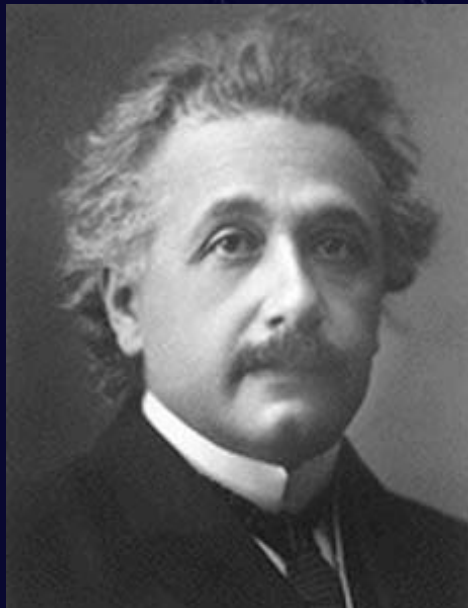


# Einstein's Universe



UNIVERSITY  
of  
GLASGOW



**Dr Martin Hendry**

*Dept of Physics and Astronomy  
University of Glasgow, UK*

# Einstein's Universe



UNIVERSITY  
of  
GLASGOW



**Einstein's  
Universe:  
Jan 2008**

10 meetings, beginning 14/01/08

## Course Aims:

To gain a deeper understanding of Albert Einstein's remarkable achievements, and their continuing legacy for modern science.

## Intended Learning Outcomes:

Students will gain familiarity with Einstein's contributions to **quantum physics** and to **special and general relativity**, and their relation to the development of these topics - up to the very latest theory and applications.

# Einstein's Universe



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GLASGOW



## Course Lecturers:

Dr Martin Hendry      Dept of Physics and Astronomy  
University of Glasgow  
martin@astro.gla.ac.uk

*Plus (provisionally):*      Matt Pitkin  
Fiona Speirits

## Course Website:

<http://www.astro.gla.ac.uk/users/martin/teaching/einstein/>

username: einstein

password:

einstein

# Einstein's Universe



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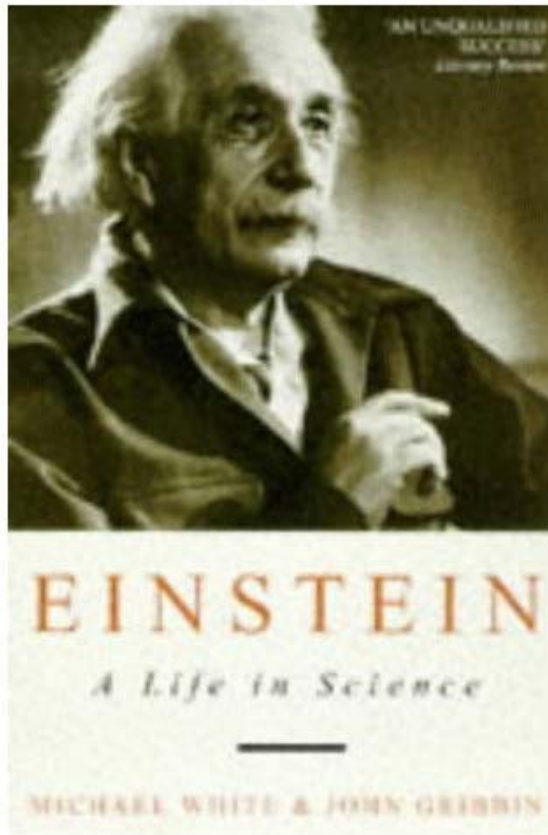
**Einstein's  
Universe:  
Jan 2008**

## Course Topics

- Overview: why a course on Einstein?
- A Brief History of Einstein
- Einstein's "miraculous year": 1905
- The weird worlds of Relativity
- The even weirder world of Quantum Physics
- Black holes: gravity at the limit
- Gravitational lensing: nature's telescope
- Ripples in the Fabric of Spacetime
- Cosmology: the Runaway Universe
- Einstein's legacy: 21<sup>st</sup> century science

