plained initial condition. Today, however, there is a ready explanation in the form of the 'inflationary Universe' scenario, involving a burst of frenetic expansion shortly after the cosmic origin. Any pre-existing irregularities would have been smoothed away by this abrupt and huge swelling of space.

This pleasing conclusion immediately begs the question of what preceded inflation and why it happened at all — which provides a convenient jumping-off point for Greene to embark on a discussion of the physics of unification. This is familiar territory for him, as he is first and foremost a string theorist. He treats the reader to a review of the current state of string/M theory, with digressions into a bewildering array of topics including higher dimensions, brane worlds, the holographic paradigm, teleportation, wormholes and time travel. If I have a criticism of this book, it is that it packs in so many challenging and abstract topics that it can leave the reader's mind reeling. Sensibly, Greene repeatedly cautions that most of the ideas he gallops across are extremely speculative and are unlikely to be tested experimentally any time soon.

The nature of space and time has exercised the minds of the world's greatest scientists and philosophers for centuries. Mostly they have regarded space and time as simply there — a given. Modern physics has shown that they are, in fact, things, just as particles of matter are things. The heady developments described in this book hold out the promise that we may one day explain how space and time have come to exist, and why they possess the properties that they do. ■

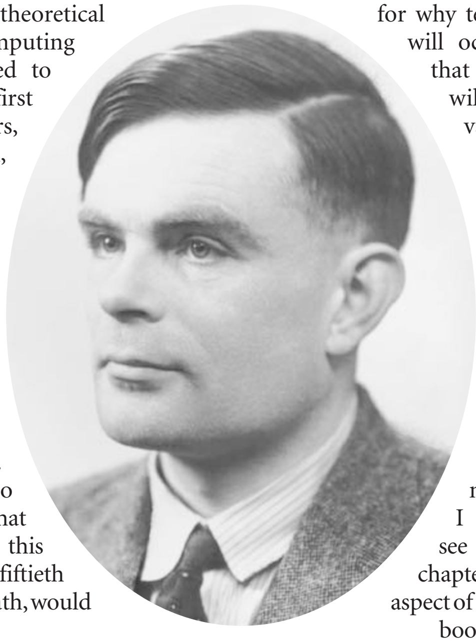
Paul Davies is at the Australian Centre for Astrobiology, Macquarie University, Sydney, New South Wales 2109, Australia. His latest book is How to Build a Time Machine.

Touring artificial minds

Alan Turing: Life and Legacy of a Great Thinker
edited by Christof Teuscher
Springer: 2004. 542pp.£46, $69.95, €59.95

John L. Casti

In 1999, *Time* magazine made Albert Einstein its 'man of the century' for the work that changed our view of time and space. It's difficult to argue too strenuously with this choice. But when it comes to scientists who have affected daily life, a far better choice would be Alan Turing, the British mathematician turned computer scientist whose invention in 1936 of what is now called the Turing machine was the theoretical backbone for every one of the zillions of computers in use today. Not only did Turing provide the key theoretical element for computing machines, he helped to build one of the first electronic computers, in Manchester, UK, shortly after the Second World War.



NATIONAL PORTRAIT GALLERY, LONDON

Machine architect: Alan Turing.

This book is the outgrowth of a workshop held in Lausanne, Switzerland, in June 2002 to honour the ninetieth anniversary of Turing's birth on 23 June 1912. Turing's work was so broad and deep that another gathering this year, to mark the fiftieth anniversary of his death, would not be out of place.

It is difficult to find the superlatives to describe the wonderful job the contributors to this book have done. Every chapter is written in an expository fashion, demanding very little in the way of background knowledge from any scientifically minded reader. The range of topics is also impressive, with sections on Turing's life and thoughts, the theory of computation and the Turing machine, artificial intelligence and the Turing test, the wartime Enigma code-breaking work and, finally, forgotten ideas.

Each section contains between two and seven chapters that explore themes ranging from what Turing might have thought about today's work in 'hypercomputation' — a field that explores information processing beyond the abilities of Turing machines — to his ideas on thinking machines and robots. The book's contributors are as sterling a collection of computer scientists, philosophers, engineers and historians as one could ever wish for, including logician Martin Davis, philosophers Daniel Dennett and Jack Copeland, technologist Ray Kurzweil and historian Andrew Hodges.

