I tried to fix it with superglue, but 'super' glue rarely lives up to its name. I resorted to taping the broken bits together, but it looked ugly and the blade wobbled when it spun. Frustrated, I smashed it on the ground. And there, among its entrails, I found something more exciting to play with.

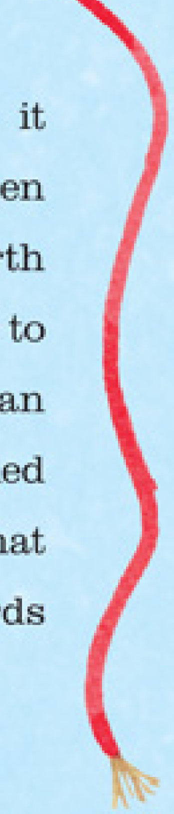
How I became a Scientist

My mother once bought me a battery-operated helicopter from the local street market — a cheap plastic thing, bright yellow with flimsy white rotor blades that spun when a small red switch was flicked. It didn't actually fly, but to a young boy recently arrived in Britain from a Bangladeshi village with no electricity or running water, it was enchanting.

Such treats were a rare thing in my family and I walked home from the market that day bursting with joy. But within minutes of taking the helicopter out of its box and playing with it, I snapped one of the rotor blades off in my hands.

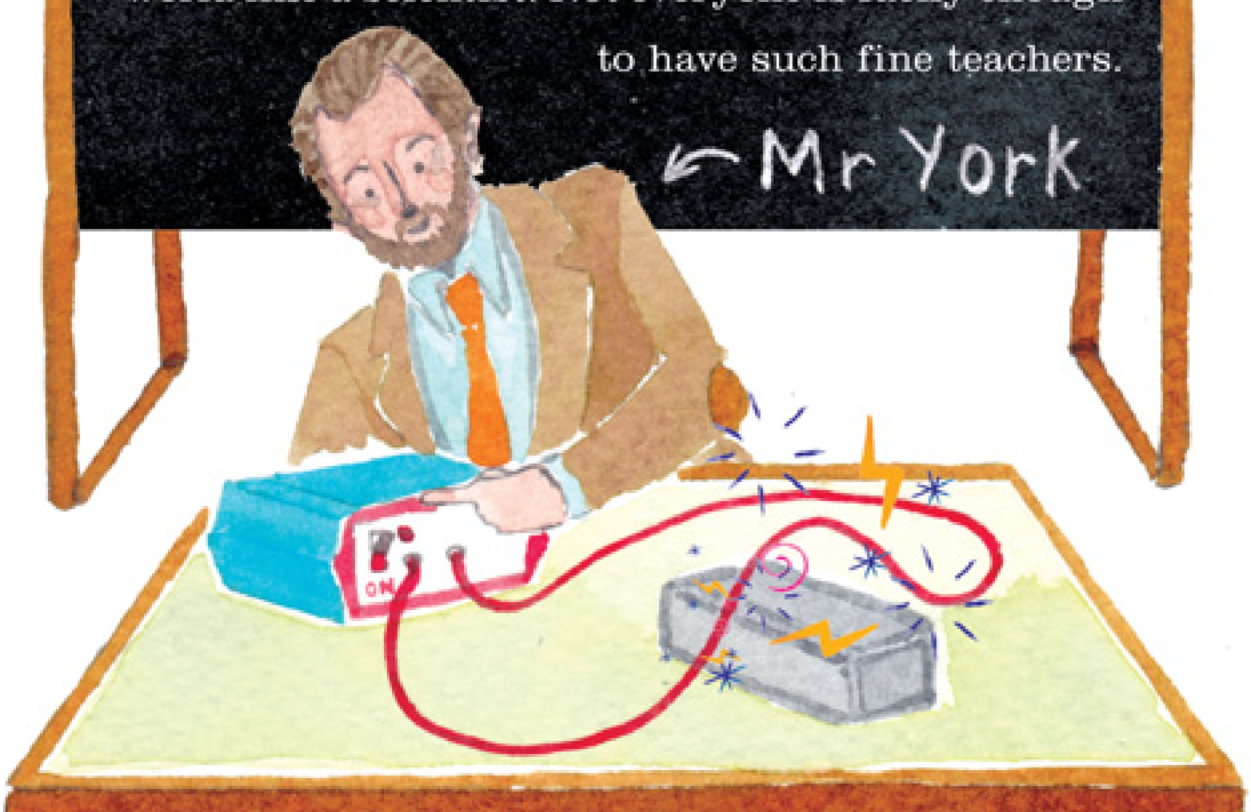
The motor inside was a silver metal cylinder, flat on one end with a spindle sticking out of the other. It had evidently been attached to the helicopter's blades via a number of plastic cogs. The most interesting thing to me was the simple circuitry that connected it to the batteries. I had discovered something that every schoolchild has to learn sooner or later: in order for a battery to power something electrical, you must have a complete circuit, an unbroken path for the current to travel from battery to device and back again.

