Staying alive

Emergency

Beth isn’t breathing and her heart has stopped beating. She’s having a heart attack. The paramedics are trying to save her. One squeezes air into her lungs. Another presses and releases her chest. This pushes blood around her body until they can restart her heart.

Someone has a heart attack every 2 minutes in the UK. Heart attacks cause 1 in 5 deaths.

1. Beth’s heart stopped. Why is that serious?

Cut off from supplies

Your heart can beat 100,000 times a day. Each heartbeat pumps blood to every part of your body.

Your cells need energy to stay alive and they get it from glucose and oxygen. Blood collects glucose from digested food and oxygen from your lungs. It delivers the glucose and oxygen to every cell.

Heart muscles work together to pump blood. The muscles are made of cells. Beth’s heart attack started when some of these muscle cells ran out of energy and stopped working. The blood vessel that supplied them was blocked by a blood clot. The cells didn’t get any oxygen so they died.

Beth was lucky. Her heart restarted. It wasn’t too badly damaged. 50% of heart attack victims live for another 10 years.

2. Why do cells need a good blood supply?

3. What happens during a heart attack?

Struck down

Jo’s left arm is paralysed. She had a stroke. A clot blocked a blood vessel in her brain, and the nerve cells there that made her arm move died. The physiotherapist is helping her to get some movement back.

In the UK, somebody has a stroke every 4 minutes.

4. How is a stroke similar to a heart attack?

Learn about

- Respiration in cells
- The role of blood

Staying alive

Cells can’t store energy. They release it when they need it using a chemical reaction called respiration. Glucose from your food reacts with oxygen from your lungs.

Your blood takes the waste products away. You breathe out carbon dioxide through your lungs and any water your body doesn’t need goes into your urine.

5. What gets used up during respiration?

6. Why do you breathe out more carbon dioxide than you breathe in?

Your cells use the energy from respiration to keep you warm, stay alive, grow and repair themselves. Some cells use energy for movement.

7. List four things muscle cells need energy for.

How do we know that living things respire?

The diagram shows a rat in a jar. No carbon dioxide enters the rat’s jar, but air from the jar turns limewater cloudy. This shows it has carbon dioxide in it.

The limewater stays clear when a control experiment is done with an empty jar.

8. What evidence is there that the rat is respiring?

9. Why is it important to do a control experiment?

Respiration and burning

The equations for respiration and for burning glucose are the same. Both processes turn a fuel (glucose) and oxygen into carbon dioxide and water, and they both release energy. But cells control the energy release so they don’t get hot.

10. What is the same about burning glucose and respiration?

Summing up

11. Are heart attacks and strokes always fatal?

12. Why does respiration take place in every cell?

13. When you do something very active like running, more blood flows to your leg muscles. Explain why.

14. How can you prove that a living thing is respiring?
Champion lungs

In 2007 Tom Sietas broke the Guinness World Record for holding his breath under water. He lasted 15 minutes. Don’t try this at home!

Tom filled his lungs with pure oxygen. He kept very still. The cold water made his heart beat more slowly and cut the blood supply to his arms and legs. That saved oxygen for his heart and brain.

1. Why do all your tissues need oxygen?

Swapping gases

Are you sitting still? If so, you’re probably taking about 15 breaths per minute. Each breath draws fresh air into your lungs. As your blood passes through them its red blood cells fill up with oxygen.

At the same time, carbon dioxide from respiring cells moves from your blood to the air. The blood swaps, or exchanges, its waste carbon dioxide gas for oxygen gas – so the process is called gas exchange.

When your cells need more oxygen you breathe faster to take in more air, and your heart rate increases to push blood through your lungs more quickly.

2. What happens to the blood in your lungs?

Sponges full of blood

Your lungs are soft and spongy. The ribs surround them and protect them from damage.

When you breathe in, muscles make your chest bigger to draw air in through your mouth and nose. When the muscles relax your chest springs back to its normal size, and air is pushed out.