In her extremely entertaining chapter "Alan's Apple: Hacking the Turing Test", the Italian writer and theatre director Valeria Patera creates a theatrical setting in which eminent figures in artificial intelligence meet in a virtual plane to consider Turing's ideas on thinking machines. A staging of this might be more interesting, intellectually at least, than the rather dull play *Breaking the Code* that ran so successfully in London and New York some years back.

Two of the more provocative contributions come from Davis, who argues against the ideas put forth by a number of researchers for transcending the Turing barrier in computation, and from Kurzweil, who explains in detail his well-known arguments for why technological progress will occur at such a pace that machine intelligence will surpass the human variety within a few decades.

On the principle that no book is perfect, I have to admit to one small quibble. Given Turing's great interest in biological processes, especially near the end of his life, and his pioneering work on what we now call mathematical biology, I was disappointed to see only one of the 20 chapters devoted to that aspect of his work. Of course, no book can do everything, and this short-changing of biology in favour of computing is more of an opportunity than a problem. Nevertheless, a couple more chapters on morphogenesis, artificial life and so on would have really made this book the definitive volume on Turing's work and its implications.

I unreservedly recommend this book to anyone even slightly interested in the continuing role of Turing's work in the development of computer science in particular, and ideas in general. Conference proceedings rarely make for good reading and are generally strange beasts to review. This volume is the exception that proves that rule. ■

John L. Casti is at Complexica, Santa Fe, New Mexico 87505, USA, and the Institute for Monetary Economics, Vienna, Austria.

In Newton's long shadow

From Newton to Hawking: A History of Cambridge University's Lucasian Professors of Mathematics
edited by Kevin Knox & Richard Noakes
Cambridge University Press: 2003. 512 pp. £27.50, $45

Lewis Pyenson

For more than 300 years, Cambridge University's Lucasian professors have promoted the mathematical elaboration of nature's laws. The founder of the chair, Henry Lucas, who was awarded an honorary MA by the university in 1636 and who represented Cambridge in both the Short and the Long Parliaments, filled a gap in his university by endowing a professorship in mathematics, Science in culture

A weighty issue

Eduardo Chillida's sculptures are a form of 'rebellion' against Newton.

Stefano Grillo

Spanish artist Eduardo Chillida (1924–2002) used the name Gravitation for a major series of works that occupied him over a span of nearly 15 years — a clear suggestion that he shared some of the concerns of physical scientists. Indeed, Chillida himself once declared that he used "weight in his sculpture in order to rebel against Newton". Was this simply a fashionably extravagant statement?

No one would claim that Chillida's sculptures and reliefs supersede Isaac Newton's theory of gravitation in the sense that Einstein's general theory of relativity does. Chillida's aim was never to create a new quantitative model to compete with that of Newton. But his statement acquires significance when seen in terms of his work's visual approach to the experience and understanding of nature. This approach consists, in the words of the Nobel-prizewinning poet Octavio Paz, of a "qualitative physics", springing from a "direct, dynamic and non-quantitative vision of reality".

Chillida's works allow one to visually grasp phenomena such as weight, and even its opposite, weightlessness or levitation. He achieves this chiefly through his sense of form and of space. His rhythmically twisting shapes, often supported in ways that defy our visual expectations, seem to possess a weight that is modulated by their form and is quite independent of the measurable properties of the piece. Thus Chillida's great steel and concrete structures often appear to be floating in the surrounding space, whereas the paper reliefs of his Gravitation series communicate a remarkable sense of visual consistency.

J. WILDE/YSP

Up in the air: the floating form of *De Música III* challenges our visual expectations.

In the steel sculpture shown here, *De Música III* — one of 45 being exhibited at the Yorkshire Sculpture Park in Wakefield, UK, until 4 May (www.ysp.co.uk) — the horizontal structure hovers above the ground in an apparent state of levitation. Our immediate reaction is surprise that there are no additional legs to provide convincing support. The realization of the structure was a remarkable creative and technical achievement. Chillida spent several months welding together the unsupported horizontal sections to ensure that the joints were stable enough.

The importance of this visual and non-quantitative way of experiencing reality has been stressed in recent years by the mathematician René Thom, a Fields medallist and admirer of Chillida's work. Thom noted that there are contexts in which nuclear physicist Ernest Rutherford's claim that "qualitative is nothing but poor quantitative" does not hold true. Thom's own field of topology, for example, essentially relies on qualitative distinctions.

It is also significant that Chillida provided the lithocollages to illustrate the book *Die Kunst und der Raum* by the philosopher Martin Heidegger, who was concerned throughout his life with the foundations of modern science and with the question of whether the mathematical approach is the only valid way of understanding physical reality.