Dismantling the motor itself was harder work: it involved throwing it against a wall and prying open the case with a screwdriver. But the effort was worth it. Inside were two smooth curved parts that, much to my delight, turned out to be magnets. There was an odd-shaped piece of metal, around which was coiled incredibly thin, beautifully shiny, copper wire that did not stick to the magnets. But these innards revealed nothing about how the motor worked.

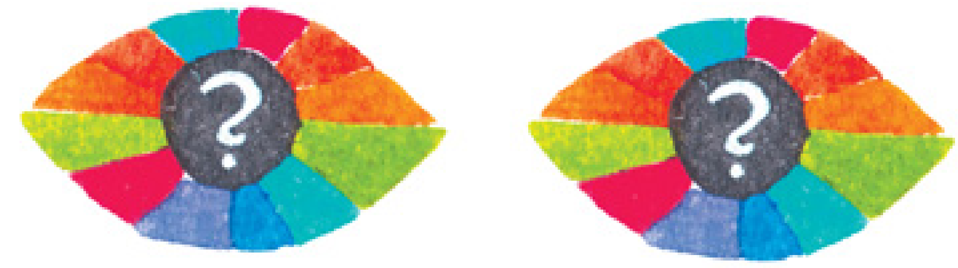


At this point, you might suspect that I've told you this story as a prelude to claiming that I was a naturally curious child who continued with these sorts of explorations, discovered some of the secrets of nature for myself, and grew up to become a brilliant scientist. But that's not how my story goes.

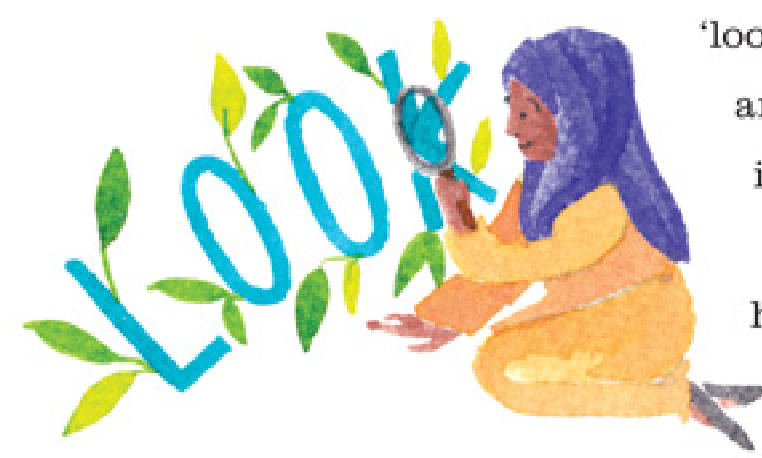
I was undoubtedly an inquisitive and playful boy who, like most children, looked at the natural world with wonder. But these things are not sufficient for a child to become a scientist or even to be able to look and think about the world scientifically. Any real scientific skills and knowledge I have is down to my science teachers, who trained me to look at, and think about, the world like a scientist. Not everyone is lucky enough to have such fine teachers.



