

THE
COSMIC
Diary OF OUR
INCREIBLE
UNIVERSE

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A Cosmic Diary of our Incredible Universe
(aged 13.8 billion years)

By Tim Peake

With Steve Cole

Illustrated by Max Rambaldi

**If found please
return this book to:**

Small planet
travelling around
a middle-aged
star called the
Sun

Seven other
planets also spin
around the Sun,
along with asteroids,
comets and minor
planets

About 80
small galaxies spin
slowly around the
Milky Way and the
galaxy next-door,
Andromeda

ADD COSMIC
CURIOSITIES
SYMBOL

This contains
about 100 small
groups of galaxies
including the
Local Group

The Solar System
is surrounded
by this distant
bubble of icy
objects

The Earth
Solar System

Oort Cloud

Orion Arm

Milky Way

Local Group

Virgo Supercluster

Laniakea Supercluster

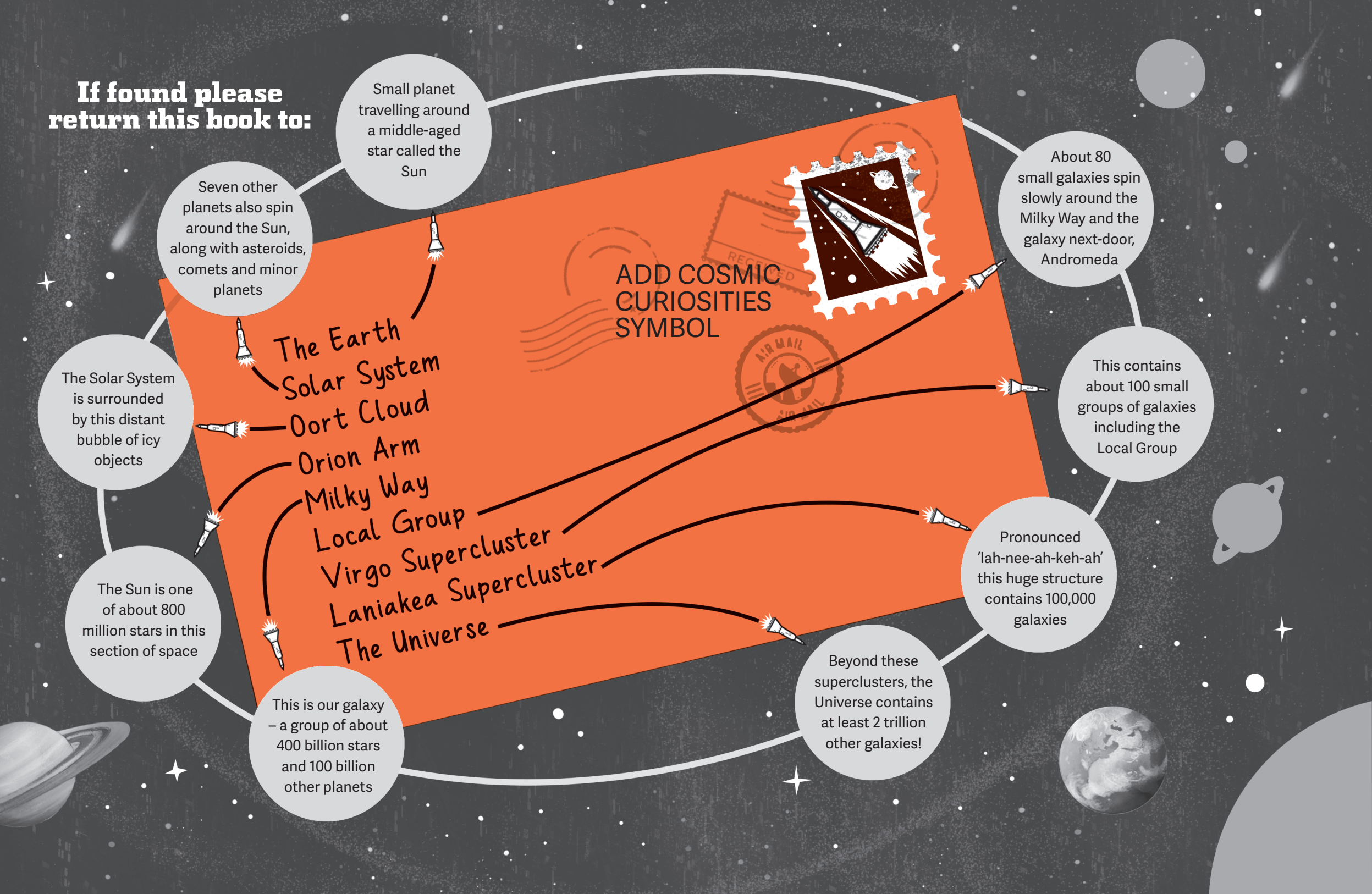
The Universe

Pronounced
'lah-nee-ah-keh-ah'
this huge structure
contains 100,000
galaxies

The Sun is one
of about 800
million stars in this
section of space

This is our galaxy
– a group of about
400 billion stars
and 100 billion
other planets

Beyond these
superclusters, the
Universe contains
at least 2 trillion
other galaxies!



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from
Tim Peake**



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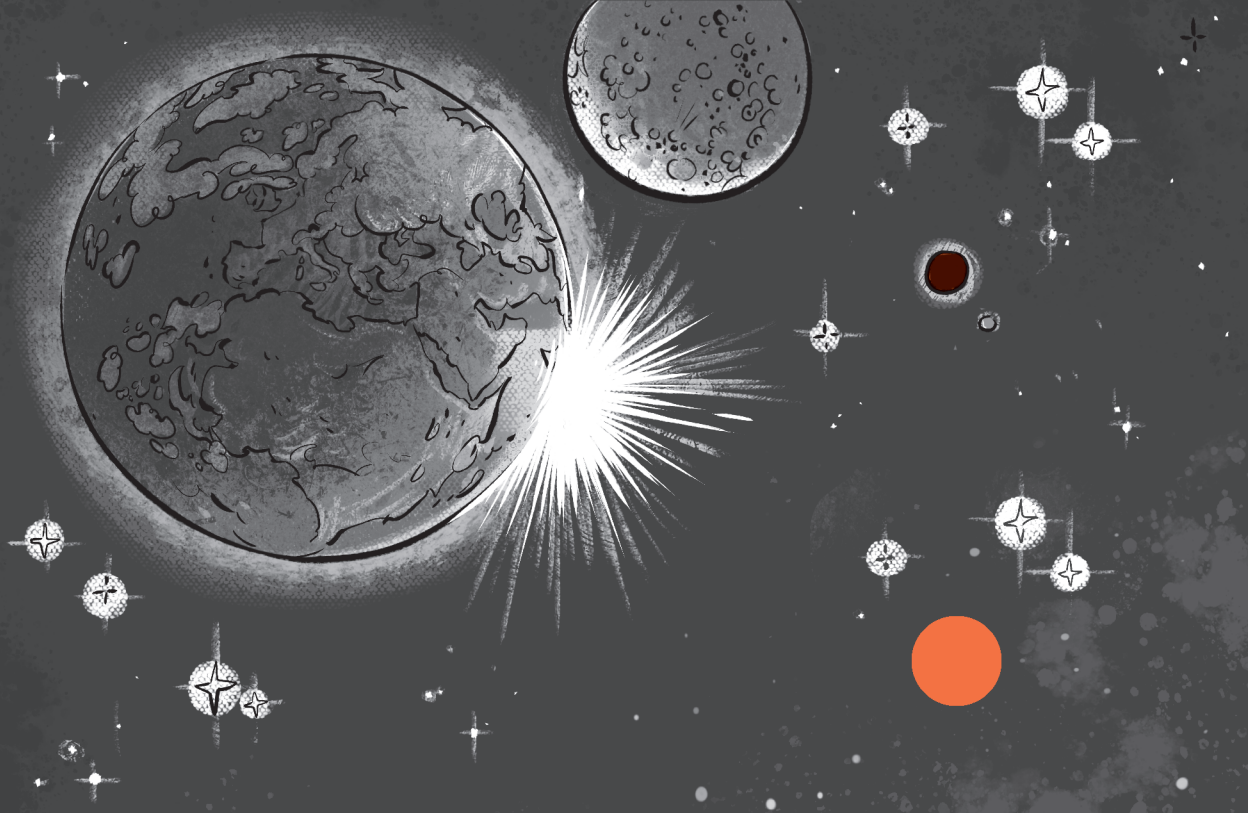
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Introduction

