A Series of Impossible Questions

By Isabel Thomas

How Does Gravity Work?

THINK
DIGITAL ACADEMY

Try throwing an object up into the air (not this book!). something makes it change direction and travel back down to your hand, or to the ground. We call this something gravity.

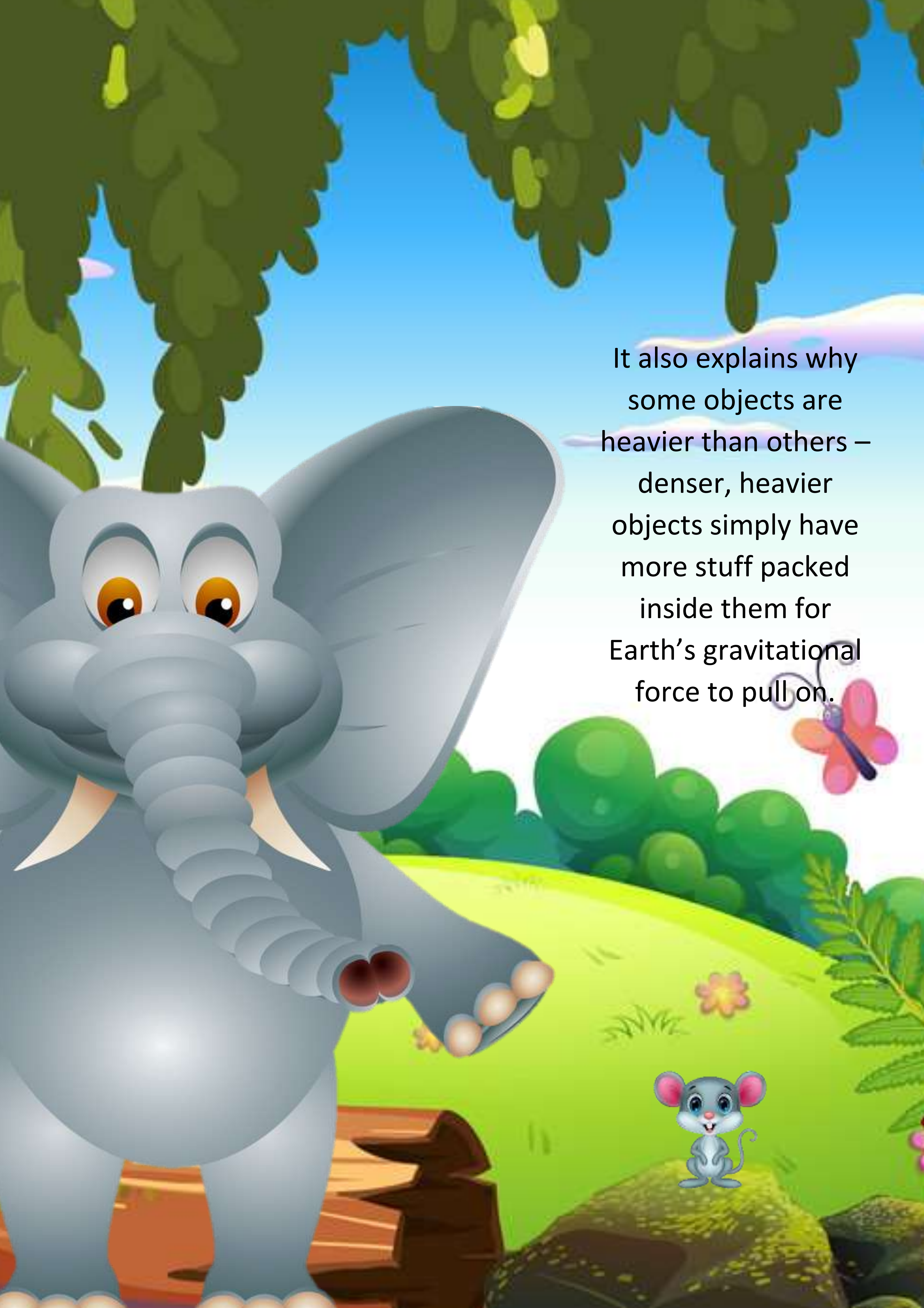
Every time you fall over, use a slide or try to leap off the planet into space, gravity brings you back down to Earth with a bump. It's easy to see gravity at work around us. Explaining how it works is much harder. That doesn't stop scientists from having a go.

Idea 1:

About 330 years ago, an English scientist called Isaac Newton said that we can think of gravity as an invisible force. His idea was that every object, big or small, has a gravitational force that pulls other objects towards it.

