[Dedications to come]

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Ouch!

TALES OF GRAVITY

Kate Simpson & Andy Hardiman

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This is Isaac Newton.

People might tell you this is the moment gravity was first discovered.

Ouch!

The truth is, people had been
discovering gravity long before Isaac.

Ouch!

Ouch!

Ouch!

Ouch!

You might even have discovered gravity yourself.

Gravity's job is to pull things towards one another. When both things are small, gravity doesn't really do much at all. Which is lucky, because otherwise—

Ouch!

Let's just say it wouldn't be good.

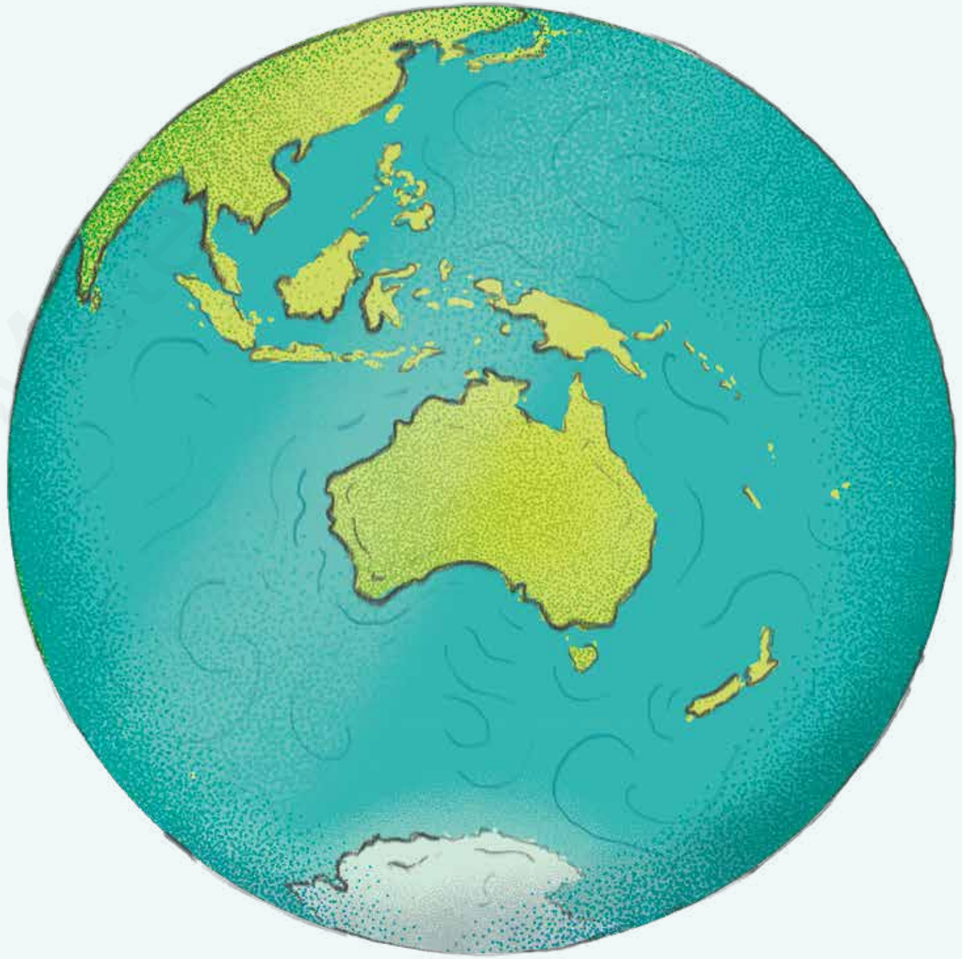
When one of the things is **big—**

No, I mean **really big.**

No, I mean **really,**

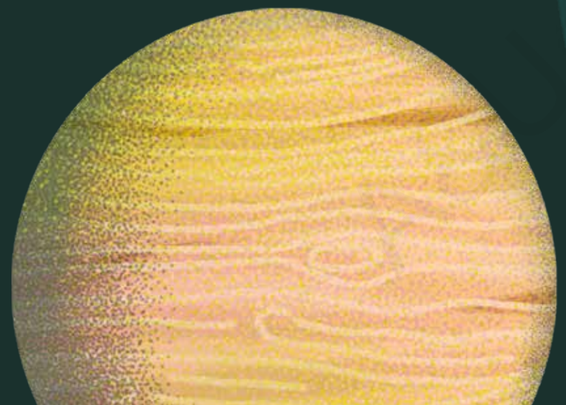
REALLY BIG.