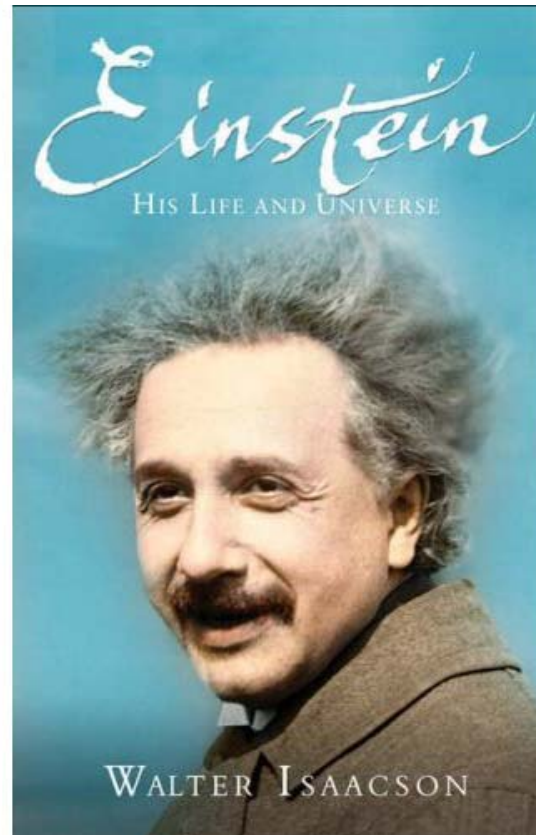


# Some recommended reading



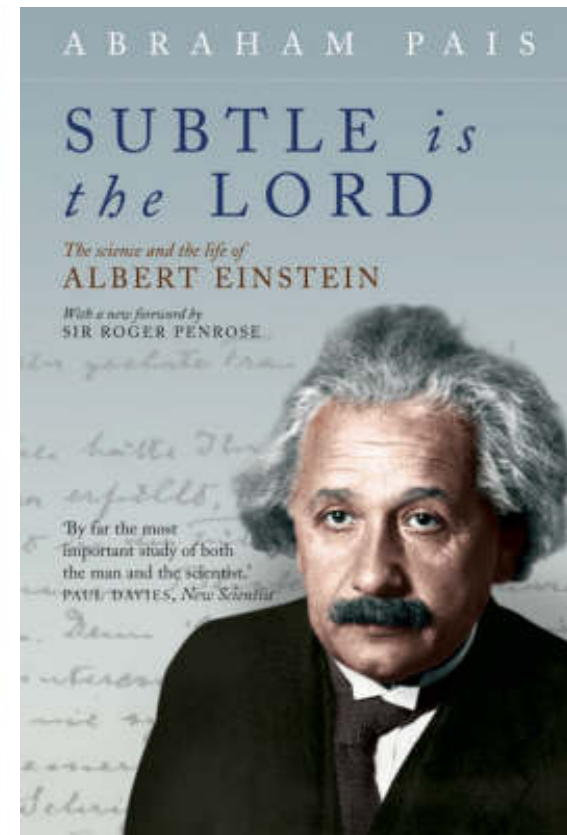
Einstein:  
A life in Science

Michael White & John Gribbin



Einstein:  
His life and Universe

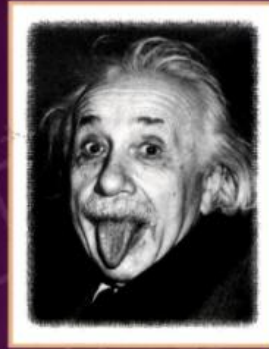
Walter Isaacson



Subtle is the Lord  
The science and the life  
of Albert Einstein

Abraham Pais