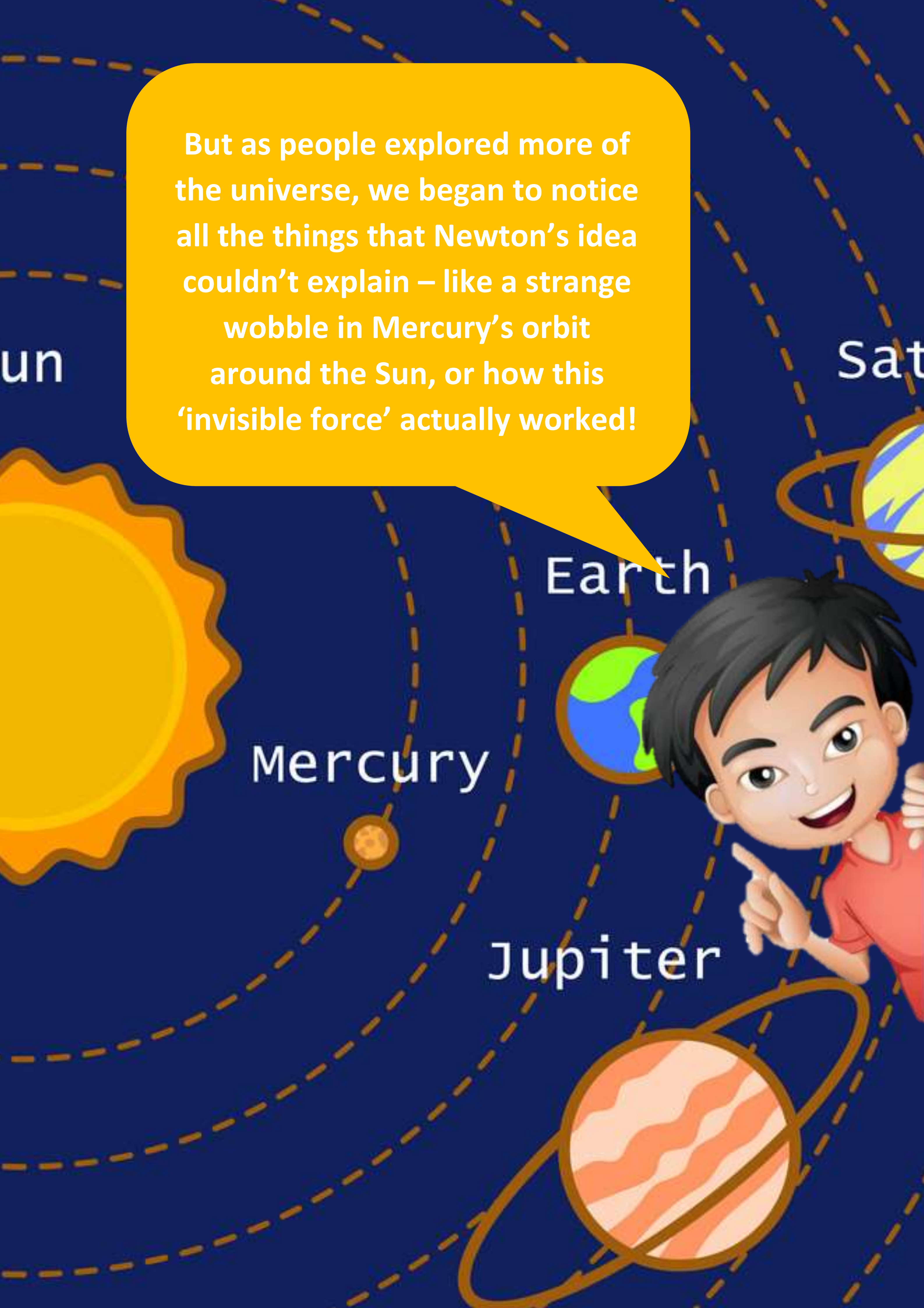
You are pulled towards the Earth … and the Earth is pulled towards you. There is even a tiny pull between you and this book. But Newton explained that bigger objects have more gravitational force than smaller ones, so we only notice the pull of massive objects like planets and moons.


He also worked out that the closer we are to an object, the more we feel the pull of its gravitational force. Newton's invisible glue was a very useful idea. It explained why on Earth small things fall to the ground, but also why huge planets stay in orbit around the Sun.



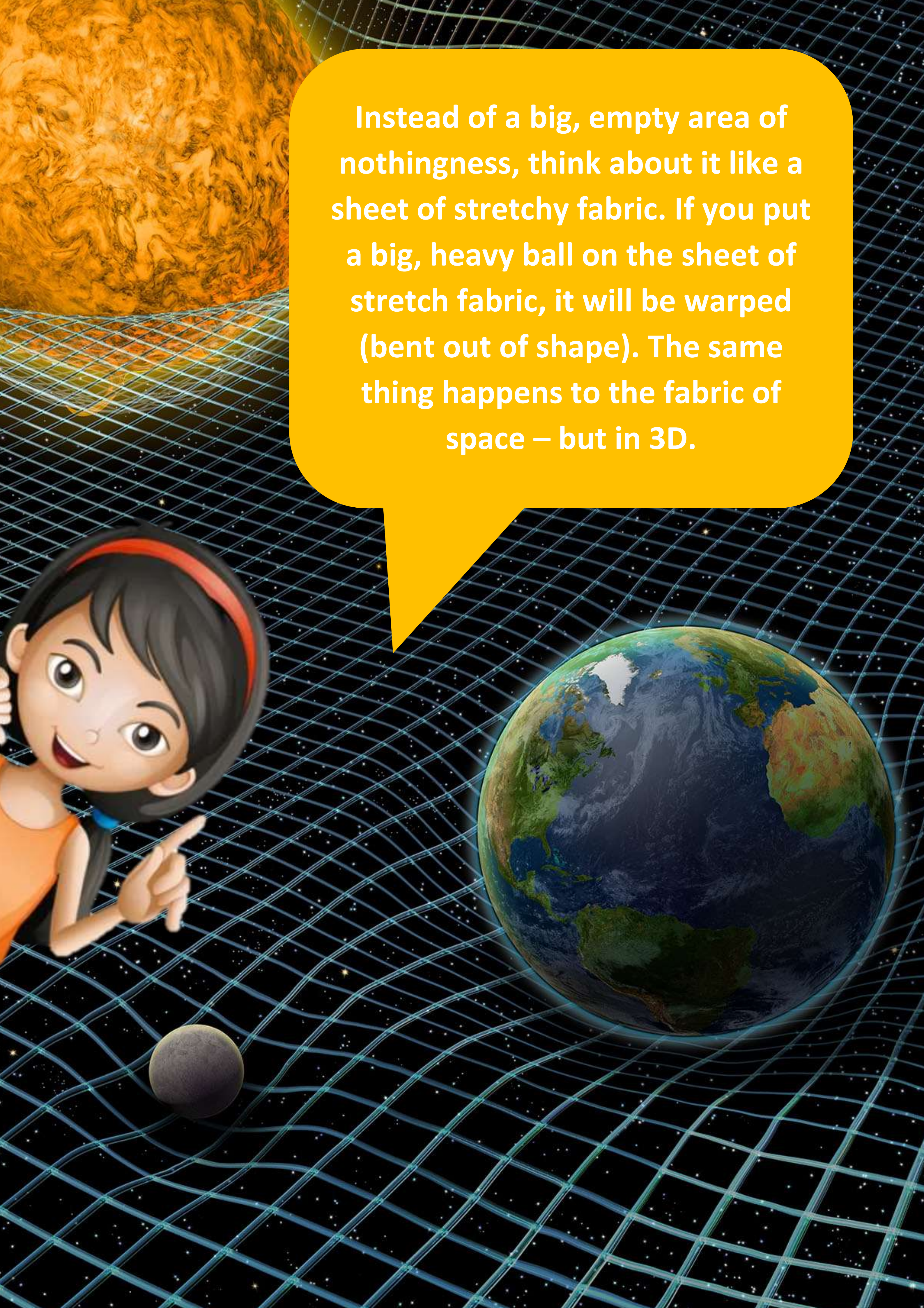
It also explains why some objects are heavier than others – denser, heavier objects simply have more stuff packed inside them for Earth's gravitational force to pull on.

