# Dark Matter

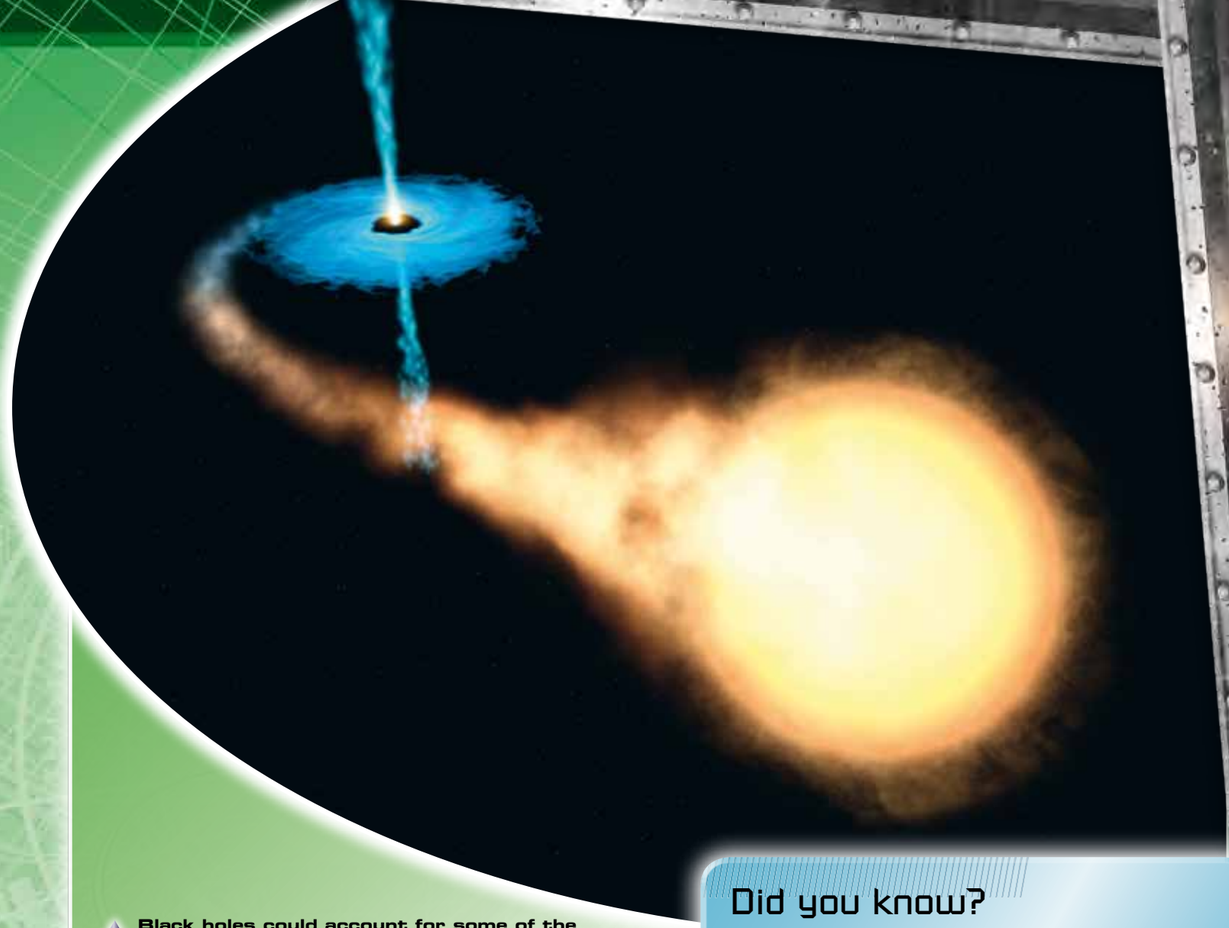
*Dark matter is matter that is not visible through telescopes because it does not emit or reflect light. Scientists believe it may account for up to 90 per cent of matter in the universe.*

## How do we know about dark matter?

If dark matter cannot be seen, how do scientists know it exists? Even though it is not visible directly, dark matter can be detected by its effect on light.

Imagine light travelling from a distant **galaxy** towards Earth. If an extremely massive, dark object were to lie between the galaxy and Earth, light from the galaxy would bend. Stars and galaxies that have had their light bent in this way appear curved.

**The *Hubble Space Telescope* captured this image of a galaxy cluster with a ring of dark matter surrounding it.**



**Black holes could account for some of the universe's dark matter as they do not emit or reflect light. This artist's impression shows a black hole (in the background) pulling a star towards it.**

### Did you know?

The word halo in Massive Astrophysical Compact Halo Objects (MACHOs) refers to where most MACHOs are likely to be — in the halos of galaxies. A halo is a large band of dark matter that surrounds the visible part of a galaxy.

