10 EXTRAORDINARY Ideas that SHAPED our UNIVERSE

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WE ARE ALL MADE *of* STARS

It was the British American astronomer Cecilia Payne-Gaposchkin who discovered what stars are made from nearly a hundred years ago. If you've ever heard the saying that humans are made of stars, well, it is actually true! The elements that are formed in stars are also found in human bodies. You really do have stardust in your fingertips!

WHAT IS A STAR?

What actually is a star? And do they really twinkle like in the nursery rhyme?

A star is a HUGE ball of gas that is 'stuck' together because of gravity. Stars also contain a special matter called plasma. This is basically gas that has become extremely hot and starts to behave in weird and unusual ways!

Stars undergo a process called fusion, which is what creates the heat and light that makes them twinkle in the night sky.

FUSION

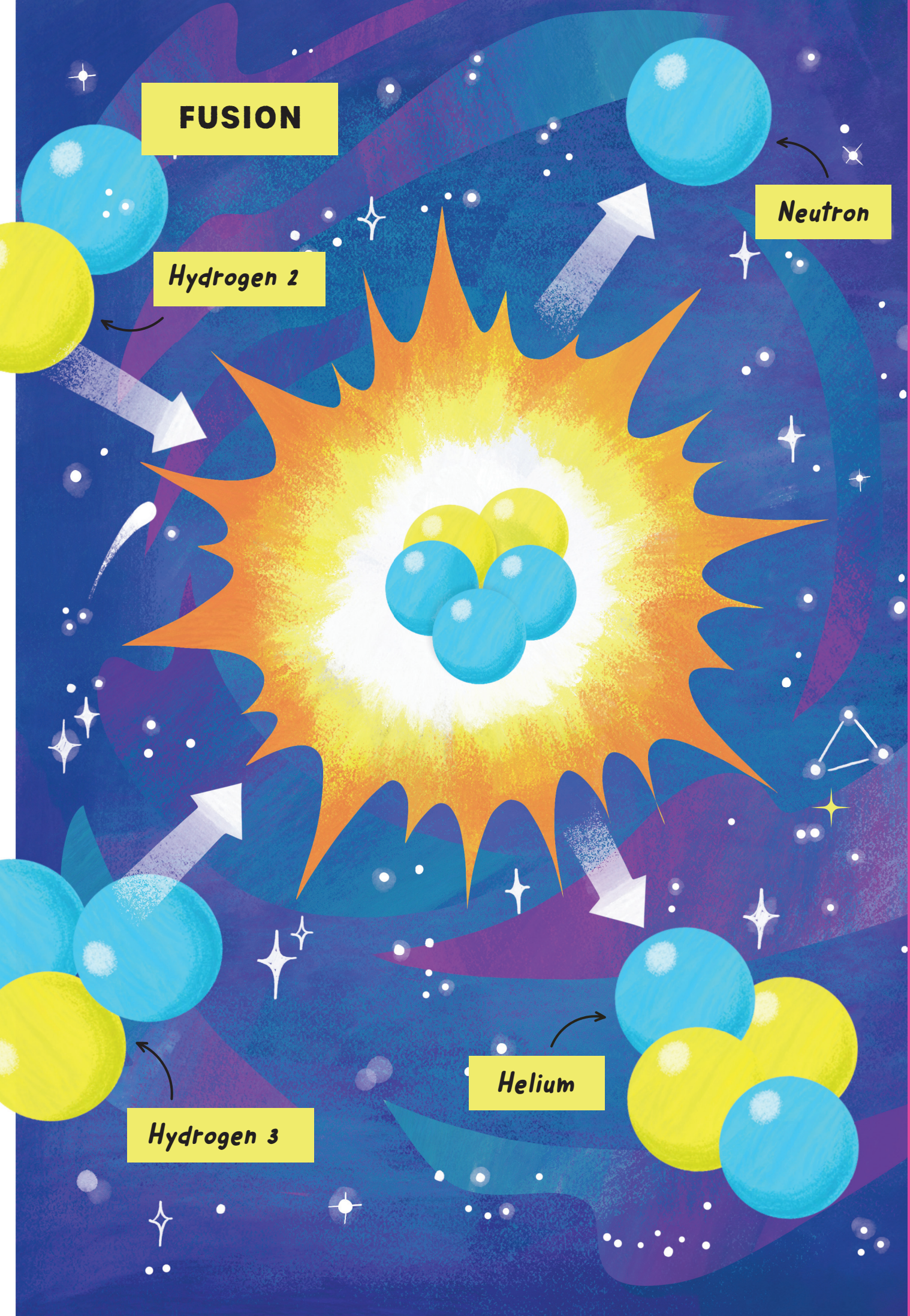
You might remember that the central part of an atom is called the nucleus. Fusion is a process in which two nuclei join together to create a single nucleus, releasing lots of energy. In the centre of a star, hydrogen gas is squashed under huge pressure, causing the nuclei of two hydrogen atoms to fuse together to form another gas: helium.