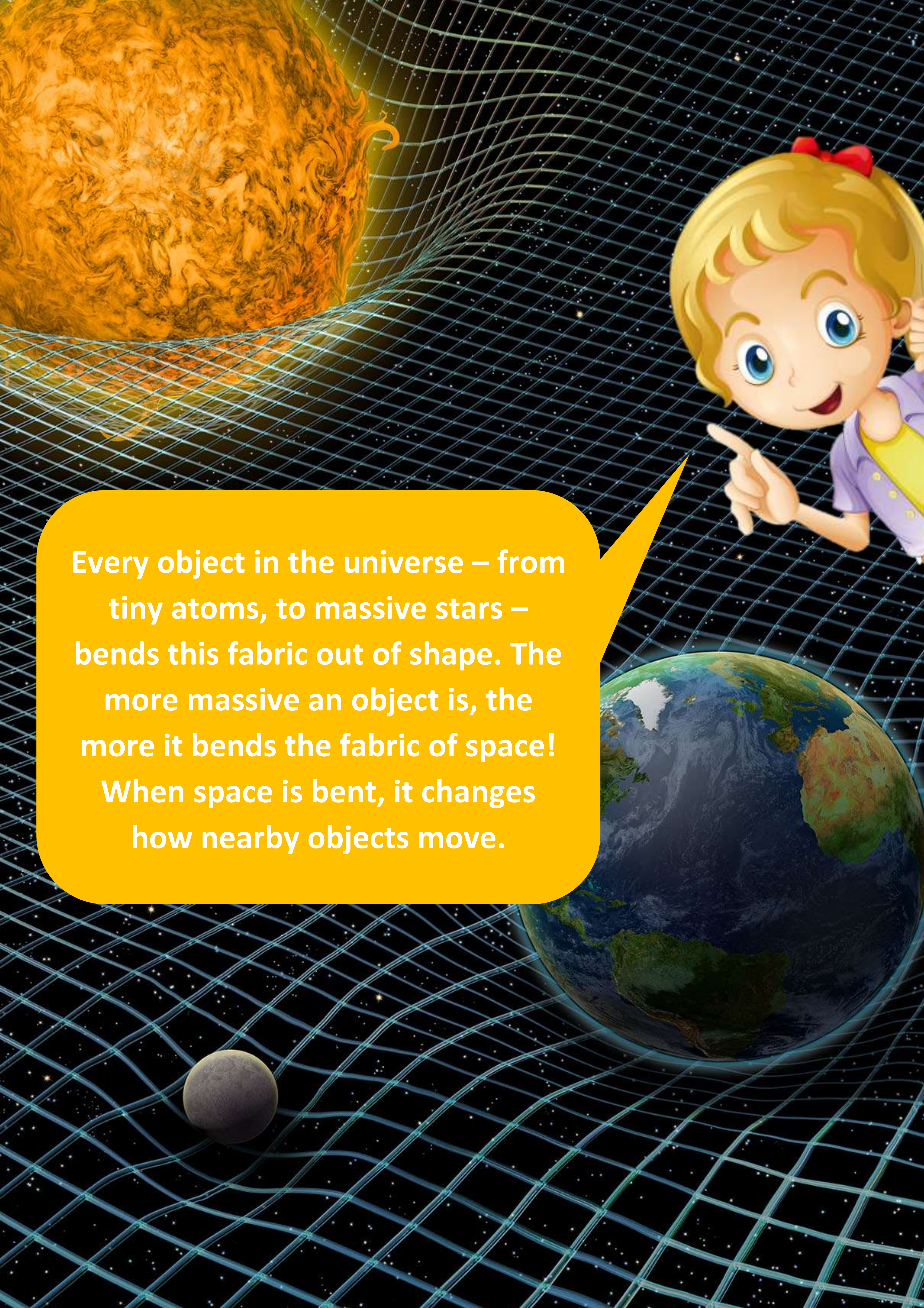

Newton used his idea to write laws describing how things behave, and how to beat gravity, and launch satellites, telescopes and people into space.


But as people explored more of the universe, we began to notice all the things that Newton's idea couldn't explain – like a strange wobble in Mercury's orbit around the Sun, or how this 'invisible force' actually worked!
Earth
Mercury
Jupiter