Imagine floating in space, with no forces acting on your body. Your muscles are completely relaxed and there is no sound, except for a small hum from a pump sending oxygen into your spacesuit, keeping you alive. It's the most peaceful feeling imaginable.

Over one shoulder you see a **beautiful planet**, full of colour: blue oceans, white clouds, orange deserts and green forests. That's Earth. That's where you were born. The planet itself looks alive – electrical storms light up the night sky, volcanoes leave trails of smoke, **swirling hurricanes** form over **warm oceans** and the eerie lights of the aurora dance over the poles. It's comforting to look at. It's home.

You look over the other shoulder. It's black. In fact, it's the blackest black you have ever seen. It's so dark you feel like you are falling into it, being sucked towards an **infinite black universe**. It's not comforting to look at. In fact, it's quite scary.



As you **effortlessly** orbit the Earth you pass from daylight to night. The Sun quickly sets and suddenly the Universe comes alive. Stars appear over the horizon and you can see the familiar planets of Venus, Mars, Jupiter and Saturn. Hundreds of billions of stars now come into view, shining their pinpricks of light through the blackness.

Your mind is trying to make sense of what you are seeing. On the one hand, looking out into endless space, you feel so **incredibly small**, so insignificant.

After all, **your planet** is just a small lump of rock orbiting a very ordinary star.

We call that star 'the Sun' like it's something special. But in fact the Sun is simply one of the **100 thousand million** stars that make up the Milky Way – a very average-sized galaxy, and one of an estimated **200 billion galaxies** that exist.

The Earth and all its neighbours orbiting the Sun – our entire solar system – could be **snuffed out** and, frankly, the Universe would barely even notice the difference.

Or would it?

To answer that, the first thing we need to do is travel back in time. So jump in, hold on tight, wind the clock back **13.8 billion years**. All the way to the beginning, and **then** pop back just a little bit further. Things are going to get pretty weird, because where we are going it seems that absolutely **NOTHING** exists.



No light.

No sound.


No time.

No space.

No school.

Just, yes – you got it ...

NOTHING.



So ... just what happened to turn that nothing into **SOMETHING?**

Well, just as you might keep a diary of all the things you've done in your life, so the Universe has left a record of how it began and how it's changed over time. Every time you look up at the stars you **look into the past**, because those stars are so far away that their light takes thousands, millions or even **billions** of years to reach us. With telescopes we can see further out into space – further back through time. If we know what we're looking for we can see all the way back to the Universe's beginning ... and work out how it might finish up.

This book is a cosmic diary of our incredible Universe, but in a way it is **YOUR** diary. So, it doesn't matter if you peek inside and read a bit ... right?

It's time for the Universe to reveal its secrets.

So let's take a peek at what lies ahead!

Look out for the symbol 
These are answers to some
of our favourite Cosmic Curiosities

Meet the Experts

**Far-out facts about the cosmos
are brought to you by:**

Particle Physicist: Malika

Hi, I'm Malika, and I'm a Particle Physicist! You may not have heard of 'particles' before, but they are tiny pieces of something. I study the tiniest building blocks of matter (the stuff that everything in the Universe is made of), and I help to develop and test theories about how the particles behave and interact. Particle Physicists are really important to understanding how our Universe came to be!



Cosmologists: Ben & Ciara

Hello, I'm Ciara. And I'm Ben. We are both Cosmologists! Our job is to explore and investigate the nature of the Universe. We study the creation and evolution of our cosmos and try to predict and understand what the future of the Universe will be. Cosmologists use and interpret data a lot. We look forward to explaining facts about the cosmos to you!