## MACHOs and WIMPs

Scientists have various theories about what dark matter might be. One theory suggests MACHOs (Massive Astrophysical Compact Halo Objects). These are large, dark, extremely dense objects such as burned-out stars and **black holes**. Another theory suggests WIMPs (Weakly Interacting Massive Particles). These are hypothetical subatomic particles, similar to neutrinos, which could have a tiny mass but could exist in huge quantities.

## Neutrinos

Neutrinos are a type of subatomic particle produced by stars in vast numbers. Even though they are common, they are very difficult to detect. Scientists once thought neutrinos had no mass at all, but experiments have proved that they do have a very tiny mass. This means neutrinos could account for at least some dark matter.

# Space and Time

*In everyday life we think of space and time as separate things, but scientists view them as two parts of a single* ***phenomenon*** *called* ***space-time****.*

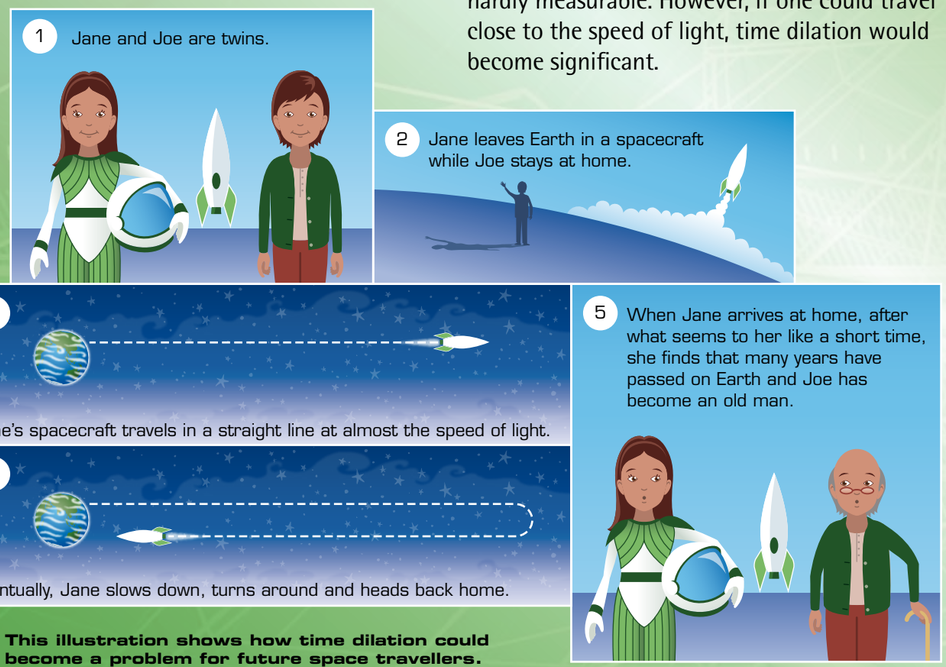
## Space-time

By combining space and time into a single concept, scientists are better able to describe how the universe works on a small and large scale. Scientists define space-time as having four dimensions. These are the usual three dimensions of space (length, height and width) and one dimension of time.