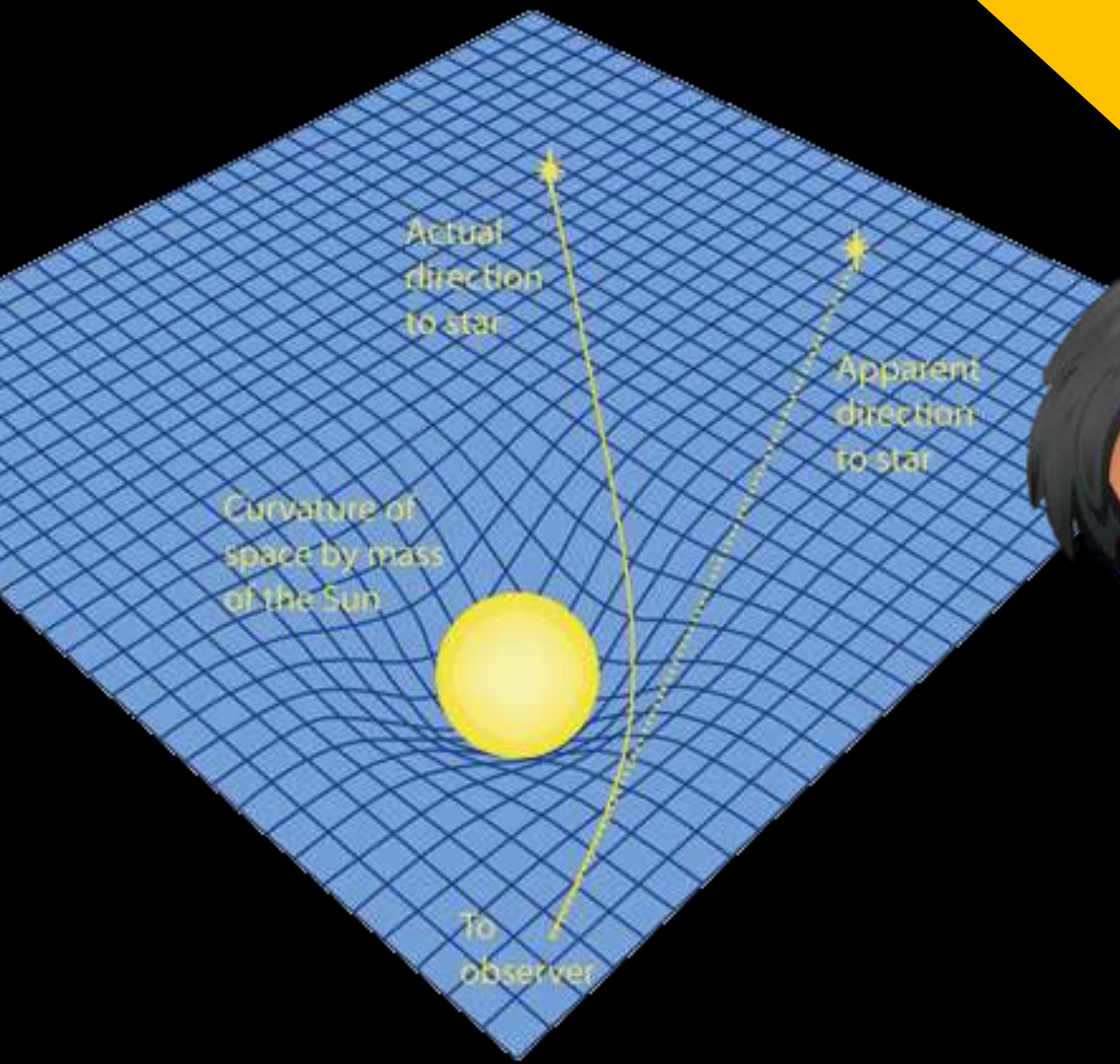
Idea 2:

Just over 200 years later, the German physicist Albert Einstein came up with a completely different idea to explain how gravity works. He said that gravity is not a force at all! it’s just a side effect that happens when massive objects ‘bend’ space. Before we can understand how this works, we need to think about space differently.


Instead of a big, empty area of nothingness, think about it like a sheet of stretchy fabric. If you put a big, heavy ball on the sheet of stretch fabric, it will be warped (bent out of shape). The same thing happens to the fabric of space – but in 3D.


Every object in the universe – from tiny atoms, to massive stars – bends this fabric out of shape. The more massive an object is, the more it bends the fabric of space! When space is bent, it changes how nearby objects move.

A planet, spacecraft or even a ray of light travelling through space might appear to change its path when it gets near a massive planet or star, but it’s really following the same path through space – the path itself has just been curved out of shape!



Imagine a meteorite zooming through space in a straight line. When it gets near Earth, its path seems to change. It crashes to the ground. Let's ask Newton and Einstein to explain why.

Earth’s invisible gravitational force pulls the meteorite away from its path and towards the Earth.

No, this is what really happens. The meteorite is still following the straightest path through space, but space itself has been bent out of shape by Earth!

Both ideas are really useful for predicting how things will behave. They are also used to design everything from space rockets to navigation systems. But it's impossible to say that either of them absolutely, 100% explains gravity.

Scientists are constantly coming up with new ideas. In the meantime, we can still count on gravity to keep our feet on the ground. We just can't completely explain why.

What is the Speed of Dark?

