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Collection, Use, Dispersal

The Library of Charles Hutton and the Fate of Georgian Mathematics

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Introduction

June 1816 saw the sale at auction of the remarkable mathematical library of Charles Hutton (1737–1823). Hutton's had been one of the leading voices in English writing about mathematics for two decades, and the dispersal of his collection of mathematical books attracted regretful comment from various quarters. It is fortunate for the historian that we possess a detailed inventory, since his library provides an unusual snapshot of the mathematical culture of which he was part, and which was—like the library itself—in the process of being swept away during the early decades of the nineteenth century. This chapter examines Hutton's activities as a collector of mathematical texts from various sources, his work as a disseminator of what he learned from those texts, and the circumstances that led to the dispersal of his library and the replacement of his mathematical culture.

Hutton as collector

Hutton's origins lay in Newcastle upon Tyne and its environs; his family was a humble one and it is likely that he worked in the coal pits for a period during his childhood.[1] Nevertheless, he early acquired a reputation as a buyer and collector of books; obituarists apparently relying on his personal reminiscences spoke of his enthusiastic purchase of books of ballads even in childhood,[2] while another anecdote relates his destruction of this material under the influence of devotional tracts and his

[1] See Benjamin Wardhaugh, *Gunpowder and Geometry: The Life of Charles Hutton, Pit Boy, Mathematician and Scientific Rebel*, London: William Collins 2019, and the evidence cited there, especially John Bruce, *A Memoir of Charles Hutton*, Newcastle 1823. Personal communication from Alyson Pigott at Tyne and Wear Archives and Museums indicates that the paybill seen by Bruce can no longer be located.

[2] Anon, 'Charles Hutton', in: *Public Characters*, 10 vols, London, 1799–1809, vol. 2, pp. 97–123 at pp. 100–1, 103. See Anon, *A Catalogue of the Entire, Extensive and Very Rare Mathematical Library of Charles Hutton, L.L.D.*, [London 1816]; subsequent references to items owned by Hutton are to this (printed) catalogue unless otherwise specified. A more complete version of Hutton's library catalogue is now available online: see http://www.benjaminwardhaugh.co.uk/HuttonsBooks/. Relevant items in the catalogue include Allan Ramsay's *Poems* (1761) and a collection of Scots poems of before 1600 (1761); also the *Gentle Shepherd* (Newcastle, 1760), *Caledonian Miscellany* (Newcastle, 1762) and *Tim Bobbin's Toy-Shop opened* (Manchester, 1763).

conversion to Methodism.[3] His library as catalogued in 1816 contained clutches of items that clearly related to certain periods of his life: two English grammars from the 1760s indicating a period of anxiety about his English skills around the time he first became a published author, for instance;[4] a number of books from the 1780s onwards relating to property law and finance, from the period when Hutton was acquiring land and erecting buildings of his own.[5] From the period of his widely publicised dispute with the Royal Society in 1784 he kept copies of the pamphlets published for and against him and his friends.[6] He also kept copies of other works critical of him, including those of Thomas Saint and Robert Woodhouse from the years around 1810. Hutton's more general immersion in the print culture of his period is witnessed by long series of periodicals: over 200 volumes in total. At one time or another he subscribed to the *Gentleman's Magazine*, the *Monthly Magazine*, the *Monthly Review*, the *Philosophical Magazine*, and the short-lived *Projector*, as well as to the *Philosophical Transactions of the Royal Society* and the *Transactions* of the American and the Edinburgh Philosophical Societies. He acquired copies of general reference works such as the *Encyclopaedia Britannica*, the *Encyclopedia Londoniensis* and the *Spectator*. He also owned about sixty pamphlets and papers produced by the Newcastle Literary and Philosophical Society, reflecting his particular interest in that institution and his continued connection with Newcastle after his move to Woolwich in the 1770s.[7]

But it is naturally as a collection of mathematical books that his library is of most interest. He acquired these books during a period of intense mathematical education from his teenage years onwards, and continued to acquire them by purchase, subscription and gift until (at least) the end of 1815 when his library was catalogued. At that time, the mathematical and scientific items numbered something like three thousand. The coverage of instructional works is conspicuous. Hutton, having learned mathematics himself, spent a decade delivering school-level instruction followed by forty years as mathematical professor at the Royal Military Academy (RMA); a friend spoke of his 'never-failing love of the act of communicating knowledge by oral instruction'.[8] He appears to have continued to acquire instructional books on mathematics throughout his career. Hutton's career and his book-buying years very largely fell after the watershed of the mid-century, when it became usual for each pupil—rather than each teacher—to own a copy of a cheap mathematical textbook. Francis Walkingame had been the pioneer in this regard, pressing for the practical advantages; Hutton followed him, writing that each scholar 'ought' to 'have a printed book', and indeed imagining them 'having the book always in their pockets, to get off any rules or tables

[3] Eneas Mackenzie, *A Descriptive and Historical Account of Newcastle-upon-Tyne*, Newcastle 1827, p. 560.

[4] Lowth's *Introduction to English Grammar*, 1763 and 1769 editions.

[5] Mortimer's *Every man his own Broker* (1785); Paul/Wilson on *Laws relating to Landlords and Tenants* (1791), Paul's *Parish Officer's Guide* (1793) and Sugden on the *Sale of Estates* (1809).

[6] Peter Pindar's works in three volumes (Dublin 1792). In total Hutton had 19 copies of the *Narrative of the Dissensions* (London, 1784) and *Appeal to the Royal Society* (London, 1784), suggesting, indeed, that he had a hand in their production.

[7] Anon, *Catalogue of a Miscellaneous Collection of Books: being the valuable and scientific library of the late Dr. Olinthus Gregory … which will be sold by auction by Messrs. Southgate and Son … on Thursday, March the 17th, 1842 and following day*, [London 1842], p. 9.

[8] Anon, [Obituary of Charles Hutton], in: *The Mathematical Repository* (N.S.) 5 (1830), pp. 187–96, at p. 194.

when they are out of school'.[9] Pupils at elementary level would almost all have prepared a 'cyphering book' consisting of extracts and worked examples;[10] dozens if not hundreds of these would have been prepared under Hutton's eye, but this is one type of mathematical text that does not appear in his library catalogue.

At a somewhat higher level, Hutton had the textbooks of Moore and Ward, and Emerson's *Cyclomathesis*. These were apparently intended for use in the grammar schools to provide students with the grounding for the mathematics they would study at the English or Scottish universities. Nineteenth-century official figures would show that only about 70% of those in public schools and only about a third of those in private schools were taught arithmetic.[11] But many specialist private schools specialized either in mathematics or in preparation for military training: the latter was conceived as involving a significant amount of mathematical work. Cyphering books which surely originated in these contexts are numerous, and show pupils continuing a study of algorithmic calculation through fractions, decimals, and the more advanced techniques of proportional reasoning, as well as, in some cases, the study of mensuration and the techniques of surveying and navigation.[12]

The military academies, another important and much-emulated educational site, on the whole took mathematics seriously: more and more so during the eighteenth century. The example of the Royal Mathematical School at Christ's Hospital seems to have been important nationally in setting both the style of the mathematical teaching at military schools and the particular content of what was taught, even perhaps down to the order in which topics were treated; a recent historian of the institution writes of its stranglehold over British mathematical curricula.[13] Other military schools appointed distinguished mathematicians as professors, and they in turn did much for the visibility of mathematics nationally and of British mathematics internationally. Hutton in particular was able to gain quite a lot of power over the curriculum at the RMA, where he was Professor of Mathematics from 1773 to 1806, and once he had established a mathematically based course at that institution his national prominence enabled him to export it to other institutions through his textbooks and his disciples.[14]

The English universities retained a commitment in principle to teaching at least part of Euclid's *Elements* as part of the arts curriculum. Daniel Waterland's *Advice to a Young Student*, written around 1706 and first published in 1740, listed the

[9] Charles Hutton, *The School-master's Guide: or, a complete system of practical arithmetic, adapted to the use of schools*, Newcastle 1764, pp. ii, iii.

[10] Nerida Ellerton and M. A. Clements, *Rewriting the History of School Mathematics in North America 1607–1861: The Central Role of Cyphering Books*, Dordrecht: Springer 2012; John Denniss, *Figuring it Out: Children's Arithmetical Manuscripts, 1680–1880*, Oxford: Huxley Scientific Press 2012.

[11] Denniss, *Figuring it Out*, p. 4; see also A. G. Howson, *A History of Mathematics Education in England*, Cambridge: Cambridge University Press 1982.

[12] Ashley Smith, *The Birth of Modern Education: The Contribution of the Dissenting Academies, 1660–1800*, London 1954, p. 250.

[13] Nerida Ellerton and M. A. Clements, *Samuel Pepys, Isaac Newton, James Hodgson, and the Beginnings of Secondary School Mathematics: A History of the Royal Mathematical School Within Christ's Hospital, London 1673–1868*, Cham: Springer 2017.

[14] W. D. Jones, *Records of the Royal Military Academy*, 2nd edn, Woolwich: Royal Artillery Institution 1895, pp. 18, 20 (entrance exam), 23, 28. Cambridge: University Library, RGO 4/187/18 (Charles Hutton to Nevil Maskelyne, Woolwich, 19 December 1793) gives some hints about how Hutton handled the students at Woolwich.

books necessary for university study in England. The mathematical books listed include Euclid's *Elements*, the *Arithmetic*, *Trigonometry* and *Astronomy* of Webster Wells, Philippe de La Hire's *Conic sections*, and the *Trigonometry* and *Optics* of Isaac Newton. On astronomy and mathematical natural philosophy Waterland mentioned works by William Whiston, John Keill, and David Gregory. Hutton owned them all. Although delivery of this curriculum was reportedly patchy by mid-century, college lecturers in mathematics continued to be appointed, certain colleges introduced examinations in mathematics, and editions of the *Elements* intended for university use continued to be produced and therefore presumably to be purchased. By the late century the mathematical tripos (properly named the Senate House Examination) was taking shape at Cambridge,[15] with its culture of intensive study with a tutor and repetitive private rehearsal of mathematical proofs and techniques.[16]

Finally, some of the Dissenting Academies took the view that mathematics was of increasing importance in the modern world and went out of their way to teach a good deal of it. On the whole they taught algebra and calculus and their applications, rather than Euclid. Pupils at the dissenting academies were (relatively) conspicuous in the mathematical periodicals, and graduates of those academies filled some of the key roles in British mathematical life, particularly towards the end of the Georgian period. But other dissenting academies took an opposite line, reasoning that mathematics in particular or abstraction in general were dangerous distractions from the serious business of intellectual life, and refusing to have anything to do with them. The result was that the influential class of nonconformist intellectuals and ministers included a wide range of levels of mathematical attainment, from the very highest proficiency to practically nil.[17]

As well as textbooks, Hutton had an ample store of the mathematical periodicals. His library contained about 170 bound volumes of almanacs, going back to the early seventeenth century. Hutton himself sometimes disparaged this material; in a letter he wrote mockingly of their prognostications as 'belonging to a Science far above my pitch'.[18] But the almanacs had a close cousin in the philomath journals, which were much more highly regarded and important to British mathematical culture.