## Time dilation

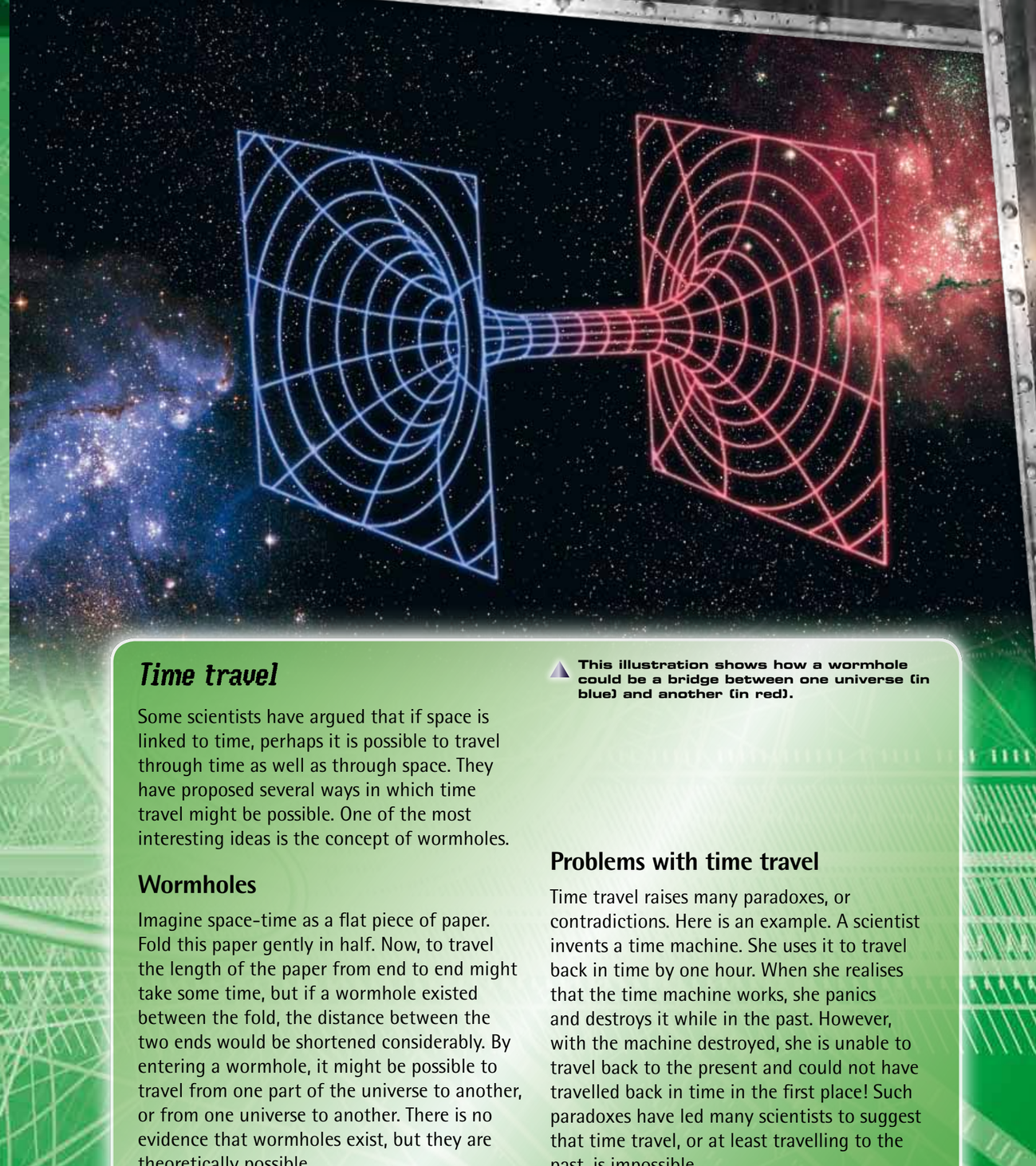
**Time dilation** is a theory that the passage of time slows down as a moving object approaches the speed of light.

Time is dependent on certain factors. The rate at which one watch ticks compared to another depends on how fast the person wearing the watch is travelling in relation to the other. In everyday life, the difference is so tiny that it is hardly measurable. However, if one could travel close to the speed of light, time dilation would become significant.




**This illustration shows how time dilation could become a problem for future space travellers.**





**This illustration shows how a wormhole could be a bridge between one universe (in blue) and another (in red).**

## Time travel

Some scientists have argued that if space is linked to time, perhaps it is possible to travel through time as well as through space. They have proposed several ways in which time travel might be possible. One of the most interesting ideas is the concept of wormholes.

### Wormholes

Imagine space-time as a flat piece of paper. Fold this paper gently in half. Now, to travel the length of the paper from end to end might take some time, but if a wormhole existed between the fold, the distance between the two ends would be shortened considerably. By entering a wormhole, it might be possible to travel from one part of the universe to another, or from one universe to another. There is no evidence that wormholes exist, but they are theoretically possible.

### Problems with time travel

Time travel raises many paradoxes, or contradictions. Here is an example. A scientist invents a time machine. She uses it to travel back in time by one hour. When she realises that the time machine works, she panics and destroys it while in the past. However, with the machine destroyed, she is unable to travel back to the present and could not have travelled back in time in the first place! Such paradoxes have led many scientists to suggest that time travel, or at least travelling to the past, is impossible.

# THE FUTURE OF SPACE SCIENCE

*In the future, new technological developments will improve the quality of observations from Earth and in space. With better observational data, scientists may be able to develop better theories explaining how the universe works and prove current theories right or wrong.*

