# Introducing the Universe experts:

## AUTHOR

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Dr Mike Goldsmith is a Fellow of the Royal Astronomical Society, with a doctorate in astrophysics. He is both a working scientist and a writer of more than 40 science books for readers ranging in age from toddlers to adults. His books have been published in 25 countries, with two of them shortlisted for the *Royal Society Prize for Science Writing*.

Super brains!

## CONSULTANT

### SUNNY VAGNOZZI

A Newton-Kavli fellow within the Kavli Institute for Cosmology at the University of Cambridge, Sunny Vagnozzi is also affiliated to the Institute of Astronomy and the Department of Applied Mathematics and Theoretical Physics, and holds a College Research Associateship position at Homerton College.

Sunny is a cosmologist with a strong background in particle theory, interested in addressing fundamental questions about the origin, composition, and fate of the Universe.



# Contents and selected spreads from:

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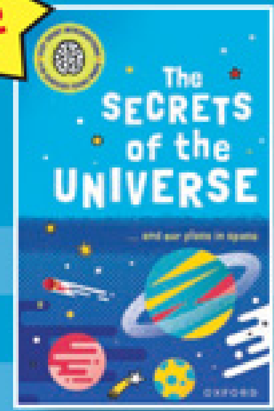



***The Secrets of the Universe*** explores the enduring fascination of space. It reveals how the Universe was discovered, how we know it is expanding, that most of it is invisible and asks some intriguing cosmic questions.

**Extent:** 96pp
**Size:** 174mm x 111mm
**Price:** £7.99
**ISBN:** 978-0-19-277921-2

## Contents

This is a very short introduction to the Universe and its secrets. You'll discover that . . .

The Universe is expanding.

It contains over a trillion trillion planets.

An awful lot happened in the Universe's first three minutes.

Most of it is invisible.

Stars work like bicycle pumps.

No one understands what most of it is.

Read on to find out some of the secrets of the Universe . . .



