

AUGUSTUS
DE MORGAN,
POLYMATH



EDITED BY KAREN ATTAR, ADRIAN RICE
AND CHRISTOPHER STRAY



<https://www.openbookpublishers.com>

©2024 Karen Attar, Adrian Rice and Christopher Stray

Copyright of individual chapters are maintained by the chapter author(s)



This work is licensed under an Attribution-NonCommercial 4.0 International (CC BY-NC 4.0). This license allows you to share, copy, distribute and transmit the text; to adapt the text for non-commercial purposes of the text providing attribution is made to the authors (but not in any way that suggests that they endorse you or your use of the work). Attribution should include the following information:

Karen Attar, Adrian Rice and Christopher Stray (eds), *Augustus De Morgan, Polymath: New Perspectives on his Life and Legacy*. Cambridge, UK: Open Book Publishers, 2024, <https://doi.org/10.11647/OBP.0408>

Copyright and permissions for the reuse of many of the images included in this publication differ from the above. This information is provided in the captions and in the list of illustrations. Where no licensing information is provided in the caption, the figure is reproduced under the fair dealing principle. Every effort has been made to identify and contact copyright holders and any omission or error will be corrected if notification is made to the publisher.

Further details about CC BY-NC licenses are available at <http://creativecommons.org/licenses/by-nc/4.0/>

All external links were active at the time of publication unless otherwise stated and have been archived via the Internet Archive Wayback Machine at <https://archive.org/web>

Any digital material and resources associated with this volume will be available at <https://doi.org/10.11647/OBP.0408#resources>

ISBN Paperback: 978-1-80511-326-3

ISBN Hardback: 978-1-80511-327-0

ISBN Digital (PDF): 978-1-80511-328-7

ISBN Digital eBook (EPUB): 978-1-80511-329-4

ISBN HTML: 978-1-80511-330-0

DOI: 10.11647/OBP.0408

Cover image: Portrait of Augustus De Morgan, in Sophia Elizabeth De Morgan, *Memoir of Augustus De Morgan (1882)*, https://commons.wikimedia.org/wiki/File:Augustus_De_Morgan_1850s.jpg. Background: Nico Baum, White round light on gray textile (2020), https://unsplash.com/photos/white-round-light-on-gray-textile-xZroI5V_dxc. Cover design: Jeevanjot Kaur Nagpal.

Introduction

De Morgan: Polymath

Karen Attar, Adrian Rice and Christopher Stray

Mathematicians must accept that their talent does not confer on them any particular competence outside their own domain.

— Jean Dieudonné¹

The field of intellectual history abounds with names of individuals whose accomplishments in a particular domain were significant, and whose learning and expertise moreover spanned an astonishing array of disciplines.² Several epithets exist for such scholars, from the Latin ‘homo universalis’ to the English ‘Renaissance man’. Perhaps the word that best describes this phenomenon is that with the oldest linguistic roots: *polymath*. From the Greek, literally meaning ‘much learning’, it first appeared in the philosopher Johann von Wowern’s *De polymathia tractatio* of 1603, which defined ‘polymathy’ as ‘a knowledge of various things, collected from every kind of study, ... roaming freely and at an unbridled pace through all the fields of learning’.³ Since then, the term ‘polymath’ has come to mean an accomplished scholar of deep and wide-ranging expertise in a variety of disciplines. The names of Aristotle, Thomas Aquinas, Leonardo da Vinci, René Descartes,

1 Jean Dieudonné, *Mathematics—The Music of Reason* (Berlin: Springer, 1992), p. 11.

2 See, for example, Peter Burke, *The Polymath: A Cultural History from Leonardo da Vinci to Susan Sontag* (New Haven: Yale University Press, 2021).

3 ‘Perfectam Polymathian intelligo, notitiam variarum rerum, ex omni genere studiorum collectam ... Vagatur enim libero & effreni cursu per omnes disciplinarum campos.’ Johann von Wowern, *De polymathia tractatio* (Basel: Officina Frobeniana, 1603), p. 16.

Blaise Pascal, Gottfried Leibniz, Benjamin Franklin, Thomas Jefferson, Mary Somerville, Henri Poincaré, Bertrand Russell and Alan Turing may spring to mind as examples of polymathic thinkers. To these we propose to add the name of another, less renowned figure, yet one who, as the content of this book will demonstrate, has every right to the title: Augustus De Morgan.

The genesis of this book, edited by scholars from three distinct academic disciplines, testifies to De Morgan's polymathic status. Christopher Stray, a classicist by training and a historian of education, encountered De Morgan via his many writings on educational matters, on which he was an acknowledged authority for many years. The volume began with an approach from Stray to Karen Attar about the feasibility of editing one of De Morgan's bibliographical essays; Attar came to De Morgan as a book and library historian and the rare books librarian at the University of London Library, cataloguing and writing about De Morgan's mathematical library at the University. It quickly became apparent that De Morgan merited broader treatment than the study of a single essay. Stray and Attar consequently approached an expert on De Morgan's mathematics, Adrian Rice, who had first encountered De Morgan through his mathematical studies at University College London (UCL). There he had learned about 'De Morgan's Laws' during lectures on algebra and logic, and also that De Morgan had been the college's first professor of mathematics when it opened for classes in 1828. The three of us started work on *Augustus De Morgan, Polymath* to re-evaluate De Morgan's multiple achievements, galvanised particularly by the approaching 150th anniversary of his death and with it the gift of his mathematical library to the University of London.

De Morgan was a mathematician, educationalist and bibliophile who furthermore published ground-breaking research in logic, the history of mathematics and scientific biography, and who exhibited substantial expertise in matters related to astronomy, almanacs, calendar computation and actuarial science. A skilled expositor, he wrote countless popular articles and surveys for the general reader. He was an influential and admired teacher, an office holder in several learned societies, an indefatigable letter writer, and a prominent and respected member of the early Victorian intelligentsia. Indeed, examination of the period in Great Britain between the passage of the first (1832) and

second (1867) Reform Acts, reveals De Morgan to have been involved to some extent in almost every area of British intellectual life during the middle third of the nineteenth century. Yet the very multiplicity of De Morgan's talents militated against his renown, since studies of different aspects of his work have appeared in widely scattered publications, including books and journals devoted to mathematics, education, and book history. Only in biographical accounts has his life and work been considered as a whole, and such accounts are relatively brief.⁴ By uniting different aspects of De Morgan's activity and environment for the first time in a single volume, we invite scholars to reconsider a remarkable and inspiring individual.