The original and arguably the best of these journals was the *Ladies' Diary*, founded in 1704 and finally terminated in 1871.[19] Formally, it was an annual almanac, the year's

[15] John Gascoigne, *Cambridge in the Age of the Enlightenment: Science, Religion and Politics from the Restoration to the French Revolution*, Cambridge: Cambridge University Press 1989, pp. 8, 183.

[16] Andrew Warwick, *Masters of Theory: Cambridge and the Rise of Mathematical Physics*, Chicago: University of Chicago Press 2003, p. 37.

[17] Smith, *Birth of Modern Education*; Irene Parker, *Dissenting Academies in England, their Rise and Progress and their Place among the Educational Systems of the Country*, Cambridge 1914; David A. Reid, 'Science and Pedagogy in the Dissenting Academies of Enlightenment Britain', PhD thesis, University of Wisconsin–Madison 1999.

[18] Charles Hutton to Robert Harrison, 19 March 1781. Printed in Sidney Melmore, 'Some Letters from Charles Hutton to Robert Harrison', in: *The Mathematical Gazette* 30 (1946), pp. 71–81, at pp. 78–9; also in Benjamin Wardhaugh (ed.), *The Correspondence of Charles Hutton (1737–1823): Mathematical Networks in Georgian Britain*, Oxford: Oxford University Press 2017, letter 15.

[19] Teri Perl, '*The Ladies' Diary or Woman's Almanack*, 1704–1841', in: *Historia Mathematica* 6 (1979), pp. 36–53; Shelley Costa, 'The *Ladies' Diary*: Society, Gender and Mathematics in England, 1704–1754', PhD thesis, Cornell University 2000; Shelley Costa, 'The *Ladies' Diary*: Gender, Mathematics, and Civil Society in Early-Eighteenth-Century England', in: *Osiris* 17 (2002), pp. 49–73; Joe Albree and

calendar filling the first 24 pages; set up initially as an almanac aimed at women it quickly became—by the choice of its contributing readers—a well-known forum for setting and answering mathematical problems. These ranged from relatively trivial puzzles and calculations to questions whose answers required formal proof in Euclidean or algebraic style. The *Diary* found many imitators; during the eighteenth century there were at least thirty more or less long-lived periodical publications containing similar material.[20] The *Gentleman's Diary* adopted a very similar format to the *Ladies'* but was subtly differentiated in its content; at least during the middle part of the century it contained a higher proportion of Euclidean material, reflecting the fact that Euclid was part of the education of a gentleman but not of a lady: the *Ladies' Diary* by contrast contained a higher proportion of algebra.[21] The two converged in their interests by the end of the century, and indeed in 1841 merged into the *Ladies' and Gentleman's Diary*. The total number of individuals participating actively by sending in solutions to the philomath journals was probably at any moment several hundred or a few thousand, while those participating passively as readers may have numbered in the tens of thousands. Some provincial newspapers (the *Newcastle Courant* was one) also printed mathematical problems and solutions.

Correspondence from the period gives a clear impression of the enthusiasm with which readers engaged with the problems in the periodicals, circulating material cribbed from proof sheets, exchanging gossip about who had solved (or claimed to be able to solve) what, and whose solutions had been included or excluded.[22] Mary Croarken notes that 'for about one-third of the [Royal Observatory] assistants the *Ladies' Diary* was an important part of their mathematical education'.[23] Hutton himself would state in the 1770s that the *Ladies' Diary* had 'made more Mathematicians within the last 60 or 70 Years, than half the Books that have been written upon the Subject';[24] Thomas Leybourne wrote in 1801 that 'there are scarcely any mathematicians of eminence in this country, who will not readily acknowledge, that in one part or other of their scientific course, they have been assisted by such works';[25] in 1823 the periodicals were noted as being 'exceedingly instrumental in exciting and augmenting a love of literature and science among the middle classes of society in England'.[26] Hutton's library bears witness to all of this, containing a complete set of the *Ladies' Diary* whose acquisition he stated cost him 'much trouble', as well as sixty issues of the *Gentleman's Diary* among other periodicals.

Scott H. Brown, '"A Valuable Monument of Mathematical Genius": *The Ladies' Diary* (1704–1840)', in: *Historia Mathematica* 36 (2009), pp. 10–47.

[20] Niccolò Guicciardini, *The Development of Newtonian Calculus in Britain 1700–1800*, Cambridge: Cambridge University Press 1989, p. 115.

[21] Shelley Costa, presentation at workshop on Georgian mathematics, All Souls College, Oxford, December 2015.

[22] Cambridge: University Library, RGO 35/115: David Kinnebrook to his father, 29 October 1795.

[23] Mary Croarken, 'Astronomical Labourers: Maskelyne's assistants at the Royal Observatory, Greenwich, 1765–1811', in: *Notes and Records of the Royal Society of London* 57 (2003), pp. 285–98, at p. 296.

[24] *Public Advertiser* (London, England), Thursday 4 July 1771, advertisement for Hutton's *Miscellany*; cf. *Public Characters*, vol. 2, p. 99.

[25] Thomas Leybourne, 'Preface', in: *The Mathematical Repository* 2 (1801), pp. v–vi at p. v.

[26] Olinthus Gregory, 'Brief Memoir of the Life and Writings of Charles Hutton', in: *Imperial Magazine* 5 (March 1823 [obituary dated 1 February]), pp. 201–27 at p. 205.

Another large category in Hutton's library was the professional mathematical books: books by and for mathematical practitioners and members of the numerate trades. Gaugers, surveyors, builders, and accountants were among those whose need for mathematical rules along with numerical tables and ready reckoners was catered for by an extensive printed literature, including works aimed at both adult and child learners.[27] Hutton had textbooks on all of these subjects. Navigation was a practice that became increasingly numerate during the century; the advent of the *Nautical Almanac* in 1767 created an expectation that at least some navigators would learn how to take and process lunar observations so as to find their longitude at sea.[28] Some of the skills were much the same as those involved in reading any almanac or extracting information from any table of numbers, but others were much more specialized, including the use of the quadrant and the detailed computational recipe that had to be followed. Training was provided by the Board of Longitude at certain ports in an attempt to create a sufficiently numerate body of navigators to make use of the new almanac. Hutton possessed fifty issues of the *Nautical Almanac*, as well as the three volumes of the 'tables requisite' for its use.

Hutton also seems to have acquired printed copies of practically everything that could reasonably be described as British mathematical research from the period of his own career. He had copies of the nearly 100 volumes of the *Philosophical Transactions*, for instance, which by his own estimate contained a good deal of mathematics and mathematical science.[29] He had the works of Nevil Maskelyne, John Bonnycastle, William Emerson (17 volumes), James Ferguson, Benjamin Franklin, Olinthus Gregory, John Leslie, Benjamin Martin, John Muller, Joseph Priestley, and Thomas Simpson. Mathematical novelties were produced by practitioners, by mathematics teachers, and particularly by the elite mathematical teachers at the RMA and the Royal Military College (RMC): the former acquired a strong reputation for applied and the latter for pure research by the end of the century. And there were the mathematical professors at Gresham College, at Oxford and Cambridge, and at the Scottish universities and Dublin, all of whose employment envisaged at least the possibility of doing new mathematical work. Many of these books would have been presented to Hutton by their authors; some were acquired by subscription (Hutton subscribed to at least 29 books, including works of Antonio Mario Lorgna, Margaret Bryan, Joseph Priestley, and John Dalton).[30]

Hutton—as did many of his contemporaries—certainly also used correspondence and the circulation of manuscripts as sources of mathematical text. From the mid-1770s onwards his correspondence was of notable size throughout Great Britain and Ireland. I have estimated elsewhere that his total correspondence is unlikely to have

[27] E. G. R. Taylor, *The Mathematical Practitioners of Hanoverian England, 1714–1840*, Cambridge: Cambridge University Press 1966.

[28] Mary Croarken, 'Providing Longitude for All: The Eighteenth Century Computers of the Nautical Almanac', in: *Journal of Maritime Research* 4 (2002), pp. 106–26; Mary Croarken, 'Tabulating the Heavens: Computing the Nautical Almanac in 18th-Century England', in: *IEEE Annals of the History of Computing* 25/3 (2003), pp. 48–61.

[29] See below of Hutton's *Abridgement* of the *Transactions*.

[30] Ruth Wallis and Peter John Wallis, *Index of British Mathematicians. Part III, 1701–1800*, Newcastle upon Tyne: University of Newcastle upon Tyne 1993, p. 72.; cf. Peter Wallis and Ruth Wallis, *Mathematical Tradition in the North of England*, Durham: NEBMA 1991, p. 13.

numbered fewer than 10,000 items,[31] and at the time his library was catalogued in 1815–16 it is likely that many of those items were still present in his house, although they were not included in the catalogues. Hutton occasionally acknowledged his informants in print, on matters ranging from methods of gauging casks and solutions of recreational problems to the provision of detailed data in experiments on gunpowder. Conversely, at least once in his publications he requested improvements to his books to be sent to him or his publishers, thereby acknowledging the possibility of readers' agency in getting the details right.[32] Early in his London career he sent drafts of his papers to Nevil Maskelyne for comment, and more than once he acknowledged the 'generous advice and assistance' of the Astronomer Royal as well as his contribution of particular details or passages.[33]

Hutton collected antiquarian mathematics, too: he had a small collection of editions of Newton's *Principia* and a larger one—twenty-odd copies—of Euclid's *Elements*; he had printed mathematical books from the sixteenth and seventeenth centuries including classics such as works by François Viète and Niccolò Tartaglia as well as more obscure items.[34] He also acquired a number of manuscripts including a medieval Bible on vellum, a manuscript copy of *Elements* I–VI, and works on mechanics, gunnery, and astronomy. Smaller items acquired through personal correspondence included papers of Henry Cavendish on cometary orbits and of Francis Maseres on problems including the motion of a vibrating line.[35] Major Edward Williams of the Royal Artillery forwarded Hutton accounts of his scientific experiments in Quebec;[36] various series of experiments on gunnery also reached Hutton from Gibraltar and elsewhere.[37] Through his hands passed the books and papers of Edward Rollinson in 1773; Hutton purchased part of the papers of John Robertson which in turn included papers of William Jones; he also seems to have seen the papers of John Whitehurst.[38]

[31] Wardhaugh, *Correspondence*, p. xxviii.

[32] See Benjamin Wardhaugh, 'Rehearsing in the Margins: Mathematical Print and Mathematical Learning', in: *The Palgrave Companion to Mathematics and Literature*, ed. Robert Tubbs, Alice Jenkins, and Nina Engelhardt, London: Palgrave Macmillan 2021, pp. 553–67.

[33] Cambridge: University Library, RGO 4/187/11: Charles Hutton to Nevil Maskelyne, 27 June 1785; printed in Wardhaugh, *Correspondence*, letter 31. Charles Hutton, *Mathematical Tables*, London 1785, dedication.

[34] Cambridge: Trinity College Library, R.1.59: Miscellaneous mathematical manuscripts by Charles Hutton and others, contains at 64^{r}–66^{r} some of Hutton's summaries and notes on his older mathematical books.

[35] Cambridge: Trinity College Library, R.1.59, ff. 168, 170: Henry Cavendish to Charles Hutton, 7 July 1779; printed in Wardhaugh, *Correspondence*, letter 10; also ff. 155^{r}–165^{r} ('On finding the Orbits of Comets in a Parabola from 3 Observations. (By the Hon[oura]ble Henry Cavendish) (Copied June 1779.) C.H.'), 90^{r}–105^{v} ('Mr Maseres's Problem of a Vibrating Line', followed by further notes of Hutton and Cavendish on the solution of the problem).