STAR LIFE CYCLES

Stars are born in nebulae – massive clouds of dust and hydrogen gas. Over time, gravity causes the gas and dust to smash together, creating blobs of higher-density matter. More and more blobs squash together until a protostar – a baby star – is born!

The protostar spins and contracts, and the pressure and temperature increase, until the star becomes stable and the temperatures are high enough for fusion to start. This first phase of a star's life can last a few million years!

Once stable, the star is in the main phase of its life, called the main sequence. During this time, the star burns hydrogen gas into helium, creating heat, light and energy. This can continue for millions of years, until the hydrogen runs out, at which point the star will leave the main phase of its life and start to die.


FUSION
Neutron
Hydrogen 2
Helium
Hydrogen 3

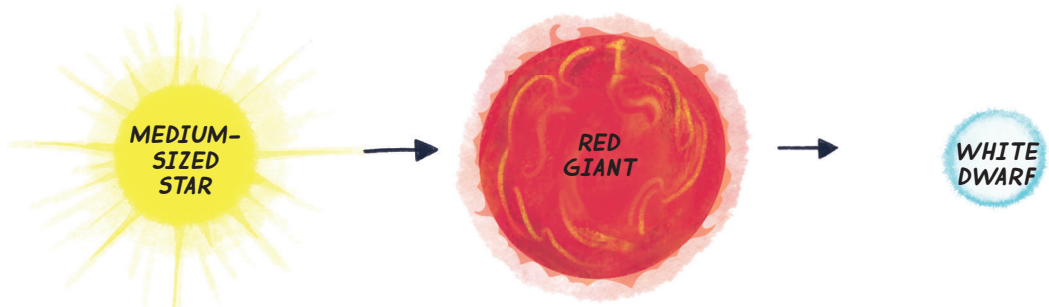
WHAT HAPPENS WHEN A STAR DIES?

The death of a star can be pretty dramatic! The star becomes unbalanced when the hydrogen runs out, and depending on the size of the star, it will go through one of the following transformations . . .

SMALL STARS

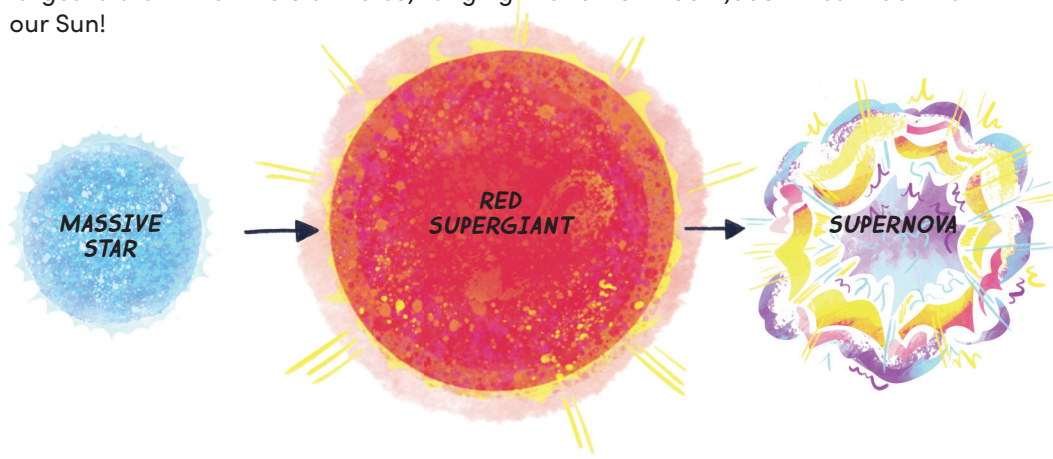
Small to medium-sized stars, like our Sun, will expand into a red giant star. The radius (or the distance from its middle to its outer edge) of a red giant can be four hundred times the size of the main-sequence star. A star like our Sun could become so big that it might swallow the first few planets in the solar system whole!