De Morgan's Life

Augustus De Morgan was born in Madurai, southern India, on 27 June 1806, the fifth child and eldest surviving son of Elizabeth (née Dodson) and John De Morgan, a colonel in the British army. His mother was the granddaughter of James Dodson, an eighteenth-century English mathematician of note at the time, due to his publication of the then-unique *Anti-Logarithmic Canon* (1742) and other mathematical works. As his great-grandson would later do, Dodson earned his living as a mathematics teacher, rising to the position of master at the prestigious Royal Mathematical School at Christ's Hospital in London; the two men also shared an interest in the mathematics of insurance, with De Morgan's great-grandfather being credited for foundational work in the embryonic discipline of actuarial mathematics. Indeed, when the Equitable Life Assurance Society was launched in 1762, it based its

4 The principal general source for Augustus De Morgan's life remains an uncritical monograph published by his widow about a decade after his death as a memorial: Sophia Elizabeth De Morgan, *Memoir of Augustus De Morgan* (London: Longmans, Green, 1882). More impartial but briefer accounts appear in standard biographical dictionaries: for example, Leslie Stephen, 'Morgan, Augustus De (1806–1871)', rev. by I. Grattan-Guinness, *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004); John M. Dubbey, 'De Morgan, Augustus', in *Dictionary of Scientific Biography*, vol. 3 (New York: Charles Scribner's Sons, 1970), pp. 35–37. Most recently, De Morgan is one of the key figures in Joan L. Richards's study of his extended family: Joan L. Richards, *Generations of Reason: A Family's Search for Meaning in Post-Newtonian England* (New Haven: Yale University Press, 2021).

insurance premiums on actuarial methods and calculations pioneered by Dodson prior to his death in 1757.⁵

On his father's side, the De Morgan family were British descendants of Huguenot refugees who, unlike their French forebears, insisted on spelling their surname with a capital D. As De Morgan later wrote to a friend:

De Morgan—not de Morgan—when I was at Cambridge, I used to *get* out of my misery in *viva voce* examinations sooner by M—D than I should otherwise have done, by insisting on this capital arrangement.⁶

For three generations since 1710, De Morgan's male forebears had been officers in the employment of the East India Company, stationed at various posts in southern India, including Madras (now called Chennai), Masulipatam (Machilipatnam) and Pondicherry (Puducherry). By the time of Elizabeth De Morgan's fifth pregnancy in 1806, her husband was in command of a battalion in the city of Madura (now Madurai in modern-day Tamil Nadu).⁷

When the young Augustus was born that summer, he was found to have the use of only one eye: his left. Many years later he recounted:

When I was in preparation, my mother attended much to a favourite native servant (in India) who had the ophthalmia, which they call the country sore eyes. When I was born it was found I had had it too, and one eye was not destroyed, but never completely formed: it is only a rudiment, with a discoloration in the centre, which shows that nature intended a pupil. ... Accordingly I have always been strictly unocular. I have seen as much with my right eye as with any one finger - no more, and no less.⁸

This distinctive physical peculiarity would soon result in his concentration on mental rather than physical activities.

5 G. J. Gray, 'Dodson, James (c.1705–1757)', rev. by Anita McConnell, *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004).

6 Robert Perceval Graves, *Life of Sir William Rowan Hamilton*, vol. 3 (Dublin: Hodges Figgis, 1889), p. 364. Unless otherwise stated, all italics in quotations are original. 'M—D' presumably stood for 'Mr De Morgan'.

7 UCL Special Collections, MS. ADD. 7, Augustus De Morgan, 'Memorandums on the Descendants of Captain John De Morgan ...', ff. 115–16.

8 Graves, *Life*, pp. 612–13.

At the time of De Morgan's birth, tensions between the British officers and their native troops—which were frequently strained—had reached critical levels, with mutiny a constant threat. It was for this reason that Colonel De Morgan broke with family tradition and took his young family back to the relative safety of England. On 22 October 1806, they set sail on the *Jane, Duchess of Gordon* in a convoy of nearly forty ships. After a voyage of nearly six months, their ship landed at Deal in Kent on 12 April 1807. 'At this period,' the younger De Morgan commented, 'I had passed three-fifths of my life on the water.'⁹ He was later to use this voyage as an excuse for his subsequent aversion to travelling: 'I consider I had my share of it in my nurse's arms, in which I began life with a journey of 11,000 miles, crossed the line twice, and knew nothing about it all—Heaven be praised.'¹⁰

After some time in London, Colonel De Morgan settled his family at Worcester so that his wife might be close to her sister. He returned to India alone in 1808, for a period of two years. On his return, the family moved to north Devon, first to Appledore, and then to Bideford. It was here that, at the age of just over four years old, the education of Augustus De Morgan began with lessons from his father in 'reading and numeration'.¹¹ In 1812, the family moved again, this time to Barnstaple. The Colonel's imminent departure to India for another tour of duty occasioned a final move to Taunton in Somerset, from where he departed on 29 January 1813. He never saw his family again, dying of a liver complaint somewhere near St. Helena on his way home in 1816.¹²

Meanwhile, the young Augustus was receiving a solid but unremarkable education in a number of private schools in the south-west of England. In common with most school teaching at the time, in addition to arithmetic and a little algebra, his learning was dominated by classical studies of Latin and Greek, augmented with a little Hebrew.¹³ For two and a half years from the age of fourteen, De Morgan attended a boarding school in Redland, near Bristol, run by the Reverend John Parsons who, by all accounts, was a good teacher, although 'not a

9 A. De Morgan, 'Memorandums', f. 116.

10 Graves, *Life*, p. 525.

11 S. E. De Morgan, *Memoir*, p. 3.

12 A. De Morgan, 'Memorandums', f. 128.

13 A. De Morgan, 'Memorandums', f. 155.

high mathematician'.¹⁴ It was around this time that the boy's hitherto uncultivated mathematical skill was first recognised, though not by Parsons. We are told, in a verbose manner typical of the period, that 'the first suspicion of Augustus having inherited the ostensibly reprehensible proclivity of his maternal forbear was due to a mere chance',¹⁵ the propensity being 'accidentally developed, and indeed made known to its possessor'¹⁶ by a family friend who, on finding him making an elaborate drawing of a figure from Euclid with ruler and compass, initiated him into the concept of a mathematical proof.

From this point, De Morgan's mathematical progress was rapid, as a school-friend, Robert Reece, later testified:

It seems an odd thing to record, but I well remember that I was advanced in 'Bland's Quadratic Equations'¹⁷ when De Morgan took up that well-known elementary book, 'Bridge's Algebra',¹⁸ for the first time. But it was so. He read Bridge's book like a novel. In less than a month he had gone through that treatise and dashed into Bland, and so got out of sight, as far as I was concerned.¹⁹

The final stage of De Morgan's intellectual development began on 1 February 1823, when he entered Trinity College, Cambridge, at the age of just over sixteen and a half.²⁰ This early start to his university career is probably explained by his rapid progress at Parsons's school where, in mathematics at least, he had 'soon left his teacher behind'.²¹ However, neither Parsons nor De Morgan's mother intended mathematics to be his principal subject of study at Cambridge, the former advising concentration on Classics to comply with the latter's wish that her son should ultimately enter the church. This aspiration would soon be frustrated by two major factors: firstly, De Morgan's insatiable appetite

14 S. E. De Morgan, *Memoir*, p. 3.

15 Anna M. W. Stirling, *William De Morgan and his Wife* (London: Thornton Butterworth, 1922), p. 25.

16 S. E. De Morgan, *Memoir*, p. 4.

17 Miles Bland, *Algebraical Problems, Producing Simple and Quadratic Equations, With Their Solutions* (Cambridge: J. Smith, 1812).

18 Bewick Bridge, *An Elementary Treatise on Algebra* (London: T. Cadell & W. Davies, 1815).

19 S. E. De Morgan, *Memoir*, p. 7.

20 Walter William Rouse Ball & John A. Venn, eds, *Admissions to Trinity College, Cambridge*, vol. 4 (London: Macmillan, 1911), p. 216.