[36] Charles Hutton, 'Experiments on the Expansive Force of Freezing Water, made by Major Edward Williams of the Royal Artillery, at Quebec in Canada … Communicated in a letter from Charles Hutton … to Professor John Robison, General Secretary of the Royal Society of Edinburgh', in: *Transactions of the Royal Society of Edinburgh* 2 (1790), pp. 23–8. Reprinted in *The Literary Magazine and British Review* 6 (January 1791), pp. 20–2.

[37] London: Royal Artillery Museum ('Firepower': closed at the time of writing; materials seen in February 2016), MD/913/2 ('Experiments in bursting ?Cochorn shells in a case in Queens Lines Gibraltar. 13th January 1781'., apparently communicated by a Captain Seward).

[38] Anon, *A Catalogue of the Curious Mathematical, &c Books of the Late Mr. Edw. Rollinson* [London, 1775]; Cambridge: Trinity College Library, MS R.1.59 52^{v}–63^{v} (items copied from Robertson's papers by

Hutton's correspondence extended overseas; we have his testimony that he was in touch with his 'worthy friend' Christiaan Damen in Leiden concerning Arabic mathematics.[39] And in view of what would later happen to British mathematics it is of interest to notice how far his collection of mathematical texts included non-British materials. Foreign mathematical works of the eighteenth century were numerous in his library, from Jean le Rond d'Alembert to Pierre Varignon: there were more than forty authors and more than eighty volumes, plus foreign serials totalling more than fifty volumes. He had multiple volumes of such advanced writers as Alexis Clairaut, Leonhard Euler, Jérôme Lalande, and Pierre-Simon Laplace. Hutton could read and write French,[40] and had dictionaries and/or grammars also in Italian, Spanish, Dutch, Greek, and German; he owned works in Latin and French, and occasionally Italian and German, plus one Dutch Bible and one Greek New Testament. He admired Continental mathematics; remarking on a recent French version of William Gardiner's tables he wrote that 'it is but justice to remark the extraordinary spirit and elegance with which the learned men and the artisans of the French nation undertake and execute works of merit'.[41] His admiration of French culture also played out in the placement of his youngest daughter Charlotte—and probably her sister Eleanor—at a convent school in France for a time in the 1780s.[42] The exact reasons for the decision are nowhere recorded, and the girls were of course brought safely home once political trouble began (his library contained a 1781 plan of Paris, very probably in connection with this sojourn, though it is not known that Hutton himself ever left England).

Hutton was not exceptional: recent research is increasingly tending to show that mathematical material both from the centres of research at Paris and St Petersburg, and from further afield, was coming into Britain, although it is certainly true that its impact was limited.[43] The Royal Society, for instance, collected (mainly by gift) a large quantity of foreign mathematical publications; the British reviewing journals did their best to keep pace with Continental scientific works including mathematical works, although they were hampered at times by the practical conditions of war. Similarly, the commercial scientific journals of William Nicholson, Alexander Tilloch, Thomas Thomson, and others aimed to 'provide readers with access to the scientific discoveries of other countries',[44] and summaries or extracts from many French works

Hutton; see also London: British Library, Loan 96 RLF 1/315/2: Patrick Kelly and Charles Hutton to the Committee of the Literary Fund, April 1814 on behalf of Robertson's daughter Ann Coppard); Hutton, *Tables*, p. 117; Wallis and Wallis, *Index*, p. 6.

[39] Charles Hutton, *A Mathematical and Philosophical Dictionary*, London: Johnson 1795–6, vol. 1, p. 67.

[40] See letters 24 and 120 in Wardhaugh, *Correspondence* for specimens (one certain, the other less so) of Hutton's written French.

[41] Hutton, *Tables*, p. 41.

[42] Anon, [Obituary of Charlotte Hutton], in: *The Gentleman's Magazine* (October 1794), pp. 960–1; Portsmouth History Centre, Vignoles Papers, Letter 127 (Eleanor Wills (née Hutton) to Charles Blacker Vignoles, December 1816).

[43] Jonathan R. Topham, 'Science, Print, and Crossing Borders: Importing French Science Books into Britain, 1789–1815', in: *Geographies of Nineteenth-Century Science*, ed. David N. Livingstone and Charles Withers, Chicago: University of Chicago Press 2011, pp. 311–44 at p. 312; Alex D. D. Craik, 'Mathematical Analysis and Physical Astronomy in Great Britain and Ireland, 1790–1831: Some New Light on the French Connection', in: *Revue d'histoire des mathématiques* 22 (2016), pp. 223–94, *passim*.

[44] Topham, 'Science, Print, and Crossing Borders', p. 320.

on subjects like heat, light, and electricity appeared in British journals.[45] Hutton's colleagues such as Peter Barlow, Olinthus Gregory, and John Bonnycastle were thus able to acquire an extensive knowledge of French work on practical subjects such as the strength of materials, magnetism, and ballistics.[46]

Foreign correspondence, however, is extremely rare in Hutton's surviving letters. We have just one letter from Edme-Sébastien Jeaurat (who visited Hutton, probably in 1781) and one from Laplace, as well his own statement that he was in touch with Damen.[47] Out of more than fifty known correspondents that is not many, and gives an impression that Hutton was keener to acquire print rather than manuscript material from overseas.

Hutton's interests as a mathematical historian ranged beyond Europe, and his library had copies of Edward Strachey's and John Playfair's works on Indian algebra and astronomy. He reported that he had seen specimens of algebraic works from India, 'both in the native language and in Persian translations' with partial translations into English, at the hands of Samuel Davis, one of the directors of the East India Company;[48] he also saw translations sent to England by Strachey. He went so far as to copy out by hand some of Reuben Burrow's articles in the *Journal of Asiatic Researches* on astronomical subjects.[49]

Hutton as interpreter and writer

Up to now I have attempted to give a sense of the range of mathematical texts being produced in, or imported into, later eighteenth-century Britain and consumed there. I have also sought to give a sense of the scale and range with which Charles Hutton collected specimens of those texts in his remarkable library. Hutton did not acquire mathematical texts in print and manuscript merely to improve his own mind, however, nor indeed to fuel his own *viva voce* teaching. He also worked over many years as an author of his own mathematical texts, in which he re-presented much of what he had assimilated from others. One of his most notable functions, indeed, was as a gatekeeper through whom historical and foreign mathematics passed before reception by a British public. When his library was sold, he disposed of 66 volumes of which he was the author or editor, as well as more than 150 offprints and pamphlets; more than 500 further volumes of his own works were disposed of after his death.

Hutton's first book was *The School-Master's Guide*, 'an Attempt to introduce a regular and rational Method of Teaching this most necessary Science [sc. arithmetic] into the generality of Schools, and to ease the Masters of part of the Labour which

[45] Craik, 'Mathematical Analysis', p. 233; cf. Guicciardini, *Development*, p. 119.
[46] Guicciardini, *Development*, p. 108.
[47] Letters 16 and 122 in Wardhaugh, *Correspondence*: respectively Washington D.C., Smithsonian Institution, MS 752 A (Edme-Sébastien Jeaurat to the Misses Hutton, 20 October 1781) and *Philosophical Magazine* 1/56 (November 1820), pp. 321–2 (Pierre-Simon de Laplace to Charles Hutton, 11 September 1820).
[48] Charles Hutton, *Tracts on Mathematical and Philosophical Subjects*, 3 vols, London: Rivington et al. 1812, vol. 2, Tract 33 (History of algebra), p. 153; cf. p. 163.
[49] Cambridge: Trinity College Library, R.1.59, 124^{r}–153^{v}: 'Extracts from the Asiatic Researches Vol. 1 & 2'.

necessarily attends their Business without such a Help'.[50] Hutton's love for ordering, reordering, and improving what he found in the works of others was evident throughout, particularly in his 'Definitions delivered in a Manner proper for Children to copy from' and the preface 'containing some Hints towards a proper Method of teaching this useful Art'.[51] He used the textbook form to present an authoritative and deceptively cosmopolitan *persona*, referring repeatedly to long-distance travel, to international trade, and to the large-scale purchase and sale of various commodities and investments. Individual problems derived from a long line of predecessors, who were not acknowledged.[52] The book was emphatically not meant for self-study: Hutton's gnomic explanations would usually have required the elucidation of a teacher in order for an uninitiated student to make any sense of them.

Hutton went on to notable success with his 1770 account of mensuration, which more resembled a reference book or encyclopaedia than either a practical manual or a schoolbook. The range of sources was wide, long lists of ancient and modern names were cited, and there was a notable historical dimension.[53] A cut-down version for schools appeared in 1786.[54]

The major textbook of Hutton's maturity, though, was the *Course of Mathematics*, which appeared in 1799 and was intended first for the use of the cadets at the RMA. He noted in an introduction that he and his colleagues had been accustomed to teach from several books by several authors 'selecting a part from one and a part from another': this was a hassle and an expense, and was far from ideal because of the non-uniformity of the material.[55] The *Course* thus exemplified Hutton's activity as a collector and digester of a range of mathematical sources into uniform wholes for the use of his contemporaries. As originally published, the *Course* covered arithmetic, algebra, geometry, applications, and fluxions,[56] though subsequent additions and re-editions did much to upset its arrangement.

With respect to philomath culture, Hutton had been a contributor from his early adulthood, writing problems or solutions for the *Ladies' Diary*, the *Gentleman's Diary*, and *Martin's Magazine of the Sciences* during the 1760s. Between 1771 and 1775 he edited a new reprint of the problems that had appeared in the *Ladies' Diary* since its inception.[57] The work was largely one of transcription rather than editing as such, although merely to have assembled a complete set of old issues of the *Diary* was a notable achievement. Furthermore, Hutton included in the edition new mathematical correspondence, with original essays and problems, amounting to around 15% of the total; Hutton himself was said to have written at least some of this material

[50] Charles Hutton, *The School-Master's Guide*, Newcastle: for the author 1764.

[51] *London Chronicle*, issue 1140 (10–12 April 1764): advertisement for Hutton, *Guide*.

[52] On the longevity of this tradition and its contents see Frank J. Swetz, *Mathematical Expeditions: Exploring Word Problems across the Ages*, Baltimore: Johns Hopkins University Press 2010.

[53] Charles Hutton, *A Treatise on Mensuration, both in theory and practice*, Newcastle and London; T. Saint 1770, p. xviii.

[54] Charles Hutton, *The Compendious Measurer: being a brief, yet comprehensive, treatise on mensuration and practical geometry*, London: G. G. and J. Robinson and R. Baldwin 1786.

[55] Charles Hutton, *A Course of Mathematics*, 2 vols, London: for G. G. and J. Robinson 1798, vol. 1, p. iii.

[56] Howson, *Mathematics Education*, p. 68.