## Observational space science

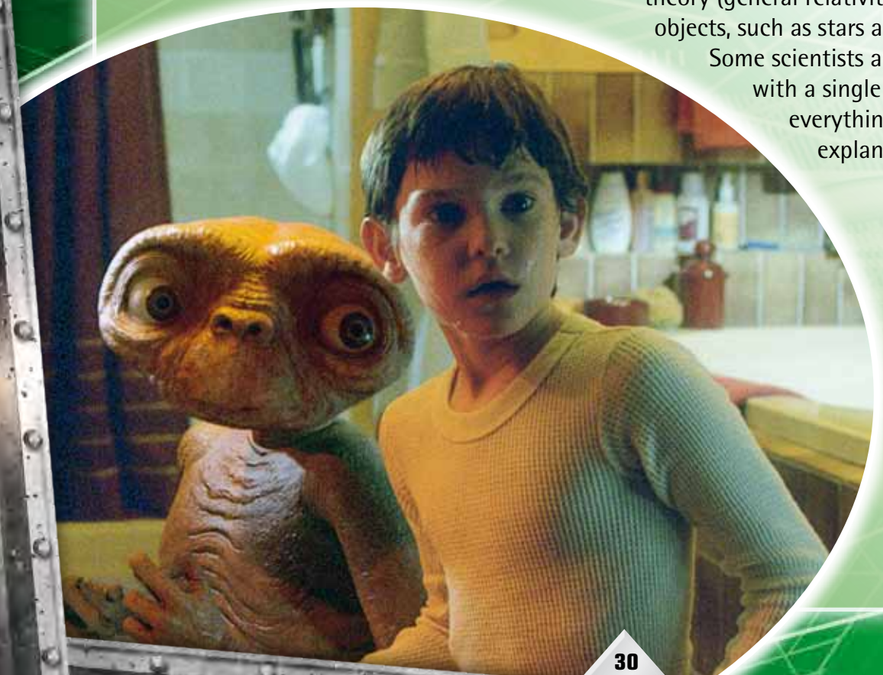
One exciting area of current research is the search for **extraterrestrial** life. So far, more than 300 **exoplanets** have been discovered. Most of them are **gas giants**, but as detection techniques improve, scientists expect to find smaller, rocky planets too. A rocky planet located far enough from its parent star and with the right type of **atmosphere** could support extraterrestrial life.

### Did you know?

One way scientists search for extraterrestrial life is by scanning the sky with radio telescopes. They hope to receive radio signals from intelligent life forms.

## Theoretical space science

At the moment there are two scientific theories explaining the way the universe works. One theory (quantum mechanics) explains how subatomic particles behave and the other theory (general relativity) explains how larger objects, such as stars and **galaxies**, behave. Some scientists are trying to come up with a single theory that will explain everything, but perhaps such an explanation does not exist.



**Humans have long been fascinated by the possible existence of extraterrestrial life and have expressed this interest through television and the movies. In *ET the Extraterrestrial*, an alien being is left behind on Earth and befriends a young boy.**



# GLOSSARY

**atmosphere**
the layer of gases surrounding a planet, moon or star

**big bang theory**
the theory that the universe expanded from an extremely dense and hot state and continues to expand today

**black holes**
regions of space where gravity is so powerful that nothing can escape, not even light

**cosmic background radiation**
a form of electromagnetic radiation that fills the universe but is not associated with any space object

**dwarf planet**
a small planet-like body that is not a satellite of another body but still shares its orbital space with other bodies

**electric charge**
a property some subatomic particles have, which can either be positive or negative

**electromagnetic radiation**
waves of energy created by electric and magnetic fields

**electromagnetic spectrum**
the range of all possible wavelengths of electromagnetic radiation, including radio waves, microwaves, infrared, visible light, ultraviolet, X-rays and gamma rays

**exoplanets**
planets that are outside our solar system, orbiting a star other than the Sun

**extraterrestrial**
coming from outside Earth, or a being not from Earth

**galaxy**
a large system of stars, gas and dust held together by gravity

**gas giants**
large planets made mostly of gas and with a metal or rock core, such as Jupiter, Saturn, Uranus and Neptune

**gravity**
the strong force that pulls one object towards another

**hydrogen**
the lightest chemical element and the most common element in the universe

**nebulae**
clouds of gas or dust in space

**neutron stars**
very hot, small and dense stars, left behind by supernovae

**nuclear fusion**
the process in which the nuclei of two or more atoms fuse together to form a single atom with a heavier nucleus, releasing huge amounts of energy

**orbited**
followed a curved path around a more massive object while held in place by gravity; the path taken by the orbiting object is its orbit

**phenomena**
things that can be observed, especially things that are unusual or interesting

**pulsars**
rotating neutron stars that emit a beam of electromagnetic radiation which can only be seen when the beam is pointing towards Earth

**quasars**
the highly energetic cores of active galaxies, believed to be powered by supermassive black holes

**satellite**
a natural or artificial object in orbit around another body

**solar system**
the Sun and everything in orbit around it, including the planets

**space-time**
a concept that combines the three dimensions of space (length, height and width) with the remaining dimension of time

**supernovae**
exploding stars

**time dilation**
a theory that a passage of time slows down as a moving object approaches the speed of light