Next, the outer layers of the red giant will be blown away into space, leaving behind a small, extremely dense white-hot core. These dying stars are called white dwarfs.

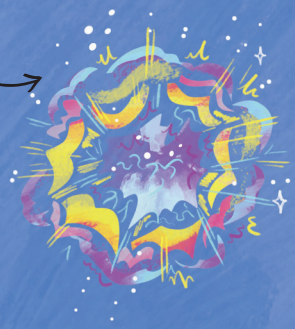


MASSIVE STARS

Massive stars, much bigger than our Sun, die in a much more spectacular way. When hydrogen runs out, these massive stars first turn into red SUPERgiants, which are way more exciting than the red giants! Red supergiants can be some of the largest stars in the whole universe, ranging in size from 100–1,000 times wider than our Sun!



SUPERNOVA



In one supernova explosion, more energy is released than the Sun can give off in its whole lifetime!

During a supernova explosion, all the heavier elements are created, from iron onwards. This includes things like gold and silver. So, if you've ever touched or worn gold or silver jewellery, this was first created in an explosion caused by a huge star violently dying!

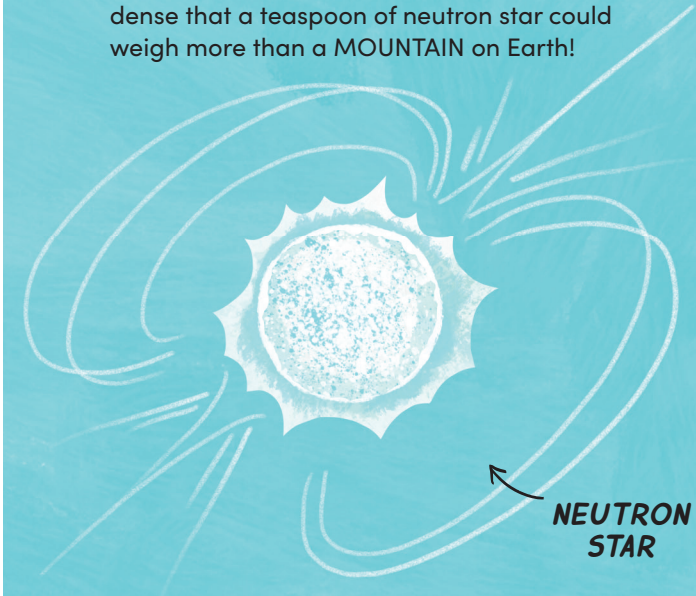


Ancient astronomers saw a supernova around the year 1054. There are records that tell us that the supernova was as bright as a full moon, and it could be seen in the daytime sky for a month!



BIG FACTS

When a supernova cools down, the core of the star is once again left behind and forms something called a neutron star. A neutron star is a very dense, very small star, made up almost entirely of neutrons. It is so incredibly dense that a teaspoon of neutron star could weigh more than a MOUNTAIN on Earth!

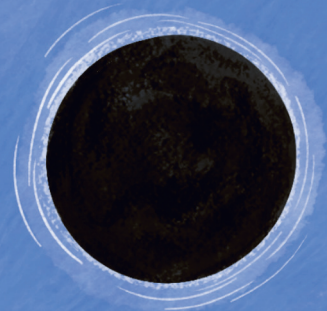


NEUTRON STAR

If the star that created the supernova was a truly massive star, more than three times the mass of our Sun, the supernova explosion creates a neutron star that keeps collapsing in on itself, eventually forming a black hole.

A black hole is an area in space where the gravitational force is so strong that not even light can escape. Black holes are still a big mystery, and scientists aren't really sure how they work, even though it's now possible to study them using mathematics.