21 S. E. De Morgan, *Memoir*, p. 4.

for mathematics; and secondly, the intellectual environment he quickly encountered at Cambridge.

De Morgan's principal tutor for the entirety of his undergraduate career was John Philips Higman, but he found himself influenced by all of his college teachers to some extent. In particular, it is highly probable that he acquired his interest in algebra from the algebraist George Peacock and his love of astronomy from the future Astronomer Royal George Airy. It is also entirely conceivable that his passion for the history of science was inspired (and certainly encouraged) by Peacock and the scientific philosopher William Whewell, both of whom had strong interests in that area.²² There is also a suggestion that it was from Whewell that De Morgan inherited his great fascination for logic,²³ although the link here is less obvious. Nevertheless, the fundamental contribution of all of these teachers was to confirm De Morgan's intention to concentrate on the study of mathematics while at college, and ultimately to determine the course of his professional career.

He was by nature a compulsive reader on almost any topic and, when not consuming mathematical books, would devote his leisure hours to the study of works on philosophy, theology, literature and history. Towards the end of his life, he wrote to a friend: 'I did with Trinity College library what I afterwards did with my own—I foraged for relaxation.'²⁴ A result of this discursive reading was the development of an almost encyclopaedic knowledge of an impressive range of scientific subjects. His wife Sophia recalled, for example, that as early as their meeting in 1827, he was already an expert in the history of science, being 'well informed in Eastern astronomy and mythology' and critical of writers on the subject, pointing out 'the insufficiency of their theories to account for all that they have tried to explain'.²⁵

In January 1827, De Morgan sat the prestigious and highly demanding 'Tripos' examination, on the basis of which candidates were awarded

22 Peacock's article 'Arithmetic' in the *Encyclopaedia Metropolitana* (vol. 1., 369–523), written in 1825, was the best historical account of the subject to date. Whewell was later famous for, amongst many other things, his three-volume *History of the Inductive Sciences*, first published in 1837.

23 Alexander MacFarlane, *Lectures on Ten British Mathematicians of the Nineteenth Century* (London: Chapman & Hall, 1916), p. 20.

24 S. E. De Morgan, *Memoir*, p. 393.

25 S. E. De Morgan, *Memoir*, p. 21.

their degrees. Graduates were divided into several classes: the lowest were known as *poll men* who, while awarded a degree, did not receive honours; above them were the *junior* and *senior optimes*, while those who achieved first-class status were called *wranglers*, from the word meaning to dispute. Of these, the student in first place was known as the Senior Wrangler, and competition for this distinction was intense. In De Morgan's year, there was a widespread expectation that this coveted position would be his. However, when the results were announced, he was disappointed to learn that he had only achieved the rank of Fourth Wrangler, a place which, as it was later said, 'failed to declare his real power or the exceptional aptitude of his mind for mathematical study'.²⁶ Ironically, it was his exhaustive programme of reading which was principally to blame for this disappointing result, since it often distracted him from the course required for examination. The realisation that wide and discursive mathematical study had actually been *detrimental* to his performance imbued a thorough distrust of competitive examinations that was to last for the rest of his life.

It was at this point that De Morgan's firmly held nonconformist religious beliefs came to the fore, a reaction to the strict evangelical education he had received in childhood. This had started at an early age with his father: 'A rigid Evangelical in tenets and practice—a heritage, doubtless, from his Huguenot ancestry—Colonel De Morgan was known to his fellow officers by the nickname of "Bible John"'.²⁷ His wife shared his beliefs and, after his death, had continued to administer the same discipline. As a child, De Morgan had been taken to church twice in the week, three times on Sunday, and required to give an abstract of every sermon he heard. Not surprisingly, this left him with a lifelong inability to listen to any speaking or lecturing for a prolonged period. The 'dreary sermons',²⁸ combined with the logical inconsistencies which formed part of the arguments used to convince him, made it inevitable that he would rebel at the first opportunity, though he never became an atheist.

26 Arthur Cowper Ranyard, Obituary Notice of Augustus De Morgan, *Monthly Notices of the Royal Astronomical Society*, 32 (1871–72), 112–18 (pp. 113–14).

27 Stirling, *William De Morgan*, p. 24.

28 S. E. De Morgan, *Memoir*, p. 11.

While admitting a personal faith in Jesus Christ, he subjected all religious arguments to the same unbending rigour of rational thought that he devoted to his other intellectual pursuits. 'My opinion of mankind,' he wrote, 'is founded upon the mournful fact that, so far as I can see, they find within themselves the means of believing in a thousand times as much as there is to believe in.'²⁹ Rejecting anything that smacked of hypocrisy or sectarianism, he refused to join any church, regarding himself throughout life as a 'Christian Unattached'.³⁰ For him, religious belief was a strictly personal experience and nobody else's concern. Moreover, he believed that one should be able to achieve one's goals in life regardless of religious persuasion. As he later wrote in his will, he refrained from any open profession of faith 'because in my time such confession has always been the way up in the world'.³¹ Such conviction and commitment to principle was to be a constant feature of De Morgan's life.

An immediate consequence of his religious nonconformity was his departure from Cambridge, for, although his degree result was more than sufficient to win him a college fellowship, it was first necessary to swear adherence to the tenets of the Church of England (a requirement not fully abolished at Oxford and Cambridge until 1871) which, due to his religious convictions, he refused to do.³² De Morgan now had to decide on a profession, since 'few, if any, occupations in England in the early nineteenth century required much training in mathematics or involved mathematics at all'.³³ An academic career thus closed to him, he toyed briefly with the idea of a medical or legal career, before his attention was drawn to the newly established London University (now called University College London, or UCL), which was then in the process of recruiting professors. Inspired by the progressive aims and explicit secular character of 'the godless institution on Gower Street', De

29 Augustus De Morgan, *A Budget of Paradoxes* (London: Longmans, Green, 1872), p. 70.

30 Ranyard, Obituary Notice, p. 114.

31 S. E. De Morgan, *Memoir*, p. 368.

32 It is worth mentioning that De Morgan's doctrinal scruples, strong though they undoubtedly were, did not prevent him actually taking his B.A. degree, which required acceptance of the thirty-nine Articles of Faith. It can only be assumed that he took the oath under (silent) protest.

33 Philip C. Enros, 'The Analytical Society (1812-1813): Precursor of the Renewal of Cambridge Mathematics', *Historia Mathematica*, 10 (1983), 24-47 (p. 41).