Chapter 2

# Discovering the Universe

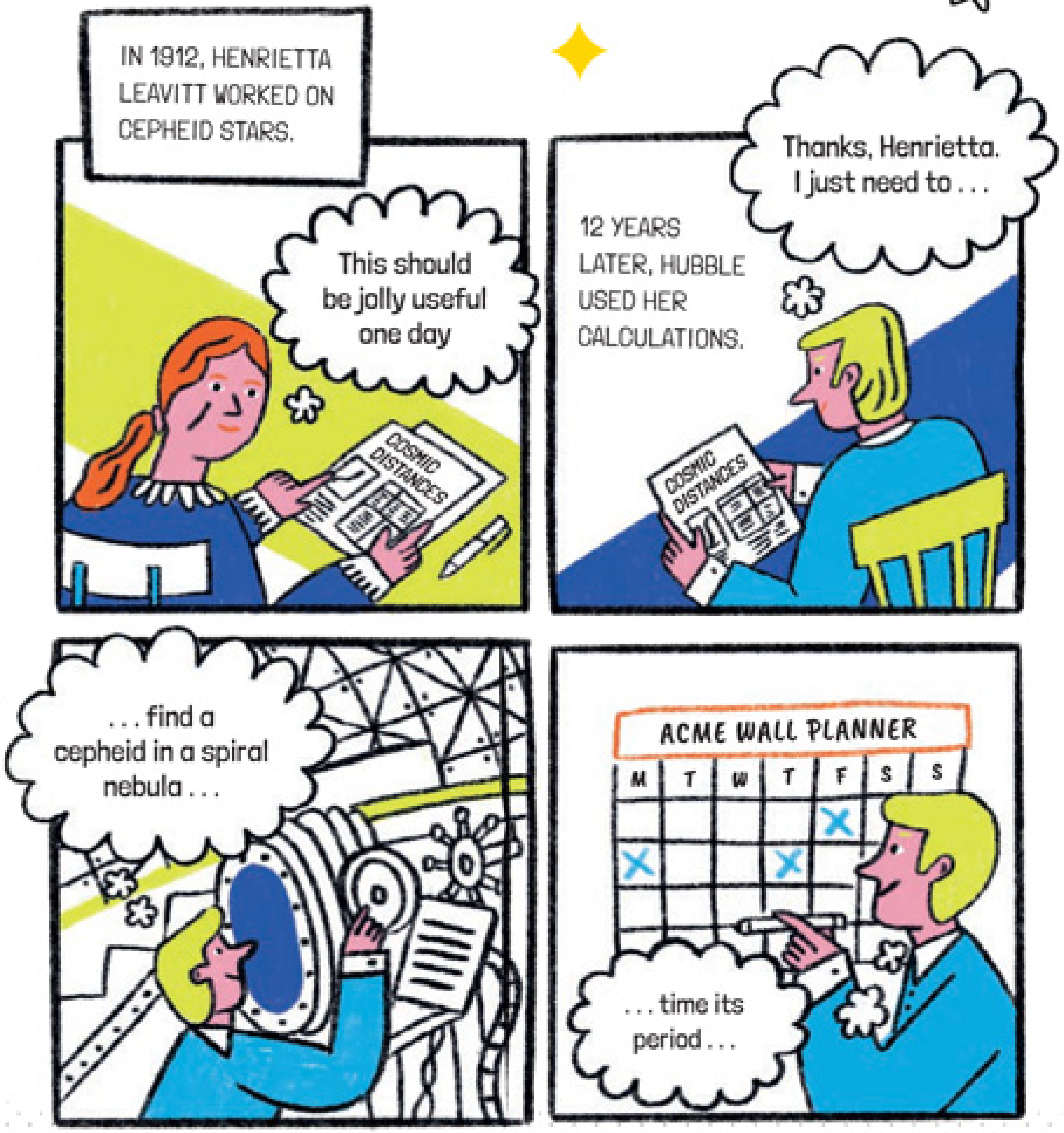
**To you and me, the word 'Universe' suggests a vast space, full of bright stars. But our ancestors had very different ideas.**

## Ancient ideas

Today, we know that there is nothing special about our place in the Universe: our Sun is just an ordinary star, and the Earth is a very average planet. But ancient people had no reason to think the stars were anything like the Sun and assumed that they were small and near—just above the