So despite Chillida's declared rebellion against newtonian physics, his work has been concerned with grasping the same phenomena in the natural world that have always interested scientists. And the result of his approach is both strikingly spectacular and thought-provoking.

Stefano Emilio Grillo is a physicist at the University of Perpignan and IMP-CNRS, Rambla de la Thermo-dynamique, Tecnosud, 66100 Perpignan, France.

explicitly beyond the reach of Cambridge's influential colleges.

The Lucasian professor was to lecture for one hour each week, deposit a transcript in the library, and hold office for a further two hours. It may have been at the request of the second incumbent, Isaac Newton, that King Charles II amended the statutes to allow a professor to hold a concurrent college fellowship and to require "all undergraduates past the second year and all Bachelors of Arts up to the third year" to attend the chair's lectures. The first Lucasian professor, Isaac Barrow, vacated the chair in favour of his pupil Newton, who has cast a long shadow over his 15 successors.

The sociologist Max Weber observed that, at least for the papal succession, the second-best candidate generally wins elected office. For much of the history of the Lucasian chair, even second best would be a stretch. Talent circulated freely in eighteenth-century Europe, but the Hanoverian regents hardly gave so much as a thought to looking for a Lucasian professor at Georg-August University in Göttingen or, closer to hand, in the great intellectual reservoir of Scotland, home to subtle minds from Colin Maclaurin to the historian and mathematician Thomas Carlyle.

Foreign musicians George Frederick Handel and Joseph Haydn created extraordinary scores in England. A. W. Hofmann brought organic chemistry to London from Germany. Any one of the Bernoullis, Leonhard Euler or Carl Friedrich Gauss would have dramatically changed the course of history had the Lucasian electors been passionate about promoting mathematical talent. Not at Cambridge. The Lucasian professors have all been English or Irish Protestant — even the one foreign national, Paul Dirac, a naturalized Briton when he received the chair in 1932, was born in Bristol.

Carlyle described the eleventh Lucasian professor, Charles Babbage, as "a mixture of craven terror and venomous-looking vehemence". Indeed, there is a quirky quality to many of the incumbents, whether they espoused apostate creeds (Arianism or spiritism) or voiced unappealing prejudices (denigration of women, contempt for labouring Britons, denial of Irish political aspirations, or flirtation with Stalinism). Certainly until the nineteenth century, Cambridge mathematicians, like much else at the university, were sexually deviant; among the early Lucasian professors, only the blind John Saunderson seems to have married. There are tantalizing suggestions about sexual orientation: Newton's avoidance of the company of women, Saunderson's enjoyment of them, John Colson's engagement of his sister as a housekeeper, and Joseph Larmor's pleasure in the college baths. Perhaps mathematical equations came to the professors as compensation for repressed libido.

The Lucasian chair is a gauge of intellectual life at Cambridge. In the century or so after Newton's tenure, the Lucasian professors were minor mathematicians and inconstant discoverers of natural law, mirroring an intellectual trough in science in England during the eighteenth century. The collective obscurity of their origins matches the extent to which Cambridge was open to all intellectually promising young men. In this time, religious scripture and orthodox dogma were a burden of the chair. Going to the university meant travelling the high road to an Establishment sinecure — a church living.

The first Industrial Revolution had an impact on the Lucasian professors, leading to Babbage's tracts on political economy and his phantom calculating machine, handsomely funded from the public purse but never constructed in his time. At the height of the second Industrial Revolution, Larmor pinned down electromagnetism. By this time, the Lucasian professors, along with an increasing proportion of undergraduates, came from relatively privileged social strata.