[57] Charles Hutton (ed.), *The Diarian Miscellany*, 5 vols, London: Robinson and Baldwin 1775.

under pseudonyms.[58] After this apprenticeship, Hutton's dominance of the philomath world became complete in 1773 when, following the death of Edward Rollinson, he was asked to take over as regular editor of the *Ladies' Diary*; he subsequently took on the editorship of all but two of the annual almanacs produced by the Stationers' Company of London, employing assistants 'to make most of the calculations & certainly all the Prognostications'.[59] Thus the essential question-and-answer material for the *Diary* passed through his hands and underwent his selection and arrangement. He saw the number of contributors more than double, and went so far as to produce an annual 'supplement' in order to accommodate more of the mathematical material. The *Gentleman's Diary*, meanwhile, came under the editorship of Charles Wildbore in 1780 at Hutton's recommendation.[60]

Hutton's public-facing work also apparently included reviewing mathematical books for the London periodicals. Three obituarists reported the fact, and one review survives in manuscript (under the pseudonym 'N. Bosworth'), although signed examples in print have not turned up.[61] Editing the works of deceased colleagues was a related activity, and it was another area in which Hutton's rich collections of printed and manuscript mathematics came into their own, as a resource for selection, arrangement, and dissemination. He edited posthumous works of William Emerson, Thomas Simpson, John Robertson, and Benjamin Robins, in most cases having acquired or borrowed portions of their papers and in the case of Emerson at least with his agreement during his lifetime: Hutton already had 'the care' of a new edition of Emerson's *Algebra* in 1779, three years before his death.[62]

The pinnacle of Hutton's editorial work was a second project ostensibly similar to his re-edition of the *Ladies' Diary*, but whose context made it something very different: the 'Abridgement' of the *Philosophical Transactions* that appeared between 1803 and 1809.[63] Three editors were named on the title pages of the series, but it was widely reported that Hutton undertook 'the general editorship and correction of the press, of the whole'[64] and that biographical articles and translations as well as abridgements of articles concerning mathematics and the mathematical sciences were all his

[58] *Public Characters*, vol. 2, p. 105.

[59] Charles Hutton to Robert Harrison, 19 March 1781, printed in Melmore, 'Some Letters', pp. 78–9 and in Wardhaugh, *Correspondence*, letter 15; cf. Reuben Burrow's statement that Hutton 'does not know how to make an Almanack': T. T. Wilkinson, 'Mathematics and Mathematicians, the journals of the late Reuben Burrow', in: *London, Edinburgh, and Dublin Philosophical Magazine*, 4th series, 5 (1853), pp. 185–93, 514–22; 6 (1853), pp. 196–204 at p. 187. Obituaries of Henry Andrews in 1820 stated that Andrews computed the *Nautical Ephemeris* and *Moore's Almanack* for the Stationers' Company for more than 40 years, never receiving more than £25: *Monthly magazine, or, British register* (December 1820), pp. 480–8 (obituary of Henry Andrews); cf. Stationers' Company of London, *The Records of the Stationers' Company 1554–1920* (microfilm series: Cambridge, 1985), Series I, Box B, folder 6, item ii (draft agreement between the Stationers' Company and Henry Andrews dated 13 September 1788).

[60] *Public Characters*, vol. 2, p. 113; Charles Hutton to Robert Harrison, 31 May 1780, printed in Melmore, 'Some Letters', pp. 77–8; also in Wardhaugh, *Correspondence*, letter 14.

[61] London: Royal Artillery Museum ('Firepower'), MS 913/6.

[62] Charles Hutton to Robert Harrison, 4 August 1779, printed in Melmore, 'Some Letters', pp. 74–6 and in Wardhaugh, *Correspondence*, letter 12.

[63] Charles Hutton, George Shaw, and Richard Pearson (eds), *The Philosophical Transactions… abridged*, 18 vols, London 1803–9.

[64] Anon, Obituary (1830), p. 193.

work. The quantity of text and the huge sum he was said to have been paid (£6000),[65] on the other hand, clearly indicates that assistants were again involved. Once more, Hutton's library came into play: his own collection of old issues of the *Transactions*, his biographical notes and his knowledge about mathematicians and others and his large store of their letters including contributions—whether published or not—to the *Ladies' Diary*.

The *Abridgement* was a particular opportunity to put Hutton's own slant on the work of the Royal Society, an institution with which he was still at odds after his catastrophic, widely publicised falling-out with its president Joseph Banks in 1784.[66] Critics commended the even-handedness of the project,[67] but it is difficult to be quite convinced. The volumes were internally arranged by subject, and mathematics and mechanical philosophy were the first two categories (contrast the 1787–91 abridgement of the *Transactions* printed in Paris, in 14 subject-specific volumes, which did not devote a volume to mathematics).[68]

Hutton's public-facing work also included perhaps the most enduring of his publications and the most important use to which his magnificent library was put during its existence: the 1795 *Dictionary of Mathematics*.[69] An immense project of reputation-building on both his own behalf and that of mathematics in general, and of British mathematics in particular, it filled two very large volumes and ranged across the whole gamut of the mathematical culture Hutton knew: from the contents of textbooks and the incremental innovations of the philomaths, through the biographies and foibles of the philomath authors themselves, recent practical and technical work, and the latest in both British and Continental mathematical research. There were probably few mathematical volumes in Hutton's library not used at least indirectly in its pages, whose compilation took him ten years of labour.[70]

On the Continental side, the *Dictionary* contained much bibliographical and biographical information to orient the British reader, with outlines of the methods and results of Jean le Rond d'Alembert, Leonhard Euler, and Joseph-Louis Lagrange. Hutton cited the output of the major journals in Paris, Berlin, St Petersburg, and Leipzig, as well as works of Marin Mersenne, Jérôme de Lalande, Christian Wolfius, Nicolas-Louis de la Caille, Gua, Girolamo Saladini, Giambatista Beccaria, and Charles Messier. It was possible to carp at individual omissions (there were no biographies of Ruggiero Boscovich, Jean Étienne Montucla, or Giuseppe Torelli),[71] and some would point out that Hutton's account was short of technical details, but on the whole it was thought that Continental work was amply covered. One reviewer even complained of

[65] Anon, [Obituary of Charles Hutton], in: *The Edinburgh Annual Register* 16 (December 1823), pp. 328–31, p. 330.

[66] Benjamin Wardhaugh, 'Charles Hutton and the "Dissensions" of 1783–84: Scientific Networking and its Failures', *Notes and Records of the Royal Society* 71 (2017) 41–59.

[67] Anon, [Review of Hutton et al. (eds), *Abridgement*, vol. 1], in: *The British Critic* (1803), p. 540.

[68] Jacques Gibelin (ed.), *Abrégé des Transactions Philosophiques de la Société Royale de Londres*, Paris: Buisson 1787–91.

[69] Hutton, *Dictionary*.

[70] See Cambridge: University Library, White b.8 (a single page advertisement for Hutton, *Dictionary*, with letter of Charles Hutton to David Stephenson, 7 February 1795 attached); also printed in Peter John Wallis, *Newcastle Mathematical Libraries: William Armstrong, Charles Hutton and Others, Northern Notes* 4 (1972: supplement), University of Durham, pp. 10–11 and in Wardhaugh, *Correspondence*, letter 70.

[71] Anon, [Review of Hutton, *Dictionary*], in: *Critical Review* (November 1796), pp. 302–5 at p. 305.

too much of Pierre Louis Maupertuis and Alexis Claude Clairaut;[72] another claimed that the *Dictionary* was little more than a translation of the mathematical parts of Denis Diderot's *Encyclopédie*.[73]

Hutton's achievement in the *Dictionary* was the more remarkable in that the wider world of scientific popularization tended very largely to take a non-mathematical approach to its subjects: scientific lecturers on the whole studiously avoided the use of mathematics in their presentations of the Newtonian world, and some lecturers were notoriously ignorant of mathematics.[74] The *Dictionary* was far from being a work of 'polite science' as it was normally understood.[75]

Hutton also, and finally, produced mathematical writings whose purpose was originality rather than re-presentation of what was already known. On the boundary of this category are his two volumes of mathematical tables, which he presented as a decisive improvement over any that had come before and were adopted and paid for with some enthusiasm by the Board of Longitude.[76] The second of these volumes, the table of logarithms, was the occasion for a lengthy history of logarithms and their calculation and use, into which Hutton put much of what he had learned from his years of collecting and reading on the subject. This was his first major historical project; a second would be the history of algebra which was published both separately and as part of the *Dictionary*, and on which he claimed to have spent two years of work, bringing together summaries, translations, and selections from the many relevant works in his library, that spanned medieval, Renaissance, and modern treatments of the topic.[77]

In a similar calculatory vein was Hutton's work on Maskelyne's project to determine the gravitational attraction—and hence the density and mass—of the earth using astronomical observations. Hutton spent nearly a year performing the calculations, transforming a ground survey into an estimate of the local gravitational field strength at two points in order to interpret the observed deflections of a plumb line from vertical.[78] The project was a clear illustration of Hutton's strengths as a mathematical technician; it was Maskelyne who received a Copley medal for the work,

[72] Anon, [Review of Hutton, *Dictionary*], in: *The Monthly Review* (1798), p. 185.

[73] Anon, [Review of Hutton, *Dictionary*], in: *English Review* 28 (July 1796), pp. 14–19 at pp. 18, 19.

[74] Hutton, *Tracts* (1812), vol. 3, Tract 38 (Miscellaneous problems), p. 379: a story about the lecturer James Ferguson.

[75] Alice N. Walters, 'Conversation Pieces: Science and Politeness in Eighteenth-Century England', in: *History of Science* 35 (1997), pp. 121–54 at pp. 122, 127–8.

[76] Hutton, *Tables*, p. 40; Mary Croarken, 'Tabulating', p. 55 (list of items to be sent to *Nautical Almanac* computers and comparers, September 1799).

[77] Hutton, *Tracts* (1812), vol. 2, Tract 33; also in Hutton, *Dictionary*, vol. 1, and cf. the history of the binomial theorem in Charles Hutton, *Tracts, Mathematical and Philosophical*, London 1786, Tract 6, pp. 67–75.

[78] Nevil Maskelyne, 'A Proposal for Measuring the Attraction of Some Hill in this Kingdom by Astronomical Observations', in: *Philosophical Transactions* 65 (1775), pp. 495–9; Nevil Maskelyne, 'An Account of Observations Made on the Mountain Schehallien for Finding its Attraction', in: *Philosophical Transactions* 65 (1775), pp. 500–42; Charles Hutton, 'An Account of the Calculations Made from the Survey and Measures Taken at Schehallien, in Order to Ascertain the Mean Density of the Earth', in: *Philosophical Transactions* 68 (1778), pp. 689–788; Charles Hutton, 'On the Calculations for Ascertaining the Mean density of the Earth', in: *Philosophical Magazine* 38 (1811), pp. 112–16; Charles Hutton, 'On the Mean Density of the Earth', in: *Philosophical Transactions* 111 (1821), pp. 276–92, reprinted in *Philosophical Magazine* 58/279 (1821), pp. 3–13.

though Hutton liked later to present his own role as an active, intellectual one. When a commemorative medal was struck in the final years of his life it showed an emblem of 'weighing the world.'[79]

Hutton's own more original research papers favoured topics in the manipulation and summation of series, including extensions of work by Euler, John Landen, and Stephen Hales.[80] Over many years he carried out experimental work on the force of fired gunpowder, and he received the Copley medal himself for one of his papers on the subject, shortly before his break with the Royal Society.[81] His work on the analysis of bridge designs, although it found a mixed reception, was the occasion in its later versions to synthesize what he had learned from William Jones and John Robertson, in both cases using their autograph manuscripts which Hutton had acquired over the years.[82]

Hutton's textbooks and his public-facing work were notably successful, and he was able in 1812 to ascribe his fairly substantial fortune to the 'liberal encouragement of the Public', meaning at least in part the sale of his books.[83] The *Guide*, *Mensuration*, logarithm tables and *Course* all continued to be reprinted for many years after his death; the *Guide* and the tables until nearly the end of the nineteenth century. The *Course* remained in use at the RMA and several sister institutions until the 1840s, its importance to training and examination several times reaffirmed.[84] In an 1841 edition it was stated that nearly 30,000 copies of the work had so far circulated.[85]

As with the presence of foreign works in his library, there is particular interest in the degree to which Hutton's own works travelled internationally. Approbation in America was provided by certain teachers who used the *Course*, notably Robert Adrain at West Point, whose list of the greatest mathematicians included Blaise Pascal, Gottfried Wilhelm Leibniz, the Bernoullis, Emerson, Robert Simpson, Hutton, and Samuel Vince.[86] There were American printings of extracts from the *Guide* up to 1824, and by chance a manuscript has survived entitled 'Book Keeping by single entry Extracted from the works of Charles Hutton', prepared by one William Mahan in 1827.[87] The *Course* meanwhile was used at West Point up to about 1823;[88] its

[79] Anon, *Tribute of Respect to Charles Hutton, LL.D. F.R.S. &c. &c.*, [London 1822].