Copyrighted Material



# einstein's refrigerator

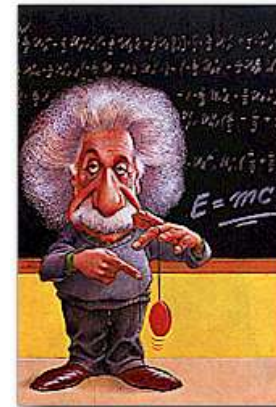
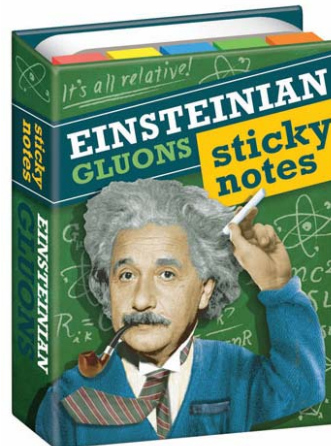
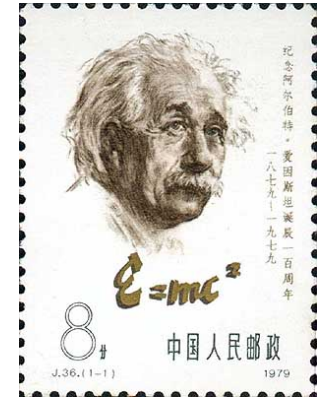
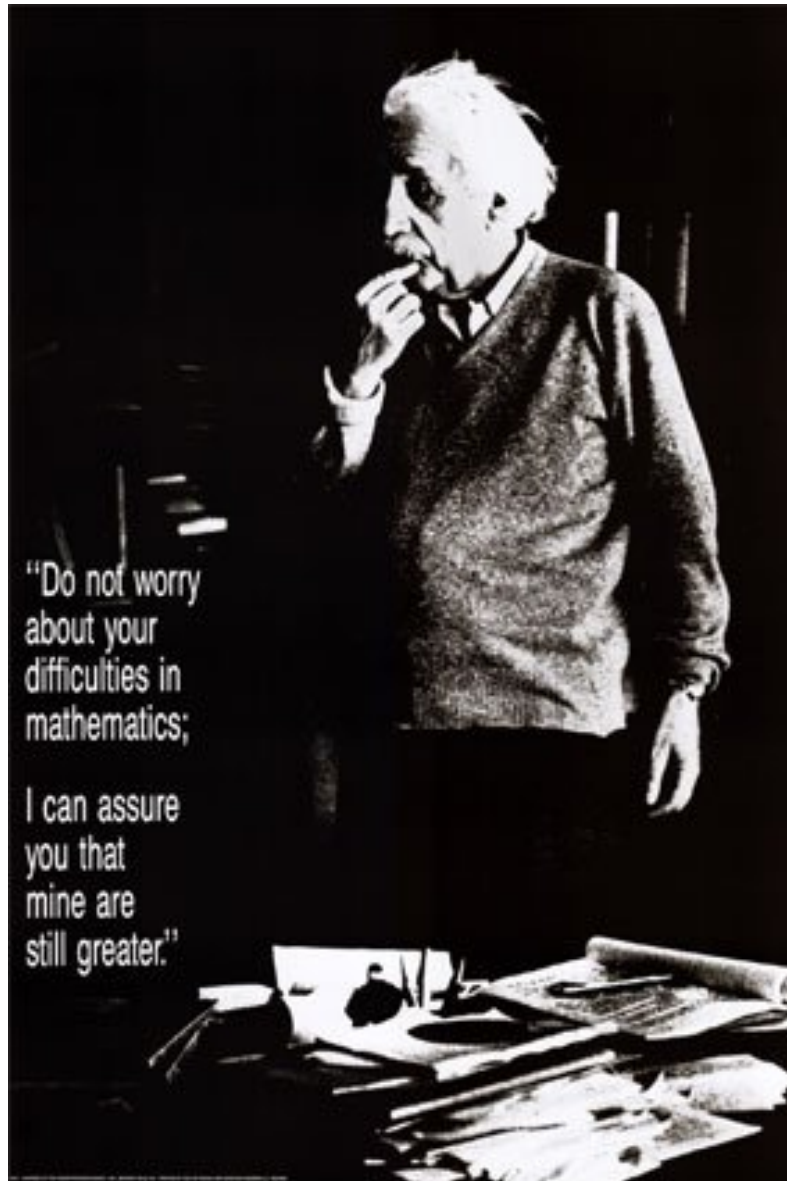
AND OTHER STORIES  
FROM THE FLIP SIDE  
OF HISTORY

steve silverman

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# Why a course about Einstein?

