

AUGUSTUS
DE MORGAN,
POLYMATH



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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>

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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

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Cover design: Jeevanjot Kaur Nagpal.

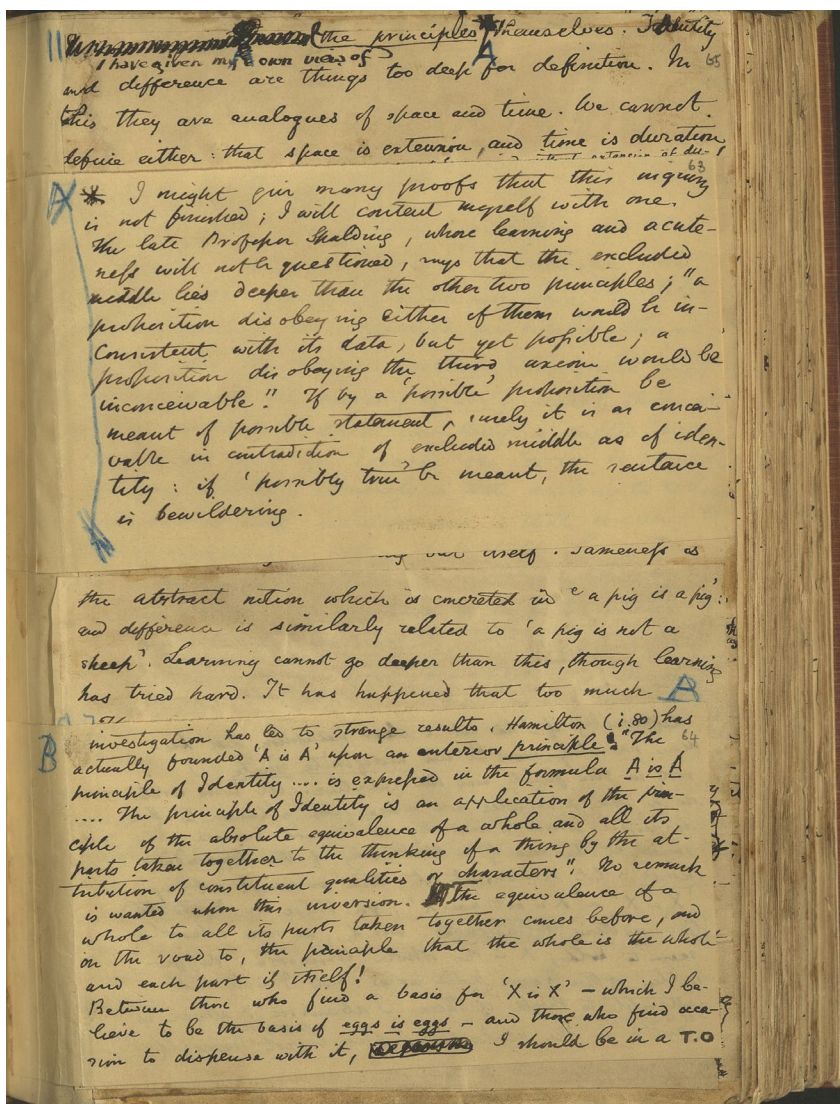


Fig. 6 This page from the manuscript of an unpublished paper from 1868 gives an evocative insight into the fervent process of composition, correction and revision that went into De Morgan's publications. Intended as the sixth installment of his series of papers entitled 'On the Syllogism', De Morgan's text is a hodge-podge of cut-and-pasted amendments and insertions. (MS 241, reproduced by permission of Senate House Library, University of London.)

4. De Morgan, Periodicals and Encyclopaedias

Olivier Bruneau

De Morgan's energy ... was chiefly absorbed by
his voluminous writings upon mathematical,
philosophical, and antiquarian points.

— Leslie Stephen¹

Introduction

According to Sally Shuttleworth and Geoffrey Cantor, Britain produced about 125,000 different periodical and newspaper titles during the nineteenth century.² Many of these had a very short life span, and few were devoted to science. De Morgan did not publish in all of them—far from it—but, by his own account, he was intensely active between 1830 and 1870, publishing more than 2,200 items of between a few lines and several dozen pages in about twenty newspapers and periodicals, including some of the most important scientific journals of this period.³ Although De Morgan's research publications focused on

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- 1 Leslie Stephen, 'De Morgan, Augustus (1806–1871)', *Dictionary of National Biography*, vol. 14 (London: Smith, Elder, 1888), pp. 331–34 (p. 333).
 - 2 Sally Shuttleworth and Geoffrey Cantor, 'Introduction', in *Science Serialized: Representations of the Sciences in Nineteenth-Century Periodicals*, ed. by Geoffrey Cantor and Sally Shuttleworth (Cambridge, MA: MIT Press, 2004), pp. 1–16. For an overview of nineteenth-century periodical literature, see *Dictionary of Nineteenth-Century Journalism in Great Britain and Ireland*, ed. by Laurel Brake and Marysa Demoor (London: British Library, 2009).
 - 3 For an overview of mathematics periodicals during the Victorian period, see, for instance, Sloan Evans Despeaux, 'A Voice for Mathematics, Victorian Mathematical

mathematics and logic, his book reviews reveal his interest in wide areas of knowledge. His contribution to encyclopaedias, in contrast, was more restricted and limited to four main venues, where he wrote only on his areas of expertise.

This review relies on the biography of Augustus De Morgan published by his widow, Sophia, in 1882 and on G. C. Smith's *The Boole-De Morgan Correspondence*, which appeared a century later.⁴ Both authors present substantial lists of De Morgan's articles and other publications. However, these lists are incomplete, because they included neither the numerous book reviews and notes De Morgan wrote for the *Athenæum* nor his fairly short contributions to *Notes & Queries*. Yet he contributed abundantly to both publications, publishing more than 210 notes in *Notes & Queries* between 1850 and 1864, plus nearly one thousand book reviews, around fifty articles in his *Budget of Paradoxes* series, and several other short notes in the *Athenæum* between 1840 and 1870.

This chapter thus aims to present a more holistic overview of the scholarly and journalistic output of Augustus De Morgan.⁵

De Morgan's Involvement in Periodicals: He is Everywhere!

