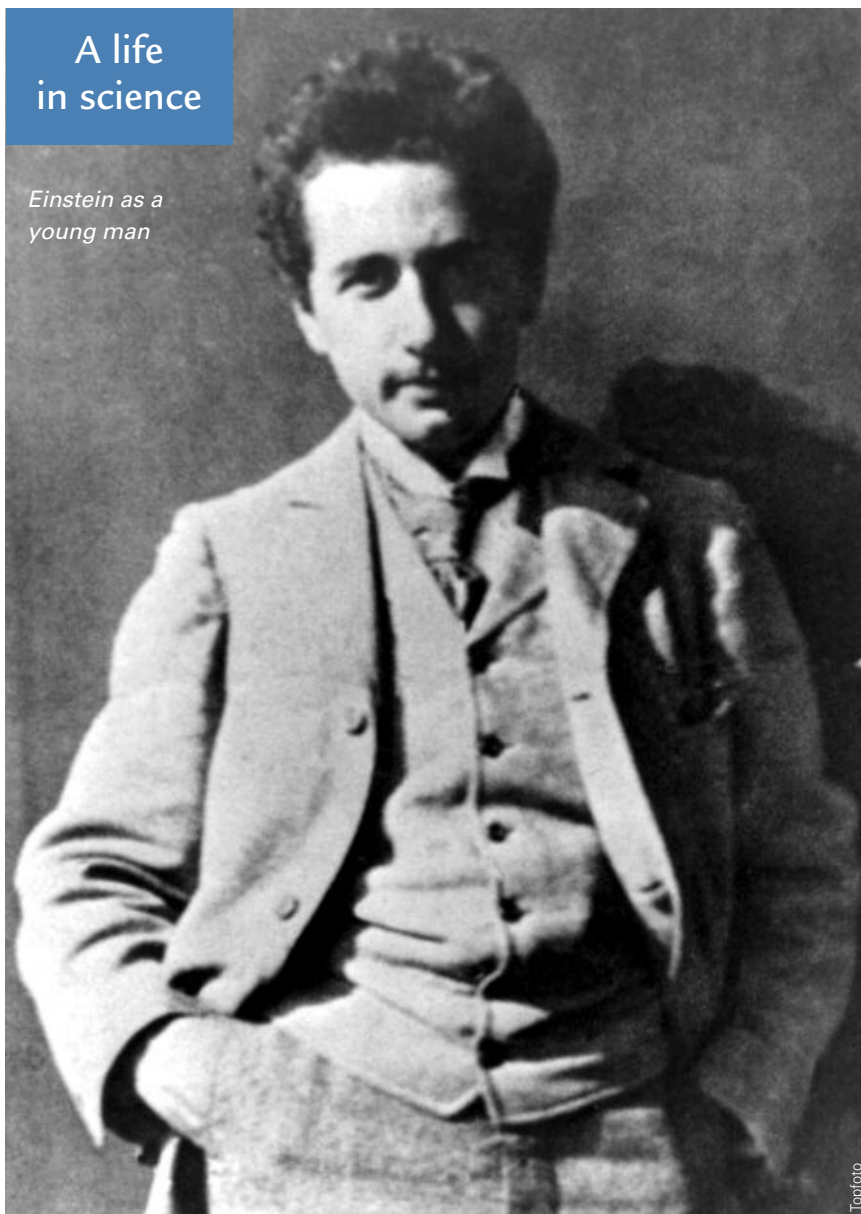


## A life in science

Einstein as a  
young man



Topfoto

### Box 1 1905: Einstein's *annus mirabilis*

Albert Einstein published three important scientific papers in 1905, his 'year of wonders'. It is extraordinary that he could develop any new scientific theory in his spare time, while working at the Patent Office in Bern. But the most remarkable thing is that these papers cover three very different areas of physics.

#### Special relativity

In this theory, Einstein proposed that the speed of light was the greatest speed at which anything can travel. He showed that this idea has many consequences — for example, as an object accelerates towards the speed of light, its mass increases and time runs more slowly. It is relativity theory which gives us the equation  $E = mc^2$ .