BLACK HOLE



WHAT IS SO SPECIAL ABOUT THE SUN?

Now, if we are going to talk about stars and astronomy, we really need to take a closer look at the Sun – it is our star, after all! The Sun is the centre of our solar system, which is made up of a star and the group of planets and other space objects that orbit around it.

But the Sun is actually quite a 'normal' type of star – nothing super fancy, not all that big, not all that bright. It's so normal in fact that it's known as an average star. And the Sun lives in a galaxy of stars – it's one of *billions* of other stars. So what makes the Sun SO special?

Us! Without the Sun having a little blue-and-green planet orbiting around it, teeming with life, it would be just another average star. But because of us, and all the living things on Earth, the Sun is possibly the most special star in the universe. It works two ways though, of course: without the Sun, we wouldn't be here! The Sun provides the light and heat that power all of the life on Earth.

HOW BIG IS THE SUN?

The Sun is MASSIVE. You can fit a million Earths into the Sun! The Sun has 99 per cent of the mass of the solar system in it. And without the gravity of the Sun keeping everything in orbit, all of the planets and everything else in the solar system would whirl off into space. Other stars in our galaxy also have been found to have planets orbiting them, but whether or not there's life elsewhere, we don't really know . . . yet!



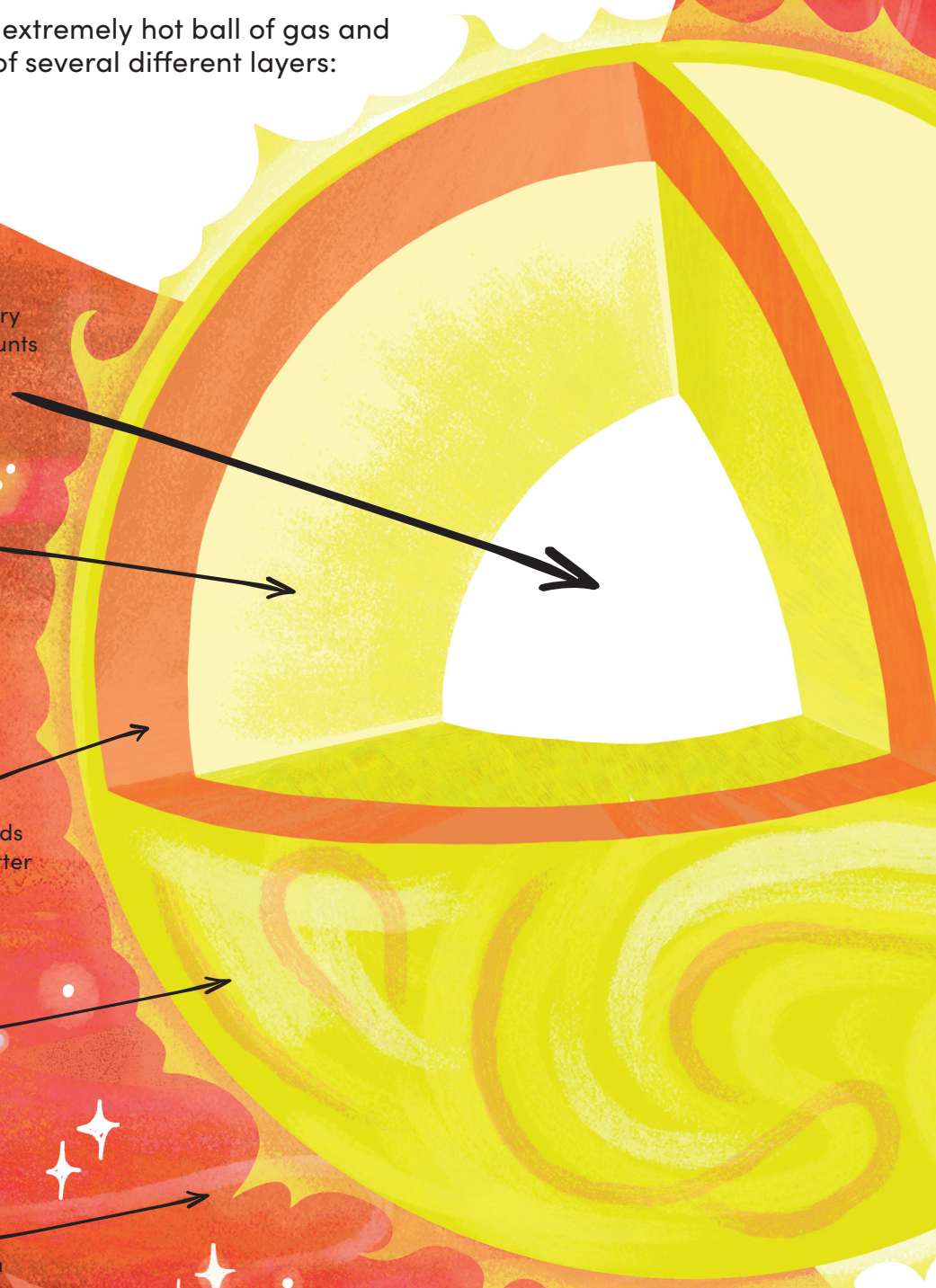
SOLAR ECLIPSES

The distance between the Earth and our Moon is about four hundred times closer than the distance between the Sun and the Earth, and that leads to something special: solar eclipses! These happen when the Moon is directly in between the Earth and the Sun, which doesn't occur very often. During a solar eclipse, the Moon can block out the disc of the Sun completely, which is called totality. The sky goes dark for a few minutes, even if it is the middle of the daytime! This eeriness can make animals feel confused – why is it suddenly night-time? Solar eclipses look incredible and they can be useful for doing solar science, too, because it is only during a solar eclipse that we can directly see the Sun's corona – the upper atmosphere that surrounds it.



WHAT IS THE SUN MADE OF?

Like all stars, the Sun is an extremely hot ball of gas and plasma, and it's made up of several different layers:



THE CORE:
This is where fusion happens. Every second, the Sun burns huge amounts of hydrogen into helium, creating temperatures over fifteen million degrees Celsius!

