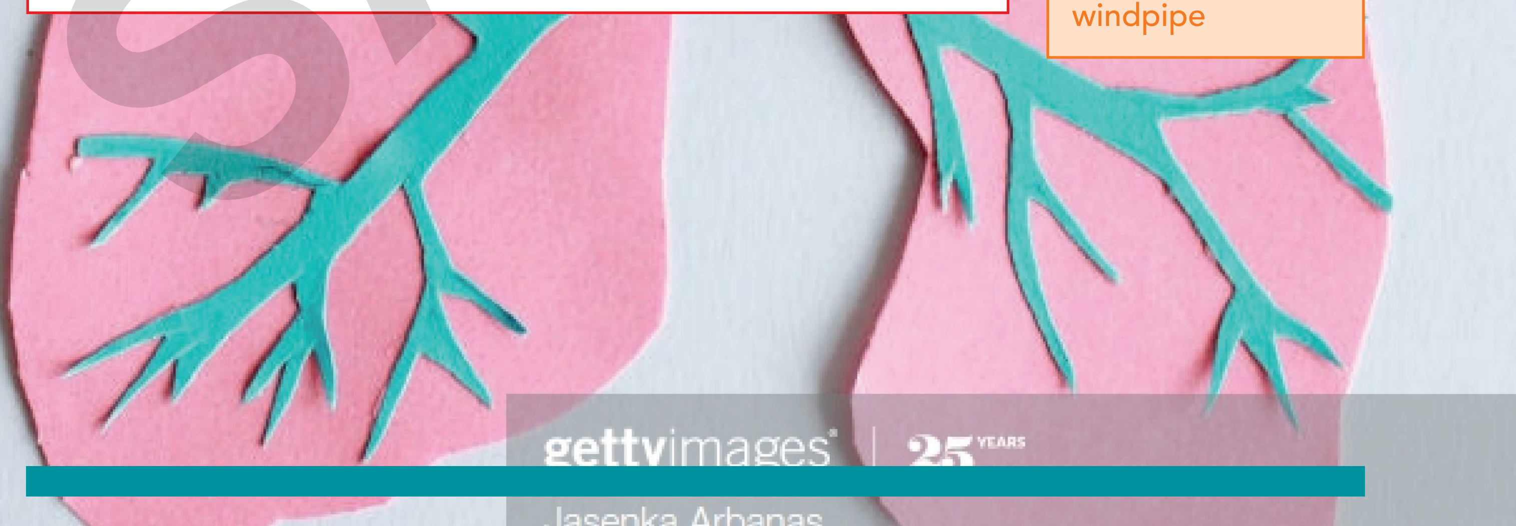
With a partner, decide which statement in each pair is correct.

Be ready to share your ideas.

First pair:	Respiration happens inside all the cells in your body.	or	Respiration only happens in cells in your lungs.
Second pair:	Respiration releases energy from food.	or	Respiration uses up energy.
Third pair:	Respiration happens in all living things.	or	Respiration happens in animals but not plants.

KEY WORDS

aerobic respiration
air sac
bronchiole
bronchus
cartilage
larynx
respiration
respiratory system
trachea
vocal cords
voicebox
windpipe



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Why we need oxygen

You may remember that one of the characteristics shared by all living things is **respiration**. Respiration is a chemical reaction that happens inside every living cell.

The kind of respiration that usually happens inside our cells is called **aerobic respiration**. Aerobic respiration uses oxygen. The cells produce carbon dioxide as a waste product.

The air around you contains oxygen. When you breathe, you take air into your lungs. Some of the oxygen from the air goes into your blood. The blood delivers the oxygen to every cell in the body, so that the cells can use it for respiration. The blood collects the waste carbon dioxide from the cells, and takes it back to the lungs.

The organs that help you to take oxygen out of the air, and get rid of carbon dioxide, make up the **respiratory system**.

Can you name any of the other organs shown in the picture?

Figure 1.1.1: Where the lungs are inside the body – they are shown in pink.

The structure of the human respiratory system

The white spaces in Figure 1.1.2 are the 'tubes' that air moves through, as it goes into and out of your lungs.

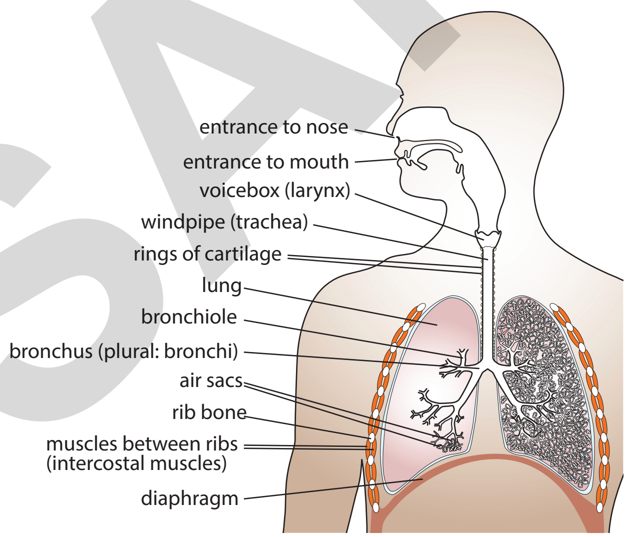

Figure 1.1.2: The human respiratory system.

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Questions

1 Put your finger on the entrance to the nose or mouth in Figure 1.1.2. Move your finger along the white space and down into the lungs.

Write down the structures that the air passes through, as it moves down into your lungs. Write them in the correct order.

2 Now write the same structures in the order in which air passes through them as it moves out of your lungs and back into your surroundings.

Air gets into your body through your mouth or nose. Your mouth and nose both connect to your **trachea**. The trachea is sometimes called the **windpipe**. It has strong rings of **cartilage** around it. If you put your fingers on the front of your neck and move them downwards, you can feel the rings of cartilage on your trachea.

The trachea branches into two **bronchi** (singular: **bronchus**). The bronchi also have cartilage to support them. One bronchus goes to each lung. Each bronchus carries air deep into the lungs. Each bronchus divides into several smaller tubes called **bronchioles**.

The bronchioles end by branching into many tiny structures called **air sacs**. This is where the oxygen goes into the blood, and the carbon dioxide comes out. You can find out more about this in the next topic.

Think like a scientist

Looking at lungs

In this activity, you are going to look carefully at some real lungs. You will practise using your senses of touch and sight, to make observations, and recording your observations.

You will need:

- a set of lungs from an animal, such as a sheep or goat (from a butcher)
- a big board to put the lungs onto
- hot water, soap and towels to wash your hands after handling the lungs

Questions

1 Describe what the lungs look like.

If you prefer, you could make a labelled drawing instead of writing about them.

2 Touch the lungs.

What do they feel like when you push them? Can you suggest why they feel like this? (Look at the diagram of the human respiratory system to help you.)

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Continued

3 Look at the tube that carries air down into the lungs.
   a What is the name of this tube?
   b Feel the tube. What does it feel like?
   c Follow the tube towards the lungs. Can you find where it divides into two? What are the names of these two tubes?
   d Now look at the top of the big tube, where it is wider. What is the name of this wide part? What is its function?

The diagram of the respiratory system includes a lot of new words.

How are you going to learn this diagram and all of its labels?

Remember that, in a test, the diagram might not be exactly the same as this one.

Activity 1.1.1

What does the larynx do?

Hold the fingertips of one hand against your **larynx** (**voicebox**).