#### Brownian motion

This is a phenomenon that was known from the nineteenth century. Tiny particles of smoke in air, or pollen in water, are seen to move about at random. Although most scientists believed that the particles were being buffeted by the random motion of the molecules of air or water, Einstein was able to analyse the way in which the particles moved and hence estimate the size of the molecules.

#### Photoelectric effect

When light shines on some metal surfaces, electrons may be released. The wave theory of light couldn't explain this; there didn't seem to be enough energy in light waves to help electrons escape from the metal. Einstein explained that light takes the form of particles (photons) when it interacts with atoms; one photon is all that it takes to release one electron. This is the basis of quantum theory.

# Albert Einstein

*It cannot have escaped your notice that 2005 is Einstein Year, or the International Year of Physics. Physicists around the world are celebrating Albert Einstein's great achievements of 1905, as well as looking ahead at the way new developments in physics will affect our lives over the next few decades.*

- To find out more about Einstein log on to the Einstein Year website ([www.einsteinyear.org](http://www.einsteinyear.org)).

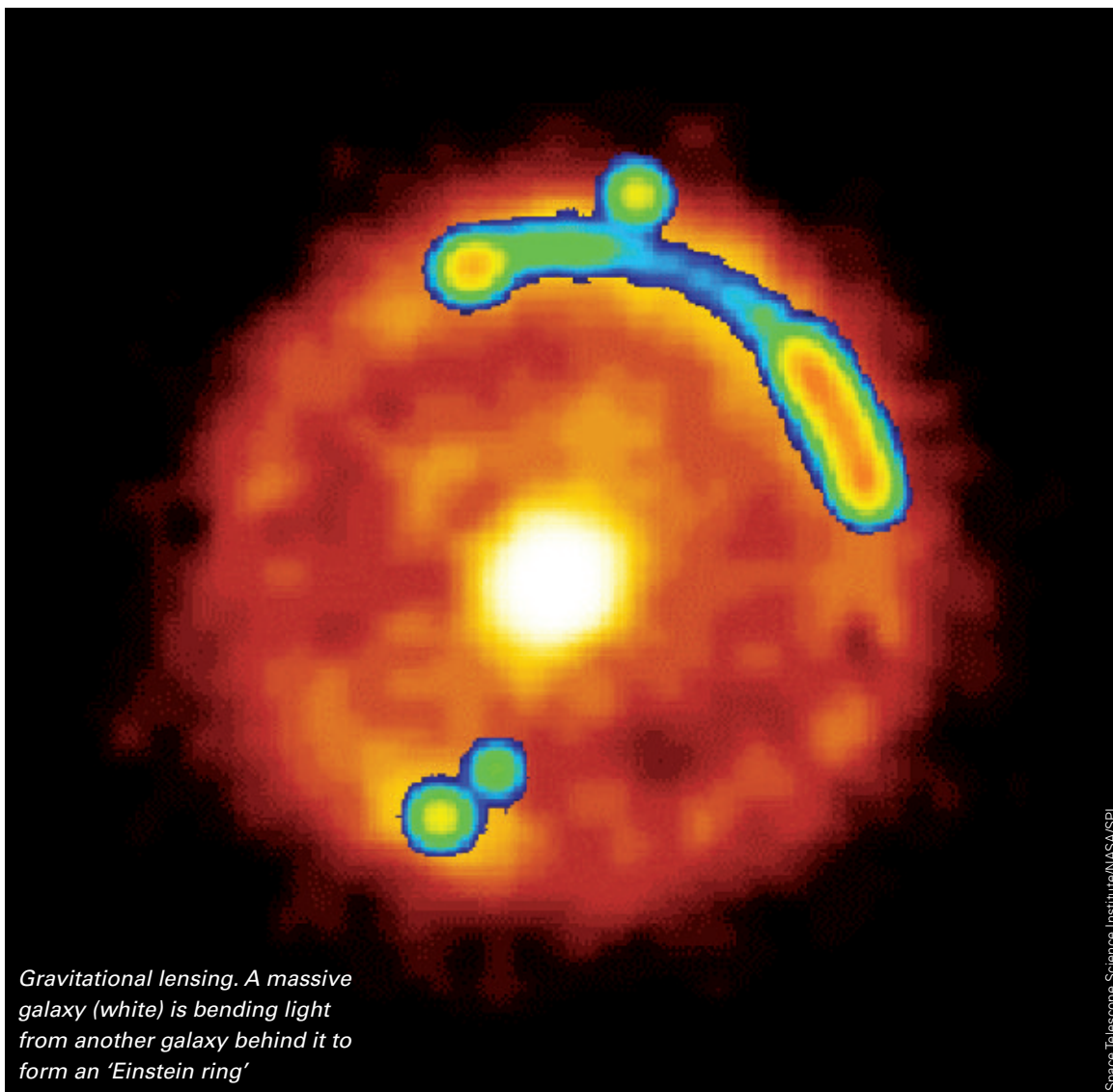
**A**lbert Einstein (1879–1955) was born in Germany and spent most of his childhood in Munich. His parents encouraged him to be independent — they let him wander the streets when he was only 4 years old. He found the education system dull and conventional, and left school when he