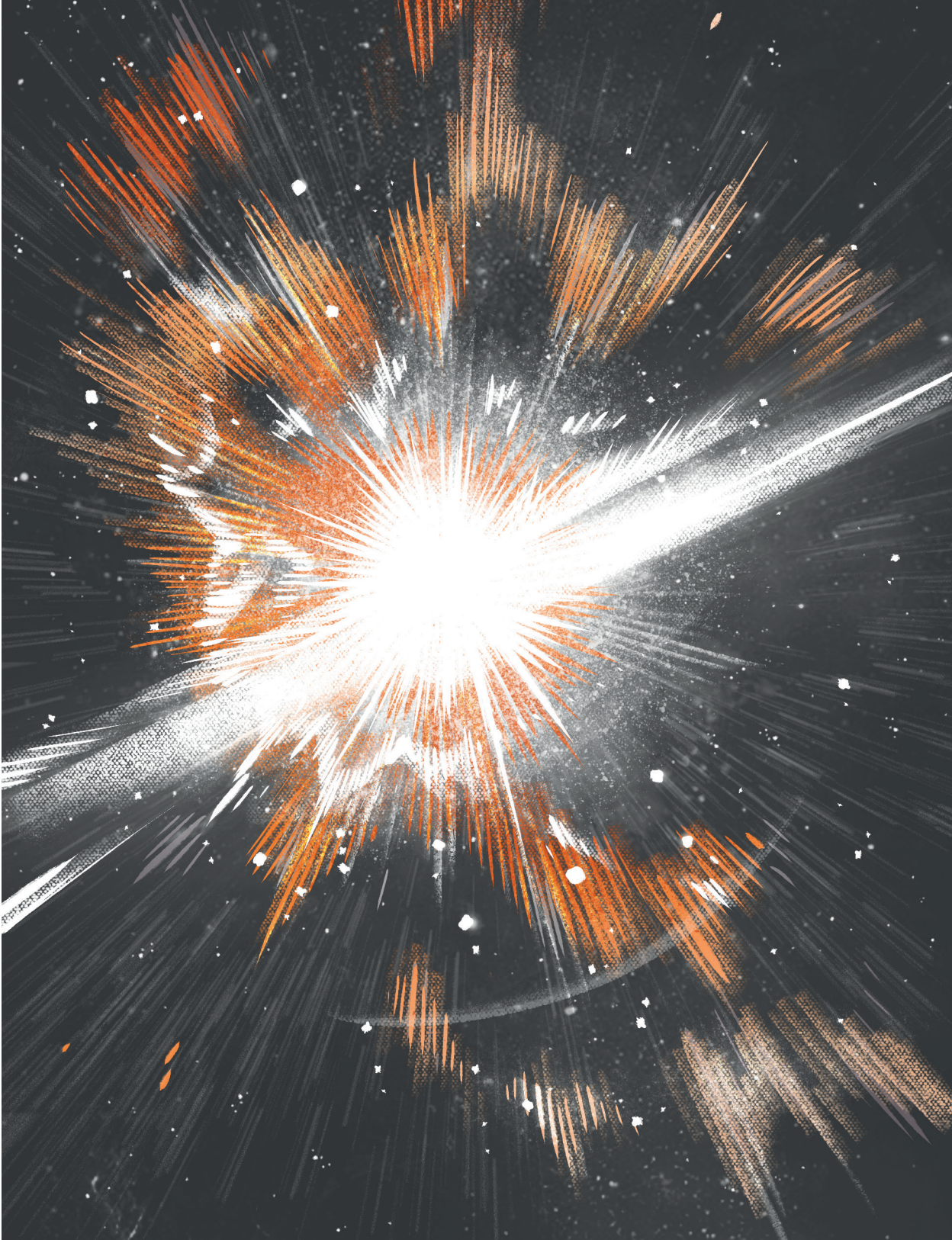
Astronaut Tim

Hi there, Tim here! I'm an astronaut for the European Space Agency (ESA), and I was the first British astronaut to visit the International Space Station (ISS). During my six-month mission on the ISS, I conducted a spacewalk, ran the London marathon from the space station's treadmill, took part in over 250 scientific experiments and engaged with more than 1.6 million schoolchildren in over 30 scientific projects. It's great to see you here, and I look forward to explaining more about space as you read on!