THE RADIATIVE ZONE:
The energy created in the core moves slowly outwards. It can take more than 170,000 years for energy to radiate through this layer of the Sun!

THE CONVECTION ZONE:
Energy continues to move outwards through convection currents – hotter gases rise and cooler gases fall down in a circular motion.

THE CHROMOSPHERE:
A thin layer of plasma in between the photosphere and the corona.

THE CORONA:
The Sun's upper atmosphere, where the temperature can reach over two million degrees Celsius!

WHO DISCOVERED WHAT STARS ARE MADE FROM?



One of the reasons we know what stars (including our Sun!) are made from is due to astronomer Cecilia Payne-Gaposchkin, who discovered that stars are made from hydrogen and helium in 1925.

Cecilia studied physics and chemistry at the University of Cambridge, but she wasn't allowed to gain a degree because she was a woman. Cecilia didn't let that stop her though, and she went on to become the first person to get an astronomy PhD from Radcliffe College, Harvard University in the USA.

And Cecilia wasn't the only woman to make discoveries about stars. For hundreds of years, female astronomers have been expanding our knowledge of stars and planets.



HYPATIA

Probably the first-ever female astronomer, Hypatia lived in Egypt around 350 CE. Hypatia's father was a famous mathematician, and he taught her about maths and astronomy. She wore similar clothes to men, and even drove her own chariot! She was particularly good at teaching others about complicated ideas in maths and astronomy, which helped future astronomers come up with their own ideas and theories.



CAROLINE HERSCHEL

Caroline Lucretia Herschel was born in 1750 in Hanover, Germany, but moved to England to work with her brother William, first as a musician, and then as an astronomer. By the time Caroline died at the age of 97, she had discovered eight comets. She was the first woman to discover a comet, the first woman to be paid to be an astronomer and also the first woman to win the Gold Medal from the Royal Astronomical Society!



MARY SOMERVILLE

Mary Somerville was a Scottish scientist who was born in 1780. Mary loved to learn new things, even though girls didn't often go to school back then. She was inspired to study maths and astronomy thanks to a book her art teacher showed her called *Euclid's Elements*. In 1842, Mary wrote a scientific book in which she talked about an unknown planet in our solar system near Uranus. This led to the discovery of Neptune four years later!

WHAT IS A CONSTELLATION?