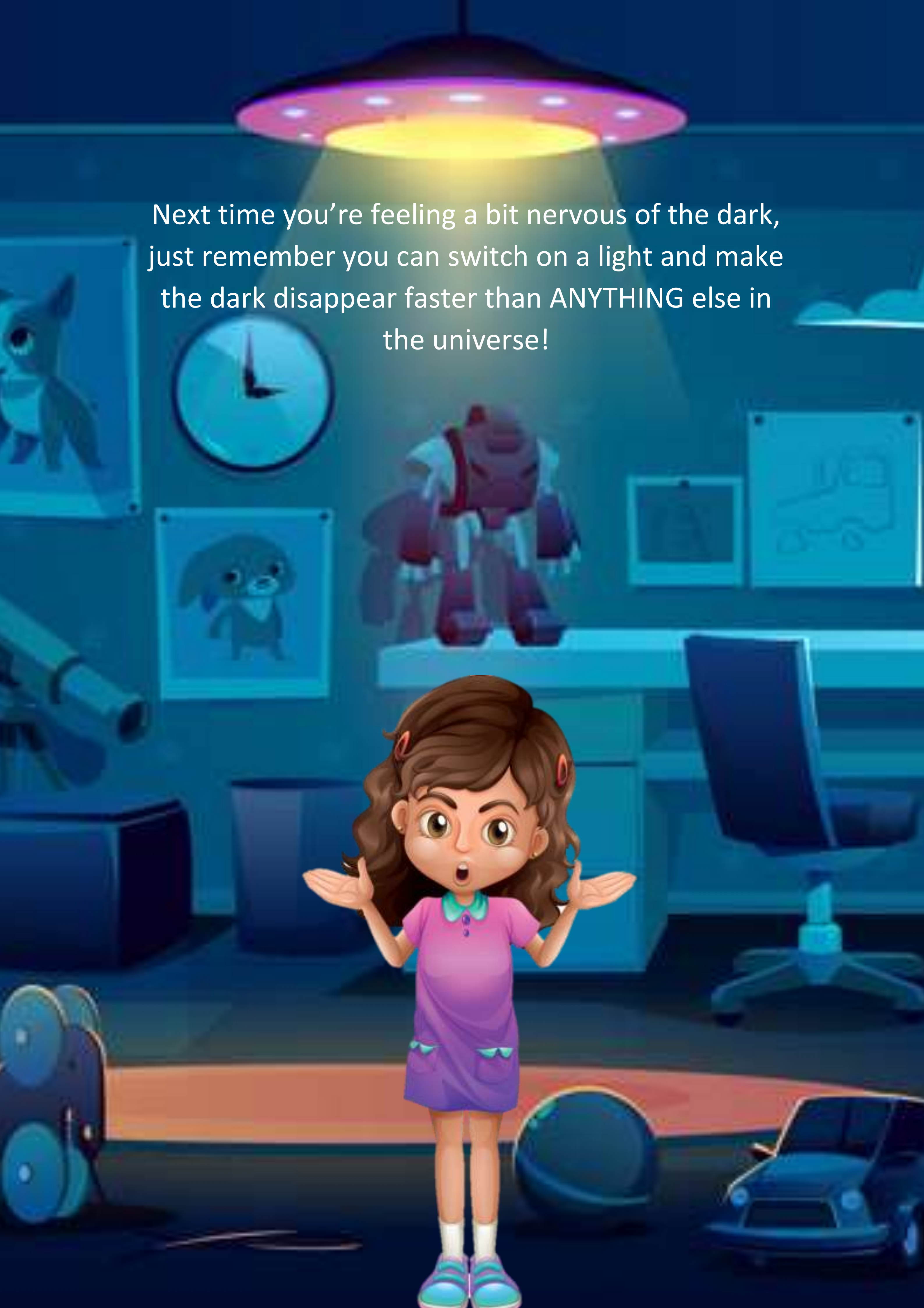
Darkness is just a lack of light. When an object blocks the path of light, we get darkness. So to measure the speed of dark, we need to know how fast light travels.

Scientists have measured the speed of light, and it’s FAST. So fast that if you stand on one side of the room and turn a torch on, the light travelling from the bulb seems to reach the other side of the room straight away.

We don't notice any delay until we are further away – a LOT further away! Even if you stood on the Moon and switched on a very bright torch, people back on Earth would see the light just 1.3 seconds later. Light is the fastest thing in the universe.

Now let’s create some darkness, by putting your hand in front of the torch and blocking its light. If you did this, a shadow would fall over Earth 1.3 seconds later, just after the last bit of light from the torch reached the Earth. So in a way, we can think of darkness as having the same speed as light.

Next time you're feeling a bit nervous of the dark, just remember you can switch on a light and make the dark disappear faster than ANYTHING else in the universe!