Keep your lips together, and make a loud humming sound.

Can you feel the larynx vibrating?

Your larynx contains your **vocal cords**. These are bands of muscle that stretch across your larynx. You can think of them as being rather like guitar strings. When these cords vibrate, they make a sound.

Now make a higher-pitched humming sound. Then try a really deep pitched one. Can you feel the larynx changing when you make the different sounds?

Summary checklist

- [ ] I can name the parts of the respiratory system, and identify them on a diagram.
- [ ] I can list the organs that air passes through, as it moves into and out of the lungs.

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1.2 Gas exchange

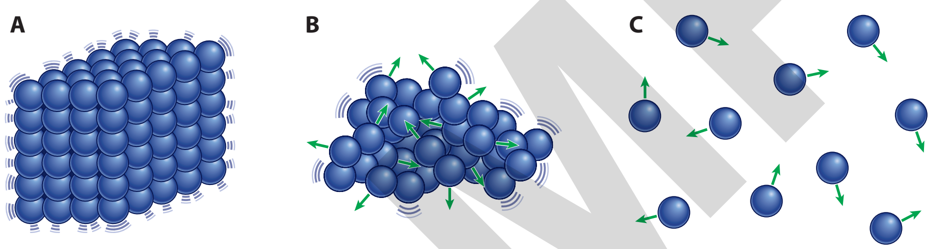
In this topic you will:

- find out how oxygen gets into your blood from the air, and how carbon dioxide goes in the other direction
- do an experiment to help you to think about why the air sacs in the lungs need to be very small
- do an experiment to compare how much carbon dioxide there is in the air you breathe in and the air you breathe out

Getting started

This topic is about two gases – oxygen and carbon dioxide.

Look at these diagrams.



With your partner, answer these questions.

1 Which diagram shows the particles in a gas?

2 Choose the correct phrases to complete these sentences:

In a gas, the particles are **far apart** / **touching each other**.

In a gas, the particles **move freely** / **vibrate on the spot**.

KEY WORDS

alveoli
analogy
capillaries
diffusion
expired air
gas exchange
haemoglobin
inspired air
limewater

Air sacs

The photograph in Figure 1.2.1 shows a tiny part of the lungs, seen through a powerful microscope. You can see the lungs are mostly holes. These holes are called air sacs. Another name for them is alveoli.

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There are also lots of very tiny blood vessels in the lungs, wrapped around the air sacs. You cannot see them in the photograph, but they are shown in Figure 1.2.2. These blood vessels are **capillaries**.

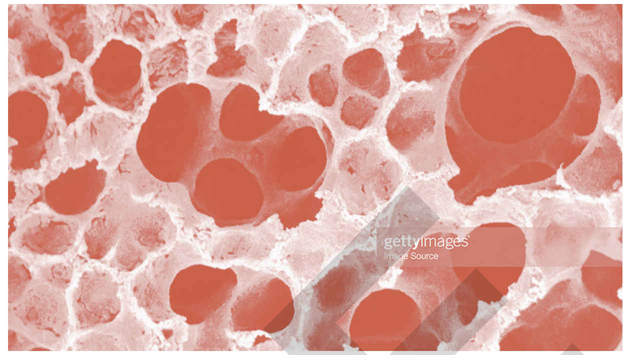

Figure 1.2.1: Part of the lungs, viewed through a powerful microscope

The structure of an air sac

Figure 1.2.2 shows one of the air sacs in the lungs. The air sac has a wall made of one layer of cells. These cells are very thin.

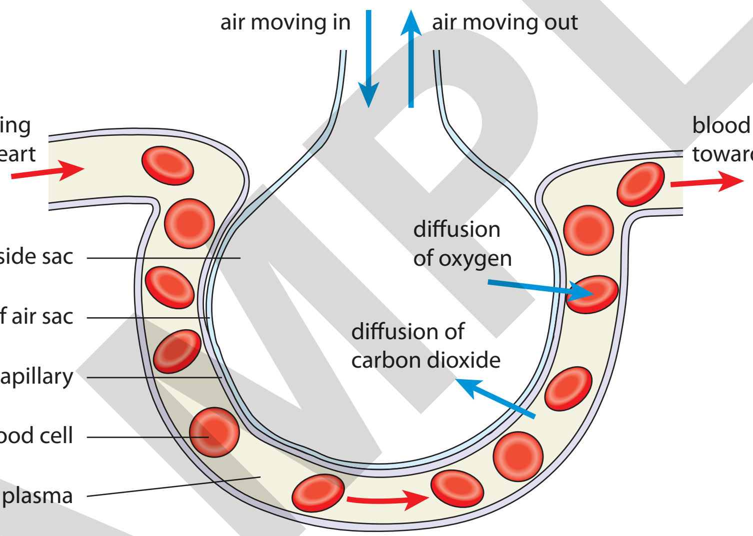

Figure 1.2.2: An air sac in the lungs

You can see that there is a blood capillary around the outside of the alveolus. The capillary is pressed tightly against the alveolus. The wall of the capillary is also made of a single layer of very thin cells.

Gas exchange in the air sacs

Inside the air sacs, oxygen from the air goes into the blood. Carbon dioxide from the blood goes into the air. This is called **gas exchange**.

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Think about the blood capillary on the left of Figure 1.2.2. The blood inside this capillary comes from the heart. Before reaching the heart, it came from the organs in the body. These organs contain cells that respire, using up oxygen and making carbon dioxide. So, the blood in this capillary contains only a small amount of oxygen, and a lot of carbon dioxide.

Now think about the air inside the air sac. It came from outside the body, where the air contains a lot of oxygen and only a small amount of carbon dioxide.

Inside the alveolus, this air is very close to the blood. There are only two very thin cells between the air and the blood.

The oxygen particles in the air are a gas, so they are moving freely. They can easily move from the air, through the cells and into the blood. This is called **diffusion**. You can find out more about diffusion in Topic 3.7. The oxygen molecules move from where there are a lot of them (in the air) to where there are fewer of them (in the blood).

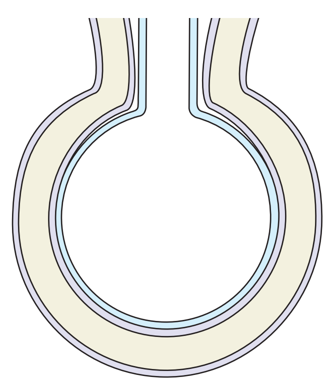
When the oxygen gets into the blood, it dissolves. (You can find out about dissolving in Topic 2.1.) It goes into the red blood cells where it combines with **haemoglobin**. You will find out what happens to it after that in Topic 1.6.

Now think about the carbon dioxide. There is a lot of it in the blood in the capillary, and only a small quantity in the air inside the air sac. So, the carbon dioxide diffuses into the air in the air sac.

Activity 1.2.1

Gases in and out

Copy this diagram.



1 On your diagram, draw a **green** arrow to show how oxygen diffuses from the air into the blood.

2 How many cells does the oxygen move through, as it leaves the blood and goes into the air?

3 On your diagram, draw a **blue** arrow to show how carbon dioxide diffuses from the blood into the air.

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Think like a scientist

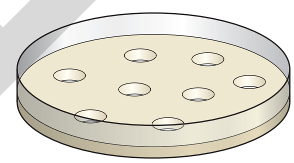
Why are air sacs so small?

In this activity, you will use some agar jelly to represent the lungs, and some coloured liquid to represent oxygen in the air.