[80] Hutton, *Tracts* (1786), Tract 1, p. 2; Tract 2, p. 34; Tract 6, pp. 73–4.

[81] Charles Hutton, 'The Force of Fired Gun-Powder, and the Initial Velocities of Cannon Balls, Determined by Experiments', in: Philosophical Transactions 68 (1778), pp. 50–85; further discussions in Hutton, *Tracts* (1786) and Hutton, *Tracts* (1812).

[82] Hutton, *Tracts* (1812), vol. 1, Tract 1, p. 89; cf. Tract 2 (a paper by George Dance on London Bridge) and Tracts 3 and 4 (papers from the Robertson papers).

[83] Hutton, *Tracts* (1812), vol. 1, p. x.

[84] Jones, *Records*, pp. 59, 60, 65, 69, 96, 100.

[85] Hutton, *Course* (1841 edition, ed. T. S. Davies), preface.

[86] Julian L. Coolidge, 'Robert Adrain and the Beginnings of American Mathematics', in: *The American Mathematical Monthly* 33 (1926), pp. 61–76, p. 75; cf. Frank J. Swetz, 'The Mystery of Robert Adrain', in: *Mathematics Magazine* 81 (2008), pp. 332–44 at p. 340.

[87] James Mulhern, 'Manuscript Schoolbooks', in: *The Journal of Educational Research* 32 (1939), pp. 428–48 at p. 443, describing an item in the collection of the Historical Society of Pennsylvania.

[88] V. Frederick Rickey and Amy Shell-Gellasch, 'Mathematics Education at West Point: The First Hundred Years', in: *Convergence* (2010): https://www.maa.org/press/periodicals/convergence/mathematics-education-at-west-point-the-first-hundred-years, esp. 'Hutton and the Notebooks'.

final American edition was printed in 1831. An American work extracted from the *Dictionary* also appeared in 1817.[89]

In British India the *Course* enjoyed a particular popularity at the hands of the East India Company and the Royal Bengal Artillery; a Gujarati translation was published in Bombay in 1828, and this was followed by Arabic, Sanskrit, and Marathi versions over the next twelve years; extracts in Urdu appeared in 1848.[90] But perhaps more surprising is that Hutton's work on ballistics was able to find acceptance in France. A few Continental journals had noticed his reprint of the *Ladies' Diary*, his tables, *Dictionary*, and *Course*,[91] and it is possible to find the occasional French or German citation of his research. But it was the work on gunpowder that found most reception here. Hutton's 1786 paper on the subject was translated into French in 1791–2, though not published; a report circulated that Lagrange himself was closely interested in the work.[92] Hutton's long, final discussion of gunpowder, published in English in 1812, was published in a French translation, as well as being reviewed, extracted, and cited.[93] A British reviewer could boast in 1822 that the French 'eagerly possess themselves of every essay, investigation, and experiment of Dr. Hutton on the subject, as soon as it is made public'.[94]

Hutton's ability to export his ideas through correspondence seems to have been much less important. Evidence of such direct contact is limited to single letters from Jeaurat and from Laplace, the suggestion that he was in touch with Damen, and a passage in Montucla's *Histoire* which may suggest contact with Hutton or his circle.[95]

The export of Hutton's books, it should be said, was not exceptional for his period. The *Philosophical Transactions* were sent to foreign members of the Royal Society in a number of countries, carrying with it a fair amount of mathematics. Ward's *Young Mathematician's Guide*, successful enough in Britain to run to fifteen editions, was translated into French in 1756 under the title *Le Guide des jeunes mathématiciens*. This translation was in fact part of a collection of mathematical works published in French by Charles Antoine Jombert; the set also included works of Newton and Colin Maclaurin. Ward's *Guide* also went to America, and is said to have been studied at

[89] Nathan S. Read, *An Astronomical Dictionary: compiled from Hutton's Mathematical and Philosophical dictionary*, New Haven 1817.

[90] J. F. Blumhardt, *Catalogue of the Library of the India Office*, vol. 2, part 5: *Marathi and Gujarati Books*, London 1908, pp. 89, 91, 245–6; Charles Ambrose Storey, *Persian Literature: a bio-bibliographical survey* 2/1 (1927), p. 19.

[91] *Journal Encyclopedique* (September 1776), pp. 355–7 (*Diary*); *Journal Encyclopédique* (October 1786), p. 179 (*Tables*); *Journal encyclopédique ou universal* 62 (October 1786), p. 339 (*Tables*); *Allgemeine Literatur-Zeitung* (November 1796), pp. 489–500 (*Dictionary*).

[92] Anon, [Obituary of Charles Hutton], in: *Monthly Magazine* 55 (March 1823), pp. 137–42 at p. 139; Louis-Bernard Guyton de Morveau, 'Notes', appended to J. B. J. Delambre, 'Notice sur la vie et les ouvrages de M. Malus, et de M. le Comte Lagrange', in: *Mémoires de la classe des sciences mathématiques et physiques de l'institut mperial de France. Année 1812. Première partie* (Paris, 1814), pp. lxxviii–lxxx; essay review including the *Tracts* in *The British Review* (1822), p. 300.

[93] Cf. J. Madelaine, [Review of Hutton, *Nouvelles expériences d'artillerie*], in: *Journal des sciences militaires* 5 (1826), pp. 350–79 and Brett D. Steele, 'Military "Progress" and Newtonian Science in the Age of Enlightenment', in: *The Heirs of Archimedes: Science and the Art of War through the Age of Enlightenment*, ed. Brett D. Steele and Tamera Dorland, Cambridge, MA: MIT Press, 2005, pp. 361–90 at p. 373.

[94] Essay review including the *Tracts*, in *The British Review* (1822), p. 299.

[95] Montucla had an English informant when he was working on books 3 and 4 of his *History*, with information about Newton and who had apparently seen the Pemberton papers. This could have been Hutton, though there are other candidates and no direct proof (personal communication by Niccolò Guicciardini).

Harvard in its early days. Another international traveller was Simson's 1756 edition of Euclid's *Elements*, which was widely used across the English-speaking world and eventually received translations into Arabic and various Indian languages.

It is notable that the *Ladies' Diary* also received some attention abroad, with French reviews of Leybourne's collection of its problems in 1817 remarking favourably on the mathematics it contained and the mathematical culture it represented. A fair case can be made, indeed, that during the whole of the eighteenth century British mathematics enjoyed at least modest success as a product for export.

Equally, certain British-trained individuals were able to make careers as teachers outside Britain, including Robert Adrain at West Point and William Marrat who went to New York 'carrying with him letters of recommendation from Dr. Hutton and Dr. [Olinthus] Gregory; and he is now a Professor of Mathematics in one of the colleges of that State'.[96] Walter Minto's trajectory was similar, taking him eventually from Scotland to America where he taught mathematics at Princeton. Britain was thus a serious player on the international mathematical stage, both exporting and importing quantities of texts and people. Expressions of self-confidence can fairly easily be found, and it was not entirely an idle boast when in 1784 Samuel Horsley claimed the country had in the person of Charles Hutton 'one of the greatest mathematicians in Europe'.

Dispersal

I have represented Hutton and his library as something like a sieve—or perhaps a better comparison would be a mangle—through which almost the widest possible range of mathematical text from eighteenth-century Britain and Europe passed, and which produced as its output a series of publications that themselves covered a wide range of genres, were addressed to a range of audiences, and successfully travelled beyond the British Isles. Hutton retired from his position at the RMA in 1807, and his books moved along with his other possessions from his house on Woolwich Common to his new residence on Bedford Row.[97] The new location was just a few streets away from the British Museum, and reasonably close to the heart of London's intellectual and scientific life. Hutton appears to have been a sociable man,[98] but his correspondence does not at this or at any other period specifically mention either lending out books from his library or granting access to it to his friends and colleagues. (The closest is a mention of books exchanged between him and Reuben Burrow at the Royal

[96] [Olinthus Gregory], 'A Review of Some Leading Points in the Official Character and Proceedings of the Late President of the Royal Society', in: *Philosophical Magazine*, series 1, no. 56 (1820), pp. 161–74, 241–57 at p. 251.

[97] Jones, *Records*, p. 57 (26 June 1807); the address is consistently given as 34 Bedford Row in Hutton's surviving correspondence, although 36 appears in the manuscript catalogue of his library (see below).

[98] Portsmouth History Centre, Correspondence and papers of C. B. Vignoles, Letter 65 (C. B. Vignoles to Mary Griffiths): 'literary friends' frequented Hutton's house during Vignoles's time there. Cf. Catherine Hutton, *Reminiscences of a Gentlewoman of the Last Century*, Birmingham 1891, p. 178: at his home in Bedford Row Hutton 'was constantly visited by an extensive circle of friends'.

Observatory in 1773.)[99] Already in 1802, a printed appreciation of Hutton had styled his library as one of the best mathematical libraries ever assembled in Britain.[100]

The exact sequence of events leading up to the library's dispersal is unclear. It appears that Hutton determined to dispose of his library during late 1815. Statements were made in print that he intended to retire into the country;[101] a later account had it that Hutton 'by reason of his advanced age, formed a determination to relinquish the habits of a student and the active pursuits of an author'.[102]

Our only detailed account of what happened next is from the pen of Olinthus Gregory, Hutton's protégé and supporter, who was writing in a polemical context shortly after the death of Joseph Banks, with whom Hutton had fallen out long before. He stated that Hutton formed the wish to sell his library to the British Museum, and that the trustees of that institution responded positively. He proposed to abide by a valuation decided upon by one representative from each party; the Museum appointed an officer to inventory the books, who reported favourably. Hutton then wrote to Banks, who was one of the trustees, in Lincolnshire, 'fearing he might take offence if not apprized of what was going on [...] and to express his hopes that the proposal would be approved'. There was, it was said, no reply, but within two weeks Banks was in London 'and busily employed among the other governors of the British Museum in dissuading them from the purchase'. Negotiations ceased.[103]

The outlines of this story find confirmation in Hutton's correspondence, where he wrote that his planned sale to the Museum had been 'cruelly prevented' by his 'old implacable enemy' Banks,[104] and even of Banks's 'triumph in disappointing me' in the matter.[105] But Hutton cannot be called an impartial observer of Banks's conduct any more than can Gregory, and I know of no other evidence that Banks continued to feel such animosity towards Hutton, three decades after their dispute at the Royal Society. It is at least possible that others at the Museum were involved in the decision not to take the mathematical books, or that the combination of mis-step and misunderstanding looked different to other eyes.