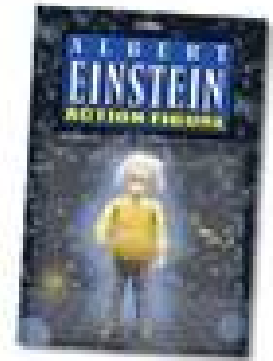


Disney

baby  
einstein.





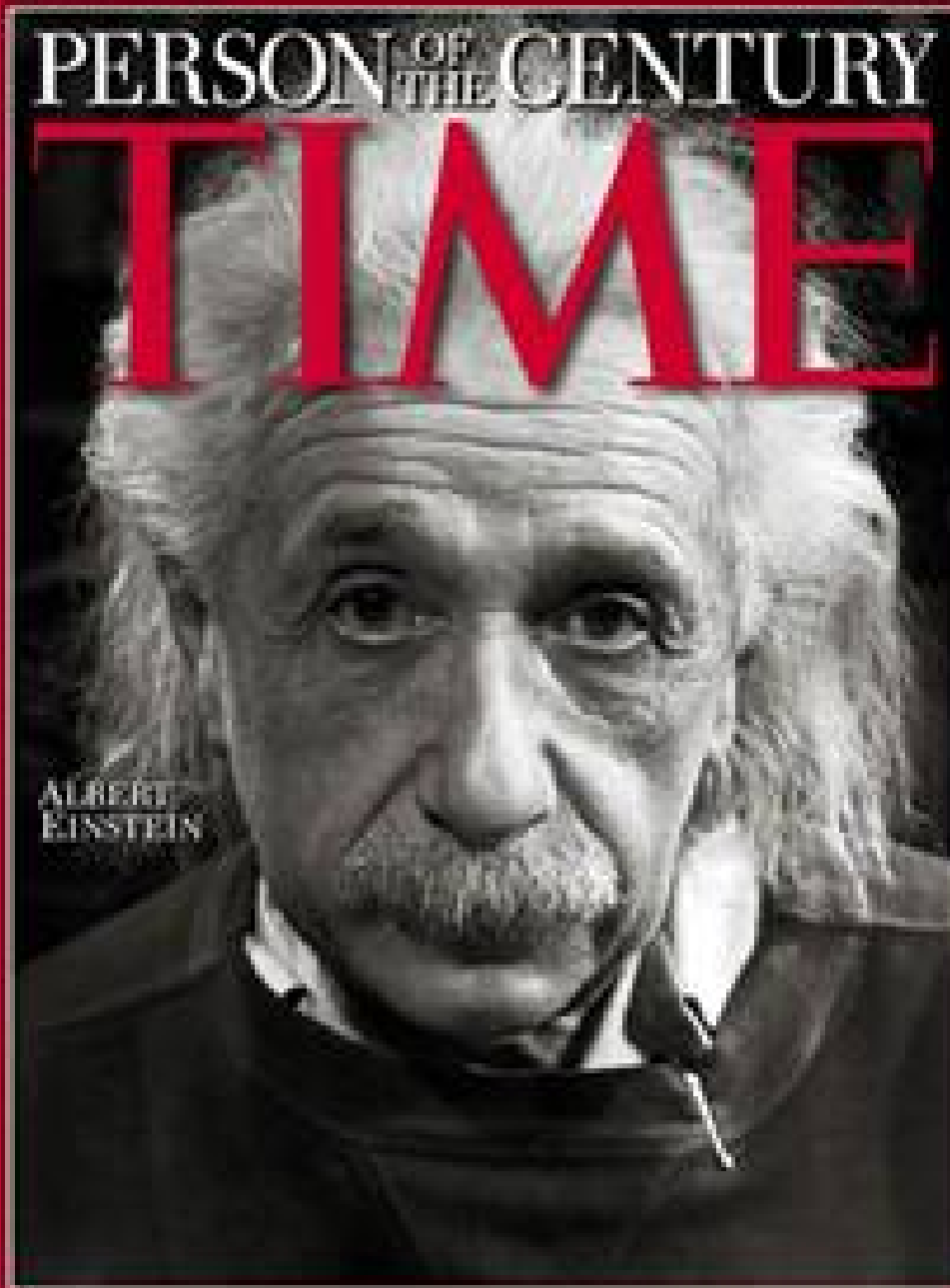




PERSON OF THE CENTURY

TIME

ALBERT  
EINSTEIN



# The Time 100

## The list

The list contains a total of 100 people, with 20 each in five broad categories: Leaders & Revolutionaries, Scientists & Thinkers, Builders & Titans, Artists & Entertainers, and Heroes and Icons.

## Person of the century

Of the 100 names chosen, Albert Einstein was crowned the person of the century, on the grounds that he was the preeminent scientist in a century dominated by science. The editors of TIME believed the 20th Century "*will be remembered foremost for its science and technology*", and Einstein "*serves as a symbol of all the scientists—such as Heisenberg, Bohr, Richard Feynman, and Stephen Hawking...who built upon his work.*"<sup>[1]</sup>

*Wikipedia entry on the Time 100*



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Franklin D. Roosevelt



Mohandas Gandhi 

*Wikipedia entry on the Time 100*

## The Person of the Century Poll Results

**TIME's Person of the Century** is that person who, for better or worse, most influenced the course of history over the past 100 years. Using that criteria, **TIME's** editors named the iconic and transforming scientist, **Albert Einstein**, as **Person of the Century**.

The Person of the Century poll is now closed. The ranking below reflects the status of nominees as of January 19, 2000, the last day of voting.

1	Elvis Presley	13.73	625045
2	Yitzhak Rabin	13.17	599473
3	Adolf Hitler	11.36	516926
4	Billy Graham	10.35	471114
5	Albert Einstein	9.78	445218