When De Morgan began his academic career at the University of London in 1828, his initial aim was to write textbooks for students and beginners. Thus, as early as March 1827, he offered to write a treatise on acoustics for the recently-formed Society for the Diffusion of Useful Knowledge (SDUK)⁶ and published several textbooks under its auspices in subsequent years. His involvement in journal publication began in

Journals and Societies', in *Mathematics in Victorian Britain*, ed. by Raymond Flood, Adrian Rice, and Robin Wilson (Oxford: Oxford University Press, 2011), pp. 155–74. De Morgan may have published more than this, for example in the Royal Astronomical Society's *Memoirs* and *Monthly Notices*; anonymous authorship in these and other periodicals renders it impossible to attribute authorship to De Morgan with certainty.

4 Sophia Elizabeth De Morgan, *Memoir of Augustus De Morgan* (London: Longmans, Green, 1882), pp. 401–15; G. C. Smith, ed., *The Boole-De Morgan Correspondence 1842–1864* (Oxford: Clarendon Press, 1982), pp. 141–47.

5 See also Chapter 12 in this volume.

6 University College London, SDUK/24: Letter from De Morgan to Thomas Coates, 30 March 1827.

1830 with his first submissions to two periodicals, both published by the SDUK. The first was the *Companion to the Almanac* for 1831, a compendium of miscellaneous articles of general interest published jointly with the SDUK's annual *British Almanac*. De Morgan's article was a twenty-page introduction to the subject of life assurance (not to be confused with life insurance),⁷ containing an account of the principal London assurance companies, an extensive table comparing the premiums charged for various policies by these companies and a discussion of how such premiums were calculated. This article represented De Morgan's first public foray into the realm of actuarial mathematics, in which he was to become an expert. In addition to publishing a variety of further articles on numerous aspects of the subject, he would also work as a freelance actuarial consultant to supplement his income during his academic career. In the *Companion to the Almanac*, he went on to publish one article every year between 1831 and 1857. And although it is difficult to compare the volume of De Morgan's contributions with those of other authors because so many of the articles were anonymous, it is hard to imagine any other contributor surpassing the sheer range of his interests: his twenty-seven articles are learned but accessible treatments of subjects pertaining to astronomy, mathematics and its history, bibliography, the calendar, currencies and actuarial matters.

At roughly the same time, De Morgan contributed the first of many pedagogical articles to the *Quarterly Journal of Education*, a new journal recently set up by the SDUK. In this article, published in the inaugural volume, De Morgan gave the first detailed account in English of the education provided at 'the most celebrated school of instruction for engineers which has ever existed', namely, the École Polytechnique in Paris.⁸ Detailing the opening decades of its operation from its foundation in 1794, he presented the school as a model for advanced mathematical and scientific teaching in Great Britain. The *Quarterly Journal of Education* appeared in ten volumes from 1831 to 1835.⁹ De Morgan contributed to it throughout the entire period with thirty-three articles divided

7 The key difference is that life insurance covers a policyholder for a specific term, whereas life assurance usually provides coverage for the policyholder's entire life.

8 'Polytechnic School of Paris', *Quarterly Journal of Education*, 1 (1831), 57–74 (p. 73).

9 Re-published in facsimile with a new introduction by Christopher Stray, 10 vols. (London: Routledge, 2008).

between original observations on the state of teaching—particularly of mathematics—in various institutions and reviews of works essentially intended for teaching science.¹⁰ As with the *Companion to the Almanac*, the anonymity of most contributions to this journal makes comparisons difficult, but probably the only contributor likely to have rivalled De Morgan's involvement with the *Quarterly Journal* would have been its editor, George Long, formerly professor of Greek and De Morgan's colleague at the University of London.

De Morgan was also an active member of the Cambridge Philosophical Society (founded by some of his former lecturers and friends). It was in its *Transactions* that he published his first scientific research papers and continued to report on his chief mathematical findings, particularly in his series of papers 'On the Foundation of Algebra' and 'On the Syllogism', which had a catalytic effect on contemporary developments in algebra and symbolic logic respectively. He delivered several papers to the Society between 1830 and 1868, and these were published between 1833 and 1871, the year of his death.¹¹

Despite its irregular publication schedule, De Morgan considered the *Transactions of the Cambridge Philosophical Society* to be a privileged venue in which to publish mathematics at the time. Yet he also disseminated his scientific work elsewhere. From 1835 until 1852, he published about twenty articles, mostly on mathematics, in the journal now called the *Philosophical Magazine*.¹² He published twenty-one articles in the newly-founded *Cambridge Mathematical Journal*, established by Duncan Gregory, Archibald Smith and Samuel Greatheed, between 1841 (its

¹⁰ See also Chapter 6 in this volume.

¹¹ De Morgan presented his first paper in the session of November 15, 1830 and the last on October 26, 1868, but due to erratic publication delays, the first published article, corresponding to his first paper, did not appear until vol. 4 (1833), and the last paper was published in vol. 11 (1871). On the history of the Society, see A. Rupert Hall, *The Cambridge Philosophical Society, A History, 1819–1969* (Cambridge: Cambridge Philosophical Society, 1969) and Susannah Gibson, *The Spirit of Inquiry: How One Extraordinary Society Shaped Modern Science* (Oxford: Oxford University Press, 2019).