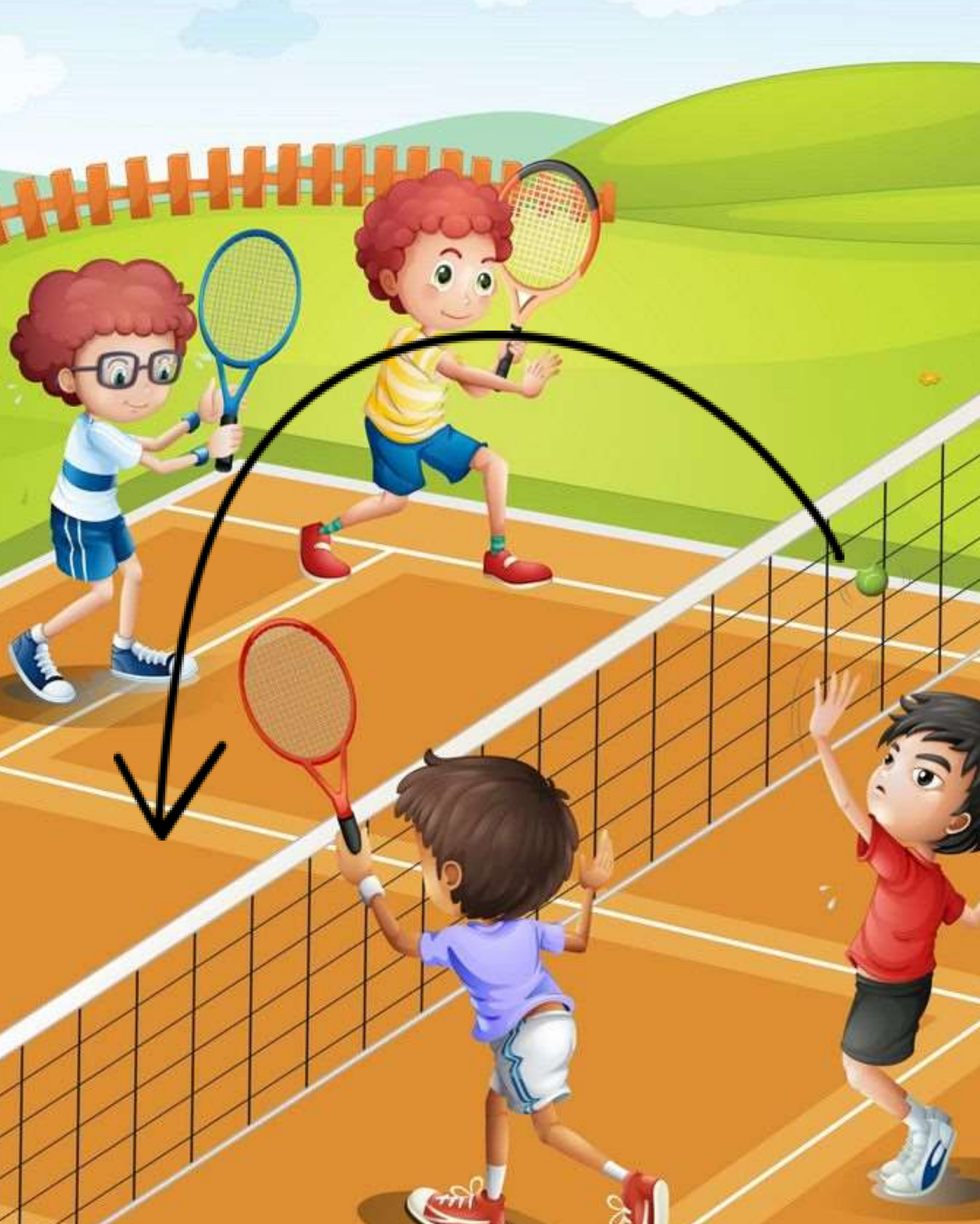


How Does Earth Float in Space?

In photographs, Earth looks like it's floating in space. But our planet is actually falling towards the Sun, because of the Sun's huge gravitational force. Don't worry though – Earth will never get any closer to the Sun!

This sounds impossible, but we can understand how it works by playing with tennis balls. Imagine gently hitting a tennis ball. It zooms forwards for a bit, then falls towards the ground because of Earth’s gravity.

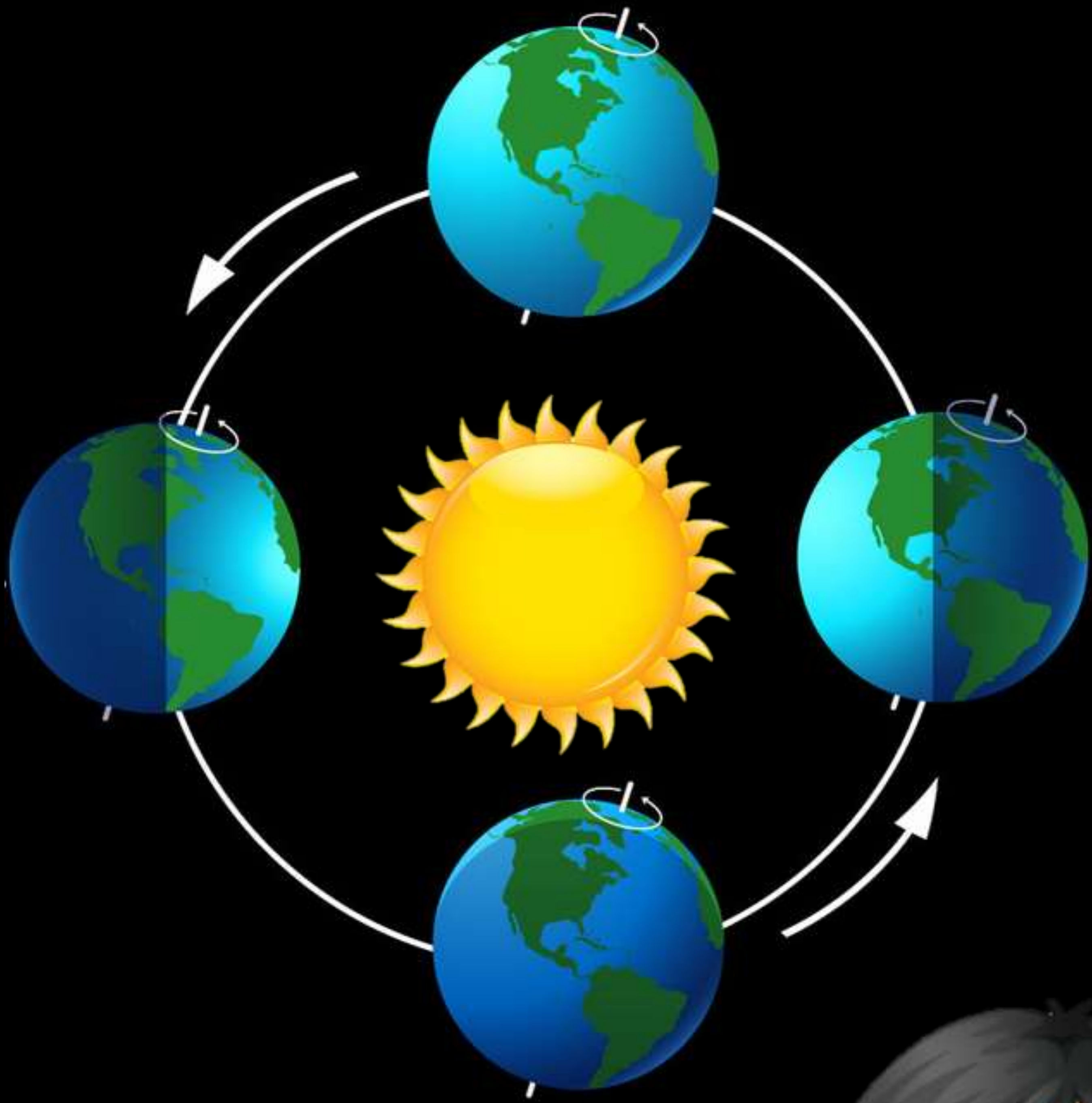
If you drew the path of the ball in the air, it would be a curved shape.



Now imagine you could hit the ball so hard that it speeds away at 28,800 km per hour! The ball would still begin to fall, just as it did before, but this time it would never hit the ground.

Its curved path would exactly match the curve of Earth's surface, so the ball would keep falling all the way around the world!

This is basically how we put things into orbit around Earth. Instead of using a tennis racket, we use a rocket to ger satellites and astronauts travelling fast enough.