It was Mr York, my Physics teacher, who revealed the mystery of how an electric motor works. He connected a long, plastic-coated wire to both terminals of a power pack, then arranged the wire so that a length of it sat on top of a large, strong magnet. He showed that the wire did not stick to the magnet and that it was not electrically connected to it – so no electricity would flow between the wire and the magnet. Then he flicked the switch on the power supply, and the wire jumped into the air. I remember being astonished, as if I had just seen magic; I finally understood that an electric motor relies on the fact that a wire with an electric current in it becomes magnetic, and so can be made to move by a magnet.



Mr York was using a powerful technique in science education – demonstration – to elicit joy, wonder, and, most importantly, curiosity from his students. As a science teacher myself, I love using entertaining, often spectacular, demonstrations to engage my students in what I believe is the first crucial step towards thinking and acting like a scientist: observation – looking more closely at the world than people ordinarily do. Follow that with enquiry – asking good questions – and experimentation, and that's it, you're doing science. When working with children, I summarise this as 'look, ask, play' and this book is filled with activities to help them do just that.



I've chosen things that I believe will be fun to do, and I've also tried to include as many activities as possible that demand experimentation because that's a key part of what real scientists do.

It doesn't matter if you don't know any science yet. You soon will.

How YOU can be a Scientist

You don't have to read this book from start to finish – just choose a 'recipe' you like the look of and start experimenting. I've tried to write my recipes in a manner that I hope will equip you to start thinking like a scientist. Here's how they work:

• Each activity starts with something to **try out or build**. Follow the instructions and look closely at what happens. You might want to try to **predict** what will happen.

• Then start thinking about what's happened or is happening.

What will happen if we do something a bit different, and why?

(The table over the page has lots of ideas to get you started).

• Try out **your own ideas** too. You won't always know what will happen in your experiment – which is exactly why you should do it.

Notes and Records

Scientists record their results so they can prove that they've done the experiment, look back to see if there are any important patterns, and share their findings with others. Here are some ways you can record your results.

Safety first!

There are times when you will be working with fire and potentially toxic ingredients, so look out for this **warning symbol** in the instructions...

There shouldn't be any danger to you as long as you are careful and sometimes get a grown-up to help. It's more fun to experiment with someone else anyway.

A note for grown-ups

If you're planning on doing an activity with a child or children, **read the whole experiment in advance** so that you are fully equipped to help them get the most out of it.

If you have the time, **try out the practical elements** of an activity on your own first, so that you can maximise its potential for eliciting wonder in children.

Most importantly, **make use of the suggested questions** in the book so that children are 'minds on' when doing the activity as well as 'hands on'.

Become a wondersmith!

Practice makes perfect.

Even if you have a gift for art or music or writing, you need to practise these things to become truly good at them. Similarly, children with a natural urge to understand how the world works need support to develop into scientists of any sort.

I've written this book to help parents, and other adults with children in their lives, to do this. These are my **'recipes for wonder'**, filled with ideas and instructions to turn anyone into a **wondersmith** — a grown-up who can foster wonder in both senses of the word, by encouraging children to feel **amazement** and admiration for the natural world, as well as to **ask questions** to learn more about it.

FIZZ ROCKETS

We say 'It's not rocket science' when trying to say something is not difficult. The basic science of how rockets work isn't really that complicated. But getting rockets to work is quite hard, and the history of science is full of stories of failed attempts to launch them. The rockets in this activity are tricky to get right, but provide a real thrill when they work.

METHOD

? What do you think will happen if we put some tablets and water in this bottle and close the lid? Why?