You will need:

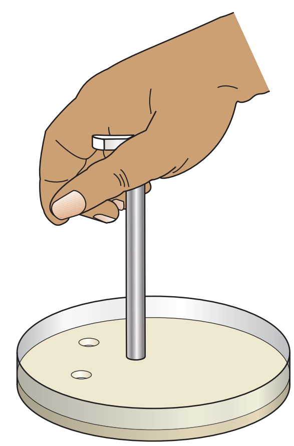
- two Petri dishes filled with agar jelly
- two cork-borers, one with a diameter of 10 mm and the other with a diameter of 5 mm
- some coloured dye
- a dropper pipette

Method



1 Use the larger cork-borer to make eight holes in the jelly in one of the dishes. Space the holes evenly in the dish.

2 Now use the smaller cork-borer to make 32 holes in the jelly in the other dish. Try to space the holes evenly in the dish.



3 Using the dropper pipette, carefully fill each hole in both dishes with the coloured dye. Try to put the same quantity of dye into each hole. It's really important not to get any dye on the jelly!

4 Leave both dishes for at least 15 minutes.

5 Predict what you think will happen.

6 After 15 minutes (or a little bit longer if things are happening slowly) record your observations.

Questions

1 The holes that you made in the jelly represent the air sacs in the lungs. The coloured dye represents oxygen in the air sacs. The holes in the jelly are an **analogy** for the air sacs, and the dye is an analogy for oxygen.

Explain how your observations help to show what happens to oxygen in the lungs.

2 The total volume of the 32 small holes is the same as the total volume of the eight large holes. Use your observations to suggest why it is better to have a lot of very small air sacs in the lungs, rather than just a few large ones.

3 Do you think that the agar jelly with holes is a good model for what happens in the lungs? Explain your answer.

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Think like a scientist

Comparing the carbon dioxide content of inspired air and expired air

In this activity, you will use **limewater** to compare how much carbon dioxide there is in the air that you breathe in and the air that you breathe out.

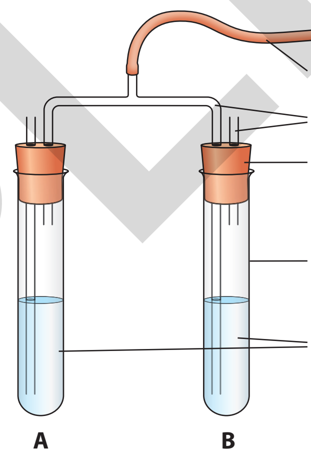
Work with a partner to do this activity.

You will need:

- rubber tubing
- glass tubing
- rubber bung
- test tube
- limewater

Safety

It is very important that the rubber tubing is perfectly clean before you use it.



Method

1 Look carefully at the apparatus.

Starting with the rubber tubing, follow the glass tube as it branches into the two test tubes.

What is different about the glass tubing that goes into test tube **A** and test tube **B**?

2 Now think about what might happen if you gently blow down the rubber tube.

Predict the tube in which you think bubbles will appear. Why do you think that?

3 Gently blow into the rubber tubing, until bubbles appear in one of the tubes. Was your prediction correct?

4 Now think about what might happen if you gently suck the rubber tube. Try it. Was your prediction correct?

5 Put your mouth over the end of the rubber tubing, and gently breathe in and out. Bubbles will appear in one tube as you breathe out, and in the other tube as you breathe in. Your partner will check the bubbles and can tell you if you are doing it correctly.

Be careful – don't suck too hard! Limewater is not poisonous, but it is not a good idea to get it into your mouth.

6 Continue until the limewater in one of the tubes has gone cloudy. Make a note of which tube it is.

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Continued

Questions

1 The air that you breathe out is called **expired air**.
In which tube did your expired air bubble through the limewater?

2 The air that you breathe in is called **inspired air**.
In which tube did your inspired air bubble through the limewater?

3 In which tube did the limewater go cloudy first?

4 Name the gas that makes limewater go cloudy.

5 Copy and complete these sentences. Use some of these words:

A B expired inspired less more

The limewater went cloudy first in tube ….

This is the limewater that … air bubbles through.

Our results show that expired air contains … carbon dioxide than inspired air.

Self-assessment

Think about how you did the experiment.

Copy each statement, and then draw a face next to each one according to how well you think you performed.

I think I did this really well.

I did OK, but I could probably do better.

I didn't do this very well at all.

- I worked out which tube the air would go into when I breathed in and when I breathed out.
- I managed to breathe in and out with just the right force to make the air bubble through the limewater.
- I stopped as soon as the limewater in one of the tubes went cloudy.
- I understand what this experiment shows about how much carbon dioxide there is in inspired air and expired air.

Is there anything that you would do differently if you did this experiment again?

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Summary checklist

- [ ] I can describe how oxygen gets into my blood from the air, and carbon dioxide goes the other way.
- [ ] I can explain why it is better to have lots of very small air sacs in the lungs, rather than a few big ones.
- [ ] I can describe how to do an experiment to compare how much carbon dioxide there is in inspired air and expired air.

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1.3 Breathing

In this topic you will:

- measure how much air you can push out of your lungs in one breath
- learn how the muscles between your ribs and your diaphragm move air into and out of the lungs

Getting started

On your own, answer each of these questions.

- What is gas exchange?
- Where does gas exchange happen in your body?
- Does the air you breathe in contain more or less oxygen than the air you breathe out?
- Is there any carbon dioxide in the air you breathe in?
- Do you think there is any oxygen in the air you breathe out?

KEY WORDS

breathing

contract

relax

How much air do you use?

Think like a scientist

Measuring the volume of air you can push out of your lungs

How much air do you think you can push out of your lungs in one breath? In this experiment, you will use some very simple apparatus to find out.

You will need:

- plastic bottle
- measuring cylinder
- bendy tubing
- marker pen
- water
- big bowl

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Safety

The bottle and bendy tubing must be really clean, and all the water you use must be safe to drink.

You may get water on the floor as you do your experiment. Take care not to slip in it.

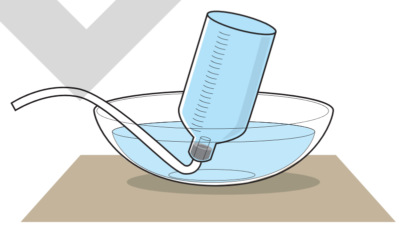
Method

1 You are going to use the plastic bottle to measure volumes.

In your group of three, discuss how you can use the measuring cylinder to mark a scale on the plastic bottle.

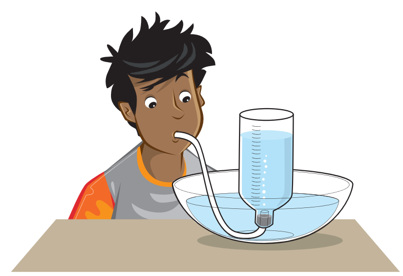
Then mark the scale on the bottle. The scale should go all the way from the bottom to the top of the bottle.

2 Fill the bottle right to the top with water. Put the lid on.



3 Pour water into the big bowl until it is about half full. Turn the bottle upside down, and hold it in the bowl. Very carefully take the lid off the bottle. You should find that all the water stays in the bottle.

4 Carefully slide the bendy tubing into the top of the bottle, under water.



5 Take a deep breath in, then put your mouth over the tubing and breathe out as much air as you can through the tubing. Your expired air will push out some water from the bottle.

