History by numbers

God Created the Integers: The Mathematical Breakthroughs that Changed History
edited by Stephen Hawking
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Jeremy Gray

The subtitle — the mathematical breakthroughs that changed history — is not mere advertising. It is a yardstick, in fact various yardsticks, for assessing the book as a whole. Stephen Hawking brings us generous selections of Euclid's *Elements*, the works of Archimedes and Diophantus, René Descartes' *Geometry* entire, Pierre-Simon Laplace's *A Philosophical Essay on Probability*, and material from Joseph Fourier, Carl Friedrich Gauss, Augustin-Louis Cauchy, Bernhard Riemann, Georg Cantor and Henri-Léon Lebesgue. There are also the first 11 chapters of George Boole's *An Investigation into the Laws of Thought*, Richard Dedekind's *Essays on the Theory of Numbers*, smaller extracts from Newton's *Principia*, and papers by Karl Weierstrass, Kurt Gödel and Alan Turing. All these have some claim to have changed history, except perhaps the work by Diophantus, remarkable though it is. The same claim can be made of quite a few other works too, but as this book has nearly 1,200 pages it would be churlish to complain.

The items are well chosen. They are an interesting mix of the well known and the unexpected, and cover a range of topics in mathematics from geometry to mathematical analysis, probability and the modern foundations of mathematics. They range over an extensive period and, because many are presented either whole or at least extensively, they can be read with pleasure.

Every anthology faces the issue of what to do with the best-known pieces. Include them and some complain that they are too well known; omit them and others lament their loss. If this book is the only collection of original works of mathematics in translation that a reader owns, there is a lot to be said for it. But as an addition to the small but useful number of collections in English it is more annoying, because the opportunity was not taken to translate more works. All but four of the items here are already available in English. The new ones are the work by Cauchy (some of which already exists in English elsewhere), some of the papers by Riemann (one of which is already in English), the passage by Weierstrass, and the extracts from the work of Lebesgue.

It is one thing to use an old translation if there is no significant improvement to be had in making a new one, but it is quite another to perpetuate an inadequate work. Here the Diophantus is annoying because it is the version by Thomas Little Heath. He turned the work into a densely written but by now old-fashioned school problem book, and the commentary, given in extensive footnotes, moves the reader even further from Diophantus' habit of mind. It is true that Diophantus' example is so strange that it reminds us how little we know about the ancient Greeks, but we do know how it was received in the Arab world and in the modern West, and it can be said to be only one of several works that helped bring about the 'modern algebra' of the seventeenth century. It would have been better if Hawking had included instead al-Khwarizmi's work on *al-jabr*, from which algebra takes

SCIENCE IN CULTURE

A culture of knowledge

An exhibition in Paris explores the golden age of Islamic science.

Pete Jeffs

There is a mosque near my studio in east Paris. Passing by at the hour of prayer, I find myself intrigued by an Islamic culture that dates from the eighth century, occupies a central place in world culture, and yet remains a mystery for other societies.

The exhibition 'The Golden Age of Arabic Sciences', which can be seen at the Institute of the Arab World in Paris until 19 March, sheds light on a people who produced exquisite manuscripts, developed experimental sciences, and added new disciplines to those of the classical world.

The exhibition questions the idea that Arab-Islamic science simply translated key classical sources of knowledge and passed them on to the West. It shows how the Arabs of the expanding empire transformed and extended Greek, Mesopotamian, Persian and Indian ideas, and turned theory into practice. Analysis preceded assimilation.

The optics of Ibn al-Haytham (AD 965–1040), for example, encouraged an experimental approach to the pursuit of physics. In 830, al-Khwarizmi, the acknowledged founder of algebra, detailed the necessary mathematics for calculating inheritances, conducting commerce and constructing canals. Baconians would surely have approved.

By this time, paper was becoming the preferred vector for the transmission of Arabic science. Industrial-scale production began around 750, first in Samarkand and then in Baghdad. Cheap paper rapidly outstripped the use of papyrus and parchment. Almost 4 million individual Arabic writings from the eighth century onwards are known to have been conserved by libraries throughout the world.

Arab society integrated its knowledge by building hospitals, observatories and libraries, beginning with the House of Wisdom — Bayt al-Hikma — in Baghdad, shortly after 800. Translations and original writings were stored in more than a thousand different public and semi-public libraries scattered throughout the empire, catering for a widespread demand for scholarship. Knowledge was transmitted by scholars who travelled regularly, as well as through written correspondence. The Koran, incidentally, encouraged scientific activity.

NASSER D. KHALILI COLLECTION

Some 200 manuscripts and objects have been assembled in Paris for the exhibition, including this planispheric astrolabe from the Nasser D. Khalili Collection and a profusely illustrated copy of Dioscorides' *Herbal*. But the exhibition opens with a map. When we can associate cities such as Damascus or Maragheh with astronomy as readily as we associate Padua with anatomy or Leiden with electricity, Arab-Islamic culture will be on its way to a fuller appreciation in the West. This exhibition offers a fine lesson in the meaning of the word 'civilization'.

Pete Jeffs is an artist based in Paris, France.