3. Where in your body are your lungs?

4. How do muscles make you breathe in?

Millions of branches

Your windpipe comes down from your nose and mouth, divides into two and keeps dividing to form millions of tiny branches.

At the end of each branch is a cluster of air pockets, called alveoli, surrounded by a fine network of blood vessels. The walls of the blood vessels and alveoli are so thin that gas molecules can move from one to the other easily by diffusion.

Blood pumped to the lungs from the heart is short of oxygen. It goes back to the heart full of oxygen to be pumped round the body. Blood that lacks oxygen is shown as blue in this diagram but it is really just a slightly darker red.

5. What happens to carbon dioxide as blood flows around the alveoli?

Smoke damage

Normal lungs are soft and pink, but these are a smoker’s lungs. They are thick with tar and can’t take in much oxygen.

Smoke contains hundreds of different chemicals. Some damage your lungs. Others increase your risk of having cancer, heart disease or a stroke. On average smokers live 13 years less than non-smokers.

6. List three ways cigarettes can harm you.

It’s all in the area!

You have about 300 million alveoli. If you spread out their walls they could cover a tennis court. At any moment, a quarter of a mug of blood flows over this large surface area. It is spread very thinly, so oxygen diffuses quickly to every red cell.

7. Why do lungs need a large surface area?

Summing up

8. What is the difference between breathing and respiration?

9. Why do your heart rate and breathing get faster when you run?

10. Most organs sink in water, but lungs float. Suggest why.

11. Imagine you are an oxygen molecule that has just been breathed in. Describe the route you take to get to the blood.

12. Many people think, wrongly, that blood is blue when it is short of oxygen. Why?
The heart pumps blood out to the lungs and the rest of the body.

Blood leaves the heart in arteries and returns in veins.

Capillaries deliver blood to every cell.

Oetzi died 5300 years ago but his body was preserved by ice. Now hospital scanners have revealed how he died. An arrow pierced an artery in his shoulder. Blood spurted out and he died within minutes.

Arteries are strong blood vessels. They carry blood away from your heart. Each heartbeat gives blood a hard push, so the blood in arteries is under pressure and moving fast. That’s why it spurts out so quickly if you damage one.

1. What are arteries?
2. Why does blood spurt out of a damaged artery?

Two big arteries leave your heart. One takes blood to your lungs to collect oxygen, and the other carries blood to the rest of the body. Blood carrying oxygen comes back from the lungs and the heart pushes it round the rest of the body. At the same time it pushes blood from the body towards the lungs.

On each trip round the body a single blood cell goes through the heart twice.

3. Why is your heart called a double pump?
4. You lift a heavy bag. Respiration in the muscle cells in your arms makes carbon dioxide. How does it get to your lungs?

The arteries divide again and again into smaller and smaller blood vessels. The smallest are capillaries like this one. Every cell in the body is close to a capillary. Red blood cells go through them in single file. Capillaries are so thin that small molecules like glucose and oxygen can diffuse out to the body cells around them.

Capillaries join up to form wide blood vessels called veins, which return blood to your heart. Blood travels slowly in veins. Flaps called valves act like one-way doors to stop blood flowing backwards.

Two veins enter your heart. One brings blood back from the lungs; the other brings it from the rest of the body.

When you cut yourself you have usually damaged capillaries. The bleeding soon stops. If blood flows out in a smooth stream, without a pulse, you have cut a vein.

5. What are the main differences between veins and arteries?
6. Why do the veins in your legs need valves?
7. Why is it much easier to stop blood flowing from a vein than an artery?

Around 2000 years ago, a Greek philosopher called Galen said that the heart made blood and pumped it to the tissues, where it was used up.

The idea was accepted in Europe until the 1600s when a doctor called William Harvey did experiments on living animals. He watched animals’ hearts beating. They pumped out massive amounts of blood. It could never be made that fast. He realised the same blood must keep going round and round.