¹² During the period of publication of De Morgan's articles, this periodical changed its title several times, being first *The London and Edinburgh Philosophical Magazine and Journal of Science* and then, after 1840, *The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science*.

second volume) and 1858.¹³ He also agreed to publish, at the request of the editors of *The Mathematician*—a periodical that was intended to be the successor of Leybourn's *Mathematical Repository*—some notes in one of the volumes of that journal.¹⁴

Of all the journals with which De Morgan was involved, it was undoubtedly in the weekly literary and scientific magazine *The Athenæum* that he was most active, contributing nearly one thousand book reviews over a period of more than thirty years (between 1840 and 1870) across a wide range of interests, from mathematics to religion to weights and measures.¹⁵ These all appeared anonymously, but reviewers' names in the editors' file copies reveal the extent of reviewing De Morgan undertook for the journal.¹⁶ In addition to these anonymous reviews, De Morgan also published his famous series of humorous articles under the heading *A Budget of Paradoxes*, together with its *Supplements*, from 1863 until 1867, along with some shorter articles. The *Budget*, a collection of witty articles and reviews about eccentric dabblers in science (and especially mathematics), was subsequently edited and expanded by their author and published by his widow the year after his death.¹⁷

A notable offshoot from *The Athenæum* began on 3 November 1849 with the publication of the first issue of *Notes & Queries*, a weekly

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- 13 This journal also changed names several times, becoming first the *Cambridge and Dublin Mathematical Journal* in 1846 and then the *Quarterly Journal of Pure and Applied Mathematics* from 1855. For a history of this journal, see especially Tony Crilly, 'The Cambridge Mathematical Journal and its Descendants: The Linchpin of a Research Community in the Early and Mid-Victorian Age', *Historia Mathematica*, 31 (2004), 407–97.
 - 14 Unfortunately, this journal produced only three volumes. For a history of the *Mathematical Repository*, see most recently, Olivier Bruneau, 'Le Royal Military College, un centre éditorial pour quelles mathématiques?: le Mathematical Repository', in *Circulations mathématiques dans et par les journaux*, ed. by Hélène Gispert, Philippe Nabonnand and Jeanne Peiffer (London: College Publications, 2024).
 - 15 For De Morgan's involvement in *The Athenæum*, see Sloan Evans Despeaux and Adrian C. Rice, 'Augustus De Morgan's Anonymous Reviews for *The Athenæum*: A Mirror of a Victorian Mathematician', *Historia Mathematica*, 43 (2016), 148–71. De Morgan undertook similar review activity for the *Dublin Review*, a Catholic journal published in London, with ten reviews and notes over ten years.
 - 16 These copies, available in the archives of City University, London, formed the basis of an online database: City University, *The Athenæum Projects*, available at: <https://athenæum.city.ac.uk/>
 - 17 Augustus De Morgan, *A Budget of Paradoxes* (London: Longmans, Green, 1872). See Chapter 7 in this volume.

journal devoted to the exchange of information between scholars and professionals in the fields of literature and history.¹⁸ De Morgan was involved from its second issue until 1864, offering notes and remarks on a wide range of subjects. In all, 214 notes are attributed to De Morgan. Short though these texts are—often only a few lines—they show an intense activity and again demonstrate the breadth of his interests, from the English language to antiquarian books to musical notation.

In 1848, a group of London actuaries founded the Institute of Actuaries in order to promote and better organise the profession, in which De Morgan's involvement has already been noted. They also decided to publish a periodical, *Assurance Magazine*,¹⁹ the first issue of which came out in 1851. Very soon after, in the fourth issue of the first volume, De Morgan published an article on the equivalence of compound interest and simple interest paid when due. By 1868, he had submitted twenty-four articles to this journal, dealing mostly with the mathematical treatment of life contingencies. Its editors also reprinted parts of his *Budget of Paradoxes*, previously published in *The Athenæum*.

Finally, towards the end of his life, De Morgan published several articles in the *Proceedings of the London Mathematical Society*, arising from his privileged position as the Society's first president. He had played a supporting but important role in its foundation, but apart from the inaugural speech he gave at the Society's first meeting on 16 January 1865, his papers in its *Proceedings* are brief and of little particular interest.

When analysing the topics of De Morgan's periodical publications, it makes little sense to include his entire output, as the nearly 1,030 book reviews in various journals distort the picture.²⁰ If we discount the reviews and focus purely on his research articles and commentaries, De Morgan published nearly two hundred items.²¹ Articles on mathematics and logic are the most numerous, numbering eighty-one (i.e. forty-one

18 For a historical study of this review, see Patrick Leary, 'A Victorian Virtual Community', *Victorian Review*, 25:2 (2000), 61–79.

19 This later became the *Journal of the Institute of Actuaries*.

20 De Morgan's book reviews can be found in *The Athenæum*, *Quarterly Journal of Education*, *Dublin Review*, *Notes & Queries* and *Assurance Magazine*. As the vast majority of these reviews are in *The Athenæum*, we refer to the article by Despeaux and Rice cited above (fn.15).

21 This figure does not include the 214 notes in *Notes & Queries* owing to their extreme brevity and anecdotal nature; they are clearly not in the same league as research articles or even commentaries on a subject.

per cent).²² Next, thirty-one articles (sixteen per cent) are on history (mainly concerning mathematics and astronomy) and biography.²³ After this come his reflections on matters related to actuarial science (life assurance, mortality tables, etc.) with twenty-one articles (eleven per cent).²⁴ Other sciences follow with sixteen articles (eight per cent), then astronomy, with thirteen articles published (seven per cent).²⁵ De Morgan's interest in education and teaching in general is found in seven per cent of his output and is concentrated towards the beginning of his career. This is principally due to the number of articles he contributed to the *Quarterly Journal of Education* during this period, before his publication of original research gained significant momentum. After 1838, articles on pedagogical matters become far less frequent.²⁶ One subject that recurs throughout De Morgan's career is his advocacy for the decimalisation of the currency, weights and measures used in Great Britain, and he devoted seven articles to this topic (four per cent), principally during the 1850s at the height of public interest in Britain on the question of a decimal coinage.²⁷

22 The literature on De Morgan's mathematics and logic is relatively abundant: we refer to the dedicated chapters in this book.

23 On De Morgan as a historian of science, see Adrian Rice, 'Augustus De Morgan: Historian of Science', *History of Science*, 34 (1996), 201–40.

24 On De Morgan's involvement with actuarial science, for instance see Timothy Alborn, 'A Calculating Profession: Victorian Actuaries among the Statisticians', *Science in Context*, 7 (1994), 433–68.

25 It is surprising to see a relatively small number of papers dealing with astronomy in his output, but this does not include his biographies of astronomers or his articles on the history of astronomy. In fact, his interest in this field was significant and he became a member of the Astronomical Society of London (which became the Royal Astronomical Society in 1831) in 1828, holding positions on its council for many years. See Adrian Rice, 'Augustus De Morgan and the Development of University Mathematics in London in the Nineteenth Century' (Ph.D. Diss., Middlesex University, 1997), pp. 101–08, and Chapter 3 in this volume.