Morgan applied for the mathematics chair. Despite his relative youth and lack of experience, he was unanimously elected as the founding professor of mathematics on 23 February 1828.³⁴

However, his academic career nearly ended as prematurely as it had begun. Being a new institution, UCL experienced considerable instability during its early years, due to the poor state of its finances, student discipline and general morale. The relationship between the professors and the college's ruling council was particularly uneasy. Matters finally came to a head in 1831 with the dismissal of the professor of anatomy, Granville Sharp Pattison, whose alleged incompetence had resulted in student unrest. De Morgan, being a man of principle, immediately resigned in support of his colleague.³⁵ But five years later, shortly before the beginning of the 1836–37 academic year, his successor was accidentally drowned while on a family holiday in the Channel Islands. With the beginning of term only days away, De Morgan offered himself as a temporary replacement and, after he had received assurances that the circumstances that had led to his resignation could not recur, this arrangement became permanent. He was to remain at the college for another thirty years.³⁶

He was now secure enough financially to propose marriage, after ten years of courtship, to Sophia Elizabeth Frennd, the daughter of William Frennd, a social reformer and fellow liberal nonconformist, with whom he had become acquainted on moving to London in 1827, due to their common interests in mathematics, their actuarial work, and their mutual membership and involvement in learned bodies such as the Royal Astronomical Society and the Society for the Diffusion of Useful Knowledge. De Morgan's wedding to Sophia, on 3 August 1837, was one of the first in England to take place in a registry office, after the practice was legalised earlier that year.³⁷ As well as being progressively-minded intellectuals, the Frennd family had good connections to a wide range of liberally-inclined social reformers, into whose orbits De Morgan was now introduced, including Lady Byron, Elizabeth Fry, and John

34 Adrian Rice, 'Inspiration or Desperation? Augustus De Morgan's Appointment to the Chair of Mathematics at London University in 1828', *British Journal for the History of Science*, 30 (1997), 257–74 (p. 268).

35 S. E. De Morgan, *Memoir*, pp. 34–39.

36 S. E. De Morgan, *Memoir*, pp. 69–74.

37 A. De Morgan, 'Memorandums', ff. 29, 30.

Stuart Mill. No doubt encouraged by his wife, he used his mathematical abilities in the service of the wider community, for example serving for twelve years as the manager of a savings bank, as 'he thought this the best way in which he could be useful to his poorer neighbours'.³⁸

He was also supportive of the first steps towards providing higher education for women, giving 'lectures or lessons on arithmetic and algebra'³⁹ for the first two terms when the Ladies' College, Bedford Square (later to become Bedford College) opened for classes in the autumn of 1849.⁴⁰ But by the end of his life, his social liberality, so progressive in the 1830s and 1840s, began to appear less broadminded, drawing the line, for example, at votes for women. As he wrote in 1868 to John Stuart Mill, who famously proposed such a measure in Parliament:

To be a voter is sometimes dangerous. A man ought to face the danger, but you have no right to enforce it on women; in principle you might as well enforce the militia on them. Many women think exemption from politics is one of their rights.⁴¹

In general, however, De Morgan tended to steer clear of political matters, largely adopting an attitude of total indifference. As he wrote in 1852: 'I never gave a vote in my life.'⁴² He went on to say:

I hate the system. Given two persons of whom I know nothing; required which is the best qualified to manage matters of which I know next to nothing. The presumption is that 5000 incompetent persons, by a contest of opposite incompetencies, will produce a competent decision. This absurdity fills the House of Commons.⁴³

His lack of interest in parliamentary democracy also extended to sightseeing and tourism:

I never was in the House of Commons, or in the Tower, or in Westminster Abbey. I spent only one and three-quarter hours in the Great Exhibition. ... I never got further north than Cambridge, and never while at Cambridge penetrated to the

38 S. E. De Morgan, *Memoir*, p. 248.

39 S. E. De Morgan, *Memoir*, p. 174.

40 Margaret J. Tuke, *A History of Bedford College for Women 1849–1937* (London: Oxford University Press, 1939), p. 65.

41 S. E. De Morgan, *Memoir*, p. 384.

42 Graves, *Life*, p. 377.

43 Graves, *Life*, p. 385.

northern extremity of the town. So much for me as a sight-seer and traveller.⁴⁴

In fact, De Morgan loved city life so much that, apart from the occasional trip to France and the odd reluctantly taken family holiday in the countryside, he rarely left London. He once said of himself,

Ne'er out of town; 'tis such a horrid life:
But duly sends his family and wife.⁴⁵

De Morgan was a man of many eccentricities. In 1859, when offered an honorary law doctorate by Edinburgh University, he declined it, saying that he 'did not feel like an LL.D.'⁴⁶ In fact, he once styled himself:

Augustus De Morgan,
H.O.M.O. P.A.U.C.A.R.U.M. L.I.T.E.R.A.R.U.M.⁴⁷

De Morgan also refused to allow himself to be proposed as a Fellow of the Royal Society, as he considered the body to be more concerned with social standing than scientific attainment.⁴⁸ 'Whether I could have been a Fellow,' he later said, 'I cannot know; as the gentleman said who was asked if he could play the violin, I never tried.'⁴⁹ But nowhere is his unconventionality better illustrated than by his endearingly whimsical sense of humour, which is curiously reminiscent of a blend of Lewis Carroll, W. S. Gilbert and Monty Python. His writings abound with witticisms, anecdotes, jokes, puns, parodies and conundrums, either of his own invention or, just as frequently, acquired from other people. It is even possible that he was the first to express a precursor of 'Murphy's

44 Graves, *Life*, p. 462.

45 A. De Morgan, *Budget*, p. 82.

46 S. E. De Morgan, *Memoir*, p. 269.

47 'Augustus De Morgan, Man of Few Letters.' MacFarlane, *Lectures*, p. 24.

48 Although membership of the Royal Society certainly included Fellows of the highest scientific calibre, under the leadership of Joseph Banks (President from 1778–1820) the Society had obtained a not unjustified reputation for admitting wealthy patrons and valuing privilege as much as high scientific attainment. This conflicted with the ideals of more progressive scientific 'professionalisers' such as De Morgan. Thus, although he was certainly an eminently suitable candidate for a Fellowship, he repeatedly refused to be put forward for the honour, despite the urging of friends and colleagues. See Rebekah Higgitt, 'Why I don't FRS my tail: Augustus De Morgan and the Royal Society', *Notes and Records of the Royal Society*, 60 (2006), 253–59.

49 A. De Morgan, *Budget*, p. 18.

Law', namely, that 'anything that can go wrong will go wrong', although De Morgan's version is considerably broader: 'whatever can happen will happen'.⁵⁰

Above all, he appears to have been a warm and generous individual, with firmly held principles and a fierce intellect, who inspired great affection and loyalty among his friends. The lawyer and diarist Henry Crabb Robinson said of him that 'He is the only man whose calls, even when interruptions, are always acceptable. He has such luminous qualities, even in his small-talk.'⁵¹ These qualities were clearly in evidence in the professors' common room at UCL, as a junior colleague wrote in 1865:

I never met a man who enjoyed telling a funny story more than de Morgan [*sic*] and he tells them well. It would be worth while to keep a record of some of them. ... [For example], Mr. Stirling Coyne, a barrister, and Albert Smith (of Mont Blanc celebrity) [who had died five years previously] married two sisters who were as like each other as two peas. Coyne was in court one very hot day with a friend. The latter afterwards repaired to the Crystal Palace; there he met a lady whom he took to be Mrs. Coyne. After shaking hands she remarked, 'How hot it is here.' 'Yes,' replied the gentleman, 'but your husband is in a far hotter place I can assure you.' The horror with which this remark was received was inexplicable to the gentleman. It was only afterwards that he discovered he had been addressing the widow of the late mountaineer.⁵²

By 1866, De Morgan had been associated with University College for nearly four decades, making him one of its longest-serving professors, a distinction which brought him considerable pride. But these feelings changed dramatically when the college's governing council refused to appoint a candidate to the vacant chair of philosophy because he was a controversial Unitarian minister. To De Morgan, the college's decision was not only an affront to his view that religious beliefs should have no bearing on professional advancement, but more importantly it was

50 A. De Morgan, *Budget*, p. 171.

51 Henry Crabb Robinson, *Diary, Reminiscences, and Correspondence of Henry Crabb Robinson*, ed. by Thomas Sadler, vol. 2 (Boston: Fields, Osgood, 1869), p. 489.