Years later Syrian manuscripts were translated and Europeans realised that an Islamic doctor, Ibn al-Nafis, had written more or less the same thing 350 years before Harvey’s discoveries.

8. What made Harvey doubt Galen’s ideas?
9. Why were Ibn al-Nafis’ discoveries not known in Europe when he made them?
Nathalie is doing a fitness test. The pads on her chest monitor her heart and the tube in her mouth senses how much oxygen she is using.

Your **fitness** depends on your heart, lungs and blood vessels. The fitter you are, the more they can increase the oxygen and glucose supply to your cells and let your muscles work harder.

1. Why is blood sent to your muscles faster when you are doing more exercise?
2. Which two organs determine your fitness?

**Working harder**

Nathalie is running on a treadmill. As she works harder she breathes faster and deeper. Her heart beats so hard she can hear it thumping.

Eventually Nathalie’s heart and lungs can’t work any harder and the test ends. The table shows how her heart and lungs responded.

3. What happened to Nathalie’s heart rate during the test?
4. How was Nathalie’s oxygen intake increased during the test?

Nathalie is pleased with her results. She has only been training for a few months, but her heart is already stronger. Her resting heart rate used to be 80 beats per minute and 190 beats per minute when she started to run.

Her lower heart rate shows that she is fitter. Like any muscle, your heart gets stronger when you exercise. This means it can pump more strongly and so doesn’t need to pump so often.

To keep fit you should do something energetic for 30 minutes, 5 times a week.

5. How much exercise do you need to stay healthy?
6. How has training affected Nathalie’s heart?

Look at the graph. How much did Nathalie’s oxygen uptake change during the test?

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**Up against resistance**

Nathalie’s dad isn’t so fit. He has **plaque** in his arteries which makes them narrower. His heart has to work harder to push blood through them.

The yellow plaque in this artery is a mixture of fat, cholesterol and blood cells. Plaque starts forming when you are in your teens.

Sometimes plaque breaks away from an artery wall, a clot forms and the artery is blocked. If it leads to your heart or brain, you have a heart attack or stroke.

Fortunately, a healthy lifestyle lowers the chance of this happening.

8. What is the plaque in your arteries made from?
9. How can plaque harm your health?

The British Regional Heart Study compared 7000 people for 25 years to look for clues. Those who had heart attacks or strokes had more of these risk factors.

- smoking
- being overweight
- no exercise, unhealthy food
- high salt intake, excess alcohol
- inherited genes

Other studies show that inhaling smoke from other people’s cigarettes is also a risk factor. More young people are having heart attacks than ever before.

10. Are there any risk factors that people can’t control?
11. Suggest why more young people have heart attacks now.
12. How might a smoking ban affect the number of heart attacks?
13. Do you think that the evidence from this survey is reliable? Why?

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**Learn about**

**Fitness**

- Exercise makes your heart and lungs work harder to deliver oxygen.
- Exercise strengthens your heart muscles.
- Plaque in arteries puts a strain on your heart and can cause a blockage.

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**Get this**

- Exercise makes your heart and lungs work harder to deliver oxygen.
- Exercise strengthens your heart muscles.
- Plaque in arteries puts a strain on your heart and can cause a blockage.
Lucy isn't well. There's something wrong with her digestive system. She isn't getting enough nutrients and her doctor wants to find out why.

The pill she's taking has a camera in it. It will take 500,000 pictures as it travels through her system.

The job of the digestive system is to turn the food you eat into forms which your body can use.

Most of the food you eat, like starch, fats and proteins, is made of big complex molecules (see page 75). Digestion breaks them down into simple molecules like glucose which your body cells can use. These pass into your blood and are carried to every cell.

What happens to food in your gut?

How do nutrients like glucose get to your cells?

Lucy's saliva makes the camera slippery, so it slides down her gullet easily. Saliva also contains an enzyme. Enzymes break down large molecules into small ones. The enzyme in saliva starts to break down starch as you chew.

Give two reasons why you need saliva.