Use the scale that you drew on the bottle to record the volume of air you breathed out.

6 If you have time, repeat steps 2 to 5 two more times. Use your three results to calculate a mean value for the volume of air you can breathe out of your lungs.

7 Replace the tubing with another piece of clean tubing. Now another person in your group can try the experiment.

8 Record all of your results in a table.

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Continued

Questions

1 Share your results with the rest of the class. Can you see any patterns in the results? For example:

- Do you think that the volume of air a person can breathe out is related to their size?
- If there is anyone in your class who plays a wind instrument, does this seem to have an effect on how much air they can breathe out?

2 Plan an experiment to investigate this hypothesis:

> People who play the trombone can breathe out more air in one breath than people who play the violin.

Activity 1.3.1

What happens when you breathe in?

Sit quietly for a moment. Shut your eyes and think about your **breathing**.

Put a hand just underneath your ribs. Take a deep breath in. You may be able to feel your ribs moving upwards. You might also be able to feel something moving inwards as you breathe.

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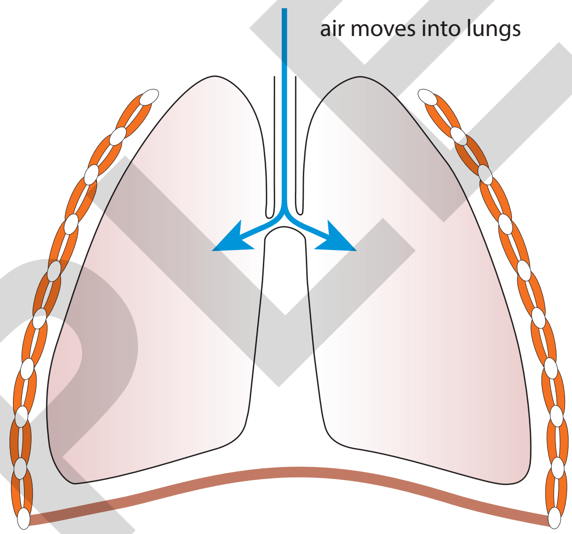
Breathing

Look at Figure **1.1.2** The human respiratory system, in Topic 8.1. Find the ribs, and the intercostal muscles between them. Find the diaphragm. Remember that air is a gas. The pressure of a gas increases when the volume of its container is decreased. You can find more about pressure in Topic 3.6 Pressure in liquids and gases.

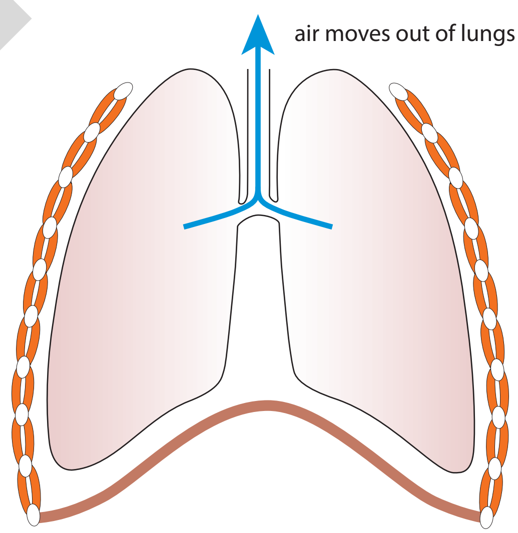
When you breathe in, these things happen:

- The intercostal muscles between the ribs **contract** (get shorter). This pulls the ribs upwards and outwards.
- The muscles in the diaphragm contract. This pulls the diaphragm downwards.
- These two movements make more space inside the chest cavity. They increase the volume inside it.
- When the volume increases, the pressure inside the chest cavity and lungs decreases.
- Air moves down through the trachea into the lungs, to fill the extra space.



When you breathe out, these things happen:

- The intercostal muscles between the ribs **relax** (return to normal size). This allow the ribs to drop down into their natural position.
- The muscles in the diaphragm relax. This allows the diaphragm to become its normal, domed shape.
- These two movements make less space inside the chest cavity. They decrease the volume inside it.
- When the volume decreases, the pressure increases. So air is squeezed out of the lungs.



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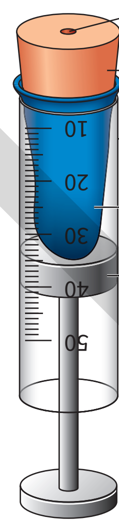
Think like a scientist

Using a model to represent breathing movements.

You will need:

- rubber bung • syringe with end cut off • balloon • plunger



1 Carefully and steadily, pull the plunger of the syringe out. Note what happens.

2 Now push the plunger back in again. Note what happens.

3 Which parts of the model represent these structures in the body?

- the lungs
- the trachea
- the diaphragm
- the rib cage

4 Explain why the balloon inflates when you pull the plunger out.

5 Explain how pulling the plunger out represents what happens in your body when you breathe in.

6 Describe **one** way in which this model does not completely represent what happens when you breathe in.

Questions

1 Copy and complete this table.

Use these words:

contract relax

Action	What do the diaphragm muscles do?	What do the intercostal muscles do?
Breathing in		
Breathing out		

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2 Copy and complete these sentences.

Use these words:

decrease   increase   into   out of

When we breathe in, the muscles in the diaphragm and between the ribs … the volume of the chest. This makes air move … the lungs.

When we breathe out, the muscles in the diaphragm and between the ribs … the volume of the chest. This makes air move … the lungs.

Summary checklist

- [ ] I can use a measuring cylinder to make a volume scale on a bottle.
- [ ] I can do an experiment to measure the volume of air I can breathe out in one breath.
- [ ] I can describe how the diaphragm and intercostal muscles cause breathing movements.
- [ ] I can explain how these breathing movements make air move into and out of the lungs.

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1.4 Respiration

In this topic you will:

- find out how every living cell gets the energy it needs to stay alive
- do an experiment to investigate how, in respiration, some energy is released as heat
- think about the difference between breathing and respiration

Getting started

Think back to Stage 7, which discussed energy.

With a partner, think about this question:

What has to happen to energy, in order to make something happen?

Can you give some examples?

Be ready to share your ideas.

KEY WORDS

glucose

mitochondria

Using energy to stay alive

Our bodies need energy for many different reasons. For example:

		
We use energy when we move around.	We use energy to send electrical impulses along neurones.	We use energy to keep our bodies warm when it is cold.

All of our energy comes from the food that we eat. Carbohydrates are especially good for giving us energy.

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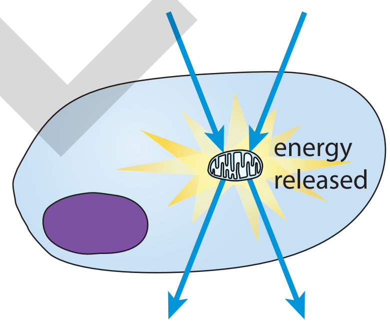
When we eat food containing carbohydrates, our digestive system breaks the carbohydrates down to a kind of sugar called **glucose**. The glucose goes into our blood. The blood delivers glucose to every cell in the body. The cells use the glucose to get the energy that they need.

Releasing energy from glucose

As discussed in Stage 7, energy must be changed from one type to another, or be transferred, in order to do something.

The energy in glucose is locked up inside it. Glucose is an energy store. Before your cells can use the energy, it has to be released from the glucose.