clouds, perhaps. Because the Sun crosses the sky by day, and the stars do the same thing by night, they assumed the Sun and stars were moving while the Earth remained still.

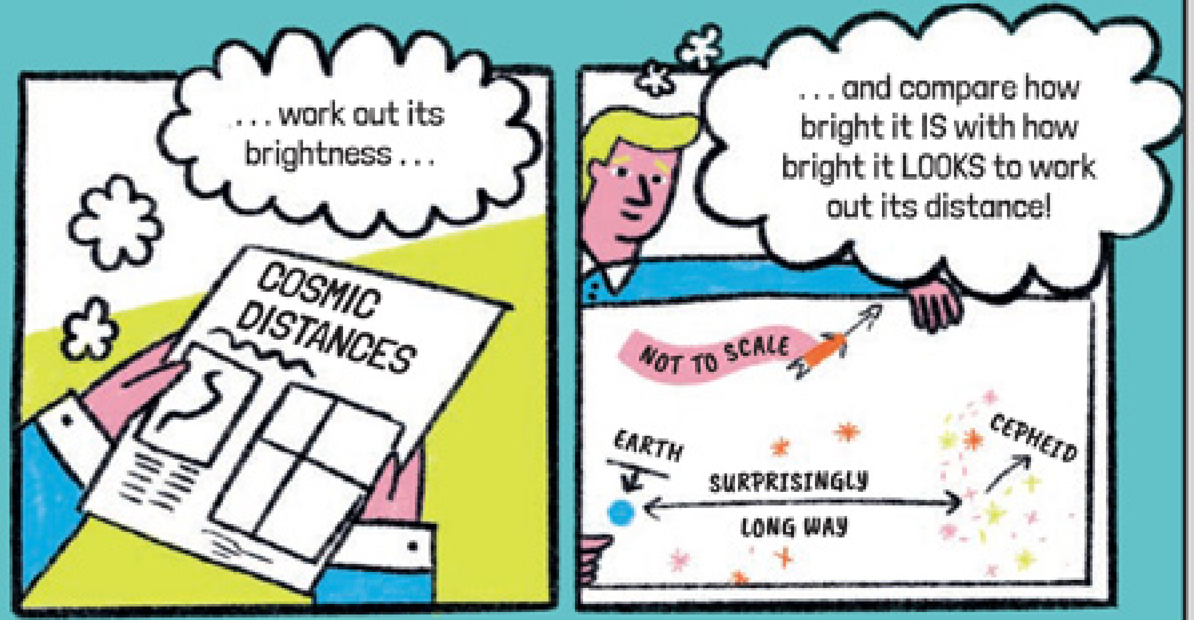
These long-ago people noticed that the noonday Sun is highest in the sky in the summer and lowest in winter, different patterns of stars are visible at different times of year, and the Moon goes through a pattern of changes of shape every 29½ days. So, the sky could tell people what time of year it was.