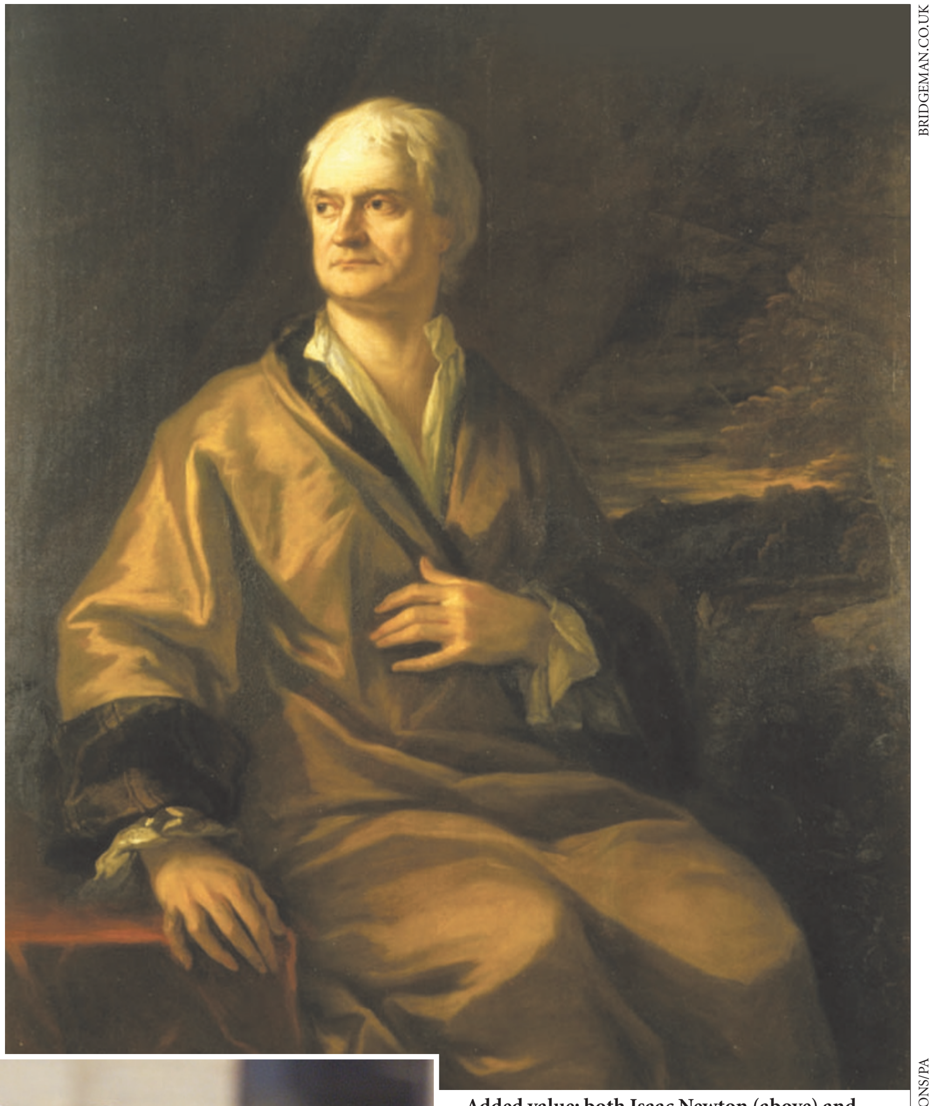
In their solid and engaging introduction to *From Newton to Hawking*, editors Kevin Knox and Richard Noakes contend that from around 1830 "the Lucasian professors played important roles in making Britain the preeminent scientific state". But in the area where the editors' contention for eminence seems most convincing, natural history, the longest-serving chair, George Gabriel Stokes, held the great innovator Charles Darwin to be both wrong and dangerous.

Only in the later part of the twentieth century was the Lucasian chair cut free from religious orthodoxy and social convention. With the most recent professors, Dirac, M. James Lighthill and Stephen Hawking, England once again radiates enlightenment about the mathematical harmonies of the natural world.

From Newton to Hawking also speaks to enlightened scholarship in England. It contains almost no trace of postmodernist whimsy. Each of the chapters focuses on one professor or on a short sequence of them. By this organizational device, the book signals a return to conventional biography, the elegant prose making relatively little appeal to social statistics and psychology. But I found myself wanting to know more about the professors' income from the chair and other sources.

Historical taste aside, the volume is striking for both its narrative and its original research. The Lucasian chair confirms the inertia of privileged institutions: no amount of swinishness, no succession of bad choices, no penury of emoluments, no long-running infelicities in pedagogical norms, no inattention to training acolytes, and no egregious prejudices against men and women of talent can permanently injure an institution that continues to offer positions of power and prestige to its graduates. It is a story to comfort any number of vice-chancellors, provosts, deans and department heads. ■

Lewis Pyenson is at the Center for Louisiana Studies, University of Louisiana at Lafayette, Louisiana 70504-0831, USA.



BRIDGEMAN.CO.UK

A. PARSONS/PA

Added value: both Isaac Newton (above) and Stephen Hawking have sought to harmonize nature and mathematics as Lucasian professors.