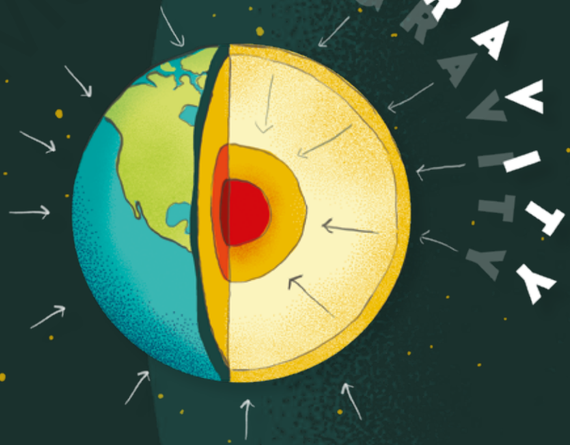
Here, let me show you ...

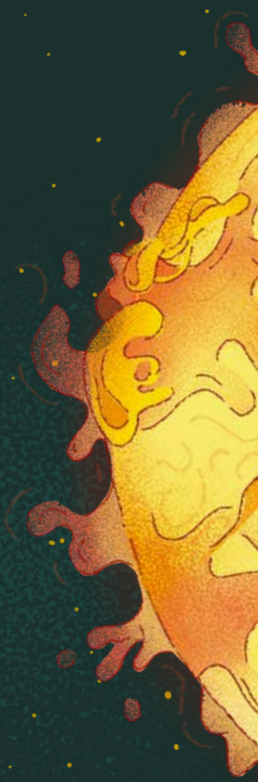


When things are as **big** as the Earth or the moon or the sun, the force of gravity becomes strong enough for us to notice it's there.

Earth's gravity pulls everything down, towards the middle of the Earth, while the sun's gravity keeps all the planets circling around it.