6	Martin Luther King	8.40	382159
7	Pope John Paul II	8.18	372477
8	Gordon B. Hinckley	5.62	256077
9	Mohandas Gandhi	3.61	164281
10	Ronald Reagan	1.78	81368
11	John Lennon	1.41	64295
12	American GI	1.35	61836
13	Henry Ford	1.22	55696
14	Mother Teresa	1.11	50770
15	Madonna	0.85	38696
16	Winston Churchill	0.83	37930
17	Linus Torvalds	0.53	24146
18	Nelson Mandela	0.47	21640
19	Princess Diana	0.36	16481
20	Pope Paul VI	0.34	15812

*From Time magazine's website*

# The Time 100

## The only people to shape both the 20th century & the early 21st

Of Time magazine's 100 most influential people of the 20th century, only the following four had the distinction of being honored again when in 2004, Time began publishing an annual list of the 100 people who continue to change the world:



Bill Gates 



Pope John Paul II 



Nelson Mandela 



Oprah Winfrey 

*Wikipedia entry on the Time 100*

Volume XXXII, No. 1, Spring 2000

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## **Einstein as Person of the Century (or Not?)**

When Time magazine named Albert Einstein as the Person of the Century at the end of 1999, the choice drew welcome attention to the role of physicists in our times. According to the newsmagazine's editors, the century coming to its end "will be remembered foremost for its science and technology," and Einstein "serves as a symbol of all the scientists—such as Heisenberg, Bohr, Richard Feynman, and Stephen Hawking...who built upon his work..." Other fields of human creativity, even other sciences despite their great achievements, got only a brief nod from Time in the century of the radio, the atomic bomb and the Internet.