1 Take the lid off the bottle and make sure the cap is closed tight.

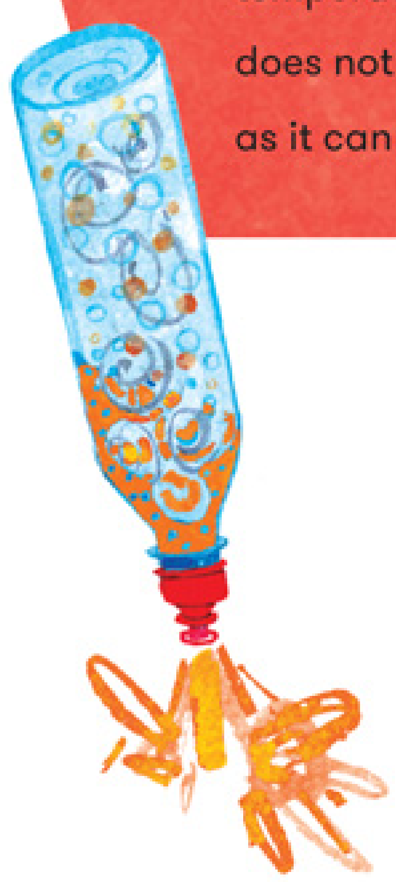
2 Half-fill the bottle with warm water.

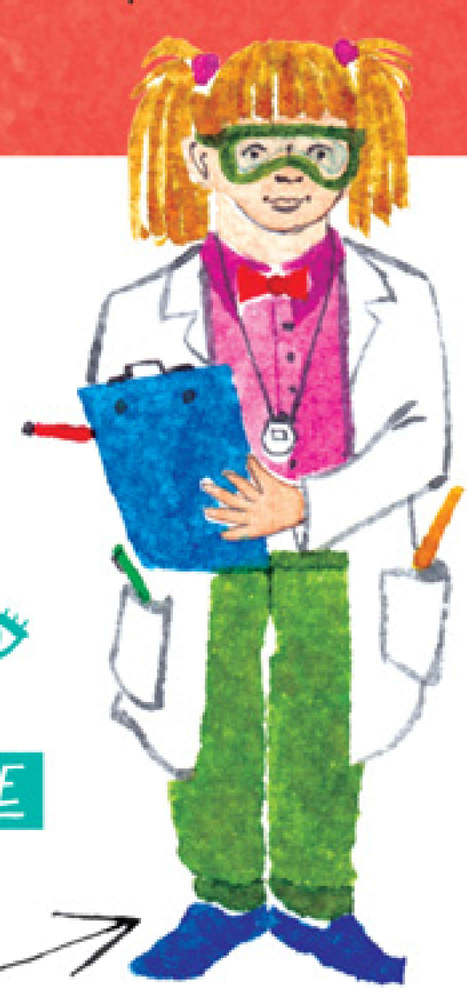
3 Break two fizzy tablets in half and drop them into the bottle. (Watch what happens!)

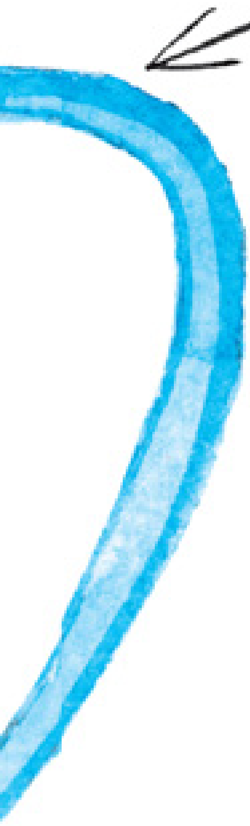
4 Quickly screw the lid back on, give the bottle a shake and place it upside down in the mug/glass/jar.

! Stand back at least 2 metres from the rocket, and wait.

5 If you find the bottle lid pops too soon, try using slightly colder water. Or if, after 3 minutes, it has not launched, try slightly warmer water. Experiment to find the best temperature. You may find that your rocket does not work the first time, but persevere as it can be spectacular.