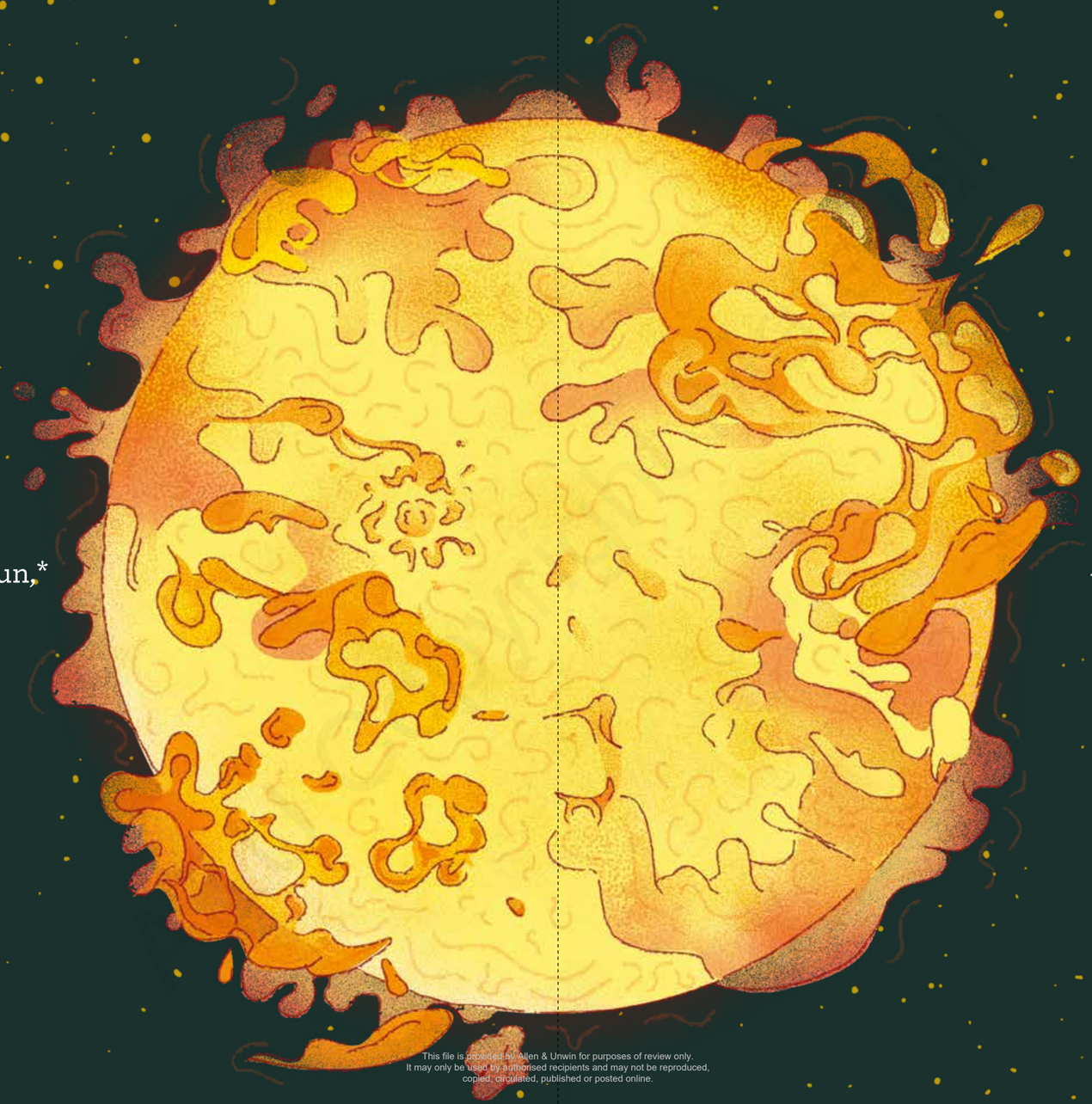


The pulling power of gravity is what makes things heavy.

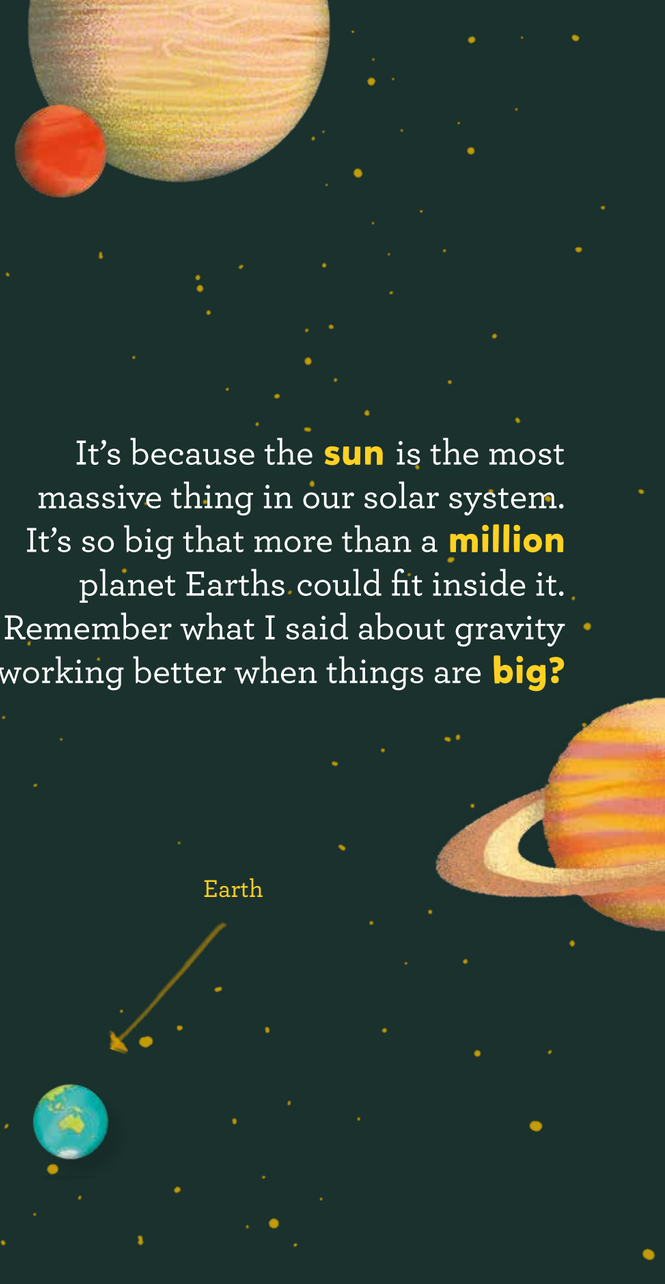
Feel this book. **How heavy is it?**

If you stood on the surface of the sun,* this book would weigh about as much as brick. **Why?**