Why should you chew your food?

When it reaches Lucy's stomach the camera gets thrown around.

The stomach acts like a mixer. It blends the food with another enzyme to make a smooth paste. Then it squirts it into the small intestine.

Break down

Learning about digestion

Getting into the blood

If you unraveled your small intestine it would be four times longer than your body, so it is really not small but very big! Most large molecules get broken down in your small intestine.

Muscles around the intestine squeeze food along and mix it with more enzymes.

These finger-like villi line the inside walls. They are 1 mm tall. Like the alveoli on page 9 they have a good blood supply. If you flattened them all out you'd also see that they have a huge surface area. This is where nutrients are absorbed into the blood.

Lucy's camera showed that her villi were very short. That's why she couldn't absorb all her nutrients. The problem is caused by an allergy to wheat. She will get better when she stops eating wheat.

How is food moved through the small intestine?

How do villi help nutrients get into your blood?

Getting extra nutrients

When a meal gets to the large intestine there is nothing left of the food but fibre. You can't break fibre down, but you still need to eat it. It makes food easier to push along, so it stops you getting constipated.

This part of the gut is full of friendly bacteria. They live off the fibre and make important vitamins that we can absorb. Probiotic foods, like live yoghurt, give you extra bacteria.

The walls of the large intestine absorb water to turn the mixture of fibre and bacteria into solid waste called faeces. It is stored in the rectum until you are ready to go to the toilet.

Why do you need fibre?

Live yoghurt contains bacteria. How could it be good for you?

What do faeces contain?

Summing up

Describe the route fibre takes through your body.

Why do most foods need to be digested?

What do the enzymes in your gut do?

Where do nutrients get absorbed into the blood?

What two jobs does the large intestine do?
1.6

**Fuel and building blocks**

Terry wants to be good at his sport. He’s training hard and building muscles, so he needs to feed himself well.

Terry eats plenty of carbohydrates for energy. He also makes sure he gets enough proteins for growth and repair, but not too much fat. He knows some types of fat have been linked to heart disease.

1. What sorts of food give you energy?
2. Which nutrients do you need for growth and repair?

**Healthy choices**

Terry uses this food wheel to balance his diet. It shows him how much to eat from each food group.

Most people get protein and fat from meat, fish and dairy products, but Terry is a vegetarian. He gets proteins from beans, nuts and cereals, and he gets fats from vegetable oils.

Terry eats bread and pasta but most of his carbohydrates come from fresh fruit and vegetables. That way he knows he will get the vitamins, minerals and fibre he needs.

3. Name four different sources of protein.
4. What sorts of food give you carbohydrates?
5. Why is it important to eat a variety of different foods?

**Vitamins and minerals**

You only need small amounts of vitamins and minerals. But if you don’t get enough it can affect your health. These are some of the most important ones, and the symptoms you can get if they are missing.

Too much can also be a bad thing. Most people get too much of one mineral – salt. It can increase their risk of having high blood pressure, a heart attack or a stroke.

6. Ben slipped over and broke his leg. What could have made his bones so brittle?

<table>
<thead>
<tr>
<th>Vitamin or mineral</th>
<th>Possible symptoms if missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Blindness</td>
</tr>
<tr>
<td>B group</td>
<td>exhaustion, depression</td>
</tr>
<tr>
<td>C</td>
<td>bleeding gums</td>
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<tr>
<td>D</td>
<td>weak bones</td>
</tr>
<tr>
<td>Calcium</td>
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</tr>
<tr>
<td>Iron</td>
<td>exhaustion</td>
</tr>
<tr>
<td>Potassium</td>
<td>heart failure</td>
</tr>
</tbody>
</table>

**Topping up your blood sugar**

The carbohydrates you eat come in two different forms. There are starches with big molecules and sugars, like glucose, with small ones (see page 14). Digestion breaks down starch to glucose.