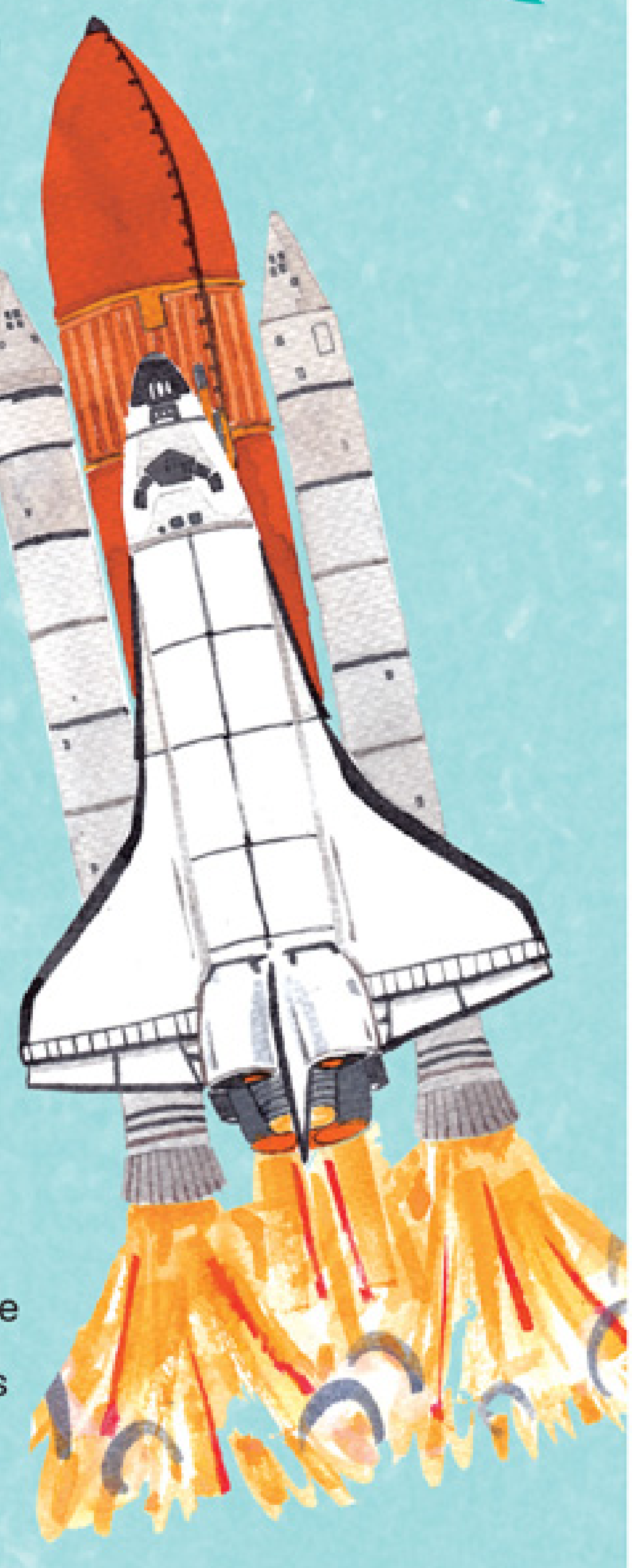
What do you think would happen if we used **more** than one tablet? Why?

Perhaps investigate how the **temperature** of the water affects the reaction?

What things could we change to make the rocket go **higher?**

MR SHAHA says...

Fizzy vitamin tablets contain chemicals which react with water to make carbon dioxide gas. This builds up inside the bottle until the pressure is enough to pop the lid. When the lid pops, it pushes down on the bottom of the glass, propelling it up. Once in the air, the liquid coming out of the bottle pushes it along just as a real rocket's gases force it upwards. To learn more about this, try the next activity.



The hotter the water, the more vigorously the tablets produce a gas. This is because, in hot water, both the chemical particles from the tablet and the water molecules have more energy and move faster. So, they collide more often, producing more chemical reactions.

HEAVY METAL HANGERS

I love being introduced to new science demonstrations that I can use in my teaching. Despite being a Physics teacher, and kind of knowing what to expect, I was astonished the first time I tried this – it is a truly startling demonstration of the way sounds are produced and how they travel.

INGREDIENTS

METHOD

1 Tie a piece of string to each end of the base of your hanger or to the corners of your oven rack.

2 Holding it by the strings, bang the object against a table leg or chair and listen to the sound it makes.

? Is the sound what you expected?