52 William H. Brock and Roy M. MacLeod, eds, *Natural Knowledge in Social Context: The Journal of Thomas Archer Hirst, F.R.S.* (London: Mansell, 1980), pp. 1759–60.

a fundamental betrayal of its founding principle of religious neutrality. He resigned his professorship on 10 November 1866 and, after his last lecture in the summer of 1867, never returned. He even refused a request to sit for a portrait or bust to be placed in the college library. As far as he was concerned, 'our old College no longer exists'.⁵³

The years following his retirement were beset by illness and bereavement. The circumstances surrounding his final resignation had put De Morgan under tremendous emotional stress, which now took a toll on his health. His previously robust constitution began to deteriorate, with the untimely death of his son George from tuberculosis in October 1867 further weakening his spirits. After suffering a stroke in 1868, De Morgan never fully recovered, and a final decline in his health followed the premature death of another child, Helen Christiana, in August 1870. He died of kidney failure at his home in northwest London on 18 March 1871 and was buried at Kensal Green Cemetery five days later.⁵⁴

De Morgan's death prompted the publication of numerous memorials and obituaries, each paying tribute to his many and varied achievements. One of the comments most frequently made regarded the sheer breadth and volume of his published work. The notice in *The Athenæum* asserted that if all his articles for periodicals and encyclopaedias were collected together, there would be found 'such a mass of literary achievement as seldom comes from the pen of a man whose sole business it is to write for journals'.⁵⁵ *The Spectator* no doubt spoke for many of his former students when it declared that 'no testimonial which can be raised to Professor De Morgan will adequately express his many pupils' deep sense of intellectual and moral obligation'.⁵⁶

But perhaps the most perceptive and candid judgement came nearly half a century later from the historian of mathematics Walter William Rouse Ball, who, although he had never known De Morgan, was able to encapsulate his personality and character in a paragraph which serves as a fitting epitaph to a remarkable man:

53 S. E. De Morgan, *Memoir*, p. 360.

54 *The Times*, 20 March 1871, 1a; 21 March 1871, 5c; Brock and MacLeod, *Natural Knowledge*, p. 1896.

55 *The Athenæum*, 25 March 1871, p. 370.

56 *The Spectator*, 13 May 1871, p. 563.

That De Morgan was obstinate and somewhat eccentric I readily admit, and I do not consider he was a genius, but he leaves on my mind the impression of a lovable man, with intense convictions, of marked originality, having many interests, and possessing exceptional powers of exposition. In those cases where his actions were criticized it would seem that the explanation is to be found in his determination always to take the highest standard of conduct without regard to consequences; he hated suggestions of compromise, expediency, or opportunism. Such men are rare, and we do well to honour them.⁵⁷

De Morgan's Work and Legacy

For all his many interests and areas of expertise, Augustus De Morgan remained first and foremost a mathematician—for which reason the opening chapter of this volume surveys his mathematical work. As a mathematician, his most significant contribution lay arguably as a catalyst in the birth of modern abstract algebra; but algebra was by no means his sole mathematical interest. In covering his work in multiple branches of mathematics, Adrian Rice grapples with the demise of De Morgan's reputation. How could somebody be lauded at the time of his death as one of the country's major mathematicians and largely forgotten half a century later? Were De Morgan's contemporaries overly generous or his successors inaccurately harsh? In a new evaluation, Rice demonstrates that neither is the case and that the nature of De Morgan's achievements as a supporter more than a trailblazer, and as a polymath within mathematics instead of a one-track researcher, both made his name and allowed it to fade.

It is significant in connection with De Morgan's diminished reputation that, in his lifetime, and for some time afterwards, he was acknowledged principally as a great mathematics teacher. His students praised him highly, their recollections revealing an idiosyncratic but talented professor whose lectures were at once thought-provoking, intriguing and challenging. He was particularly critical of student examinations, preferring independent thought to

57 Walter William Rouse Ball, 'Augustus De Morgan', *The Mathematical Gazette*, 8 (1915–16), 42–45 (p. 45).

the mere regurgitation of proofs in an exam,⁵⁸ while his rigorous and uncompromising attitude towards academic standards would establish UCL as the centre for advanced mathematical instruction in London. Christopher Stray's chapter discusses De Morgan's strong opinions on mathematical education and his numerous articles on the subject. Stray further enters new territory in his discussion of De Morgan's own undergraduate education.

Later described by the American philosopher Charles Sanders Peirce as 'the greatest formal logician that ever lived',⁵⁹ De Morgan is best remembered as a logician for the famous De Morgan's Laws and for his logic of relations, which appeared later in his career. He was one of the few mathematicians of his time to realise the importance of logic to mathematics, and vice versa:⁶⁰

We know that mathematicians care no more for logic than logicians for mathematics. The two eyes of exact science are mathematics and logic: the mathematical sect puts out the logical eye, the logical sect puts out the mathematical eye; each believing that it sees better with one eye than with two.⁶¹

De Morgan attempted to bring mathematical ideas into his logic by introducing a numerically precise method of 'quantifying the predicate'.⁶² His consequent controversy with the Scottish philosopher

58 One ex-student later wrote: 'All cram he held in the most sovereign contempt. I remember, during the last week of his course which preceded an annual College examination, his abruptly addressing his class as follows: "I notice that many of you have left off working my examples this week. I know perfectly well what you are doing; you are cramming for the examination. But I will set you such a paper as shall make all your cram of no use."' S. E. De Morgan, *Memoir*, pp. 100–01.

59 Peter Heath, 'Editor's Introduction', in Augustus De Morgan, *On the Syllogism, and Other Logical Writings* (London: Routledge & Kegan Paul, 1966), vii–xxxii (p. xxx).

60 *The Athenæum*, 18 July 1868, p. 71.

61 De Morgan always had an eye for a *bon mot*; but, recalling his forementioned ocular disability, perhaps no passage in all of his writings better illustrates his sublime sense of humour than this.

62 This rather technical term can be explained as follows. In logical statements such as 'All men are mortal', the word 'men' is the subject and 'mortal' is its predicate—a characteristic or attribute of the subject. In traditional Aristotelian logic, problems arise with statements like 'Some men are dead', because we are told neither how many men are dead nor the total quantity of dead things. To rectify this defect, De Morgan introduced more precise notions of number and quantity into his logic. This was known as 'quantifying the predicate'.

Sir William Hamilton,⁶³ who mistakenly accused him of plagiarism,⁶⁴ served to stimulate his contemporary George Boole to publish his ideas on logic in 1847.⁶⁵ Anna-Sophie Heinemann, in her chapter on De Morgan's logic, focuses on his early research on the subject, particularly on logical 'quantification'. She argues that, despite its relative lack of influence on later developments, it still represented a notable departure from traditional syllogistic methods and anticipated the modern understanding of quantification in logic.