Glucose doesn’t need digesting, so it passes straight into your blood. Cells can use it for respiration straight away. But a quick burst of energy leaves you feeling tired later. Starch digests slowly so it releases less glucose at a time over a longer period.

Spare glucose molecules are stored in your muscles and liver until you need them. When these stores are full the rest is converted to fat.

7. How is glucose different from starch?
8. What happens if you eat more carbohydrates than you need?

**Building with proteins**

Your whole body is made of proteins. Proteins are long molecules made of chains of amino acids. When they break down in your gut, the amino acids separate. There are 20 different ones. Cells join them in different combinations to make every protein they need. It’s a bit like building thousands of different models with just 20 different types of Lego brick.

9. How does your body build the proteins it needs for growth and repair?

**Summing up**

10. List the nutrients a healthy diet must contain. Say what each is used for and name one type of food it is found in.
11. Plant proteins are very different from human proteins. Explain why that does not matter.
12. Why is it good to eat starchy foods for breakfast?
13. You can manage for weeks without food if you need to. Explain how.
How Science Works

Favourite foods

Think of your favourite food. Is it chips, pizza, chocolate or ice cream? If it is you are in good company. We inherit a taste for sweet, fatty foods. They make us relax.

Everyone except babies also likes the taste of salt. Sugar and salt are plentiful now but were hard for our ancestors to find. These cravings helped them survive by making them search for salt deposits and foods packed with energy.

Bitter foods have the opposite effect. They make you want to spit them out. Most poisonous plants taste bitter, so that’s useful.

You learn what not to eat quickly. If you are sick soon after you’ve eaten something, it puts you off that food for life.

What tastes do newborns prefer?

Why is it useful if harmful foods make you feel bad?

Learning from others

Juan loves red hot chilli peppers. He couldn’t stand them when he was young but his parents kept giving him a taste and he soon learned to like them.

Most people won’t eat eyeballs, testicles (testes) or caterpillars – even though they are packed with nutrients. But people from some cultures learn to find these tasty.

You often grow to like things you see other people eating. Advertisers know this so they show foods being eaten by people you admire.

Most people hate the taste of coffee when they first taste it. Why do they end up liking it?

Why are famous footballers used in adverts for snacks that students might buy?

Convenience

Carl feels hungry. His parents are out and there’s nothing in the house to eat – only stuff that needs cooking. He can’t face walking to the supermarket, so he gets a takeaway, or some chocolate. The sugar and fat in them makes him feel good, and it’s the easiest option.

Describe one thing that might stop you eating healthily.

1. What tastes do newborns prefer?
2. Why is it useful if harmful foods make you feel bad?
3. Most people hate the taste of coffee when they first taste it. Why do they end up liking it?
4. Why are famous footballers used in adverts for snacks that students might buy?
5. Describe one thing that might stop you eating healthily.

Shopping

Psychologists study how and why we do what we do. They find that shoppers subconsciously balance the nutrient content of food against:

- what their families like
- taste
- convenience
- value for money.

Families are buying more ready meals and less fresh foods – especially for teenagers. These can contain large amounts of sugar, salt or saturated fats. The Food Standards Agency recommends that traffic light labelling is used on all processed foods so we can see what’s in them at a glance.

How do people decide which foods to buy?

Why are some convenience foods bad for you?

Why was the traffic light labelling system introduced?

Making good health easier

In 2006, one-quarter of UK adults were obese.

Psychologists say the only way to prevent obesity is to make fatty and sugary foods harder to buy, and get people to take more exercise.

Schools make everyone do at least two hours of physical activity per week and many new offices make adults use the stairs instead of the lift.

On average people eat less now than they used to. Suggest why more people have become obese.

Why is exercise one of the best ways of keeping weight under control?

Health authorities want you to choose a healthy balanced diet and keep fit. Then you will avoid the risk factors that make heart disease, strokes and cancer more common.

Get this

- We are born with a taste for sweet, fatty foods.
- We learn to prefer what those around us eat.
- Convenience plays a big part in deciding what we eat.