Leavitt studied thousands of them, and found that the brighter the cepheid, the longer its period. This was useful to Hubble because it meant he could measure distances to spiral nebulae.








Hubble found that the spiral nebulae are millions of light years away, far beyond the outer limits of our Milky Way Galaxy. In fact, he realized, they are galaxies themselves. Suddenly, the Universe had become a

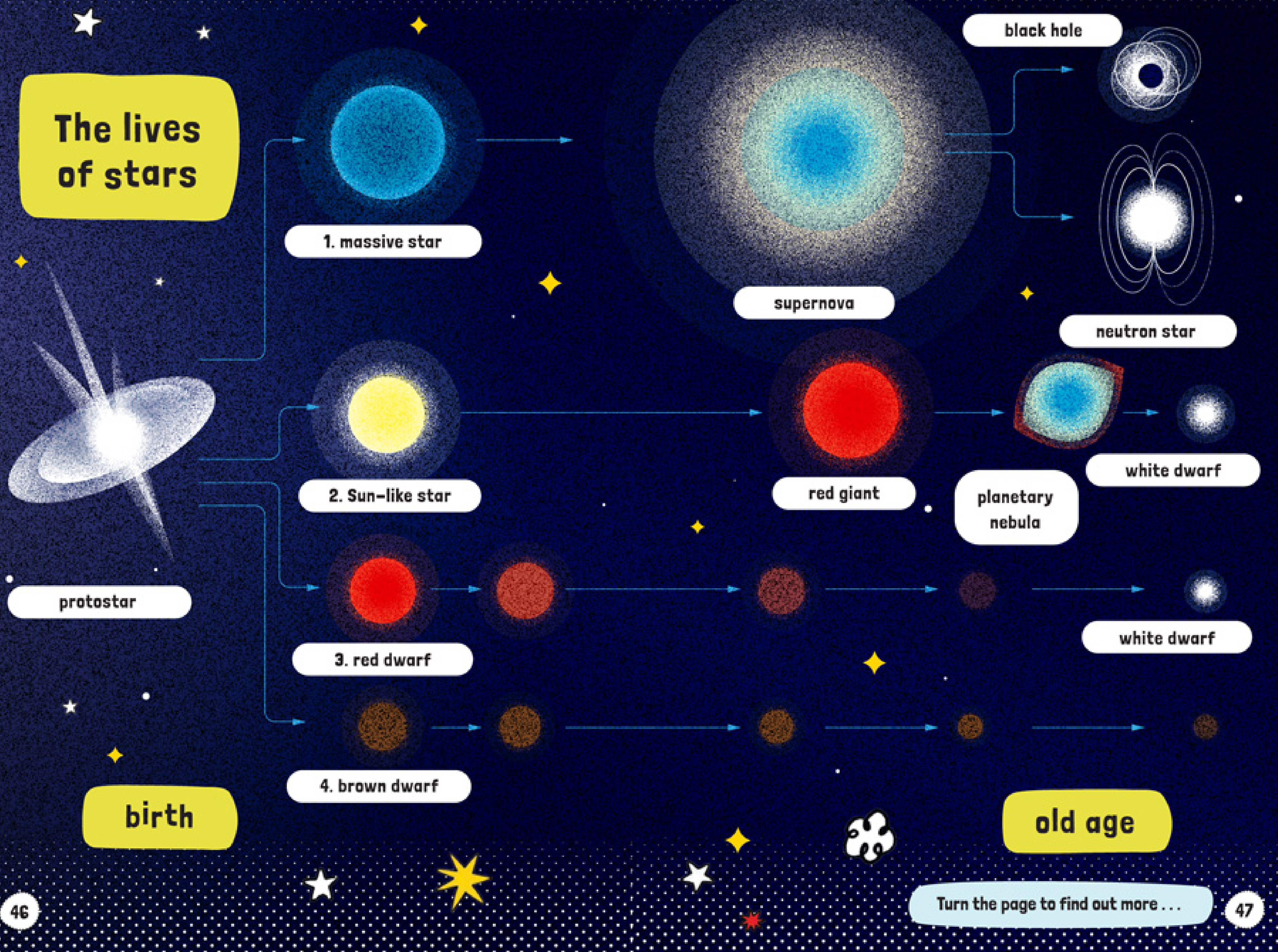
**much larger place.**

## Speak like a scientist

### GALAXY

A group of thousands or millions of stars, held together by gravity. Our own galaxy is called the Milky Way Galaxy.

# The lives of stars



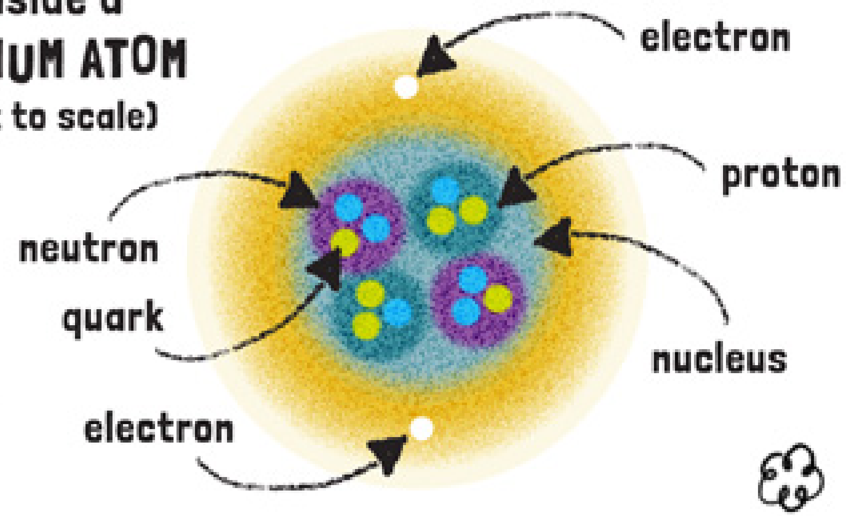

Turn the page to find out more . . .

Less than a second after all these particles and antiparticles had appeared, almost every one of the new particles of matter had encountered an antimatter particle, and they had destroyed each other.


Mysteriously, but very luckily for us, the Universe originally had about one billion and one matter particles for every one billion particles of antimatter, so there was a little matter left over from this enormous storm of destruction.

As the temperature of the Universe fell further, quarks joined together, forming neutrons and protons. All this happened in the first second of the history of the Universe.

Inside a **HELIUM ATOM** (not to scale)








Three minutes later, some of the neutrons and protons had joined to form helium nuclei (which are made up of two protons and two neutrons). Other protons remained separate, as did all the electrons.

