

Desmond MacHale: The Life and Work of George Boole: A Prelude to the Digital Age, Cork University Press, 2014.
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REVIEWED BY PETER LYNCH

University College Cork is currently celebrating the bicentenary of the birth of mathematician and logician George Boole. UCC has planned a wide range of events for the *Year of George Boole*,¹ which runs until November 2015. Boole's work has had a growing influence in recent decades, in computer science and digital technologies of all kinds.

A new issue of Desmond MacHale's biography of Boole has just been published by Cork University Press. This is a corrected version of the 1985 book published by Boole Press. The earlier edition had a foreword by the noted Irish mathematical physicist John L. Synge. The current book has a new foreword by Ian Stewart of the University of Warwick. The first edition was reviewed in this Bulletin by Ivor Grattan-Guinness.²

This is a very comprehensive biography, and an invaluable contribution to our knowledge and understanding of an important nineteenth century mathematician and logician. It provides a well drawn portrait of Boole, not just as a man of science, but as a social reformer, religious thinker and family man. He was quintessentially a philosopher. The book is clearly the result of extensive and thorough research. It is well-written, with the story of Boole's life and work unfolding systematically and with sustained interest.

EARLY LIFE

George was the eldest of four children, a shy but exceptionally bright youth. He had mastered Latin and Greek by his early teens and taught himself French, German and Italian. This later gave him direct access to mathematical developments on the continent,

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¹georgeboole.com

²Vol. 14, Sept. 1985, <http://www.maths.tcd.ie/pub/ims/n114/>

allowing him to go far beyond most of his compatriots. He had an elementary school teaching but, too poor to attend grammar school, he taught himself advanced mathematics by studying the original works of the leading mathematicians of the time.

Boole's serious study of mathematics began around the age of sixteen. Having mastered calculus, he studied the works of Newton, Lagrange, Laplace, Jacobi and Poisson. As an autodidact, Boole developed a fiercely independent approach to research. His initial interest in mathematics was for its applications to the solution of scientific problems but he soon came to appreciate pure mathematics as interesting and beautiful in its own right. He published papers on differential equations, integration, logic, probability, geometry and linear algebra.

In 1841, Boole's *Exposition of a General Theory of Linear Transformations* led to a new area of mathematics, Invariant Theory. Cayley and Sylvester brought the theory of invariants to an advanced stage of development, and both acknowledged Boole as the instigator and inspiration for their efforts.

His paper "On a General Method of Analysis" was published in 1844 in the *Philosophical Transactions of the Royal Society*. For this he won the society's Gold Medal, the first such award in the field of mathematics. The paper presented a general, systematic method of solving a broad class of differential and difference equations with variable coefficients.

QUEEN'S COLLEGE CORK

In October 1846 Boole applied for a position as Professor of Mathematics in one of the three Queen's Colleges, that were being established in Belfast, Galway and Cork. Boole's letter of application is amazing, containing the statement "I am not a member of any University and have never studied at a college." But his application included several very strong testimonials from leading mathematicians. After a long delay, he was offered a position in Cork and took up residence in October 1849 at a salary of £250 per annum.

The Queen's Colleges were multi-denominational, and were controversial from the outset, being described by the Catholic hierarchy as Godless Colleges. For a time, Boole managed to avoid direct involvement in the many religious conflicts, but he could not remain unaffected by them. Although a man of mild manners, he was drawn

into a series of acrimonious college squabbles. Perhaps more details of these are given by MacHale than is really necessary, with long letters to the newspapers quoted *in extenso*.

During his early years in Cork, Boole was lonely and not very happy. Things changed when in 1855, aged 40, he married Mary Everest, then but 23 years old. Mary was the niece of the professor of Greek at Queen's College and also a niece of Sir George Everest, Surveyor General of India, after whom the world's highest mountain is named. The marriage was a happy if brief one, and they had five daughters, all extraordinary in different ways.