This is done by tiny structures called **mitochondria** that are found inside cells. Most cells have many mitochondria inside them. Mitochondria release energy from glucose, so that the cells can use the energy.



The mitochondria carry out a chemical reaction called **aerobic respiration**. Aerobic means that is uses oxygen, from the air. Here is the word equation for aerobic respiration:

glucose + oxygen → carbon dioxide + water

In this reaction, some of the energy inside the glucose is released. This is done in a very controlled way. Just a little bit of energy is released at a time – just enough for the cell's needs.

Questions

1 Neurones contain more mitochondria than cheek cells. Suggest why.

2 Look at the word equation for aerobic respiration.

a What are the reactants in this reaction?

b What are the products of this reaction?

3 Use the equation for aerobic respiration to explain why the air that you breathe out contains more carbon dioxide than the air that you breathe in.

Respiration and heat production

As discussed in Stage 7, every time energy is transferred, or transformed, some of it is changed to heat energy.

In respiration, chemical energy stored in glucose is transferred to other substances, so that cells can use it. In this process, some of the energy is changed to heat energy. So respiring cells get a little bit warmer than their surroundings.

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Think like a scientist

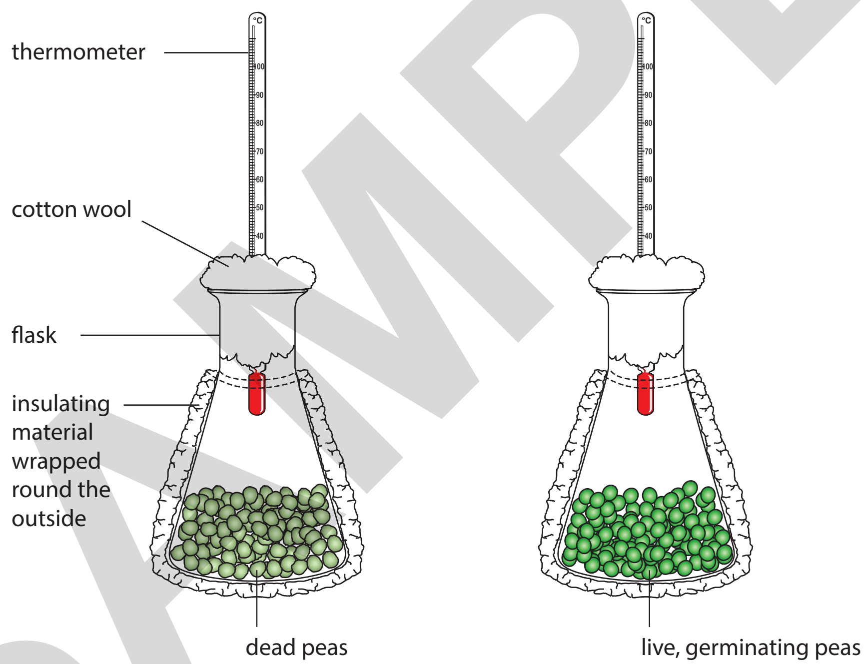
Investigating respiration in peas

All living things need energy. So all living things respire. Even seeds respire.

Seeds respire especially quickly when they are germinating, because they need a lot of energy to do this. You can make pea seeds start to germinate by soaking them in water for about an hour.

You will need:

- thermometer
- cotton wool
- flask
- insulating material wrapped round the outside
- dead peas
- live, germinating peas



Method

1 Set up your apparatus as shown in the diagram. Take care to make everything exactly the same in each piece of apparatus. The only difference is that one flask contains dead peas, and the other flask contains live, germinating peas.

2 Measure the temperature inside each flask. Record it in a results chart.

3 Continue to measure and record the temperature at regular intervals. For example, you could do this every hour during the school day.

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Continued

4 Display your results as a line graph.

- Put time in hours on the horizontal axis.
- Put temperature in °C on the vertical axis.
- Plot the points for the live peas as neat crosses.
- Plot the points for the dead peas as dots with a circle around them.
- Join the points for each set of peas with ruled, straight lines between the points.

Questions

1 What was the variable that you changed in this experiment?

2 Which variables did you keep the same?

3 Which variable did you measure?

4 Suggest an explanation for your results.

5 If you did the experiment again, would you expect your results to be exactly the same? Explain your answer.

6 Suggest any improvements you would make to your experiment, if you were able to do it again. Explain why each of your suggestions would improve your experiment.

Activity 1.4.1

Thinking about a thermogram

The photograph in Figure 1.4.1 is a thermogram of a woman working at her computer.

The colours on the photograph show the temperatures of the different objects.

In a group of three, think about the photograph, and discuss these questions. Be ready to share your ideas.

1 Which object in the photograph has the highest temperature? Can you suggest why?

2 What is the approximate temperature of most of the woman's body?

3 Explain why the woman's body has a higher temperature than the chair she is sitting on.

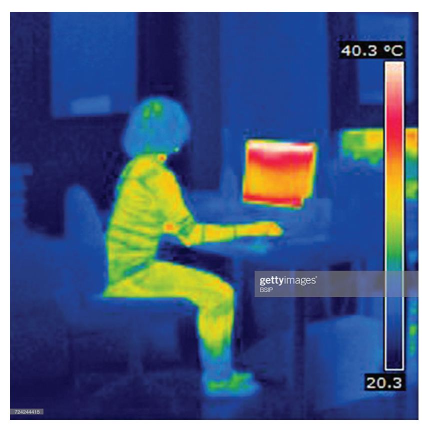

Figure 1.4.1: A thermogram of a woman working at her computer

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Activity 1.4.2

Explaining the difference between breathing and respiration

Many people who have not studied science think that respiration and breathing mean the same thing.

In your group of three, think about the meanings of these two words. (Look at Topic 1.3 to remind yourself about breathing.) Think of a good way of explaining the differences between respiration and breathing, to someone else.

Choose one of these methods to give your explanation:

- making a poster
- producing a slide presentation
- giving an illustrated talk.

Decide how to share the tasks between you, and then work on your explanation.

Self assessment

How well did you do each of these things as you worked on this activity?

- I made sure that I really understood the difference between breathing and respiration.
- I helped to decide which method we would use to give our explanation.
- I carried out my part of the task really well.
- I helped others in my group to carry out their tasks.
- I discussed what I was doing with the others in my group.
- I think that our explanation helped other people to understand the difference between breathing and respiration.

In the activity, you had to work out for yourself how to explain the difference between breathing and respiration.

Do you think this helped you to understand the difference yourself? Or would it have been better just to be told the difference by your teacher?

Why do you think that?