26 On De Morgan's work in education, see Chapter 6 in this volume, as well as Abraham Arcavi and Maxim Bruckheimer, 'The Didactical De Morgan: A Selection of Augustus De Morgan's Thoughts on Teaching and Learning Mathematics', *For the Learning of Mathematics*, 9 (1989), 34–39; Adrian Rice, 'What Makes a Great Mathematics Teacher? The Case of Augustus De Morgan', *American Mathematical Monthly*, 106 (1999), 534–52; Adrian Rice, 'Augustus De Morgan and the Development of University Mathematics', pp. 111–21.

27 From its beginning in 1854, De Morgan was involved with the International Association for a Decimal System, which included many of his contemporaries: George Airy, Charles Babbage, John Herschel and George Peacock.

Thus, to summarise, the *Transactions of the Cambridge Philosophical Society* remained De Morgan's preferred venue for publishing lengthy mathematical (or logical) research papers from the beginning of his career until the end of his life. The *Cambridge Mathematical Journal* and its successors played a similar role but over a narrower period, and for shorter papers. These venues were among the only places in which to publish substantial research in mathematics in Britain at this time, aside from the publications of the Royal Society, a body that De Morgan famously refused to join. For his broader interests, De Morgan had a much wider range of non-specialist publications from which to choose. But he clearly enjoyed publishing in *The Athenæum* and, to a lesser extent, *Notes & Queries* to satisfy the breadth of his interests, including mathematical biography, bibliography and more. His motivations for choosing these particular venues are hard to determine precisely, but there is no doubt that his willingness to write so many book reviews for *The Athenæum*—and the editor's willingness to publish them—greatly facilitated the expansion of De Morgan's personal library at no cost to himself.

Although De Morgan played no founding role in any of the journals in which he published, he was privileged to contribute to the earliest issues of several of them, especially those edited by the SDUK. In some instances, as with the *Quarterly Journal of Education*, this arose from his closeness to the publishers. In others, the presence of an article by a well-known and recognised scholar could help to ensure the viability of young journals. This certainly applied to the journals of both the Institute of Actuaries and the London Mathematical Society, the fledgling publications of which both benefitted in no small measure from the imprimatur bestowed by the inclusion of De Morgan's work. De Morgan, then, published extensively in a variety of venues ranging from highly specialised mathematical journals to publications aimed at a very broad audience without a scientific background: he was both a polymath and a communicator at multiple levels.

The British Encyclopaedic Landscape in the First Half of the Nineteenth Century

Although the first English-language encyclopaedia was published in the seventeenth century, the genre began to develop in the eighteenth century, reaching its peak at the turn of the nineteenth century.²⁸ These reference works, mostly general, comprised several volumes arranged alphabetically, going beyond simple definitions and dealing with a vast range of subjects.²⁹ They were more or less scholarly, addressing either a broad public or a specific community.³⁰

Between 1800 and 1854, the year of publication of the *English Cyclopaedia*, at least twenty-four encyclopaedias were partially or completely published in Great Britain, to which must be added multiple editions of the *Encyclopaedia Britannica* (from the fourth to the eighth) and reissues of earlier dictionaries. John Harris's *Lexicon Technicum* (1704) is considered to be the first attempt to organise scientific knowledge in a work of reference in the English language. Among the British encyclopaedias of the eighteenth century, Ephraim Chambers' *Cyclopaedia* (1728), had an important influence on this type of production in Britain and elsewhere,³¹ as did the *Encyclopaedia Britannica*

28 For a useful bibliographical review of this period, see S. Padraig Walsh, *Anglo-American General Encyclopaedias: A Historical Bibliography, 1703–1967* (New York and London: Bowker, 1968).

29 Not all encyclopaedias were arranged alphabetically; for example, the *Encyclopaedia Metropolitana* was arranged by genre and then by subject.

30 Studies on encyclopaedias are mainly concentrated on those of the eighteenth century, but see: Richard Yeo, 'Reading Encyclopaedias: Science and the Organization of Knowledge in British Dictionaries of Arts and Sciences, 1730–1850', *Isis*, 82 (1982), 24–49; Richard Yeo, *Encyclopedic Visions, Scientific Dictionaries and Enlightenment Culture* (Cambridge: Cambridge University Press, 2001); *Notable Encyclopaedias of the Seventeenth and Eighteenth Centuries: Nine Predecessors of the Encyclopédie*, ed. by Frank A. Kafker (Oxford: Voltaire Foundation, 1981); *Notable Encyclopaedias of the Late Eighteenth Century: Eleven Successors of the Encyclopédie*, ed. by Frank A. Kafker (Oxford: Voltaire Foundation, 1994); *The Early Britannica: The Growth of an Outstanding Encyclopedia*, ed. by Frank A. Kafker and Jeff Loveland (Oxford: Voltaire Foundation, 2009); Peter Burke, *A Social History of Knowledge: From Gutenberg to Diderot* (Cambridge: Polity, 2000); Jeff Loveland, *The European Encyclopaedia, from 1650 to the Twenty-First Century* (Cambridge: Cambridge University Press, 2019).

31 Diderot and D'Alembert's *Encyclopédie* was initially a translation of this work. On the conditions of writing and the genesis of this enterprise, see among others Marie Leca-Tsiomis, *Écrire l'Encyclopédie* (Oxford: Voltaire Foundation, 1999);

(1771), first edited by William Smellie, and Abraham Rees's update of Chambers' *Cyclopaedia*.³² In the first half of the nineteenth century, several encyclopaedias competed with each other: the various editions of the *Britannica* faced the *Encyclopaedia Londinensis* by John Wilkes (24 volumes, 1810–29), the *Pantologia* by Newton Bosworth, Olinthus Gregory and John Mason Good (12 volumes, 1813) and the *Penny Cyclopaedia* edited by George Long (27 volumes, 1833–1843). When the first sheets of the latter came out in 1833, it was competing with about twenty encyclopaedias of varying sizes. The shortest was Samuel Maunders' two-volume *Treasury of Knowledge and Library of Reference* (1830), and the largest Dionysius Lardner's *Cabinet Cyclopaedia*, with 133 volumes. The others fell into three categories: those between four and six volumes long, those of a dozen volumes and those with more than twenty volumes.