THE LAWS OF THOUGHT

In 1833, when he was eighteen, Boole had had a flash of inspiration, that logical relations could be expressed in symbolic form. This idea would later grow into his major contribution to science: to explain the process of human thought in precise mathematical terms. Efforts to make logic a precise science could be traced back to Aristotle, and Leibniz had gone some way to express logical relations in symbolic form but, he lacked an adequate notation. In 1847, Boole wrote *The Mathematical Analysis of Logic*, which was described in a subtitle as "a calculus of deductive reasoning". This book marked the beginning of symbolic logic.

Boole's greatest work, *The Laws of Thought*, was written during his tenure at Queen's College. One of his profound insights was that mathematics is not confined to number and quantity alone but has a larger nature as universal reasoning expressed in symbolic form and conducted in accordance with definite rules. The objective of his work was the reduction of logical propositions to a symbolic form, so that logical conclusions become mathematical consequences of the initial assumptions. By considering classes rather than number as the focus of attention, it adumbrated set theory, now a central foundation of mathematics.

Boole was the first to perform algebraic operations on symbols that represented logical propositions, thereby giving a powerful impetus to the field of symbolic logic. Previously, no one had appreciated the mathematical nature of everyday language. The algebra devised by Boole is now the ideal tool for handling information and modern computers operate following its principles. Boolean algebra encompasses a vast array of topics including set theory, binary numbers,

probability spaces, electronic circuit structures and computer technology. Many of Boole's ideas are today considered as self-evident and are found in elementary set theory and probability. They find wide applications in fields such as medical diagnosis, insurance and legal evidence.

BOOLE AND HAMILTON

Boole tried his hand at poetry but, as with his contemporary William Rowan Hamilton, the results were unremarkable. A full chapter is devoted to the surprising lack of contact between the two men. Boole was born ten years after Hamilton, and they died within a year of each other. They had common interests, in both mathematics and prosody, and had ample opportunity to collaborate or at least to interact. Yet the minimal contact between them suggests that there was some significant difficulty or disagreement between them, although no solid evidence of this has yet emerged. MacHale wrote in 1985 that the mystery of this lack of contact remains. The chapter is subtitled "Some unanswered questions". It is disappointing that, after a lapse of thirty years, nothing further is added in this edition. [MacHale has since told me that he has a new speculation about the possible rift, but we must wait for information on this to appear elsewhere.]

FAMILY

The final chapter is interesting if somewhat peripheral. George and Mary Boole had five daughters, all interesting in different ways. Alicia made significant discoveries in 4-dimensional geometry. She coined the term *polytope* for the 4D equivalent of a polyhedron. G. I. Taylor, the leading British fluid dynamicist of the twentieth century, was a son of Boole's daughter Margaret. Another daughter, Ethyl Lilian (Voynich), had an adventurous life, and wrote a novel, *The Gadfly*, which was amazingly popular in Russia. Her life story is fascinating.

At the end of the penultimate chapter, The Final Years, MacHale writes of Boole: "His name will live on as long as the digital computers which depend so vitally on Boolean algebra continue to operate and as long as students of mathematics study ring theory, differential equations, probability theory, difference equations, invariant theory, operator theory, set theory and, of course, mathematical

logic.” He closes by noting how Boole would have been delighted to have known how all modern communication, whether of data, text or images, comprises long strings of the Boolean symbols 0 and 1.

CONCLUSION

The book is well produced and appears to be relatively error-free. One glitch that might perplex readers is the repeated reference to Lebesgue. The analyst Henri Lebesgue was not born until 1875, long after Boole’s death. The reference must be to the number theorist Victor-Amédée (1791–1875) but the index lists Henri. A more serious problem is the omission of an appendix listing 27 “Additional References”, which appeared in the first edition but has been omitted from the new version.

Some of the quotations are over-long, with a number of dubious digressions. For example, there are long pen-portraits of many religious thinkers contemporary with Boole who had an influence on him. The wisdom of including these is a matter of opinion, but I felt that they tended to interrupt the Boole narrative.

Bulletin readers may well feel that the level of mathematical detail is inadequate. Certainly, mathematical readers with a general idea of Boole’s work, and who wish to deepen their knowledge, will not find this the ideal book for that purpose, and will have to revert to Boole’s original publications. However, there is a quite complete and valuable list of these in the book.

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