Once the sale to the Museum had fallen through, Hutton determined instead to sell the books at auction. I am at a loss to account for this decision: Hutton possessed a fairly sizeable personal fortune and cannot plausibly have needed the money. In private correspondence he stated that the library 'would prevent me from chusing [*sic*] another residence' and that 'I shall have little or no further use for it'; but in the event he neither moved from Bedford Row nor ceased to publish mathematical work, including new editions of his books and a new paper in the *Philosophical Transactions*. Hutton also stated with uncharacteristic harshness that the library 'could be

[99] London: UCL Library Services, Special Collections, MS Graves 23/3/5: Reuben Burrow to Charles Hutton, 24 September 1773, printed in Wardhaugh, *Correspondence*, letter 4.

[100] *Public Characters*, vol. 2, p. 112.

[101] Anon, *A Catalogue* (1816): title page; cf. 'Literary Intelligence', *The Literary Panorama* 4 (June 1816), p. 432.

[102] [Gregory], 'A review', p. 248.

[103] [Gregory], 'A review', p. 248 (no direct evidence of the independent inventory is known).

[104] Charles Hutton to John Bruce, first half of 1816; extract printed in Bruce, *Memoir*, pp. 32–3; also in Wardhaugh, *Correspondence*, letter 115.

[105] Charles Hutton to John Bruce, 22 March 1822; printed in Bruce, *Memoir*, pp. 39–42; also in Wardhaugh, *Correspondence*, letter 129.

of no use to any of my family, after my death':[106] but that still does not explain why its dispersal had to take place during his lifetime.

A manuscript catalogue, consisting of an alphabetical list of the books, was made by Hutton's daughter Isabella, listing 2,193 items in 3,315 volumes.[107] This was a draft, with poor bibliographic data in a number of cases, and underwent some revisions in Isabella's hand as well as some additions in Hutton's. Tick marks were added—presumably by Hutton—indicating items to be kept rather than sold. Many of the ticked items were non-mathematical ones, though the list was not in any event a complete list of the books Hutton had in his house: sheet music, for instance, is conspicuous by its absence, despite references in letters to pianos (plural) and music-making in the household; novels likewise are not listed in any quantity, though references in the correspondence indicate that both Hutton and his daughter read them.[108]

There is no evidence to show when this first catalogue was made. A fair copy was taken by Hutton himself in November 1815.[109] Now styled a 'Catalogue of Doctor Hutton's Mathematical Library', it quite consistently omitted the items ticked in the draft, although there were some second thoughts and some further revision of the list. This time there was no count made of the items (by my count there were 1,749).

Finally, and independently of the existing catalogues, Hutton's books were catalogued in print by the firm of Leigh and Sotheby. Copies of the printed catalogue were distributed nationally; the sale took place over six days from 11 June 1816, at the auctioneers' establishment on the Strand.[110] This final catalogue listed 1,841 lots of books: something of a reduction compared with the first manuscript catalogue, although since the books were now organized by day of sale and by physical format it is difficult to correlate or compare them in detail. Still, the number compared favourably with the 757 lots of Maskelyne's library sale in 1811 or the 1,421 of John Playfair's in 1819.[111] It is typical of the obscurity of the whole tale that there were sold with Hutton's books nine lots of mathematical instruments, described as formerly the property of Benjamin Franklin, including a theodolite, a microscope, a sextant, geometrical models, and two telescopes.[112] We have no other evidence of a direct connection between the two men (they had acquaintances in common in the Royal Society in the 1770s), and it seems impossible to say whether Hutton himself had actually owned Franklin's instruments during the more than forty years since the latter had left England.

After the sale, regret was expressed from more than one side, with the Literary and Philosophical Society in Newcastle stating that had it only known of the unfolding

[106] Charles Hutton to John Bruce, first half of 1816; extract printed in Bruce, *Memoir*, pp. 32–3; also in Wardhaugh, *Correspondence*, letter 115.

[107] Yale University: Lewis Walpole Library, LWL Mss Vol. 54, part 1.

[108] Portsmouth History Centre, Vignoles Papers, Letter 295 (C. B. Vignoles to Mary Vignoles, 4 August 1823), with a reference to 'one of the pianos'; Catherine Hutton, *Reminiscences*, pp. 182–3 (letter to Isabella Hutton, 6 November 1822).

[109] Yale University: Lewis Walpole Library, LWL Mss Vol. 54, part 2.

[110] Anon., *A Catalogue* (1816), title page.

[111] Christa Jungnickel and Russell McCormmach, *Cavendish: The Experimental Life*, 2nd edn, s.l., 1999, p. 323.

[112] Anon, *Catalogue* (1816), p. 80.

situation, it would have stepped in and purchased the library complete.[113] In fact, it was able to secure only a few volumes. It seems certain that other friends and colleagues attended the sale, too.

In fact, the sale of printed books was the most visible but not the only and perhaps not even numerically the largest dispersal of material from Hutton's library, if manuscript materials are taken into account. Just fifteen manuscripts were sold in 1816, including items which may have been Hutton's own work such as 'Experiments on Gunnery' as well as others such as copies of works by Euclid and by Flamsteed. A huge quantity of manuscript material, as well as many printed books, was evidently dispersed by other routes.[114]

The evidence for this is patchy. Some items were certainly destroyed in accidents during Hutton's lifetime. These included his manuscript lectures on natural philosophy and some of his experimental equipment, the latter succumbing to a fire at the RMA in 1802.[115] Notes for an enlarged treatise on bridges was also apparently lost,[116] and there is no trace of the calculations and map relating to his work on Schiehallion: frustratingly so, since the map appears to have been the first to have included lines of equal height, qualifying Hutton as the inventor of contour lines in that sense.[117] It is quite possible that some manuscript material was left behind at the RMA on Hutton's retirement, where it was subsequently affected by another fire. By contract he was required to return to the Stationers' Company relevant papers when he ceased to compile almanacs in 1818, but the Company's archive does not in fact seem to contain more than a few isolated documents relating to Hutton's long period of work.

Hutton had a reputation for methodical habits, and some of the surviving letters and manuscripts do possess numbers or labels added in his later life: but it is clear in fact that he treated some manuscripts carelessly. In two cases, printed books were sold which had letters (from Maskelyne and from the bishop of Clonfert) pasted into them.[118] Two letters, according to later endorsements, found their way into the archives of third parties.[119] Hutton also had the habit of cutting up manuscript sheets—particularly of calculations, but in at least one case a letter was affected—in order to reuse their reverses.[120]

A group of manuscripts including material on gunnery was given to his protégé Gregory in November 1818,[121] and the collection of pamphlets from Newcastle was

[113] Charles Hutton to John Bruce, 22 March 1822; printed in Bruce, *Memoir*, pp. 39–42; also in Wardhaugh, *Correspondence*, letter 129. Charles Hutton to John Bruce, 8 May 1817; printed in Bruce, *Memoir*, pp. 33–4; also in Wardhaugh, *Correspondence*, letter 116.

[114] Anon, *Catalogue* (1816), p. 79.

[115] Wardhaugh, *Correspondence*, p. xxviii.

[116] Anon, Obituary (1830), p. 190.

[117] K. Rann and R. S. Johnson, 'Chasing the line: Hutton's contribution to the invention of contours', in: *Journal of Maps* 15 (2019), pp. 48–56.

[118] Anon, *Catalogue* (1816), pp. 30, 70.

[119] Cambridge: University Library, RGO 35/92 (Nevil Maskelyne to Charles Hutton, 20 June 1796, 1797, or 1798); an endorsement states that this letter found its way into Waring's papers. London: Wellcome Collection, MS 5270 no. 70 (Patrick Kelly to Charles Hutton, 24 December 1821, fragment); this letter was endorsed later by Catherine Hutton and had probably come into her possession.

[120] Cambridge: Trinity College Library, R.1.59, fols. 52–63 are mostly written on cut-up sheets of calculations; fol. 56 is a fragmentary draft letter in French, possibly in Hutton's hand.

[121] London: the Royal Artillery Museum ('Firepower'), MS 913/5, item 551(1); MS 913/3; MS 913/1, item 1.

presented to Gregory after his death.[122] Gregory also acquired other manuscripts, including Hutton's calculations relating to the division of the quadrant, his selections from Archimedes and Pappus, and the treatment of the vibrating line by Maseres, as well as a pendulum. Gregory's books, in turn, were dispersed at auction after his death in 1842: the gunnery material remained at the RMA, but the other manuscripts of Hutton's were sold. They passed through the hands of Joseph Clinton Robertson (1788–1852), founder and editor of the *Mechanic's Magazine*, and of J. S. Davies, a mathematical master at the RMA. He left them to his son Charles Butler Davies, a fellow of Trinity College, Cambridge, and the volume of Hutton's manuscripts was given to his college in 1873 (where it remains).[123] This trajectory may be typical of the complex paths of individual items; it is exceptional in being fully documented. Charles Babbage also acquired some of Hutton's books, perhaps indirectly, and they are now in the Crawford Collection at the Royal Observatory in Edinburgh.[124] Similarly, Augustus De Morgan acquired several printed and manuscript items of Hutton's from Gregory's sale and at other public sales, including a manuscript translation from Tartaglia, and these remain in the Senate House Library in London.[125]

In April 1835, the London scientific bookseller John Weale issued a catalogue indicating that he had made substantial acquisitions from the libraries of Maskelyne, Horsley, and Hutton (as well as William Phillips and Richard Heber).[126] It is impossible to make any surmise about those books in his catalogue for which provenance is not specifically given, but of the more than 1,000 volumes listed, sixteen are specifically identified as having been Hutton's.[127] Where these books had been during the twelve years since Hutton's death, or the twenty years since the sale of his library, we do not know.

What was not sold or dispersed during Hutton's lifetime passed to his descendants. His will left virtually everything to his eldest daughter Isabella, and family letters show that what she received included a large number of books. Five hundred copies of Hutton's 1812 *Tracts* are mentioned: some were given away or sold individually;

[122] Anon, *Catalogue* (1842), p. 9.

[123] Cambridge: Trinity College Library, MS R.1.59: 4th initial unfoliated leaf, r, and bookplate.

[124] Eric G. Forbes, 'Collections II: The Crawford Collection of Books and Manuscripts on the History of Astronomy, Mathematics, etc., at the Royal Observatory, Edinburgh', in: *British Journal for the History of Science* 6 (1973), pp. 459–61 at p. 459.