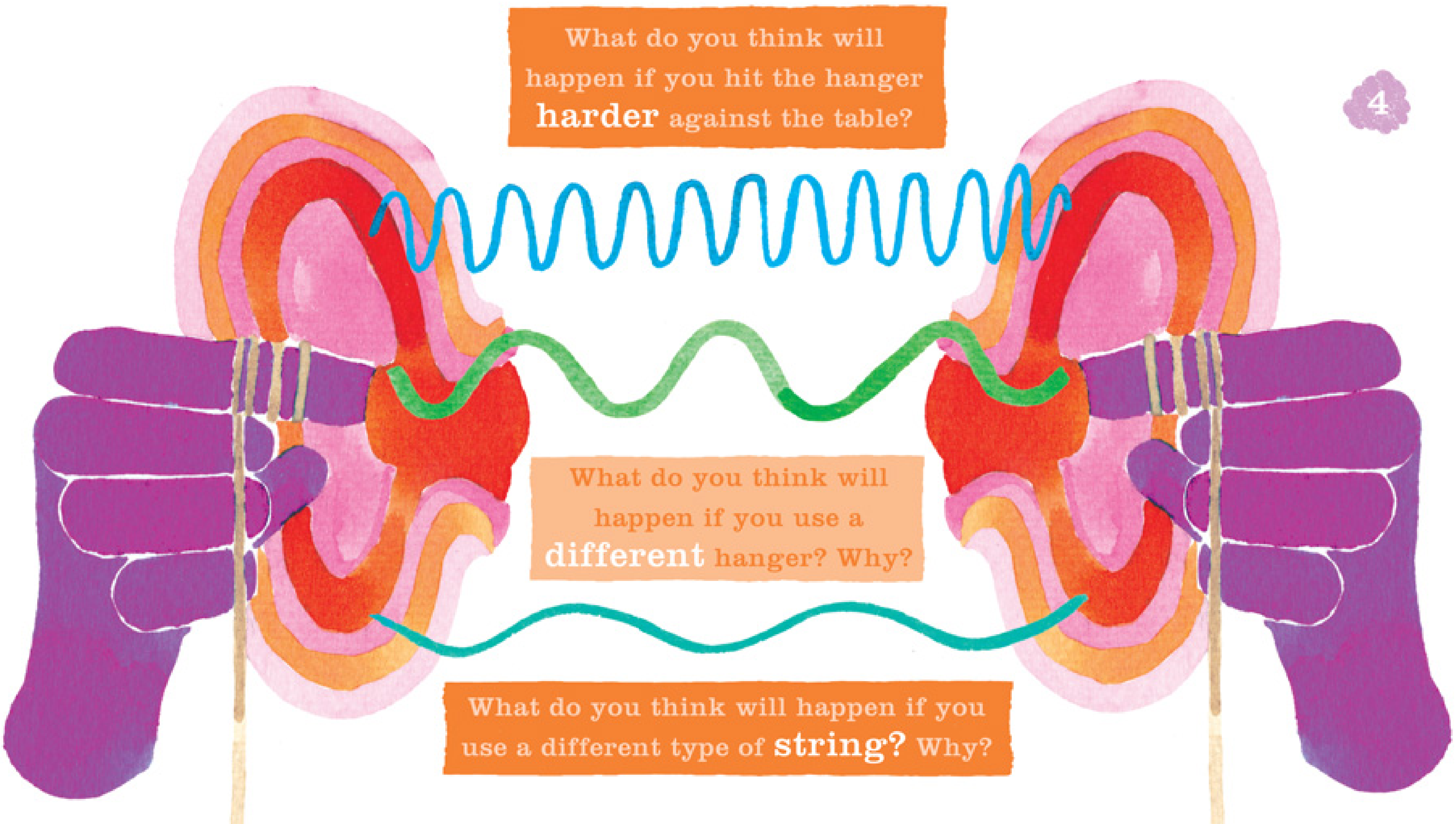
3 Next, loop a few centimetres of each string around the ends of each of your index fingers.

