Foreword to new edition

A search for 'Boolean' on the internet reveals a long list of terms containing this rather curious word: Boolean algebra, circuit, data type, expression, function, model, module, network, processor – even the Boolean satisfiability problem. A more technical request, say for 'Boolean' AND ('algebra' OR 'circuit'), is an example of yet another such term: a Boolean search, which looks for information that satisfies a combination of conditions.

One common thread that links all these things is logic: the formal properties of 'true' and 'false'. Another is the source of that strange word. 'Boolean' is derived from a name: the English-born mathematician, logician and philosopher George Boole, who was appointed Professor of Mathematics at Queen's College, Cork, and died at Ballintemple in 1864. If judged by name recognition, Boole pretty much sank without trace, except among mathematicians and computer scientists. If judged by results, he was one of the most influential intellectuals of his era, and one of the great unsung architects of today's world.

It was Boole, perhaps more than any other, who first came to appreciate the deep connections between mathematics and logic. Not the use of logic in mathematical proofs but the use of mathematics to illuminate the workings of logic. He summed up his ideas about this connection in two books. *The Mathematical Analysis of Logic*, written in some haste, appeared in 1847; it was followed in 1854 by *The Laws of Thought*, developing the subject in greater generality. Boole had noticed that logical inferences can be represented by algebraic formulas, in which the symbols 0 and 1 denote 'false' and 'true' respectively. These obey most of the usual algebraic rules but not all and it is these exceptions that capture the essence of logic. With suitably amended rules, Boolean algebra can perform logical deductions using routine algebraic calculations.

Boole was not entirely alone in pursuing such ideas; others included Gottfried Leibniz, Johann Lambert and Augustus De Morgan. But Boole formalised and systematised the underlying concepts and appreciated the vital

role of symbolic reasoning. Others developed a new branch of mathematics, mathematical logic, from these beginnings. However, for a long time the subject remained esoteric, accessible only to specialists, opaque even to most mathematicians, more a branch of philosophy than one of mathematics.

Only with the invention of the digital computer did the real value of Boole's ideas emerge. What had seemed little more than abstruse philosophy suddenly became engineering practice. His take on logic was exactly what electronic engineers needed to give computers the ability to perform different tasks according to the truth or falsity of some condition. 'If cursor on button 1 and mouse clicked, display e-mail message. If cursor on button 2 and mouse clicked, open new field for reply to be typed into. If cursor on button 3 and mouse clicked, display photo.' His true/false symbols 0 and 1 can be interpreted as 'no electrical current flowing' and 'some current flowing'. His algebraic operations and rules translate into electronic circuits that carry out logical tasks. Boole's reduction of basic features of logic to mathematics informs both computer software and hardware design.

Boole worked in other areas of mathematics: differential equations, finite differences, invariant theory, probability. To them all, he brought the same key insight: the importance of abstract symbols, manipulated according to formal rules. He ushered in the age of abstract algebra, in which symbols no longer represented unknown numbers, but took on a life of their own. In particular, his discovery of invariants – algebraic formulas that remain the same when the variables involved are transformed – created an entire new area of mathematics, now basic to both relativity and quantum mechanics. Boole left it to others to develop this particular insight but with one simple idea he had invented an entire new field of mathematics.

His work on logic was even more influential but not immediately. Boole was a century ahead of his time. When the world was ready, his brainchild changed the working philosophy of mathematicians, freed algebra from its numerical shackles, and – most importantly of all – gave electronic engineers and computer programmers vital thinking tools. As a result, computers ceased to be merely powerful calculating devices. They became machines that could carry out instructions to manipulate and represent data of any kind: numbers, messages, images, audio, video. Every laptop, every tablet, every mp3-player, every smartphone owes its existence, in part, to Boole's mathematical legacy; so does the internet.

This new edition of Desmond MacHale's marvellous biography will help to nudge the balance of fame in Boole's favour. He was a brilliant thinker, the possessor of a truly original mind. His story is *our* story: the

creation of one of the great intellectual pillars that support our modern world. It is a remarkable story of a remarkable man, beautifully told.

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