[125] London: Senate House Library, MS 235 (translation from Tartaglia by Charles Hutton), librarian's annotation on fol. 1r; MS 913B/3/1 (xiv) (letter of John Playfair to Charles Hutton, 12 December 1782), endorsement on fol. 2^{v}; MS 913B/3/1 (xv) (letter of John Leslie to Charles Hutton, 14 October 1795), endorsement on fol. 2^{v}. See also Karen Attar, 'Augustus De Morgan (1806–1871), his Reading, and his Library', in: Mary Hammond (ed.), *The Edinburgh History of Reading: Modern Readers*, Edinburgh: Edinburgh University Press 2020, pp. 62–82.

[126] John Weale, *A catalogue of Books, on the Sciences: Astronomy, Mathematics, Natural Philosophy, &c; With some added that are curious and miscellaneous; chiefly from the libraries of Rev. Nevile Maskelyne, D.D., Astron. Royal and F.R.S.; Bishop Horsley, F.R.S., &c.; Dr. Charles Hutton, LL.D. F.R.S., &c.; William Phillips, F.R.L. and G.SS.; and Richard Heber, esq. On Sale, By John Weale, (Scientific and Architectural Bookseller, 59, High Holborn, London.)*, [London] 1835.

[127] There were works by Apollonius, d'Alembert, d'Auvergne, Gautier, Guarini, Heron, Descartes, Borelli, Huygens, Kiel, Maupertuis, Fine, Ptolemy, Porphyry, Sacrobosco, Euclid, Saul, Michell, Templehof, Ferguson, Simson, Voltaire, and Young: some were bound together.

most were sold in bulk in 1830.[128] There was also an unknown number of copies of his treatise on bridges,[129] and at least a few copies of his other works. Some family papers remained with the archive of his grandson Charles Blacker Vignoles, now at the Portsmouth Library and Archive; some personal items including a journal—seen by Gregory in 1823—appear to have vanished.[130] Vignoles mentioned an 'accident',[131] but deliberate pruning is also possible. The fate of what must have been a large collection of mathematical letters is particularly obscure: only fifty-seven letters addressed to Hutton have been located to date.

Today, Hutton's books and papers are scattered over more than two dozen archives, with none holding more than a few volumes: the largest group appears to be the seven books held by the Senate House Library. Some are certainly in private hands;[132] many may have been destroyed.

The dispersal of Hutton's library and papers—a doleful tale of destruction, gift (sometimes disorganized), and sale—is an apt if an imperfect metaphor for the destiny of the mathematical culture it in many ways reflected.

British mathematics in Hutton's lifetime was to all appearances succeeding in its own terms, and there seems nothing feigned about the pride and enthusiasm expressed by Hutton and his colleagues; in a letter to Hutton, Maskelyne wrote of the achievements of 'Lyons, Emerson, Landen, Waring; the last of whom is [...] the author of some of the greatest discoveries in Algebra; algebraic curved lines, infinite series, increments and fluxions'.[133] This was a dynamic, active, and creative mathematical world, whose work seemed important and worthwhile to its authors and readers. The *Nautical Almanac*, for instance, was no trivial innovation in what mathematics could do or how it could do it; it was no trivial innovation in the fields of the organization of calculation or the large-scale printing of accurate mathematical tables. New proofs of the binomial theorem and new results about the convergence of series; new methods for the calculation of trigonometric ratios; and, of course, practical outcomes such as improvements in artillery or the determination of the density of the earth: all of these were the proud achievements of a culture that felt no need to apologise for itself.

Compared with Continental methods, partisans of British mathematics could point to the important role it gave to physical analogy and to geometrical and physical intuition.[134] In their view 'in point of intellectual conviction and certainty, the

[128] London: British Library, MS Add. 58,203 (Diary of C. B. Vignoles, 1824), 15r (week of 15 March); MS Facsimile *920 (1–3), 514 (27 December 1830); Portsmouth History Centre, Vignoles Papers, Letter 514.

[129] Portsmouth History Centre, Vignoles Papers, Letter 526; London: British Library, MS Facsimile *920 (1–3), 526 (21 July 1821).

[130] Gregory, 'Memoir', pp. 220, 221; Mackenzie, *Newcastle-upon-Tyne*, p. 560.

[131] Portsmouth History Centre, Vignoles Papers, Letter 751 (C. B. Vignoles to the Marquis of Northampton, 25 March 1841); London: University College archives, MS Galton 2/4/1/2/9 (C. B. Vignoles to Francis Galton, 17 November 1865).

[132] Peter John Wallis, *Newcastle Mathematical Libraries*, pp. 12–13; a copy of the 1815 (second edition) *Dictionary* sold during 2019 contains a long letter to J. B. Wise (Raymond V. Giordano, pers. comm.).

[133] Cambridge: University Library, RGO 35/92 (Nevil Maskelyne to Charles Hutton, 20 June 1796, 1797, or 1798), 2.

[134] Niccolò Guicciardini, 'Dot-Age: Newton's Mathematical Legacy in the Eighteenth Century', in: *Early Science and Medicine* 9/3 (2004), pp. 218–56 at p. 255; cf. Philip C. Enros, 'The Analytical Society

fluxional calculus is decidedly superior to the differential and integral calculus.'[135] The production of fluxional textbooks continued throughout the century and included the celebrated account by Maclaurin as well as works by Emerson and Simpson;[136] Hutton's own works regularly assumed familiarity with fluxional methods; his *Conics* contained a table of common fluxions and fluents for the use of students.[137]

Nevertheless, it could not escape the attention of a man as widely read as Hutton, nor of a culture as widely read as that of the Georgian mathematicians, that in Paris, Berlin, St Petersburg, and other Continental locations, things were done very differently. There, the status of original researchers in mathematical fields was high, and they enjoyed a protected leisure that had no equivalent for their British counterparts.[138] This small, privileged group had, over the decades, transformed the Leibnizian calculus into Eulerian analysis, stripping it of its geometrical roots.[139] The new methods were powerful but difficult, and it is hard to form an accurate estimate of how many British mathematicians at any given date would have been able to read the latest Continental research with full understanding. It is reported that by the 1770s Edward Waring at Cambridge 'found it virtually impossible' to follow Euler's 'use of partial differential equations and the calculus of variations to tackle problems in mechanics'.[140] Something like a language barrier came to exist, sustained by the belief of each side in the superiority of its methods as well as the understandable reluctance of teachers and expositors to introduce unfamiliar new notation to their students and readers.[141] Peter Barlow, for instance, in various works including encyclopaedia articles showed clear acquaintance with Continental works, but retained the language of fluxions.[142] Much the same was true of Hutton; a necessary feature of the activity of gatekeeper figures like him was that they translated into fluxional terms what could be so translated and left out what could not. The accounts of Continental figures in his *Dictionary*, for instance, often conspicuously lack technical details. I do not believe that that lack reflected incapacity on the part of Hutton to read and understand at least a good proportion of their work; it did reflect the deficiencies of the mathematical

(1812–1813): Precursor of the Renewal of Cambridge Mathematics', in: *Historia Mathematica* 10 (1983), pp. 24–47 at p. 38.

[135] Guicciardini, *Development*, p. 113, citing Gregory in the preface to the 1836–7 edition of Hutton's *Course*.

[136] Colin Maclaurin, *A Treatise of Fluxions: In Two Books*, Edinburgh 1742; Thomas Simpson, *The Doctrine and Application of Fluxions: Containing (besides what is common on the subject) a number of new improvements in the theory: and The Solution of a Variety of New, and very Interesting, Problems in different Branches of the Mathematicks*. Part I, London: Printed for J. Nourse 1750; William Emerson, *The Doctrine of Fluxions: not only explaining the elements thereof, but also its application and use in the several parts of mathematics and natural philosophy*, London: Printed for J. Richardson 1757.

[137] Charles Hutton, *Elements of Conic Sections: with select exercises in various branches of mathematics and philosophy. For the use of the Royal Military Academy at Woolwich*, London: Printed for J. Davis 1787, p. 171.

[138] Guicciardini, 'Dot-Age', p. 252; Enros, 'The Analytical Society', p. 41, quoting a letter of Herschel to Bromhead of 19 November 1813; Warwick, *Masters of Theory*, p. 35; also Jeremy Gray, 'Overstating their Case? Reflections on British Mathematics in the Nineteenth Century', in: *Bulletin of the British Society for the History of Mathematics* 21 (2006), pp. 178–85.

[139] Guicciardini, 'Dot-Age', p. 241; see Warwick, *Masters of Theory*, p. 34.

[140] Warwick, *Masters of Theory*, p. 34; cf. Guicciardini, 'Dot-Age', p. 246.

[141] Warwick, *Masters of Theory*, p. 75: Guicciardini, *Development*, p. 108; David Philip Miller, 'The Revival of the Physical Sciences in Britain, 1815–1840', in: *Osiris* 2 (1986), pp. 107–34 at p. 109.

[142] Guicciardini, *Development*, p. 113.

language in which he felt constrained to write, and probably the deficiencies in understanding he imputed to those for whom he was writing. For periods between the 1770s and the 1810s, too, France in particular was a hostile country, and the French associations of analysis did something to discourage British mathematicians from its use: in 1815 the patriotism of Robert Woodhouse was questioned because of his use of the French mathematical notation.[143] For all these reasons, it remained possible into the 1820s to become senior wrangler with little or no facility in Continental mathematical methods.

It has been clearly documented, though it probably bears repeating, that none of this means that British mathematical culture was in its 'dot-age' or that there was anything self-evidently wrong with it. Its practitioners show no sense of feeling that they were working in a field that had been exhausted or that their location—physical or intellectual—was a backwater. Very substantial numbers of Continental books were coming into Britain, and if they needed to be digested and translated before they could be presented beyond a narrow circle of specialists, no one during the years from mid-century up to the 1790s seems to have judged that that was a problematic state of affairs. British mathematicians did not feel—and had no very obvious reason to feel—they were cut off from the mainspring of mathematics.

Around 1800, however, things changed. A few whispers could be heard in the late 1790s: Woodhouse, reviewing the *Dictionary*, noted that Hutton had 'scarcely announced' the foreign method of analysis and hinted that a proper English work on the principles of fluxions was needed, as well as implying delicately that the English might be wrong not to take the Continental methods seriously.[144] But the watershed was the publication of Laplace's *Traité de mécanique céleste*, beginning in 1799. Early British reviews in 1799 and 1803 praised the work as an instance of French prowess but regretted its purely analytic character, its lack of diagrams. Suggesting a need for geometrical interpretation, they spoke to the existence of a language barrier which made the work less than perfectly comprehensible even to the best British mathematicians.[145] Woodhouse, reviewing it for the *Monthly Review*, judged it necessary to transliterate the word 'differentiation' and explain that it meant 'putting an equation or expression in fluxions'.[146] And in January 1808 Playfair, in what has become a much-quoted passage, wrote in the *Edinburgh Review* that

> a man may be perfectly acquainted with every thing on mathematical learning that has been written in this country, and may yet find himself stopped at the first page of the works of Euler or D'Alembert. He will be stopped, not from the difference of the

[143] Anon., 'Mr. Woodhouse on the rectification of the hyperbola', in: *Gentleman's Magazine* 85 (1815), pp. 18–22 at pp. 18–19, quoted in Harvey Becher, 'Radicals, Whigs, and Conservatives: The Middle and Lower Classes in the Analytical Revolution at Cambridge in the Age of Aristocracy', in: *British Journal for the History of Science* 28 (1995), pp. 405–26 at p. 410; cf. Warwick, *Masters of Theory*, p. 67.