The objectives differed from one encyclopaedia to another. All of them aimed to present and disseminate scientific knowledge for educational purposes, but some, like the first edition of the *Encyclopaedia Britannica*, contained a preliminary discourse that was either not very or not at all technical.³³ The aim could be to build up a small library of mathematics, as with Harris's *Lexicon Technicum*. The publication of some encyclopaedias was justified by the need to replace older and outdated ones: those published in the second half of the eighteenth century were published to replace the multiple editions of Chambers' *Cyclopaedia*, which had changed little, or not at all, since 1728. Diderot and D'Alembert's *Encyclopédie* was also the driving force behind a reaction, and the *Britannica* can in part be seen as a response to this French enterprise.

Finding a new approach made it possible to establish a foothold in this extremely competitive market. For example, the *Encyclopaedia Metropolitana* was based on a division of knowledge and each part is

Robert Lewis Collison, *Encyclopaedias: Their History throughout the Ages* (London and New York: Hafner, 1966).

32 The *Encyclopaedia Britannica* remains in existence: it has gone through fifteen print editions and since 2012 it has been digital only. For a history of the early editions, see Kafker and Loveland, *The Early Britannica*, and, more broadly, Herman Kogan, *The Great EB: The Story of the Encyclopaedia Britannica* (Chicago: University of Chicago Press, 1958).

33 Later, as the number of volumes and authors recruited increased, the level of the articles was raised.

treated as a treatise.³⁴ In the pure sciences, we find not only mathematics but also grammar and morals—which can be seen as a return to an old form of encyclopaedic organisation, as in Gregor Reisch's *Margarita Philosophica* (1504).³⁵ The *Encyclopaedia Metropolitana* was distinguished by having treatises written by subject experts to quite a high level—in addition to De Morgan's two contributions, treatises by John Herschel, Richard Whately and George Peacock were also highly regarded. These encyclopaedias were often expensive, and hence intended for an educated population.

Of course, no encyclopaedia should be studied in isolation, as encyclopaedias were, at least in part, interrelated. Indeed, borrowings and verbatim copying between two encyclopaedias were frequent.³⁶ Moreover, encyclopaedias compiled by editors who were not necessarily subject experts might draw on multiple sources—previous encyclopaedias as well as reference works or manuals—and two encyclopaedias could follow the same sources, so it is not uncommon in an article to read verbatim extracts from several manuals. One author could also be involved in several encyclopaedic undertakings: for example, William Wallace wrote the article on fluxions both in the fourth edition of the *Britannica* (1810) and in the *Edinburgh Encyclopaedia* (1815).³⁷ The fact that some encyclopaedias were written in reaction or opposition to others renders comparison additionally useful. Finally, some titles ran through several editions, which may or may not have

34 On the organisation of knowledge in encyclopaedias, see for example Yeo, *Encyclopedic Visions*.

35 The first division contained the so-called formal sciences (universal grammar, logic, mathematics and metaphysics) and real sciences (morals, law and theology). The mathematical part is divided into fifteen treatises (from 50 to over 200 pages).

36 If two texts are identical, this does not necessarily mean that one is a copy of the other: they may be a copy of a third text or there could be an intermediate version. This methodological point is developed in Jeff Loveland, 'Two Partial English-Language Translations of the *Encyclopédie*: The Encyclopaedias of John Barrow and Temple Henry Croker', in *British-French Exchanges in the Eighteenth Century*, ed. by Kathleen Hardesty Doig and Dorothy Medlin (Newcastle: Cambridge Scholars, 2007), pp. 168–187 (p. 176).

37 On the study of fluxion articles in British encyclopaedias and on the construction phenomena of these articles see Olivier Bruneau, 'Encyclopaedias as Markers of Heritage Building: Fluxion Articles in British Encyclopaedias, 1704–1860', *Philosophia Scientiae*, 26:2 (2022), 67–90.

been updated. For example, between 1771 and 1853, the *Britannica* underwent eight editions and two supplements.³⁸

De Morgan and Encyclopaedias: Promoting Mathematics and Astronomy for All

De Morgan was involved in several encyclopaedic ventures. He contributed to the *Encyclopaedia Metropolitana*, Lardner's *Cabinet Cyclopaedia*, the SDUK's *Penny Cyclopaedia*, and the *English Encyclopaedia*, in addition to writing seven entries about mathematicians and astronomers for William Smith's *Dictionary of Greek and Roman Biography and Mythology*.³⁹ These different encyclopaedias had different objectives and targeted different audiences. The *Encyclopaedia Metropolitana* was intended to be scholarly and was aimed at a literate public wanting an authoritative collection of scientific, legal, moral and theological texts by prominent recognised authors. De Morgan was commissioned to write two texts for the second volume of the section devoted to the so-called pure sciences. The first, a book-length treatise on 'Calculus of Functions', built on the recent work of the Frenchmen Lazare Carnot and Augustin-Louis Cauchy and of De Morgan's friends Charles Babbage, John Herschel and George Peacock. Its eighty-eight densely printed pages, which highlighted the latest advances in the field at the time of its publication in 1836, can be considered as a monograph in its own right. The second text, published in 1837 and of an equivalent size, was a mathematical treatment of probability theory, inspired chiefly by the work of Pierre-Simon Laplace.⁴⁰

38 Updates between editions are very uneven and do not necessarily encompass all entries. For example, the mathematics articles in the first three editions are identical, even reproducing typographical errors from the first edition.

39 William Smith, ed., *A Dictionary of Greek and Roman Biography and Mythology*, 3 vols. (London: Taylor & Walton, 1844) and subsequent editions. For Smith and his dictionaries, see Christopher Stray, 'William Smith and his Dictionaries: A Study in Scarlet and Black', in *Classical Books: Scholarship and Publishing in Britain since 1800*, ed. by Christopher Stray, Bulletin of the Institute of Classical Studies, Supplement 101 (London: Institute of Classical Studies, University of London, 2007), pp. 35–54.