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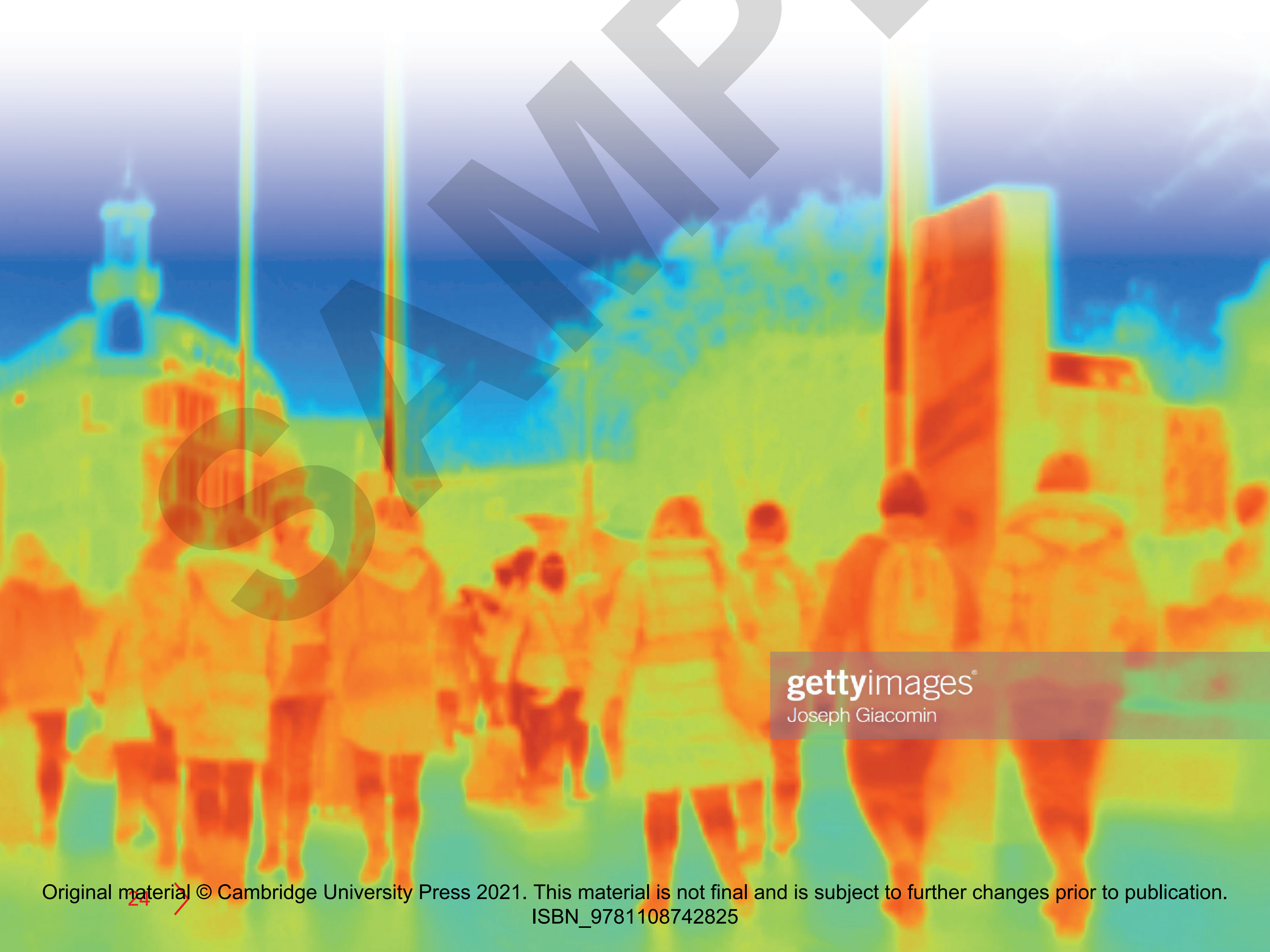
Summary checklist

- [ ] I can explain that respiration is a chemical reaction that releases useful energy from glucose, in a controlled way.
- [ ] I can write the word equation for respiration.
- [ ] I can state that respiration happens inside every living cell.
- [ ] I can state that aerobic respiration uses oxygen, and happens inside mitochondria.
- [ ] I can explain the difference between breathing and respiration.



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1.5 Blood

In this topic you will:

- learn about the structure of blood
- find out about the functions of red blood cells, white blood cells and blood plasma.

Getting started

With a partner, think about these questions.

- What do red blood cells look like?
- What is the function of a red blood cell?
- How do the features of red blood cells help them to perform this function?

Be ready to share your ideas.

KEY WORDS

antibodies
blood plasma
oxyhaemoglobin
pathogens
phagocytosis
red blood cells
white blood cells

Delivering the requirements for respiration in cells

You have seen that all of your cells need energy to stay alive. Each cell gets its energy through a chemical reaction called respiration.

Aerobic respiration happens inside the mitochondria in the cells. The reactants are glucose and oxygen:

$$\text{glucose} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{water}$$

So, every cell in your body needs a good supply of glucose and oxygen, and the carbon dioxide and water that the cell makes must be taken away. The delivery and removal is done by the blood.

The blood moves around the body inside blood vessels. The heart pumps constantly, to keep the blood moving.

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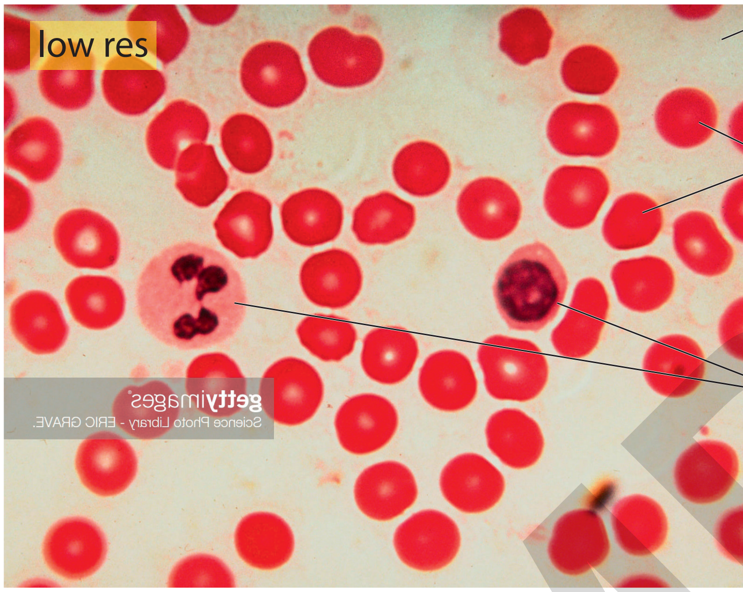
What is blood?

Everyone knows that blood is a red liquid. But if you are able to look at some blood through a microscope, you may get a surprise. The photograph in Figure 1.5.1 shows what you might see.



This is the liquid part of the blood. This liquid is called **blood plasma**You can see that it is not red at all. It is a very, very pale yellow.

Blood looks red because it contains a lot of **red blood cells**, which float in this liquid. Most of the cells in our blood are red blood cells. An adult person has at least 20 trillion red blood cells in their body. There are about five million of them in every $1\,cm^3$ of your blood.

These are called **white blood cells**. There are not many of them, but they may be quite a lot bigger than the red blood cells. They don't look white in the photograph because a stain has been added to the blood, to make the cells show up more clearly. The dark purple areas in these cells are their nuclei. (Red blood cells don't have nuclei!)

Figure 1.5.1: Blood viewed through a microscope

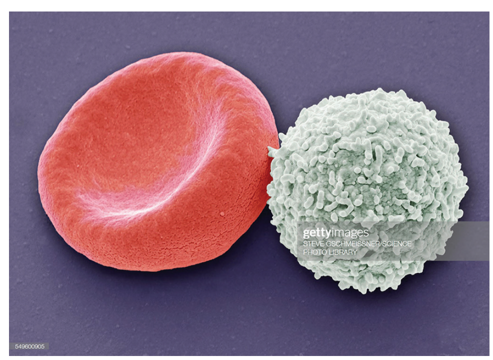
Questions

1 Look at the photograph in Figure 1.5.1.

Approximately how many times more red blood cells are there than white blood cells?