1

BANG!
I'M HERE!



Dear Diary

Today began a bit weirdly when, all of a sudden, I just POPPED into existence! Call it what you want - magic, or a miracle, or some mysterious law of nature - but one minute there was nothing and then there was something ... ME!

And boy, did I create HAVOC on my arrival.

I burst in on the scene as just a mega-ultra-super-teeny-weeny speck, and then grew at least a gazillion times larger in just a tiny fraction of a second.

That might not sound like much, but it's basically the same as a marble expanding to **10 million times** the width of the Milky Way in a tiny fraction of a second.

This is known as **cosmic inflation**.

Utterly mind-boggling, isn't it? Cosmologists like me are here to explore and explain the nature of the Universe, and - I must tell you - we struggled to make sense of **cosmic inflation** for many years. The rate of expansion was so great and happened so quickly that it appeared to exceed the speed of light- a universal speed limit that cannot be broken.



However, some bright spark realized that this speed-of-light limit does not apply to the expansion of space itself.. So, the Universe was NOT arrested for speeding!

There are lots of theories as to what happened during this incredibly early phase. But most evidence suggests that the Universe expanded unbelievably quickly, then slowed down to a steadier pace. Phew!




How can we tell the age of the Universe?

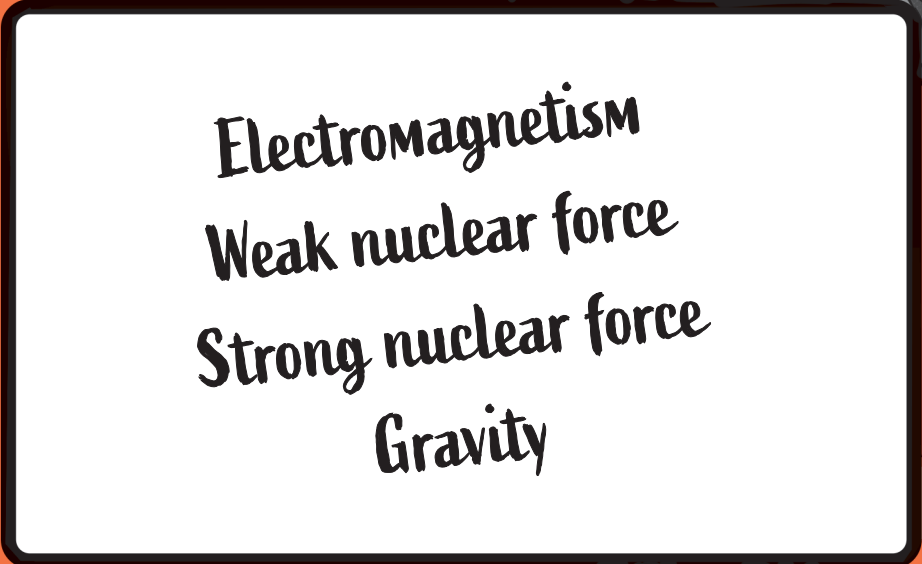
It takes some very careful measuring ... and a lot of number crunching! One technique is to estimate the age of the oldest stars. A more accurate way is to measure the present rate of the Universe's expansion and work backwards. Using vast amounts of data gathered from powerful probes and telescopes, different space agencies have arrived at slightly different dates. But they all suggest that the Universe is in the region of 13.8 billion years old.

WHAT CAUSED THE BIG BANG?

Experts think that at the **Beginning Of All Things** the fundamental forces of nature were bundled together as a single, unified force. It may have been the breakdown of this unified force that gave the Universe the 'kick' needed for the Big Bang to occur.



There are four fundamental forces that govern everything that happens in the Universe. I know your mind is already getting blown, but don't worry, I'll explain these as we go through!




- Electromagnetism
- Weak nuclear force
- Strong nuclear force
- Gravity

SMALL BUT NOT (YET) PERFECTLY FORMED ...