40 For a study of this text and the relationship with Laplace, see Adrian Rice, "'Everybody Makes Errors": The Intersection of De Morgan's Logic and Probability, 1837–1847', *History and Philosophy of Logic*, 24 (2003), 289–305; S. L. Zabell, 'De Morgan and Laplace: A Tale of Two Cities', *Journal électronique d'Histoire des Probabilités et de la Statistique*, 8 (2012), 1–29, www.jehps.net.

Dionysius Lardner's *Cabinet Cyclopaedia* (1829–1844) tried to reach a wider public by offering small volumes on individual subjects.⁴¹ Lardner, by then an erstwhile colleague of De Morgan at the university, asked him to write a text on the theory of probability. De Morgan's *Essay on Probabilities and on their Application to Life Contingencies and Insurance Offices* was the 107th volume in the series and was published in 1838. The *Cabinet Cyclopaedia* was much more affordable and more application-oriented than the *Encyclopaedia Metropolitana*. But the appearance of De Morgan's *Essay* prompted a minor controversy between its author and the editors of the *Encyclopaedia Metropolitana*, who, being unaware that the *Essay* differed substantially in content and mathematical sophistication from his earlier book-length treatise on probability in the *Metropolitana*, accused De Morgan of copyright infringement by publishing what 'might be deemed a second edition of the treatise'. Although the matter was eventually settled, the affair led to the end of De Morgan's association with the *Encyclopaedia Metropolitana*, whose editors, he said, had been guilty of 'wasting a good deal of grumbling'.⁴²

It was to be the *Penny Cyclopaedia* in which De Morgan invested most of his time.

The *Penny Cyclopaedia*: An Encyclopaedia for the Masses

In 1826, London University (now University College London) had been created in opposition to the Anglican universities of Oxford and Cambridge. One of its founders, then a radical leader in the House of Commons, was Henry Brougham. Highly committed to promoting knowledge to a very wide audience, he created the Society for the Diffusion of Useful Knowledge (SDUK) in the same year, with the aim of providing the working and middle classes with the means to access knowledge, often at modest prices.⁴³ The two institutions were born of

41 For a history of this original encyclopaedic enterprise, see Morse Peckham, 'Dr. Lardner's *Cabinet Cyclopaedia*', *Papers of the Bibliographical Society of America*, 45 (1951), 37–58.

42 S.E. De Morgan, *Memoir*, p. 93.

43 For a study of the SDUK in the publishing world, see Lucy Warwick, 'Print and British Imperialism: The Society for the Diffusion of Useful Knowledge, 1826–46' (Unpublished Ph.D. Diss., Oxford Brookes University, 2016). For a study of the involvement of De Morgan in this society, see Rice, 'Augustus De Morgan and the

the same ideal and, because many of the university's teachers were also members of the SDUK, they cooperated closely. As noted above, De Morgan had offered his services to the SDUK as early as 1827. Following his recruitment to the university in 1828, he became an active member and soon published books and articles under the SDUK aegis.

From January 1833, on the initiative of the SDUK and under the direction of George Long, the founding professor of Greek at London University, Charles Knight published a few pages of a new encyclopaedia every Saturday, priced at one penny. The aptly-named *Penny Cyclopaedia* was thus aimed at the less well-off who could not afford the other, very expensive encyclopaedias. Together with a monthly supplement, the annual cost of a volume amounted to six shillings.⁴⁴

For the first few years the *Penny Cyclopaedia* sold 55,000 copies each week. By the end of the 1830s, however, only 20,000 copies were sold weekly. As the venture neared its conclusion, publication intensified, with the result that poorer readers were less able to keep up financially. Nevertheless, in 1843, the encyclopaedia reached completion in twenty-seven substantial volumes.⁴⁵ It advertised itself as having shorter articles under more heads than other encyclopaedias, enabling more rapid retrieval of information.⁴⁶ Some contemporary critics saw this plan as providing access to superficial knowledge assembled for convenience. They complained, moreover, that because of the multiplicity of entries which were often very short, readers would be unable to make the link with other acquired knowledge.⁴⁷ While most of the entries did not exceed a few columns, some were very long, extending to 86 columns on 'Yorkshire' and 98 columns on 'Rome'. Articles describing animals were also quite long: for example, 46.5 columns on 'Antelope' and 22.5 columns on 'Bear'.

Development of University Mathematics', pp. 108–22; Monica Grobel, 'The Society for the Diffusion of Useful Knowledge, 1826–1846' (Unpublished MA Diss., University of London, 1933).

44 Mark W. Turner, 'Companions, Supplements, and the Proliferation of Print in the 1830s', *Victorian Periodicals Review*, 43 (2010), 119–32 (p. 123).

45 Supplements were published in 1845, 1846, 1851 and 1858.

46 *Penny Cyclopaedia of the Society for the Diffusion of Useful Knowledge*, 27 vols. (London: C. Knight, 1833–1843), vol. 1, p. iii.

47 De Morgan was one of these critics, see De Morgan, *Budget*, pp. 438–48, on p. 442.

De Morgan and the *Penny Cyclopaedia*: A Major Investment

After resigning in 1831 as a university mathematics professor, De Morgan found himself temporarily without salaried employment. Yet he did not remain inactive and compensated for his lack of professorial income partly through heavy involvement in the *Penny Cyclopaedia*.⁴⁸ From her husband's copy (apparently no longer extant) and that at the British Museum, Sophia De Morgan was able to reconstruct a list of De Morgan's contributions. Although this list excludes articles on constellations and planets, because of uncertainty regarding their authorship, it nonetheless reveals that De Morgan wrote more than seven hundred articles, approximately one sixth of the entire encyclopaedia.⁴⁹

The list of contributors in the last volume of the *Penny Cyclopaedia* names De Morgan as the author of the articles on astronomy and mathematics. According to Sophia's list, he also covered topics from other areas including physics, scientific instruments and the calendar. Furthermore, he was the main, but not the sole, contributor of mathematical or astronomical articles. For example, Thomas Stephens Davies, mathematical master at the Royal Military Academy in Woolwich, wrote the article on the compass, and perhaps a few others.