Volume XXXII, No. 1, Spring 2000

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Several columnists criticized the choice. David Broder wrote that it “sent a clear message: Science, not statesmanship, was the hallmark of the era just ended.” But to Broder, “the saga of the 20th century is one of enfranchisement and empowerment,” characterized by female suffrage, civil rights and the like. Charles Krauthammer similarly declared that not Einstein but Winston Churchill deserved the accolade. “If Einstein hadn’t lived, the ideas he produced might have been delayed.” But take away Churchill’s stand in 1940, and fascism might well have triumphed. No, “the originality of the 20th century surely lay in politics.” E.J. Dionne Jr. agreed. While giving “Three cheers for Einstein and his brethren,” Dionne insisted that “the most important achievement of the century... is the triumph of a certain view of politics and a certain set of principles...”

Volume XXXII, No. 1, Spring 2000

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It is not surprising that political columnists stressed the importance of politics. In fact the Time editors had taken that into account, stating clearly that they found it hard to choose among scientific achievements, the triumph of democracy over totalitarianism, and the battle for civil rights as the hallmark of the century. (Indeed, those could be taken as the grand themes of the entire millennium that now comes to its close.) Einstein was chosen, said Time, not only because of his science but because he was himself an outspoken refugee from fascism, a “humanitarian,” and a “political idealist.” As columnist William Saletan of Slate.com explained it, “The ideal POC [Person of the Century] represents all the big themes... Einstein wins the triathlon because in addition to acing the science test, he prodded Roosevelt to build the bomb (10 points for defeating totalitarianism), fled Germany and immigrated to the United States (five more points for defeating totalitarianism and five for liberation and justice), and preached pacifism and praised Gandhi (10 more points for liberation and justice).”



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physicsworld.com

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**FEATURES**

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Dec 6, 1999

**Physics: past, present, future**

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**Q1. What have been the three most important discoveries in physics?**

**Q2. Which five physicists have made the most important contributions to physics?**

**Q1. What have been the three most important discoveries in physics?**

Words like "important" and "discovery" may be dangerous as far as historians and sociologists of science are concerned, but the vast majority of physicists in our survey had no qualms about answering our first question. Time and time again three key discoveries were singled out: quantum mechanics, Einstein's special and general theories of relativity, and Newtonian mechanics and gravitation.









$E=mc^2$   
 $E=hf$   
 $\lambda = \frac{h}{mv}$   
 $\Delta x \Delta p \geq \frac{\hbar}{2}$   
 $\Delta x \Delta t \geq \frac{\hbar}{2}$



- Relativity
- Atomic physics
- Quantum physics

"In each of these three cases, the discovery in question not only revolutionized the branch of physics that it nominally addressed, but also provided a framework so deep and universal that all subsequent theories in physics have been formulated within it," said quantum-computation pioneer David Deutsch of Oxford University.





String theorist Michio Kaku of the City University of New York was even more clear-cut: "The sum total of our physical knowledge of the universe is contained in two theories: relativity and quantum theory. This is the crowning achievement of 2000 years of investigation into the universe, since the time of the Greeks."



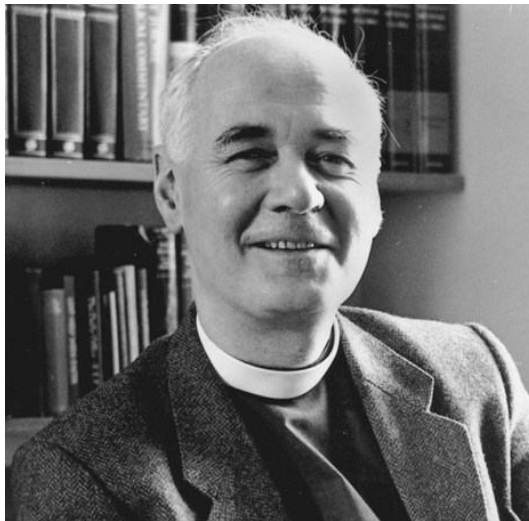
Newton's laws of motion and gravity were selected because together they represented the first major attempt to create laws of physics that can be expressed in mathematical terms and tested by experiment. They also overturned the long-held belief that heavenly bodies obey different principles to those on Earth. "Newton set the pattern for all of us to follow," said Bernard Schutz from the Max Planck Institute for Gravitational Physics in Potsdam, Germany.