Over the centuries, humans have found patterns in the sky showing animals, inanimate objects or people. These are known as constellations, and they are often based on religions and myths. Different cultures and religions have different constellations, tracing back to the ancient Egyptians and Chinese.

CASSIOPEIA THE QUEEN

The constellation Cassiopeia features five bright stars that look like the letter W. This is supposed to represent an evil queen from Greek mythology – Cassiopeia! This is how the story goes . . . Cassiopeia boasted that she was the most beautiful queen in all the land – more beautiful than the sea nymphs, which angered the god of the sea, Poseidon. He tried to destroy her by sending a sea monster to her kingdom, but Queen Cassiopeia used her daughter as bait by tying her to a rock. Her daughter was saved, but Cassiopeia was punished for her vanity by being placed in the sky upside down, where she remains today!

In other cultures, the constellation Cassiopeia is seen as a queen holding a crescent moon, a hand with henna on, a camel, and even a moose with antlers! This goes to show that constellations are quite subjective and can vary depending on where in the world you come from.

Today there are 88 official constellations recognized by the International Astronomical Union (IAU). Most are named after stories in Western mythology and religion. But since 2016, the IAU has started to rename stars (and hopefully one day, constellations), to recognize all the astronomers from history, not just those from the Western world.


Constellation
Cassiopeia

BEYOND THE MILKY WAY

The Milky Way is one of billions of other galaxies. While ours is spiral-shaped, some galaxies might be elliptical or egg-shaped, and others are irregular and don't fit into any category.

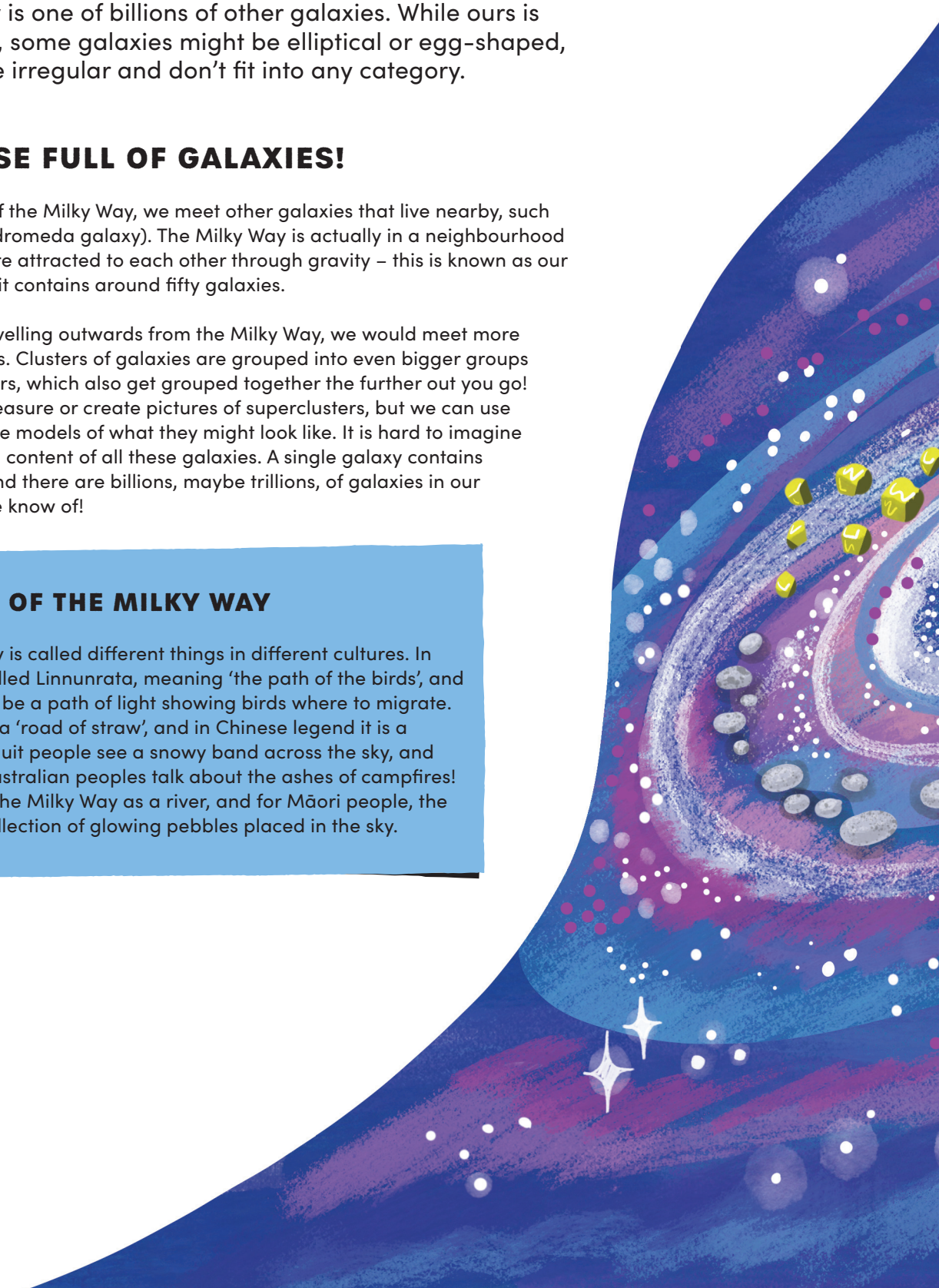
A UNIVERSE FULL OF GALAXIES!