In common with most entries in the *Penny Cyclopaedia*, the majority of De Morgan's articles are quite short, with an average length of 1.75 columns (roughly 1,300 words).⁵⁰ Thirty per cent are less than fifteen lines long, and half are less than three-quarters of a column. Nevertheless, over one quarter of the articles (twenty-seven per cent) are longer than one page (i.e. more than 1,500 words). Fewer than five per

48 Although extant correspondence and documentation relating to De Morgan's involvement with the SDUK contain no details of remuneration, payment for his articles for the *Penny Cyclopaedia* must be assumed in accordance with standard practice. For authorship and remuneration in the periodical press of the time, see Patrick Leary and Andrew Nash, 'Authorship', in *The Cambridge History of the Book in Britain*, 7 vols. (Cambridge: Cambridge University Press, 1999–2019), VI: 1830–1914, ed. by David McKitterick (2009), pp. 172–213 (pp. 173–74, 178–81).

49 See S.E. De Morgan, *Memoir*, pp. 407–14. George Long's annotated copy of the *Penny Cyclopaedia*, formerly housed in Brighton, has vanished. Attributions can be made from the marked copy in the British Library, 733L.

50 But the standard deviation is 2.9, which means that there is a large disparity between the size of the items. A full page contained two columns.

cent exceed four pages. The longest articles are 'Trigonometrical Survey' (25.5 columns),⁵¹ 'Weights and Measures' (21 columns), 'Astronomy' (18.2 columns), 'Circle, astronomical' (18 columns) and 'Virtual Velocities' (17 columns). Although they are too short to be considered as mini-treatises, they contain a substantial amount of information. In the articles 'Weights and Measures' and 'Astronomy', for example, De Morgan provides a detailed history of each subject and refers more technical or specific questions to other articles.

Forty-four per cent of De Morgan's articles pertain to mathematics or logic; sixteen per cent to each of astronomy and biography. Sixty articles, or eight per cent of the total, are on physics. Articles on weights and measures are also present but in smaller numbers (four per cent), albeit with the second-longest article. Finally come several categories which have few articles, but which nevertheless show De Morgan's interest in these subjects (such as actuarial science, navigation, climatology, architecture, etc.). Over half of the biographical articles (fifty-five per cent) are about mathematicians, with others devoted mainly to astronomers (twenty-seven per cent) and to scientists more generally. The biography of François Viète is more than fifteen columns long; but this is because De Morgan considered previous biographies of him to be in error and because he also added biographical details of Luca Pacioli and Fibonacci. Of the others, De Morgan devoted 6.8 columns to Laplace and 6.5 columns to Bernoulli. Fifty-six per cent of the biographies of mathematicians are less than one column long. Of De Morgan's biographies of astronomers, the longest entry is that about Tycho Brahe with 7.5 columns, the second is Copernicus (6 columns), the third is William Herschel (5.3 columns), then the Cassini dynasty and James Bradley (4 columns each). Physicists account for eight per cent of De Morgan's biographical entries, philosophers for five per cent.⁵²

Of course, the category with the most articles is mathematics, within which the dominant subject is geometry, with more than thirty-eight per cent of the articles, followed by algebra (twenty per cent), miscellaneous

51 This entry is included in the list provided by Sophia De Morgan, but the list of authors in the last volume of the *Penny Cyclopaedia* names Thomas Galloway as the author.

52 Comparing De Morgan's entries using their lengths in columns rather than the number of articles results in more or less the same proportions.

(i.e. concerning several branches or generalities) with eighteen per cent, arithmetic (thirteen per cent) and analysis (nine per cent). Probability theory is found in only four articles.⁵³ Two-thirds of the geometry articles are short or very short, being less than one column. With just over ten columns, the article entitled 'Geometry' is the second-longest, behind the article on trochoidal curves (more than fifteen columns).⁵⁴ Those concerning algebra are also brief except for two. The first one, 'Viga Ganita' (fourteen columns), presents a survey of the content of this Hindu work on algebra before turning to the topics of Hindu arithmetic and astronomy which had not been covered sufficiently by entries in the previous volumes. The second article, which extends to over fifteen columns, gives an exposition of 'Negative and Impossible Quantities': after stating the main principles and giving some results, De Morgan lists his sources by providing a bibliography of French and British authors, including himself.⁵⁵

Such self-citation by De Morgan in the *Penny Cyclopaedia* was rare, occurring on only three occasions: in the article on 'Negative and Impossible Quantities' above (vol. 16), as well as 'Micrometer' (vol. 15) and 'Probability' (vol. 19). This can perhaps be explained by the fact that De Morgan published his most important writings after the completion of the *Penny Cyclopaedia* in 1843. By contrast, in the *English Cyclopaedia*, which appeared in the 1860s, De Morgan was not only quoted more often by others, but also cited himself in his revised articles.

Only two of the mathematical articles concern specific theorems. One is on Sturm's theorem, which makes it possible to find the number of

53 Nevertheless, the article on the theory of probability is still more than eleven columns long. De Morgan starts by giving the main principles and some examples, before stating that it is one of the subjects in which mathematicians are prone to make the most mistakes. He then provides a detailed history of probability and provides bibliographical references, citing the works of Laplace, Condorcet, Lacroix and Poisson, while noting that few English-language works are available, these being almost exclusively his own.

54 Many geometry articles are concerned with particular curves, but there appears to be no obvious reason why the article on trochoidal curves is considerably longer than the others. The engravings of epicycloids in this article were produced by Henry Perigal using a chuck constructed by John Ibbetson, the characteristics of which are given in John Holt Ibbetson, *A Brief Account of Ibbetson's Geometric Chuck, Manufactured by Holtzapffel & Co.* (London: A. Hancock for the author, 1833).