Einstein's theories of relativity, on the other hand, showed that our intuitive understanding of physical quantities can be challenged at every level. "Part of the wonder of science is its ability to peel away layers of common intuition to reveal the true nature of our universe - to reveal features that are remarkable, stunning and sometimes rather distant from our day-to-day experiences," enthused string theorist Brian Greene from Columbia University. "The special and general theories of relativity completely overturned previous conceptions of a universal, immutable space and time, and replaced them with a startling new framework in which space and time are fluid and malleable." Einstein's theories also have practical applications: for example satellite-based global positioning systems, which are widely used for navigation on the Earth, have to take general relativistic effects into account.



The other hugely popular choice, quantum mechanics, was dubbed "the most radically revisionist physical discovery of all time" by the physicist and Anglican priest John Polkinghorne. Or, as astrophysicist Piet Hut of the Institute for Advanced Study in Princeton explained: "Quantum mechanics completely overturned the classical notions of causality, objectivity and repeatability of experiments, introducing instead a form of spontaneity intrinsic to the natural world." Many respondents also emphasized that quantum mechanics is not only elegant and powerful, but outstandingly useful as well. After all, quantum theory led to the development of semiconductors, transistors, lasers and - some might say - the entire microelectronics industry. It is also central to the design of new drugs and materials.



Many respondents, however, chose individual moments of discovery that paved the way for new revolutions in physics. David Awschalom from the University of California at Santa Barbara, for example, selected Planck's discovery of the quantum nature of light: "It was the first recognition of the fundamental inadequacy of classical physics. That was the hard part of quantum theory."





Meanwhile, Lydia Iconomidou-Fayard of the Linear Accelerator Laboratory in Orsay, near Paris, chose the discovery of radioactivity: "It was the starting point for nuclear and high-energy research, and completely modified the view that people had of matter."



## Q2. Which five physicists have made the most important contributions to physics?

"Some scientists are great because they are good all-rounders. Others make a major discovery by accident, but are not especially brilliant - just lucky. Others are brilliant, but never have a big discovery, although they can be immensely influential behind the scenes." It was with these words of warning from Paul Davies that we added up the answers to this question in the *Physics World* office.



A total of 61 physicists received at least one vote, but it will come as no surprise to see Albert Einstein at the top of our list with 119 votes (see [below](#)). Einstein's development of the special and general theories of relativity changed physics forever by revolutionizing the way in which we view space and time. Even one of his other "lesser" achievements, such as the explanation of the photoelectric effect, would have been enough to secure his reputation as one of the leading scientists of all time.



In second place with 96 votes is Isaac Newton - the man whose laws of mechanics and gravitation form the basis of vast swathes of classical physics, and who contributed much to the fields of optics, light and heat. Newton may have received fewer votes than Einstein because some respondents preferred to restrict their choices to scientists from the 20th century. Others felt that Galileo (6th in the list) deserved credit for paving the way for Newton's discoveries.

In third place is the Scottish physicist James Clerk Maxwell, who expressed in his four famous equations two centuries of experimental discoveries in electricity and magnetism, and who successfully unified the two phenomena into one - electromagnetism. Although he mistakenly believed that electromagnetic radiation was carried through an invisible "ether", Maxwell's equations still remained valid even when Einstein's theories disproved the notion of an ether.





- Relativity
- Atomic physics
- Quantum physics

# EINSTEIN SIMPLIFIED