De Morgan's logic was also innovative in its attempt to develop a coherent system of symbolic notation to facilitate logical deductions. Indeed, one of Hamilton's objections to De Morgan's work on the subject was the latter's introduction of mathematical ideas and concepts into a discipline then regarded purely as an area of philosophy. In both his research and in his teaching, De Morgan's mathematics was often very philosophical in nature, although he always retained a healthy sense of humour about philosophical modes of inquiry:

I would not dissuade a student from metaphysical inquiry; on the contrary, I would rather endeavour to promote the desire of entering upon such subjects: but I would warn him, when he tries to look down his own throat with a candle in his hand, to take care that he does not set his head on fire.⁶⁶

He was, however, keenly interested in matters of 'meta-science', an area of the philosophy of science relating to methodology. Lukas Verburgt explains in his chapter how the dominant underlying scientific methodology of Victorian Britain was grounded on an appreciation of the work of the seventeenth-century philosopher Francis Bacon, and how,

63 Not to be confused with the Irish mathematician Sir William Rowan Hamilton, who was one of De Morgan's great friends and a regular correspondent.

64 Anna-Sophie Heinemann, *Quantifikation des Prädikats und numerisch definierter Syllogismus. Die Kontroverse zwischen Augustus De Morgan und Sir William Hamilton: Formale Logik zwischen Algebra und Syllogistik* (Münster: Mentis, 2015); Luis María Laíta, 'Influences on Boole's Logic: The Controversy between William Hamilton and Augustus De Morgan', *Annals of Science*, 36 (1979), 45–65 (pp. 51–60).

65 De Morgan strongly encouraged Boole's own research in this area; see Gordon C. Smith, *The Boole-De Morgan Correspondence 1842–1864* (Oxford: Clarendon Press, 1982).

66 Augustus De Morgan, *Formal Logic* (London: Taylor & Walton, 1847), p. 27.

via his correspondence with Whewell and in various publications, De Morgan revealed himself to be one of a relatively small group of British scientists who were anti-Baconian in outlook. Thus, the contemporary debate about the merits of Baconianism in British science provides a further example of De Morgan going against the grain—this time in opposition to what was then mainstream meta-scientific thinking.

De Morgan's knowledge of the history of science in general, and mathematics in particular, was encyclopaedic. His historical publications are characterised by their extensive use of primary sources, particularly archival documents, and an obvious desire to set the historical record straight. Significant contributions included his recognition of the earliest known printed work to contain the + and – signs, as well as extensive research into the infamous calculus priority dispute between Isaac Newton and Gottfried Leibniz. He drew attention to previously hidden flaws in Newton's character and initiated the rehabilitation of Leibniz's reputation in Britain, thereby leading scientific biography away from hagiographical studies and towards the more measured style of modern historiography.

Another area of prolonged interest was astronomy and its history. Except perhaps for his writings on the calendar, De Morgan's astronomical work has received little attention. Daniel Belteki redresses this to foreground his contributions to that subject, through the publication of a host of learned papers, biographical studies, book reviews, popular articles and encyclopedia entries throughout his career, and through his organisational role in the Royal Astronomical Society. Belteki's chapter shows De Morgan as a prominent member of the British astronomical community, despite his inability to participate in observational astronomy due to his visual impairment. In particular, we see De Morgan's merging of his astronomical knowledge with his historical interest in almanacs and calendar reckoning, particularly with regard to the calculation of the date of Easter, which is in itself a noteworthy achievement.

De Morgan's historical scholarship and his eccentric sense of humour came together in *A Budget of Paradoxes*, a collection of humorous writings and witty reviews originally featured in the weekly periodical *The Athenæum*. Its wealth of witticisms, anecdotes and sayings included his famous remark that 'I was X years old in A.D. X²,' a peculiarity unique

to those born in years such as 1640, 1722, 1806, 1892, 1980, and so on.⁶⁷ Adrian Rice's chapter delves into the pages of this book, which spanned a 375-year period from the invention of printing from moveable type to the mid-nineteenth century. Cheerfully lampooning scientific ignorance in all its many forms, the *Budget* gives perhaps the best insight into De Morgan's intellect, revealing alongside his comedic ability and love of the absurd his vast erudition and extensive knowledge of a broad range of topics from mathematics to theology.

De Morgan applied the same combination of historical scholarship and anecdotal wit in his bibliography of nearly 400 published works on arithmetic, *Arithmetical Books from the Invention of Printing to the Present Time* (1847). Whereas the *Budget* was based entirely on works De Morgan owned, in *Arithmetical Books*, De Morgan used his own books alongside others. From a modern bibliographer's point of view, *Arithmetical Books* is not a good work. It provides too little in terms of bibliographical description, for example, failing to record pagination or foliation. Despite the published presence of British Museum cataloguing rules which De Morgan could have used, it does not note when books are in black letter (Gothic type), and it applies the terms folio, quarto and octavo anachronistically to size rather than bibliographical format, as De Morgan himself discusses.⁶⁸

Nonetheless, *Arithmetical Books* gained De Morgan a reputation as a bibliographer, with his most detailed obituary noting his interest in such matters of physical bibliography as watermarks, colophons and catchwords.⁶⁹ Bibliographically, it stood out for De Morgan's insistence on seeing the books he described in order to ensure accuracy, a concern he also expressed elsewhere,⁷⁰ and it also drew attention to the relationships between editions. Idiosyncratically, he spelt out dates of publication in words: a decision also made to promote accuracy by avoiding errors

67 We leave it as an exercise for the reader to discover the value of X.

68 Augustus De Morgan, *Arithmetical Books from the Invention of Printing to the Present Time* (London: Taylor & Walton, 1847), pp. xi–xiii. For a modern assessment of *Arithmetical Books*, see David McKitterick, *Readers in a Revolution: Bibliographical Change in the Nineteenth Century* (Cambridge: Cambridge University Press, 2022), pp. 88–91.

69 Ranyard, Obituary Notice, p. 117; see also A. De Morgan, *Arithmetical Books*, pp. xii–xiii.

70 Augustus De Morgan, 'Mathematical Bibliography', *Dublin Review*, 41 (Sept. 1846), 1–37.

that can arise when copying or printing figures. As a list, *Arithmetical Books* is incomplete because, as De Morgan notes frankly, inclusion depended on his personal examination of works.⁷¹ Yet it quickly became a standard reference tool, as references to it in Victorian sale catalogues of mathematical books in and beyond Britain demonstrate.⁷² In 1908, David Eugene Smith was able to write of it, in terms of its overview of its subject matter, as 'still one of our best single sources, although sixty years have elapsed since it first appeared', while, in a 1967 reprint, A. Rupert Hall called it 'a minor classic', still of use, on the same basis.⁷³

De Morgan's personal library comprised nearly 4,000 items and was known as one of the most impressive collections of mathematical books in Britain, although it was not in fact the largest mathematical library of its time. Karen Attar has written elsewhere about De Morgan's library and his annotations on a significant minority of the books therein. In her chapter here, she tests the various nineteenth- and twentieth-century statements about its excellence by comparing and contrasting it with contemporary mathematical collections such as those of Francis Baily, Charles Babbage and John Thomas Graves. She demonstrates its unique importance through the connection between the books and their owner, a feature absent from the other collections. The second part of her chapter treads further new ground by chronicling the library's fate after Lord Overstone purchased and gifted it to the University of London Library (now Senate House Library, University of London), which opened in 1877.