As we travel out of the Milky Way, we meet other galaxies that live nearby, such as M31 (or the Andromeda galaxy). The Milky Way is actually in a neighbourhood of galaxies that are attracted to each other through gravity – this is known as our Local Group, and it contains around fifty galaxies.

If we continue travelling outwards from the Milky Way, we would meet more and more galaxies. Clusters of galaxies are grouped into even bigger groups called superclusters, which also get grouped together the further out you go! We can't really measure or create pictures of superclusters, but we can use computers to make models of what they might look like. It is hard to imagine the sheer size and content of all these galaxies. A single galaxy contains billions of stars, and there are billions, maybe trillions, of galaxies in our universe – that we know of!

LEGENDS OF THE MILKY WAY

The Milky Way is called different things in different cultures. In Finland it's called Linnunrata, meaning 'the path of the birds', and it's thought to be a path of light showing birds where to migrate. In Turkish it is a 'road of straw', and in Chinese legend it is a 'silver river'. Inuit people see a snowy band across the sky, and Indigenous Australian peoples talk about the ashes of campfires! The Inca see the Milky Way as a river, and for Māori people, the galaxy is a collection of glowing pebbles placed in the sky.





IS THERE LIFE OUT THERE?

Of all those stars in the universe, currently the only star with life orbiting it (that we know of) is our Sun! But are there other planets with life on them out there?