55 The other British authors are Robert Woodhouse, John Warren, Benjamin Gompertz, George Peacock, Davies Gilbert and William Rowan Hamilton; the French ones are Jean-Robert Argand and Augustin-Louis Cauchy.

real roots of an algebraic equation. The first version of this theorem was published in 1829, and it was used very soon afterwards, especially for teaching algebra at the École Polytechnique. Although it was fashionable in France in the 1830s, it is surprising to find an entry on it in a British general encyclopaedia. The only other encyclopaedia of this period to refer to Sturm's theorem was Charles Knight's *English Cyclopaedia*, an updated and expanded version of the *Penny Cyclopaedia* which, along with many other De Morgan-authored articles, carried the piece over verbatim. The other article is on Taylor's theorem, a crucial result in mathematical analysis which expresses a differentiable function in terms of an infinite series. First published by Brook Taylor in 1715, this was the subject of a sixteen-column article which also contained a biography of its author.

Two of De Morgan's articles on mathematics have a special status because they are about books.⁵⁶ The first discusses Newton's masterpiece *Philosophiæ Naturalis Principia Mathematica*, and the second the notorious *Commercium Epistolicum*. The former article, on Newton's iconic 1687 work, is over fourteen columns long. In it, De Morgan described the text and commented on it section by section, revealing his interest in Newton's work and its importance more than 150 years after its publication. The latter article is only one and a half columns long, but its significance is far greater. The *Commercium Epistolicum*, published by the Royal Society in 1712, was the highly partisan report used by Newton and his English supporters to disseminate unfounded allegations of plagiarism against the German mathematician Gottfried Leibniz, with respect to the invention of the calculus. De Morgan was subsequently to devote considerable time to detailed research on the calculus priority dispute, revealing previously unknown flaws in Newton's personality in the process, such that this short article served as a prelude to his rehabilitation of Leibniz's mathematical reputation in Britain.

What conclusions can then be drawn from the mass of information contributed by De Morgan to the *Penny Cyclopaedia*? What can explain the extreme length of certain articles? What factors determined the topics on which De Morgan wrote his entries? And what characteristics of De Morgan can be seen through his articles? Firstly, it must be remembered

56 The Viga Ganita article is also about a book, but it goes well beyond this with a lengthy account of Hindu astronomy.

that, as a ten-year commercial enterprise, the whole project was constantly having to re-adjust and re-calibrate in response to a variety of circumstances, from the death of contributors to the need to correct mistakes or omissions in previous volumes. Consequently, articles originally destined for inclusion on a certain subject sometimes missed the deadline for their intended volume and had to be incorporated into another (usually related) entry. For example, De Morgan's article on the 'Viga Ganita' was artificially lengthened to accommodate material on Hindu arithmetic and astronomy that should have appeared in an earlier volume. Thus, articles of above-average length were often the result of the merging of multiple topics under the same heading.

Secondly, it is clear that the topics covered in De Morgan's *Penny Cyclopaedia* articles are consistent with his scholarly interests: a significant proportion of the entries concerned subjects which related directly to his teaching, research, prior (and future) publications, professional activities or other academic concerns. And although the subjects of a large number, probably the majority, of his entries would have been commissioned by the editor, there is no doubt that De Morgan's own idiosyncrasies played a not insignificant role in the selection of several topics. Who but De Morgan would have considered a publication as recondite as the *Commercium Epistolicum* to be an appropriate entry for inclusion in an encyclopaedia of general knowledge? But of course this is not surprising given his strong interest, not just in mathematics and science, but in their historical development. Moreover, in common with his later books and research articles, his articles in the *Penny Cyclopaedia* contributed more generally to the dissemination of mathematical and astronomical knowledge via their history.⁵⁷

Finally, one has only to read a few of the articles themselves instantly to recognise De Morgan's voice. His literary style in this format is distinctive, simultaneously both formal and accessible. His pedagogical talent shines through clarity of exposition, which combines with good use of examples and a pithy turn of phrase to make even the driest of subjects quite readable. We see him also as an innovator, for it was in an article in volume 12 that he introduced the term 'induction' to describe a method of proof that is now universally used by mathematicians

57 See Rice, 'Augustus De Morgan: Historian of Science'.

across the globe. But above all, the *Penny Cyclopaedia* articles show De Morgan to have been early Victorian Britain's most gifted mathematical expositor. And as such, they enabled him to communicate his love of mathematics and its history to the masses.

Conclusion

Augustus De Morgan wrote prolifically from the start of his career to the end of his life. With more than 1,400 articles, notes, reviews and over seven hundred encyclopaedia entries, he was clearly interested in many subjects, but regularly focused on mathematics, logic and astronomy. His strong interest in history and biography pervades all of his writing, featuring not only in many of his research papers, but also permeating many of his expository articles. The result is a distinctive style of mathematical discourse quite different from most of his contemporaries, in Britain at least.

De Morgan's participation in journals increased the number of his monographs. The most salient example is his posthumous *A Budget of Paradoxes*, which arose from his regular columns in *The Athenæum*. De Morgan's final book, *Newton, his Friend, and his Niece*, a historical investigation of the marital status of Isaac Newton's niece, Catherine Barton, was the extension of an article intended for, and rejected by, the *Companion to the Almanac*.⁵⁸

To the extent that De Morgan was known to the general Victorian public, it would have been primarily as an author of textbooks which were well received and commercially successful, and which displayed his name prominently. Most readers of his more popular expository articles would have been unaware of his authorship, as they were mostly published anonymously. Only among the clique of scientific cognoscenti would his authorship presumably have been a well-kept but open secret, while practising contemporaneous mathematicians knew and respected him for his research papers in prestigious journals.

Today, mathematicians remember De Morgan principally for De Morgan's Laws and historians of science for his *Budget of Paradoxes*, both

⁵⁸ Augustus De Morgan, *Newton, his Friend, and his Niece*, ed. by S.E. De Morgan and A.C. Ranyard (London: Elliot Stock, 1885). For discussion of this, see S.E. De Morgan, *Memoir*, p. 264.

of which have their roots in journal articles.⁵⁹ Thus, while much of his writing is now long forgotten, De Morgan's greatest claims to fame can both be traced back to the periodicals of yesteryear.

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59 De Morgan's Laws appeared, for example, in Augustus De Morgan, 'On the Syllogism III, and on Logic in General', *Transactions of the Cambridge Philosophical Society*, 10 (1858), 173–230 (p. 208). The multiple articles from *The Athenæum* (1863–67) that were later re-published in *A Budget of Paradoxes* (1872) are listed in Chapter 12 of this volume.

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