The words De Morgan left behind him are not only those he published and the printed words he collected but are also contained in an enormous amount of archival material: mathematical manuscripts, and in particular personal letters, scattered among several repositories. De Morgan's entry in the *Oxford Dictionary of National Biography* lists these institutions, all of which have archival catalogues. The penultimate chapter of this volume, written by curators, brings the material in these

71 A. De Morgan, *Arithmetical Books*, pp. ii, ix–x.

72 See for example *Catalogue de Livres Astronomiques, Mathématiques et Physiques Provenant des Bibliothèques de Feu M. A.C. Petersen ... dont la Vente Publique se Fera à Berlin le Lundi 17 Decembre 1855 Et Jours Suivants* (Berlin, 1855), lot 1789.

73 David Eugene Smith, *Rara Arithmetica: A Catalogue of the Arithmetics Written before the Year MDCL, with a Description of Those in the Library of George Arthur Plimpton of New York* (Boston: Ginn, 1908), p. xii; A. Rupert Hall, 'Introduction', in A. De Morgan, *Arithmetical Books* (London: Hugh K. Elliott, 1967), p. vii.

archives to life. The descriptions demonstrate, as the catalogues cannot, how the papers held illumine De Morgan's work, character and life; his personal and professional relationships—and also why edited extracts do not substitute for the originals.

De Morgan spent his entire working life in London's Bloomsbury, where University College was situated on Gower Street. Now a fashionable district in central London, Bloomsbury in the early nineteenth century was a relatively uninspiring neighbourhood on the city's northernmost edge. Yet notwithstanding the area's aesthetic shortcomings, UCL students could benefit from its flourishing intellectual atmosphere, as Richard Holt Hutton, one of De Morgan's erstwhile pupils, recalled:

It is sometimes said that it needs the quiet of a country town remote from the capital, to foster the love of genuine study in young men. But of this at least I am sure: that Gower Street, and Oxford Street, and the New Road, and the dreary chain of squares from Euston to Bloomsbury, were the scenes of discussions as eager and as abstract as ever were the sedate cloisters or the flowery river-meadows of Cambridge or Oxford.⁷⁴

Rosemary Ashton puts her expertise as leader of the UCL Bloomsbury Project⁷⁵ to good use in her chapter to contextualise De Morgan in his physical and intellectual surroundings. She paints an evocative picture of Bloomsbury in the early years of the nineteenth century, when social reformers like Henry Brougham and George Birkbeck founded 'The London University' on one of its main thoroughfares, thereby creating the possibility of an academic career for De Morgan in the capital and initiating Bloomsbury's strong and enduring association with higher education, culture and the arts.

While Ashton discusses De Morgan's geographical environment, Joan Richards places De Morgan in his familial context. His wife Sophia and two of the De Morgans' children, the writer Mary and especially the novelist and ceramic artist William (creator of 'De Morgan tiles') have

74 Walter Bagehot, *Literary Studies*, ed. by Richard Holt Hutton, vol. 1 (London: Longmans, Green, 1879), p. xiii.

75 University College London, *UCL Bloomsbury Project*, <https://www.ucl.ac.uk/bloomsbury-project/index.htm>

received their own studies,⁷⁶ while Richards herself has done much to shed light on the family in her recent monograph *Generations of Reason*. Her chapter here balances De Morgan's intellectual legacy with his familial legacy through his children's achievements. Richards's exploration of Sophia's fascination with the development of her offspring's powers of reasoning underlines that interest in education was the preserve of both husband and wife, not of Augustus De Morgan alone.

De Morgan published no magnum opus, proved no major theorem and made no major scientific discovery. Yet it has been said: 'Were the writings of De Morgan published in the form of collected works, they would form a small library.'⁷⁷ His published output comes to more than 2,200 individual items, including 1,400 papers, articles and surveys, and over 700 encyclopedia entries. These varied in length from just a few lines to scores of pages, appearing in newspapers, literary magazines, proceedings of learned societies, and some of the premier research journals of the day. The wide range of De Morgan's publication venues and the anonymity under which many of his articles appeared renders the task of listing every item herculean, and previously unknown De Morgan-authored texts will probably be unearthed by subsequent literature searches. But in our final chapter, William Hale has produced the fullest and most detailed De Morgan bibliography to date. Olivier Bruneau's chapter discusses some of this raw material, considering the length as well as the quantity of these publications to balance the areas of his work. He analyses De Morgan's scholarly and journalistic output, showing the extent of his writings for a general audience, and revealing him to have been one of early Victorian Britain's most prolific and gifted mathematical expositors.

76 Sophia Elizabeth De Morgan, *Threescore Years and Ten: Reminiscences of the Late Sophia Elizabeth De Morgan to which are Added Letters to and from her Husband the Late Augustus De Morgan, and Others*, ed. by Mary A. De Morgan (London: Bentley, 1895); Marilyn Pemberton, *Out of the Shadows: The Life and Work of Mary De Morgan* (Newcastle upon Tyne: Cambridge Scholars Publishing, 2012); Anna M. W. Stirling, *William De Morgan and His Wife* (London: Thornton Butterworth, 1922); William Gaunt and M.D.E. Clayton-Stamm, *William De Morgan* (London: Studio Vista, 1971); Jon Catleugh, *William De Morgan Tiles* (New York: Van Nostrand Reinhold, 1983); Mark Hamilton, *Rare Spirit: A Life of William De Morgan 1839–1911* (London: Constable, 1997); Rob Higgins and Christopher Stolbert Robinson, *William De Morgan: Arts and Crafts Potter* (New York: Bloomsbury, 2010).

77 MacFarlane, *Lectures*, p. 24.

As a polymath, De Morgan was no dilettante: his erudition was deep and his knowledge wide, and the chapters that follow reflect the richness and diversity of his intellectual output. To do justice to his extraordinarily multifaceted career, our team of fifteen authors have covered a wide area, from the relatively well known to the more obscure. Naturally, this volume does not claim to be the last word—page constraints and the nature of scholarly interest mean that there are inevitable omissions. For example, although this book includes information on De Morgan as a professor and as a historian, no specific chapters are devoted exclusively to these subjects.⁷⁸ Detailed studies of his work as a bibliographer and as an actuary and of his religious views, yet to be undertaken, will further nuance our picture of De Morgan.⁷⁹ Yet this volume brings together examinations of various facets of his life and legacy as no previous book has done. As the 150th anniversary of the opening of the University of London Library and the 200th anniversary of the commencement of De Morgan's career at University College London approach, we hope that this volume will spark interest in, and provide the impetus for, further research into a significant but largely overlooked figure in British intellectual and cultural history.

Bibliography

- Bagehot, Walter, *Literary Studies*, ed. by Richard Holt Hutton, 2 vols. (London: Longmans, Green, 1879).
- Bland, Miles, *Algebraical Problems, Producing Simple and Quadratic Equations, with their Solutions* (Cambridge: J. Smith, 1812).
- Bridge, Bewick, *An Elementary Treatise on Algebra* (London: T. Cadell & W. Davies, 1815).