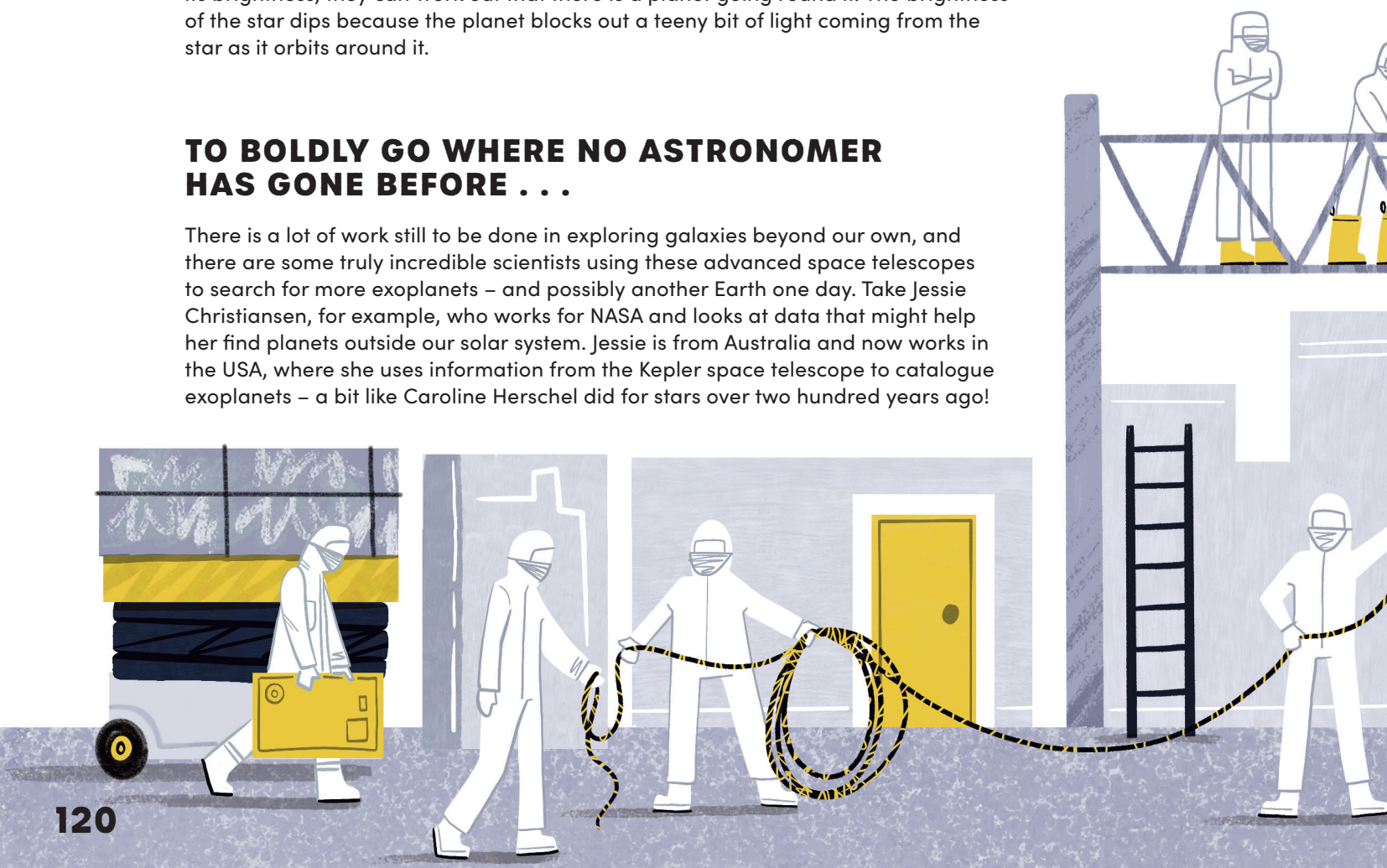
DISCOVERY OF EXOPLANETS

So far, since we started looking for other planets, we've found over six thousand exoplanets! That seems like a pretty good start towards finding another Earth-like planet, but so far scientists have not found any planets that really look like ours. Most of the planets scientists have found are more like 'hot Jupiters' than 'Earth 2.0'!

There are a few different ways to look for planets around other stars using telescopes in space, such as the James Webb Space Telescope (or JWST). The main way that scientists look for exoplanets is by pointing a huge telescope at a star and waiting! Scientists measure the brightness of the star, and if there are regular dips in its brightness, they can work out that there is a planet going round it. The brightness of the star dips because the planet blocks out a teeny bit of light coming from the star as it orbits around it.

TO BOLDLY GO WHERE NO ASTRONOMER HAS GONE BEFORE . . .

There is a lot of work still to be done in exploring galaxies beyond our own, and there are some truly incredible scientists using these advanced space telescopes to search for more exoplanets – and possibly another Earth one day. Take Jessie Christiansen, for example, who works for NASA and looks at data that might help her find planets outside our solar system. Jessie is from Australia and now works in the USA, where she uses information from the Kepler space telescope to catalogue exoplanets – a bit like Caroline Herschel did for stars over two hundred years ago!



SMELLS LIKE A PLANET . . .

Scientists using the JWST have recently been able to 'sniff' out an exoplanet. A team of astronomers, including Guangwei Fu and Luis Welbanks, used the space telescope to work out what the atmosphere of planet HD 189733 b is made from. HD 189733 b is a giant planet, close to its parent star. It's a 'hot Jupiter' – meaning a gas giant with very high temperatures – and its atmosphere has lots of hydrogen sulphide gas in it. And hydrogen sulphide smells like rotten eggs, so if it were possible to visit HD 189733 b, it would be pretty stinky!