2 The photograph in Figure 1.5.1 was taken with a powerful electron microscope.

What differences can you see between the red blood cell and the white blood cell?



A red blood cell and a white blood cell

Plasma

Plasma is the liquid part of blood. It is mostly water. The red and white blood cells are transported around the body in the blood plasma. Plasma also has many other different substances dissolved in it. For example, glucose, dissolved in blood plasma, is transported from the digestive system to every cell.

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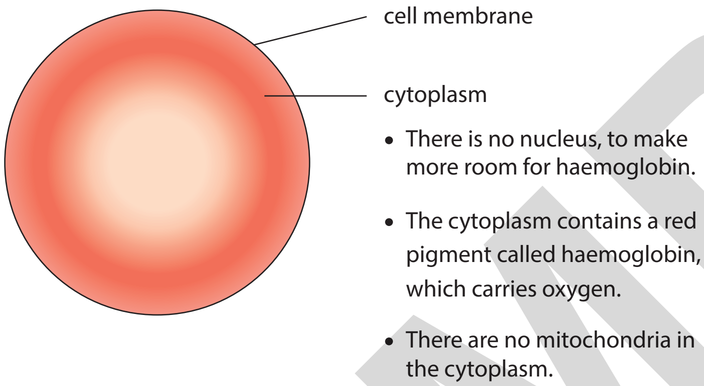
You will remember that carbon dioxide is produced in every body cell, by respiration. The carbon dioxide dissolves in blood plasma and is carried away from the cells. The blood takes it to the lungs, where the carbon dioxide diffuses out and is breathed out in your expired air.

Red blood cells

Stage 7, Topic 1.3 described how the structure of red blood cells is related to their function. Now you are going to think about this in a little bit more detail.

Red blood cells are very unusual cells. They do not have a nuclei and they do not have mitochondria. They are full of a red pigment called **haemoglobin**. It is haemoglobin that makes blood look red. Think about why they have such a strange structure.



A red blood cell

The haemoglobin helps the red blood cells to transport oxygen.

- As the blood flows through the tiny capillaries next to the alveoli in the lungs, oxygen from the air diffuses into the blood, and into the red blood cells.
- Inside the red blood cell, the oxygen combines with haemoglobin. It forms a very bright red compound called **oxyhaemoglobin**.
- As the blood continues on its journey around the body, it passes cells that are respiring. The oxyhaemoglobin lets go of its oxygen and gives it to the cells.
- The blood, which has given away most of its oxygen, now travels back to the lungs to collect some more.

This explains why red blood cells have haemoglobin – but why don't they have nuclei or mitochondria? Scientists think that not having a nucleus makes more space for haemoglobin. They also think that not having mitochondria stops the red blood cells from using up all the oxygen for themselves, instead of delivering it elsewhere.

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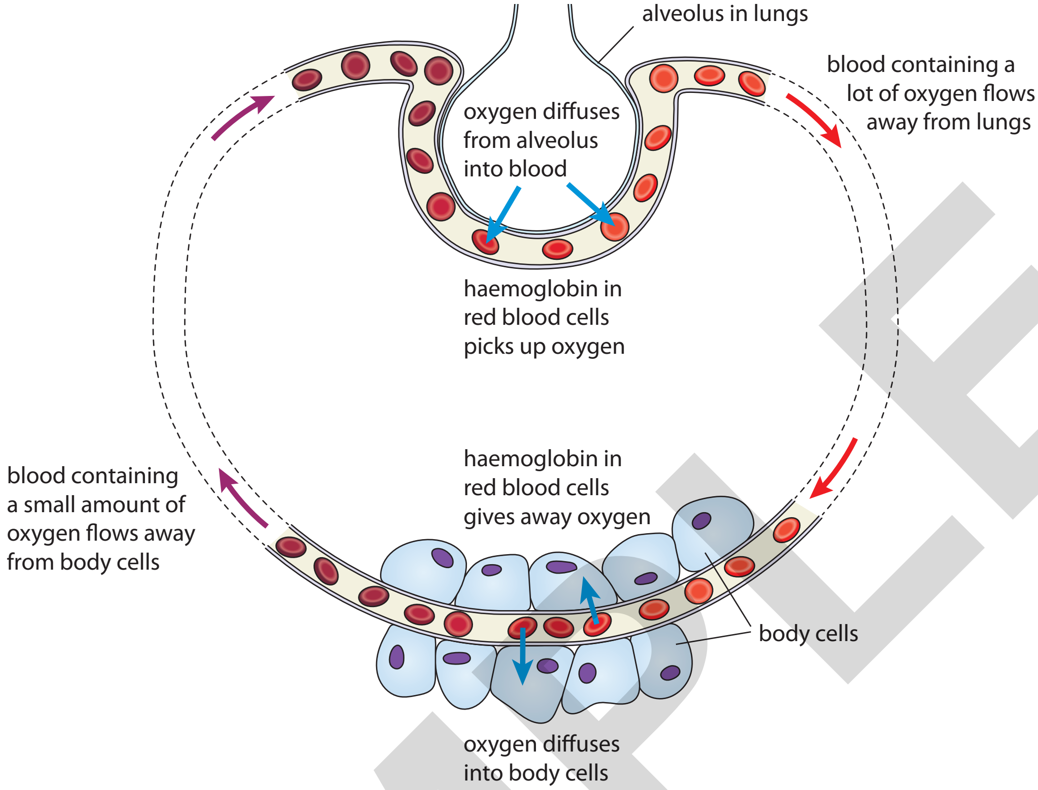

How oxygen is transported around the body

Another way in which red blood cells are adapted for their function is that they are quite a lot smaller than most cells in the body. Being so small helps them to get through very tiny blood capillaries. This means they can get really close to the alveoli in the lungs, and to the respiring cells in other parts of the body.

Question

3 Explain why red blood cells might use up oxygen, if they have mitochondria.

White blood cells

White blood cells are easy to distinguish from red blood cells. They always have nuclei, which red blood cells do not have. Some kinds of white blood cell – but not all – are larger than red blood cells.

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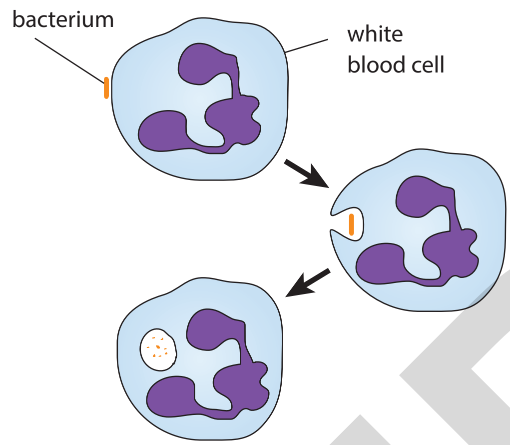
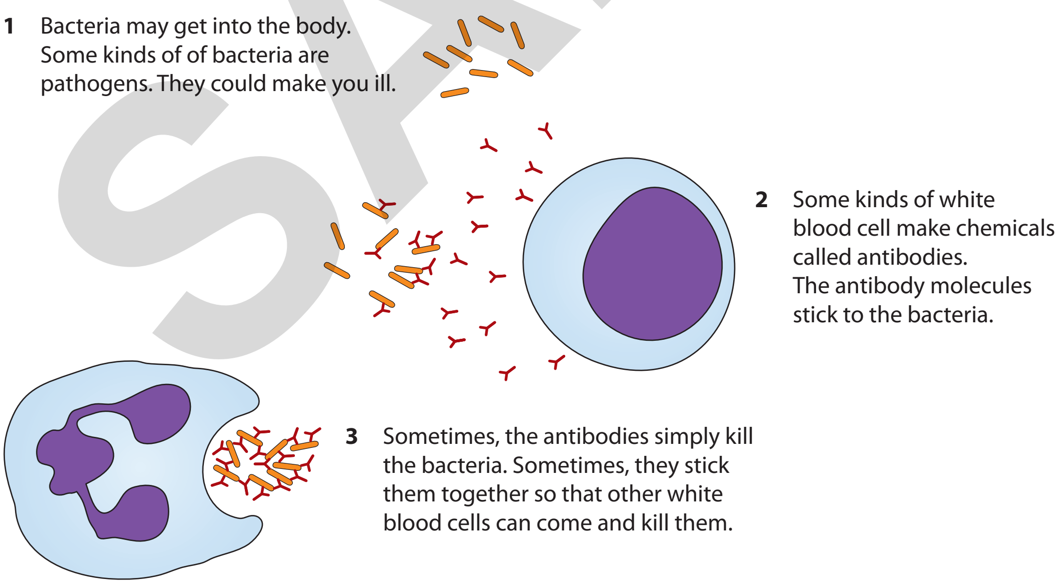
Some bacteria and viruses can cause illness when they get into the body. These bacteria and viruses are called **pathogens**. White blood cells help to defend us against pathogens.