was 16. He followed his family, first to Italy, and then to Switzerland — this had the advantage that he avoided military service in the German army.

In Zurich, Einstein attended the Institute of Technology. He only just scraped through the final exams, not because he was stupid, but because he liked to sit around in cafés discussing the latest physics theories, rather than studying the official curriculum. He distracted the others in his class from their studies and his girlfriend failed the exams completely.

### Going it alone

Einstein was confident that he could be a theoretical physicist, but the institute refused to keep him on. He got a job in the Patent Office in Bern and spent his spare time (and some of his working hours) developing his ideas about space and time. In 1905, he published the three important papers which eventually made him famous (Box 1).



Gravitational lensing. A massive galaxy (white) is bending light from another galaxy behind it to form an 'Einstein ring'

Space Telescope Science Institute/NASA/SPL

Einstein was famous for his 'thought experiments'. He said to himself, 'What would an observer notice if...' and he developed his ideas from there. Subsequently, many practical experiments and observations have confirmed his ideas.

Scientific research is often described in a 'paper', published in a science 'journal'. This is the equivalent of an article in a magazine. In a science journal, papers are all laid out in much the same way, with the same sections – rather like your science coursework when it is written up, except often much longer!

In the equation  $E = mc^2$ ,  $E$  is energy,  $m$  is mass and  $c$  is the speed of light.

$E = mc^2$  tells us how energy and mass are related. If we measure the mass of an object, we are measuring the total amount of energy in it.

When an object gains energy, its mass increases. That's why a fast-moving object (with lots of kinetic energy) has a greater mass than when it is stationary.

## Box 2 Gravitational lensing

Gravitational lensing is an effect of **general relativity**. An astronomer sees two identical stars. There's really only one star, but light rays from the star are bent round either side of a massive object (such as a black hole), giving rise to a double image.

It is not unusual for a new theory to come from the fresh mind of a young physicist; but Einstein was unusual in that he kept on producing new ideas into his middle age. He later extended his ideas on relativity to form the **theory of general relativity**, in which he showed that gravity could be explained as the effect of large masses on space. A massive object such as a star distorts space, so that even light will follow a curved path near objects with mass (Box 2).

## War and the bomb

Einstein was Jewish. In the 1930s, when war loomed in Europe, he left for America. He realised that physicists' new understanding of matter and energy meant that

the atom bomb was a real possibility and that there was a danger that Hitler might get there first. He wrote a warning letter to Roosevelt, the US president.

After the war, Einstein worked with other scientists and politicians to try to control the spread of nuclear weapons. Joseph Rotblat, a British scientist who worked with him on this, said:

Einstein was quite the opposite of what people think about scientists – being absent-minded and immersed in their work and naïve. He was fully aware of what was going on in the world and trying to do something about it. I admire him not only as a great man of science but as a great human being.

*David Sang writes textbooks and is an editor of CATALYST.*

## Answers to metals wordsearch, page 15

Aluminium	Al	Iron	Fe	Rhodium	Rh
Americium	Am	Magnesium	Mg	Scandium	Sc
Barium	Ba	Mercury	Hg	Sodium	Na
Copper	Cu	Nickel	Ni		
Gold	Au	Potassium	K		