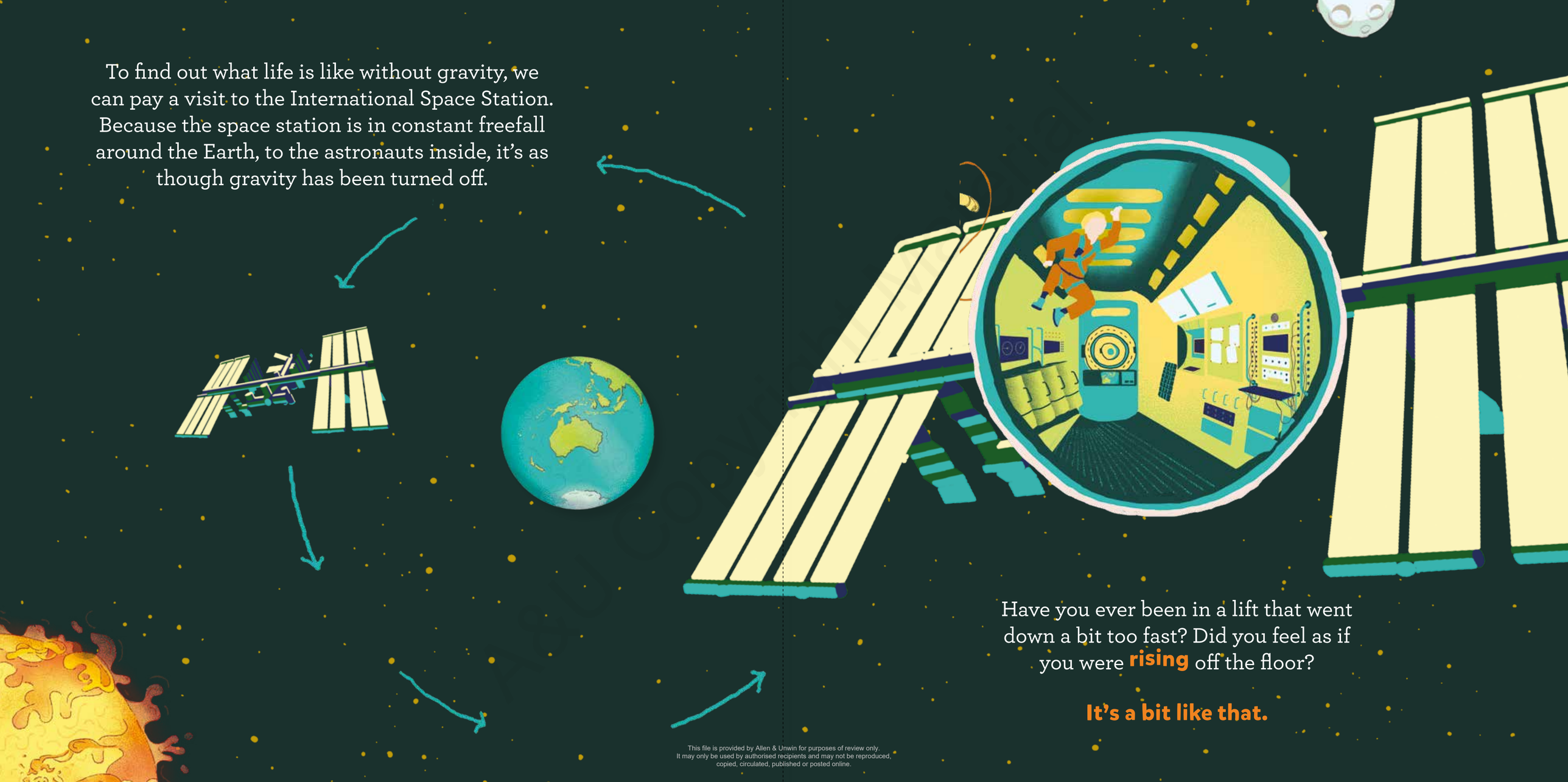
*The sun is a giant ball of fire.
Do *not* try to stand on it.



It's because the **sun** is the most massive thing in our solar system. It's so big that more than a **million** planet Earths could fit inside it. Remember what I said about gravity working better when things are **big?**



To find out what life is like without gravity, we can pay a visit to the International Space Station. Because the space station is in constant freefall around the Earth, to the astronauts inside, it's as though gravity has been turned off.



Have you ever been in a lift that went down a bit too fast? Did you feel as if you were **rising** off the floor?

It's a bit like that.