78 However, studies do exist. For example, for De Morgan as a professor, see Adrian Rice, 'What Makes a Great Mathematics Teacher? The Case of Augustus De Morgan', *American Mathematical Monthly*, 106 (1999), 534–52; and on De Morgan as historian, see Joan L. Richards, 'Augustus De Morgan, the History of Mathematics, and the Foundations of Algebra', *Isis*, 78 (1987), 7–30; Adrian Rice, 'Augustus De Morgan: Historian of Science', *History of Science*, 34 (1996), 201–40; and Rebekah Higgitt, *Recreating Newton: Newtonian Biography and the Making of Nineteenth-Century History of Science* (London: Pickering & Chatto, 2007), Chapters 4–6.

79 For early gestures towards a bibliographical study, see McKitterick, *Readers in a Revolution*, pp. 87–91.

- Brock, William H., and Roy M. MacLeod, ed., *Natural Knowledge in Social Context: The Journal of Thomas Archer Hirst, F.R.S.* (London: Mansell, 1980).
- Burke, Peter, *The Polymath: A Cultural History from Leonardo da Vinci to Susan Sontag* (New Haven: Yale University Press, 2021). <https://doi.org/10.12987/9780300252088>
- Catleugh, Jon, *William De Morgan Tiles* (New York: Van Nostrand Reinhold, 1983).
- De Morgan, Augustus, *A Budget of Paradoxes* (London: Longmans, Green, 1872).
- , *Arithmetical Books from the Invention of Printing to the Present Time* (London: Taylor & Walton, 1847; repr. London: Hugh K. Elliot, 1967).
- , *Formal Logic* (London: Taylor & Walton, 1847).
- , 'Mathematical Bibliography', *Dublin Review*, 41 (Sept. 1846), 1–37.
- , 'Memorandums on the Descendants of Captain John De Morgan ...', MS. ADD. 7, UCL Special Collections.
- De Morgan, Sophia E., *Memoir of Augustus De Morgan* (London: Longmans, Green, 1882).
- , *Threescore Years and Ten: Reminiscences of the Late Sophia Elizabeth De Morgan to which are Added Letters to and from her Husband the Late Augustus De Morgan, and Others*, ed. by Mary De Morgan (London: Bentley, 1895).
- Dieudonné, Jean, *Mathematics—The Music of Reason* (Berlin: Springer, 1992).
- Enros, Philip C., 'The Analytical Society (1812–1813): Precursor of the Renewal of Cambridge Mathematics', *Historia Mathematica*, 10 (1983), 24–47.
- Gaunt, William, and M.D.E. Clayton-Stamm, *William De Morgan* (London: Studio Vista, 1971).
- Graves, Robert Perceval, *Life of Sir William Rowan Hamilton*, vol. 3 (Dublin: Hodges, Figgis, 1889).
- Gray, G. J., 'Dodson, James (c.1705–1757)', rev. Anita McConnell, *Oxford Dictionary of National Biography* (Oxford: Oxford University Press, 2004). <https://doi.org/10.1093/odnb/9780192683120.013.7756>
- Hall, A. Rupert, 'Introduction', in Augustus De Morgan, *Arithmetical Books*, repr. (London: Hugh K. Elliott, 1967), pp. [i–vii].
- Hamilton, Mark, *Rare Spirit: A Life of William De Morgan 1839–1911* (London: Constable, 1997).
- Heath, Peter, 'Editor's Introduction', in Augustus De Morgan, *On the Syllogism, and Other Logical Writings* (London: Routledge & Kegan Paul, 1966), pp. vii–xxx.

- Heinemann, Anna-Sophie, *Quantifikation des Prädikats und numerisch definierter Syllogismus. Die Kontroverse zwischen Augustus De Morgan und Sir William Hamilton: Formale Logik zwischen Algebra und Syllogistik* (Münster: Mentis, 2015).
- Higgins, Rob, and Christopher Stolbert Robinson, *William De Morgan: Arts and Crafts Potter* (New York: Bloomsbury, 2010).
- Higgitt, Rebekah, *Recreating Newton: Newtonian Biography and the Making of Nineteenth-Century History of Science* (London: Pickering & Chatto, 2007). <https://doi.org/10.4324/9781315653068>
- , 'Why I don't FRS my tail: Augustus De Morgan and the Royal Society', *Notes and Records of the Royal Society*, 60 (2006), 253–59. <https://doi.org/10.1098/rsnr.2006.0150>
- Laíta, Luis María, 'Influences on Boole's Logic: The Controversy between William Hamilton and Augustus De Morgan', *Annals of Science*, 36 (1979), 45–65.
- MacFarlane, Alexander, *Lectures on Ten British Mathematicians of the Nineteenth Century* (London: Chapman & Hall, 1916).
- McKitterick, David, *Readers in a Revolution: Bibliographical Change in the Nineteenth Century* (Cambridge: Cambridge University Press, 2022). <https://doi.org/10.1017/9781009200882>
- Pemberton, Marilyn, *Out of the Shadows: The Life and Work of Mary De Morgan* (Newcastle upon Tyne: Cambridge Scholars Publishing, 2012).
- Ranyard, Arthur Cowper, Obituary Notice of Augustus De Morgan, *Monthly Notices of the Royal Astronomical Society*, 32 (1871–72), 112–18.
- Rice, Adrian, 'Augustus De Morgan: Historian of Science', *History of Science*, 34 (1996), 201–40. <https://doi.org/10.1177/007327539603400203>
- , 'Inspiration or Desperation? Augustus De Morgan's Appointment to the Chair of Mathematics at London University in 1828', *British Journal for the History of Science*, 30 (1997), 257–74. <https://doi.org/10.1017/s0007087497003075>
- , 'What Makes a Great Mathematics Teacher? The Case of Augustus De Morgan', *American Mathematical Monthly*, 106 (1999), 534–52. <https://doi.org/10.2307/2589465>
- Richards, Joan L., 'Augustus De Morgan, the History of Mathematics, and the Foundations of Algebra', *Isis*, 78 (1987), 7–30. <https://doi.org/10.1086/354328>
- , *Generations of Reason: A Family's Search for Meaning in Post-Newtonian England* (New Haven: Yale University Press, 2021). <https://doi.org/10.12987/yale/9780300255492.001.0001>

- Robinson, Henry Crabb, *Diary, Reminiscences, and Correspondence of Henry Crabb Robinson*, ed. by Thomas Sadler, 3 vols. (Boston: Fields, Osgood, 1869).
- Rouse Ball, Walter William, 'Augustus De Morgan', *The Mathematical Gazette*, 8 (1915–16), 42–45.
- Rouse Ball, Walter William, and John A. Venn, ed., *Admissions to Trinity College, Cambridge*, vol. 4 (London: Macmillan, 1911).
- Smith, David Eugene, *Rara Arithmetica: A Catalogue of the Arithmetics Written before the Year MDCL, with a Description of Those in the Library of George Arthur Plimpton of New York* (Boston: Ginn, 1908).
- Smith, Gordon C., *The Boole-De Morgan Correspondence 1842–1864* (Oxford: Clarendon Press, 1982).
- Stirling, Anna M. W., *William De Morgan and his Wife* (London: Thornton Butterworth, 1922).
- Tuke, Margaret J., *A History of Bedford College for Women 1849–1937* (London: Oxford University Press, 1939).
- von Wowern, Johann, *De Polymathia Tractatio* ([Basel]: Officina Frobeniano, 1603).