Some kinds of white blood cell can change their shape, and push their cytoplasm out to make ‘fingers’ that can capture a bacterium. The white blood cell then produces chemicals that kill and digest the bacterium. This is called **phagocytosis**.



Other types of white blood cell produce chemicals that kill pathogens. These chemicals are called **antibodies**. Different kinds of antibodies are needed for each different kind of pathogen.

The antibodies stick onto the pathogen. Sometimes, they kill the pathogen directly. Sometimes, they glue lots of the pathogens together so that they cannot move. This makes it easy for other white blood cells to capture and kill the pathogens.



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Activity 1.5.1

Making a picture of blood

You are going to make a picture of some blood, as it might look if you saw it through a microscope. Work as a pair, or in a small group.

You will need:

- a sheet of plain paper
- some red card
- some white card
- scissors
- glue

Method

1 Use the red card to make some red blood cells. Think about how many you need to make.

2 Use the white card to make some white blood cells. Use a pen or pencil to draw a nucleus in each one. Think about how many you need to make.

3 Stick the red blood cells and white blood cells onto the white paper. The white paper can represent the blood plasma.

4 Write labels to stick onto the paper. Remember to label the blood plasma.

Question

4 Copy and complete this table.

Component of blood	Appearance	Function
red blood cell		
white blood cell		
plasma		

Summary checklist

- [ ] I can describe what blood plasma is, and its function.
- [ ] I can explain how red blood cells, containing haemoglobin, transport oxygen.
- [ ] I can explain how white blood cells help to protect us against pathogens.

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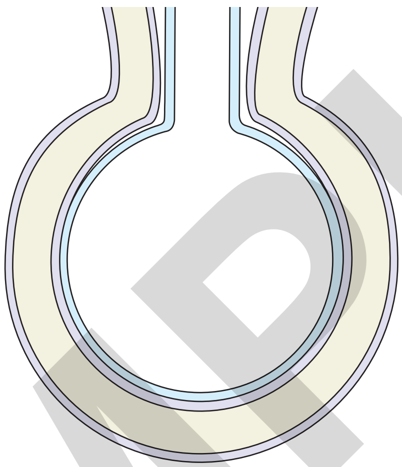
Check your progress

1 The list includes some of the structures that air passes through, as it moves from outside the body to the place where gas exchange happens.

Write the structures in the correct order.

bronchiole **trachea** **bronchus** **alveolus (air sac)** [2]

2 The diagram shows an air sac and a blood capillary.



a Copy the diagram. Label:

- the blood capillary
- the wall of the air sac. [2]

b Draw two red blood cells in the correct place on your diagram. [1]

c Draw an arrow to show the direction in which oxygen diffuses. Label your arrow O. [1]

d Draw an arrow to show the direction in which carbon dioxide diffuses. Label your arrow C. [1]

e Describe how the red blood cells transport oxygen to all the cells in the body. [2]

3 In each of these groups of statements, only one is correct.

Choose the correct statement, and write down its letter.

a A Every living cell respires.

B Only animal cells respire.

C Respiration uses up energy. [1]

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b **A** Expired (breathed out) air contains only carbon dioxide.

B Expired air contains more carbon dioxide than inspired (breathed in) air.

C Expired air contains more oxygen than inspired air. **[1]**

c **A** Respiration means using your diaphragm to move air into the lungs.

B Respiration is the diffusion of gases between the air sacs and the blood.

C Respiration is a chemical reaction that releases useful energy from glucose. **[1]**

d **A** Muscles in the lungs contract to make air move into them.

B The diaphragm muscles contract to move air into the lungs.

C Muscles between the ribs pull them downwards when we breathe in. **[1]**

4 The diagrams show two blood cells.

a Copy the drawing of the red blood cell. Label the cell membrane and cytoplasm. **[1]**

b Name **two** structures that most cells have, but that red blood cells do not have. **[2]**

c The white blood cell kills pathogens by phagocytosis. Describe how it does this. **[2]**

d Other kinds of white blood cell have a different way of killing pathogens. Explain how they do this. **[3]**

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Project: Helping white blood cells to protect us from pathogens

This project is about how scientific knowledge develops over time, and how scientific discoveries can help people all over the world.

Background

Our white blood cells are amazing at keeping us safe from pathogens. Most of the time, they manage to destroy the pathogens so that we recover quickly from an infection.

But there are some pathogens that white blood cells cannot destroy in time. The virus that causes rabies is one of these. If the rabies virus gets into a person's body, the body needs outside help in order to stop the virus spreading. Without treatment, most people die if they are infected with the rabies virus.

Your task

You are going to work in a group to find out information about rabies, and how it can be successfully treated. Each group will work on a different topic.

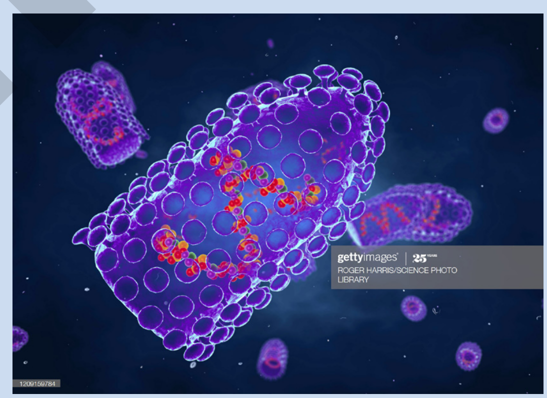
Choose **one or two** of these topics to research with your group. Also choose how you will present your findings to others. You could make a poster, or give an illustrated talk.

Discovering what causes rabies

Who first discovered the cause of rabies, and when did they do this?

First vaccine for rabies

Who created the first vaccine for rabies, and how did they do this?



How rabies is transmitted

How can a person be infected with rabies?

Preventing rabies

In which countries is rabies most common? What can people in these countries do to reduce the risk of getting rabies?

Treatment for rabies

What should someone do if they have been bitten by an animal with rabies? How do rabies vaccines help our white blood cells to fight the virus?

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