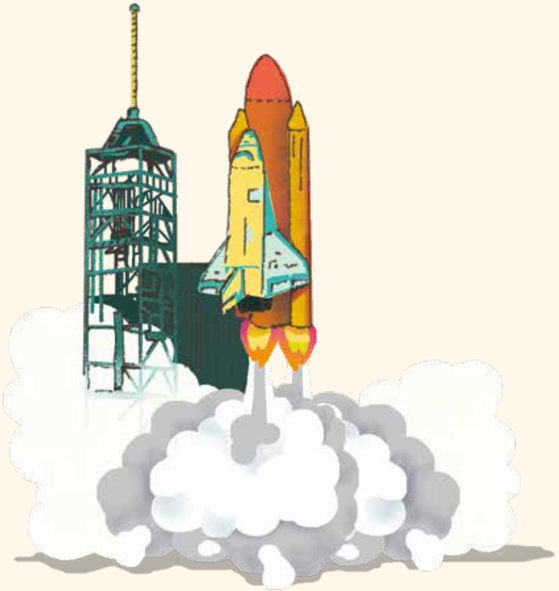
Life without gravity is pretty

FUN...

... but it's also a lot more **complicated.**

For hundreds of years, humans have
tried to **overcome gravity.**

And in recent times, we've had reason to feel
pretty pleased with ourselves.



But at the end of the day, gravity is the **force** that gave **birth to the stars.**

Come up against a force like that and there's always the risk of a little bit of—

Ouch!

Facts about gravity

Sir Isaac Newton is one of history's most famous scientists. He lived 300 years ago.

Newton's ideas about gravity began when he watched an apple fall from a tree. He wondered why apples always fall straight to the ground. Why not fall sideways, or even upwards?

Newton realised that something must be *pulling* the apple to the ground. He wondered whether that 'something' would also pull on an object further away than the top of an apple tree. Would it pull on something as far away as the moon?

This was a new idea. Could the moon circling the Earth and an apple falling from a tree really be two examples of the same thing? Newton believed they were.

He imagined firing a cannon from the top of a mountain. The cannonball would fall to the ground. But what if he could find a higher mountain, and a more powerful cannon? The cannonball would travel further. If he could find a powerful enough cannon, then the cannonball would travel so far that as it fell, the spherical Earth would start to curve away beneath it. With the right speed, the ball would never reach the ground at all, but would continue falling around and around and around the Earth. It would be in orbit.

Newton's orbital cannon

For more than 200 years, everything we knew about gravity came from Newton's ideas.

Then in 1916, a scientist called **Albert Einstein** published a new theory about gravity. While Newton had described what gravity *does*, Einstein began to explain *how*.

Einstein realised that gravity is caused by massive objects bending the fabric of space and time, a bit like how you bend the fabric of a trampoline when you stand on it.

He also realised that as well as making things fall, gravity has another surprising effect – it slows down time. In fact, time runs slower when it is close to massive objects such as the Earth, compared to high in the air or in outer space, where gravity is not so strong.

These were incredible ideas about gravity. But they're not the end of the story!

Scientists today still have lots of questions about gravity that can't quite be explained by Newton's and Einstein's theories. People around the world are working to solve these mysteries, so that one day we can have an even better understanding of just how gravity works.

Experiment with gravity

Try this simple experiment to see gravity at work.
(Outside on the grass is the best place!)

1. **Grab two plastic water bottles of a similar size.**

2. **Fill one with water and close the lid tightly. Leave the other empty.**

3. **Feel how heavy the bottles are. If you drop the two bottles at the same time, which do you think will hit the ground first?**

4. **Drop the bottles and find out!**

Did you see that the two bottles reached the ground at the same time?

Most people have seen a feather or a dandelion floating on the breeze, or watched a piece of paper fall slowly to the ground. It's easy to think that light objects fall more slowly under gravity than heavy objects, but scientists have shown this is not true.

A very light object such as a feather or a piece of paper will fall slowly because the air helps to hold it up. But most objects will fall at the same speed no matter how heavy they are. Even though gravity pulls harder on the heavier object, we also know that heavy objects are more difficult to move than lighter ones (try taking an elephant for a walk and you'll see what I mean!). The two effects cancel each other out, and the heavy object and the light one fall at the same speed.

In 1971, astronaut **David Scott** demonstrated these effects by dropping a hammer and a feather on the moon. Because there is no air on the moon to hold the feather up, the hammer and the feather hit the moon's surface at the same time. If you look on the internet, you can even find the video footage!

Kate Simpson is a picture book author, podcast host and incurable bookworm. She loves books about girls who march to the beat of their own drum and about women who change the world. She is also a scientist with a Bachelor of Chemical Engineering.

Andy Hardiman is a Sydney-based creative who works for a number of advertising agencies. *Ouch!* is his first picture book.