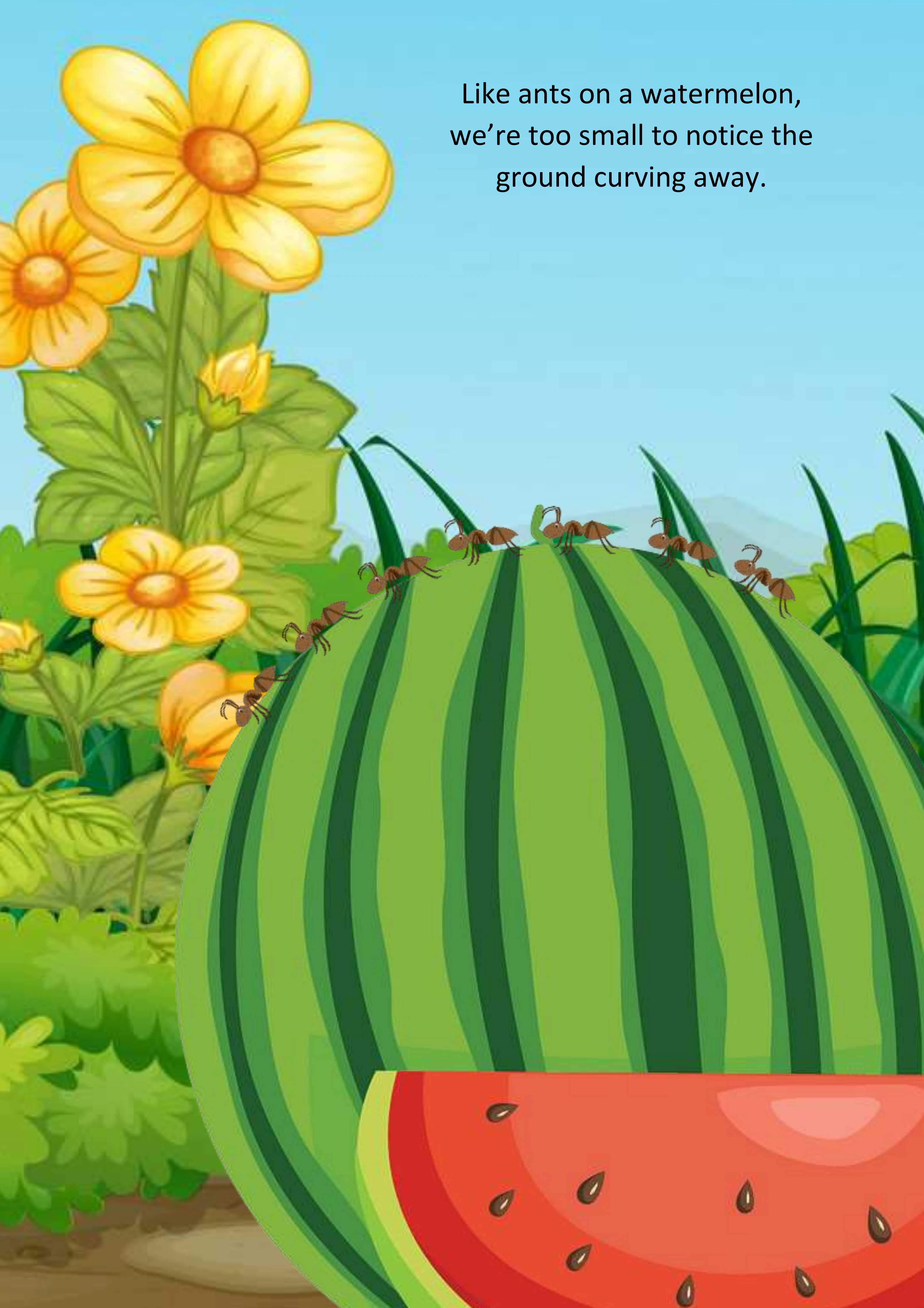
In the same way, Earth is moving sideways compared to the Sun, but it's moving so quickly that it falls all the way around the Sun once every year.

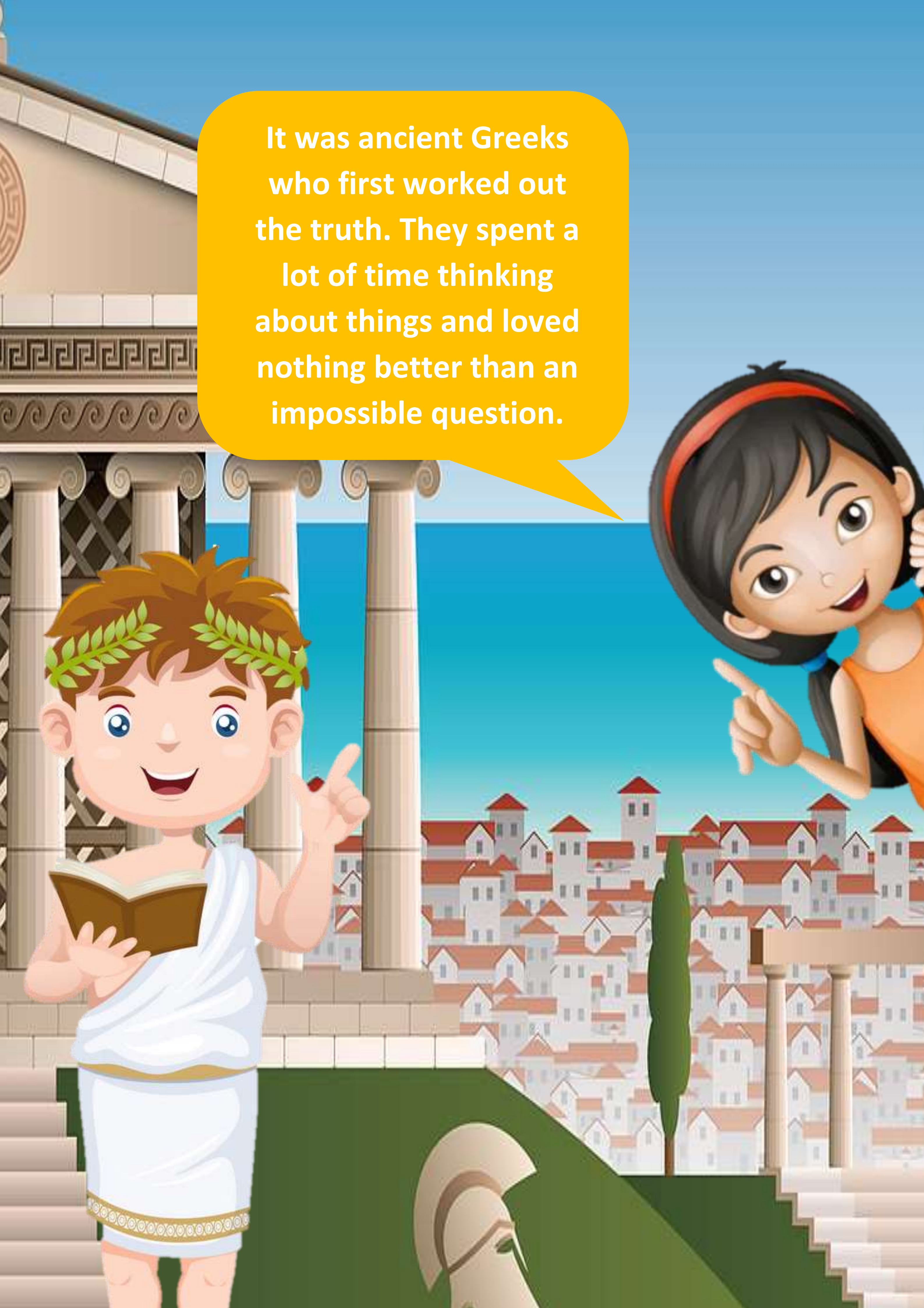
We don’t notice being on this cosmic rollercoaster, because we too are falling around the Sun at exactly the same speed as our planet!