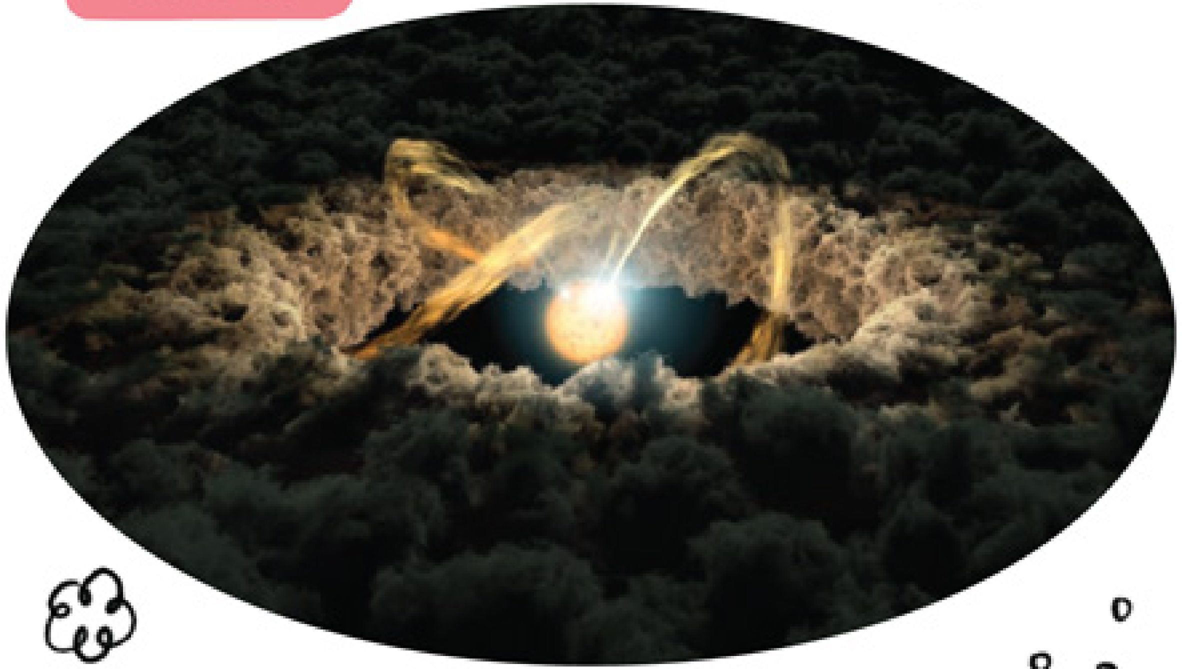
**For 380,000 years**, the Universe was too hot for these particles to develop any further, but it was cooling all the time. Finally, when the Universe had cooled to about 3,000 K, electrons could stick to the helium nuclei to form helium atoms and to the protons to form hydrogen atoms (a hydrogen atom's nucleus is just a proton).

Until now, although the Universe had been packed with high-energy radiation, it was also stuffed full of so many particles that this radiation was trapped. But, as the electrons became parts of atoms, this radiation was set free.

This radiation was infrared at the time, but it has long since turned into microwaves: the CMB we met on pages 38–39.

So, the oldest radiation that we can possibly detect comes from about 380,000 years **after the Big Bang**. Can we ever look back to an earlier time than this? Thanks to gravitational waves (see page 26), perhaps we can. They could travel through the

## PROTOSTAR



Many, perhaps most, of this new generation of stars had planets, which formed from billions of orbiting dust particles that surrounded the stars, making discs.

Why did these discs form? The stirring of the cloud that started the clumping process meant that there were trillions of dust grains rushing around at high speeds.

**Imagine one of these dust grains speeding past a protostar.**





The protostar's gravity will pull on the grain which will then move towards the protostar . . .

. . . but its speed means it will start to orbit the protostar instead of crashing into it. This is exactly how spacecraft are sent into orbit around other planets.

# Timeline

This timeline builds a picture of when the important events in the study of the Universe happened.