Whatever kicked things off, the **crazy speed** of cosmic inflation was vital for **YOUR** existence. If the Universe had expanded more slowly, its temperature would have been perfectly uniform and all its ingredients neatly and evenly laid out. As it turned out, tiny variations in the make-up of the miniscule Universe would prove vital later on. These variations led to regions that were richer in the exotic particles that would eventually allow stars and galaxies and planets to form.

So without these early flaws in the just-born Universe, **none of us would be here.** And space as we observe it today would not exist either. It just goes to show, nobody's perfect – and thank goodness for that!



All the matter and energy that will ever exist in the entire Universe was squashed into this tiny beginning. How come? Because the weird conditions that created the Big Bang made it possible!



What is space?

Space is basically what it sounds like – space! Space is the airless vacuum in which every galaxy, star and planet exists. On Earth we say that outer space begins about 62 miles above sea-level at the Kármán line – this is the point where our planet's atmosphere runs out. It's easy to think of space being full of nothing. But it's actually full of particles, energy, light, heat, gas, rocks, ice and loads of other stuff. Including a lot of stuff that we know must be there but just cannot see, like dark matter and dark energy.

WHAT WAS THERE BEFORE THE BIG BANG?

The simple answer is – we don't know for sure. This is a difficult thing for us humans to get our heads around, because our minds understand everything in terms of beginnings and endings. But even asking the question of what came before the Big Bang doesn't make sense, because there was no time before the Big Bang.

It's a bit like asking what lies south of the South Pole?

NOTHING. It's impossible to answer. That's one reason why so many different theories have sprung up around what started the Big Bang. But whether you believe the Universe was created by God, a quirk of science or a teenage alien kid in another universe who made us all up in a simulated game, the simple answer is that **no one knows for sure.**

We may never truly understand what was there before the Big Bang, or just how the Universe came into being. Perhaps one day, **YOU** can help to answer that question.

Meanwhile, in trying to learn the truth, we have uncovered and solved so many other mysteries ...



OUR 'SPACESHIP' EARTH ...

In our imaginations we can travel anywhere, as we will in this book. But in real life, the only way we know to journey through space is in a spaceship ...

The word 'spaceship' makes us think of sailing across an ocean of space. And the word '**astronaut**' in Greek literally means a 'star sailor'. In fact, there are many similarities between a spaceship and a sailing ship. Both vessels are designed to protect us, to keep us alive in a **hostile** environment and to carry us safely from one place to another.

What's more, both ships are being **pulled by gravity**. A sailing ship is designed to float on water, to stop the force of gravity from sinking it. A spaceship is designed with thrusters – it needs some sort of propulsion system to stop gravity from pulling it in a direction it shouldn't be going in. And whereas a sailing ship can catch the wind in its sails, some future spaceships might also be able to catch the 'wind' in their sails too. However, in space the **wind is not molecules of air**, but streams of charged particles flying away from the Sun, and the sails are big mirrors bombarded by these particles.

But there's only one place in space we know of that has exactly the right conditions to keep you alive as you whizz through it ... and **you're standing on it** (or maybe sitting or lying down on it) right now! That's right, it's the incredible **Spaceship Earth**.

Even with all its problems, there's no better place to be that we know of!



Can you ever reach the edge of the Universe?

The Universe doesn't have real edges – that would imply that the Universe has a centre too, like an enormous map. But the Universe isn't built that way, because the **Big Bang** was not like a real explosion that starts from a single point. The Big Bang happened everywhere all at once. The Universe is expanding equally from every point.

It might help to imagine dots drawn on the surface of a balloon. As you blow up the balloon all the dots move further apart from all the other dots. If you think of each dot as a galaxy, you can picture how they move away from each other.

In a way, though, **YOU** are the centre of the Universe – because wherever you might be, it appears as if all of space is expanding away from YOU. It's like if you could sit inside a ball of dough with raisins in, rising in an oven. Wherever you sit, the raisins would seem to be moving away from you in all directions.

Now, get out of there, **it's far too hot.**

Ugh, now you're all covered in dough and raisins!

Clean yourself up and we'll move onto the **next chapter ...**