How Do We Know Earth is Round?

Photographs snapped from space show that our planet is a giant ball of rock, water and gas. That’s the short answer, but it took a long time to get to it. After all, doesn’t feel like we’re waling around on a sphere.

Like ants on a watermelon,
we’re too small to notice the
ground curving away.




It was ancient Greeks who first worked out the truth. They spent a lot of time thinking about things and loved nothing better than an impossible question.


Greek astronomers noticed that Earth casts a round shadow on the Moon during a lunar eclipse.

They also noticed that the bottom of a ship is the first thing to disappear over the horizon as it sails away. If Earth was flat, the whole ship would just get smaller and smaller, until it became a dot. The bottom if a ship could only disappear first if Earth's surface was curved.

The ancient Greeks also noticed that the midday Sun appears lower in the sky the further north you go. If Earth was flat, the Sun would be the same height above the horizon no matter where you stood.

One ancient Greek astronomer used this information to work out Earth's circumference! Not everyone believed the strange truth straight away, even when ships set sail heading west, sailed all the way around the planet, and arrived back home from the east.

When space travel began in the 1950s, humans final saw Earth for themselves. But we've also discovered that it's not perfectly round. Our planet spins so quickly in the middle – rather like a watermelon!

How Long Would it Take to Go All Around the World?

It’s impossible to give you just one answer. It depends who (or what) is travelling, and how!

Astronauts orbiting Earth in the International Space Station zoom all the way around the world in just 90 minutes, but they're flying about 400 km above Earth's surface, travelling almost 8 km every second.

Closer to the ground, the big blanket of air around Earth slows a flying object down – just like walking through water slows you down. The fastest flight around the equator (the fattest part of our ball-shaped planet) took 31 hours, 27 minutes and 49 seconds – that was in a supersonic plane!

Giant birds called albatrosses have made the same journey in just 46 days, but without jet engines to help.

Down on Earth's surface, both humans and animals move even more slowly. Walking around the planet would take almost a year, even if it was possible to walk non-stop without loo-breaks or sleep! Most people use some kind of vehicle, and the distance travelled depends on where their journey starts and ends.

The very first circumnavigation (journey around the world) was by ship and took three years. That voyage around the world took just 40 days, 23 hours and 30 minutes. People like to break records, so we can expect even speedier journeys in the future.

Perhaps you will make one yourself. But don't worry if you'd rather stay put. Earth is constantly spinning on its axis, so just by sitting still you actually travel all the ay around the centre of our planet and back to where you started once every 24 hours!

Why am I Me and Not Someone Else?

Think about all the things that make you unique. Not just the way you look (which helps your friends and family spot you in a crowd), but try thinking about your likes and dislikes …

You’re not just one in a million. You’re one in 7.7 billion, and counting! It’s impossible to say EXACTLY what makes you YOU.

Your genome is part of the answer. This is like an instruction manual from your parents, which your body follows as it grows and develops. It guides how your body looks and also how it works. If these instructions were written down as a string of letters, the genome would be 3 billion letters long – that's enough information to fill 16,000 books like this one! Our bodies are following the instructions in our genome when they grow two ears, a stomach, one nose and ten toes.

Our genome is what makes us grow into humans rather than starfish, daffodils or mice. Those living things all have different genomes.

But human genomes are also a little different from each other. If you compared your genome with the genome of your best friend, you'd spot around 5 million small differences. That sounds like a lot, but it's actually a tiny number in a list of 3 billion letters. So our genomes alone can't explain all the differences between us.

Scientists have discovered that the human genome is fairly 'plastic'. This doesn't mean that it's made of plastic, but that it's a bit squidgy and flexible. It means that many of the instructions in our genome are just a starting point for who we are going to become. Our bodies can follow these instructions in a variety of ways, depending on all the different things we experience as we grow and develop.

Everything you've ever seen, heard, smell, done, touched, drunk and eaten is part of your environment – the second big thing that shapes the person you are. Your genome and environment often work closely together.

For example, your genome makes it possible for you to learn languages by telling your body how to build a brain, ears, eyes, hands and a mouth. But the actual languages you know depend on your environment – where you grow up, who is around and what you learn at school.

Often, it's impossible to say exactly how much of a particular feature is thanks to your genome, and how much is thanks to your environment.

But you can be certain that you’re the only person in the whole history of the world to combine your genome AND your life experiences. That’s what makes you YOU instead of someone else.

THINK

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