4 Put one finger in each ear so that your metal object hangs down in front of you.

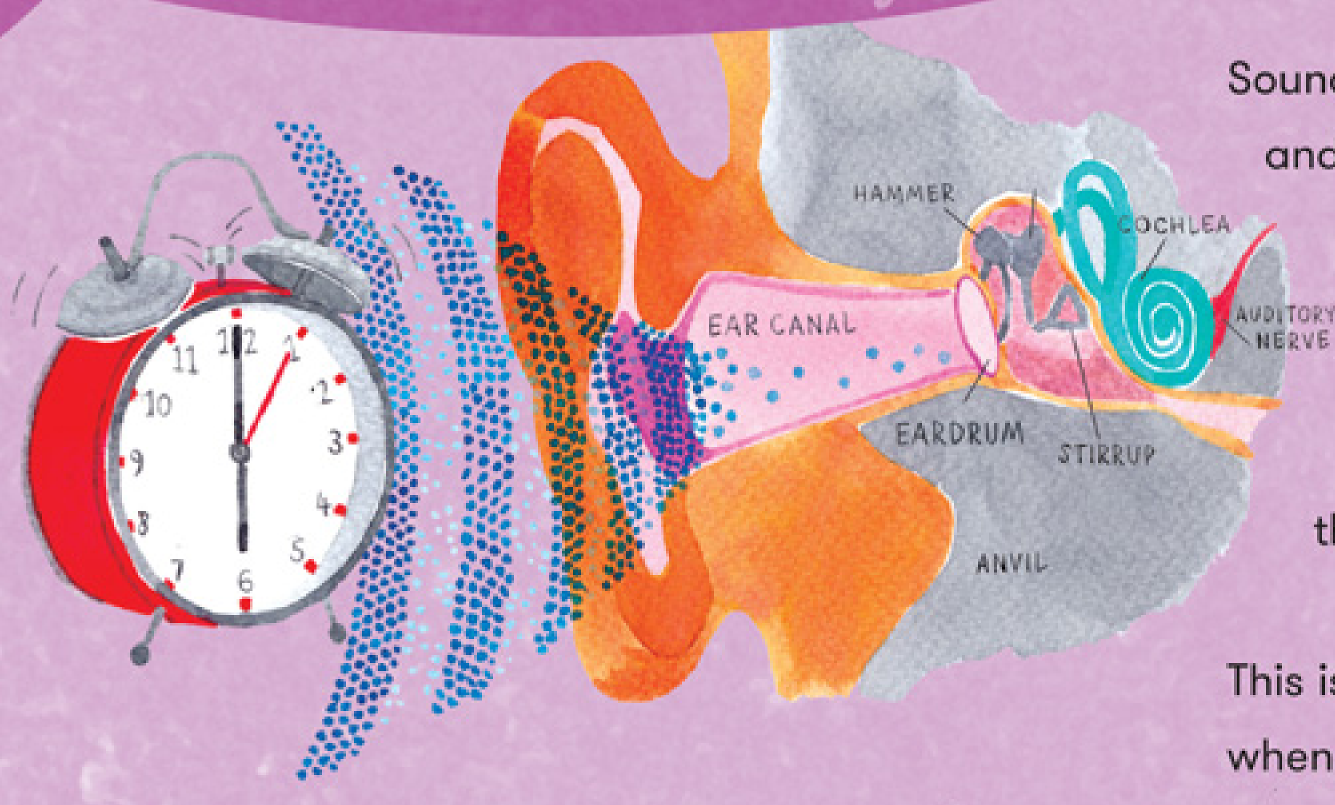
? What do you expect to hear now if you hit the object against the table?

5 Try it!

? Why do you think what you hear is so **different** when you do it like this?



MR SHAHA says...



Sounds are made when objects vibrate. It's not always obvious, but if something is making a sound, some part of it must be vibrating.

The precise way in which the object vibrates determines the sound we hear. Usually, we hear sounds because the vibration of the object makes the air around it vibrate, and those vibrations travel through the air and make our ear drums vibrate.

Sound travels differently through solids, liquids and gases. The string is a solid, so the sound we hear through the string (when we have our fingers in our ears, for example) is different to the sound we hear when the vibrations of the hanger travel to our ears through the air (a gas).

This is why our own voices sound different to us when we hear a recording - we are hearing them through the air when we are used to hearing them through our solid skulls.