[144] Anon., [Review of Hutton, *Dictionary*], in: *The Monthly Review* (1798), pp. 184–201, pp. 364–83 at pp. 193, 194–5; see also Howson, *History of Mathematics Education*, p. 232.

[145] Jonathan R. Topham, 'Science, Print, and Crossing Borders: importing French science books into Britain, 1789–1815', in: *Geographies of Nineteenth-Century Science*, ed. David N. Livingstone and Charles Withers, Chicago: University of Chicago Press 2011, pp. 311–44 at p. 326.

[146] Topham, 'Science, Print, and Crossing Borders', p. 326; for the attribution see B. C. Nangle, *The Monthly Review, Second Series, 1790–1815: indexes of contributors and articles*, Oxford: Clarendon Press 1955, vol. 2, p. 74; also Craik, 'Mathematical Analysis', p. 243.

> fluxionary notation, (a difficulty easily overcome), nor from the obscurity of these authors, who are both very clear writers, especially the first of them, but from want of knowing the principles and the methods which they take for granted as known to every mathematical reader. If we come to works of still greater difficulty, such as the *Méchanique Céleste*, we will venture to say, that the number of those in this island, who can read that work with any tolerable facility, is small indeed. If we reckon two or three in London and the military schools in its vicinity, the same number at each of the two English Universities, and perhaps four in Scotland, we shall not hardly exceed a dozen; and yet we are fully persuaded that our reckoning is beyond the truth.[147]

Playfair had been active as a promoter and improver of Hutton's own work on the density of the earth and air resistance, and was no enemy to British mathematics in general. His critique—and the blame he gave to the English universities and the Royal Society—weighed the heavier as a result. There followed a wave of criticism, in which the virtues of British mathematics were re-read as vices.[148] Thus it was now 'unnatural' to found the calculus on motion or velocity, which applied properly only to dynamics.[149] The fluxional notation, it was said, had been preserved merely out of sentimental attachment to the work of Newton.[150] The diversity of versions of 'Newtonianism' was itself no longer a sign of richness but of fragmentation.[151] The high technical standard of the Cambridge examinations denoted sterility, and the gradual improvements and discoveries of the philomaths were 'trifling':

> A mathematical production, above the level of school-practitioners, finds little encouragement in this country; to enable a book to sell, it must be trifling; it must reduce all rules to mere mechanical operations; it must in fact be suited to the taste of solvers of problems, and not to investigators: – we have more of the former class, and fewer of the latter, than any empire in Europe.[152]

John Toplis, Herschel, and even Gregory also took to the press with accounts of the 'decline' of mathematics in Britain.[153] Babbage in 1830 was still lamenting at book length 'the decline of science in England'.[154]

[147] John Playfair, '*Traité de Méchanique Céleste* [review]', in: *The Edinburgh Review* 11 (1808), pp. 249–84 at p. 281. See also Amy Ackerberg-Hastings, 'John Playfair on British Decline in Mathematics', in: *Bulletin of the British Journal for the History of Mathematics* 23 (2008), pp. 81–95.

[148] See Topham, 'Science, Print, and Crossing Borders', p. 328 on Herschel's review of translations of the *Mecanique Céleste*.

[149] Florian Cajori, 'Discussion of Fluxions: from Berkeley to Woodhouse', in: *The American Mathematical Monthly* 24 (1917), pp. 145–54 at p. 154.

[150] Craik, 'Mathematical Analysis', p. 264; Robert Woodhouse, [Review of Lagrange, *Theorie des fonctions*], in: *The Monthly Review* 28 (1799), pp. 481–99 at p. 487.

[151] See Guicciardini, 'Dot-Age', pp. 219, 223.

[152] Anon., 'Lagrange's "A Treatise upon Analytical Mechanics…"', in: *The Monthly Review or Literary Journal* 78 (October 1815), pp. 211–13; see Craik, 'Mathematical Analysis', p. 243.

[153] John Toplis, 'On the Decline of Mathematical Studies, and the Sciences dependent upon them', in: *Philosophical Magazine* 20 (1805), pp. 25–31; Olinthus Gregory, *A Treatise of Mechanics*, London 1806, vol. 1, preface; J. F. W. Herschel, *Memoir of Francis Baily, Esq*., London 1845.

[154] Charles Babbage, *Reflections on the Decline of Science in England, and on Some of its Causes*, London 1830.

Several of those who wrote in this vein had—unlike Playfair—personal axes to grind. Some were younger mathematicians keen to show that they were more up to date than their older predecessors. Some, like Gregory, were enemies of Banks and wished to blame or at least embarrass him and the Royal Society;[155] others bore grudges against the universities.[156] Others again blamed the circle around Hutton for its now long-lived failure to cooperate with the Royal Society.[157] The rhetoric of the short-lived Analytical Society based at Cambridge was particularly exaggerated and self-serving.[158] Yet the judgement of these critics took hold, and the identification of a 'dot-age' in British mathematics has persisted to the present day.

The positive outcomes have been well documented. A wave of importation and translation of Continental books took place during the first two decades of the nineteenth century, introducing the differential notation to British mathematicians. A translation of Sadi Carnot's *Réflections* appeared in the *Philosophical Magazine* in 1800–01 using differential notation, even though its translator preferred fluxions;[159] John Colson and John Hellins translated Maria Gaetana Agnesi's textbook in 1802.[160] Gregory kept up with the works of Gaspard Monge, Jean Nicolas Pierre Hachette, and Claude-Louis Navier; his 1806 *Treatise of Mechanics* and 1807 translation of René Just Haüy's *Traité élémentaire de physique* were outcomes.[161] Toplis in 1814 published Book 1 of the *Méchanique céleste* as *A Treatise upon analytical mechanics*.[162] The Analytical Society completed a translation of Silvestre François Lacroix's calculus textbook in 1816, with a further volume in 1820.[163] Cambridge tutors meanwhile mastered the Continental notation and began to teach it.[164]

Periodicals and reference works became an important venue for the new mathematics. The fourth (1801–10) edition of the *Encyclopaedia Britannica* introduced much Continental mathematics, and William Wallace's article on 'Fluxions' for the Edinburgh *Encyclopedia* of 1815 was the first complete account of the calculus in English to use Continental notation.[165] The *Philosophical Transactions* carried three of James Ivory's papers on topics related to the *Mécanique céleste* between 1809 and 1812.[166] From 1806 the new series of the *Mathematical Repository*, edited by

[155] David Philip Miller, 'Between Hostile Camps: Sir Humphry Davy's presidency of the Royal Society of London, 1820–1827', in: *British Journal for the History of Science* 16 (1983), pp. 1–47.

[156] Gascoigne, Cambridge in the *A*ge of the Enlightenment, p. 6; Miller, 'The Revival', p. 108.

[157] David Philip Miller, 'Sir Joseph Banks: An Historiographical Perspective', in: *History of Science* 19 (1981), pp. 284–92 at p. 289.

[158] Elizabeth Garber, 'On the Margins: Experimental Philosophy and Mathematics in Britain, 1790–1830'. in: *The Language of Physics: The Calculus and the Development of Theoretical Physics in Europe, 1750–1914*, Boston: Birkhäuser 1999, pp. 169–206 at p. 191.

[159] Guicciardini, *The Development*, p. 119.

[160] W. Johnson, 'Contributors to Improving the Teaching of Calculus in Early 19th-Century England', in: *Notes and Records of the Royal Society of London* 49 (1995), pp. 93–103 at p. 99.

[161] Albree and Brown, 'A Valuable Monument', p. 26; Ivor Grattan-Guinness, *Convolutions in French Mathematics, 1800–1840: From the Calculus and Mechanics to Mathematical Analysis and Mathematical Physics*, Basel: Birkhäuser 1990, pp. 437–8; cf. the letter of John Gough published in *The Mathematical Repository* 2 (1809), p. 7; Guicciardini, The Development, p. 113.

[162] Craik, 'Mathematical Analysis', p. 272.

[163] Warwick, *Masters of Theory*, p. 68.

[164] Warwick, *Masters of Theory*, p. 49; also Alex D. D. Craik, *Mr Hopkins' Men: Cambridge Reform and British Mathematics in the Nineteenth Century*, London: Springer-Verlag 2007.

[165] Guicciardini, *Development*, p. 120; Craik, 'Mathematical Analysis', pp. 242, 249.

[166] Maurice Crosland and Crosbie Smith, 'The Transmission of Physics from France to Britain: 1800–1840', in: *Historical Studies in the Physical Sciences* 9 (1978), pp. 1–61, p. 17.

Thomas Leybourne of the RMC, became a particularly important site for translations of shorter pieces of Continental mathematics as well as announcements of recent works available in Britain.[167] The teachers of the RMA and RMC were highly visible in its pages, and its contents included extracts from Lagrange, Legendre, and Euler; differential and integral notation were used.[168] Although the first volume of the *Repository*'s first series, in 1795, had been dedicated to Hutton (and gave more than a hint of being the mathematical rival to the *Philosophical Transactions* Hutton had once wished for),[169] the publication had now become one in which he and his style of mathematics were scarcely at home.

In the end, British mathematicians adopted Continental notation and methods wholesale, and formed a new set of research agendas influenced, though not dictated, by what they found in imported Continental works. The details varied in different locations.[170] In the Scottish universities, and at Sandhurst, Laplacian astronomy was taken up as a research interest, though teaching changed little. At Dublin, teaching reform centred on applied topics including Lagrange's work;[171] at Cambridge the focus was more on pure mathematics and algebra. Indeed, at Cambridge the teaching reform initially failed, but during the 1820s the foundation of the Classical Tripos and the solidification of a mathematical Tripos provided an occasion for a new start.[172] In respect of research at Cambridge, the Analytical Society was not the beginning of French mathematics or French notation in Britain (as they and others sometimes later claimed), but instead reinforced the acceptance of Lagrange's calculus and began a focus on the calculus of operators and functional equations, which lasted until the days of Arthur Cayley and George Boole.[173] Arguably this involved only a limited appreciation of Augustin-Louis Cauchy's rigorization of calculus, and thus paradoxically left British mathematicians once again somewhat isolated.[174]

Metropolitan mathematical practitioners were on the whole somewhat later adopters of these novelties; as late as 1816, Barlow could criticize Herschel and Babbage as too fond of 'a sort of parade' common in France which made 'a great display of intricate and almost unintelligible formulae, without the least consideration of their application to any purpose of real utility'.[175] But the RMA and the other military academies were by then following French engineering work; and pure topics such as Legendre's elliptic integrals and Lagrange's algebraic foundation of calculus

[167] *Mathematical Repository* 2 (1809), p. 64 and 3 (1814), p. 51: lists of foreign works. See also Brigitte Stenhouse, 'Mary Somerville's Early Contributions to the Circulation of Differential Calculus', in: *Historia Mathematica* 51 (2020), pp. 1–25, and for developments in the *Ladies' Diary* Albree and Brown, p. 27.

[168] Guicciardini, *Development*, pp. 108, 117.

[169] *Mathematical Repository* 1 (1795; 2nd edn 1799), pp. iii, iv; cf. Wardhaugh, *Gunpowder and Geometry*, pp. 120–1.

[170] Guicciardini, *Development*, p. 141.

[171] Maria Panteki, 'William Wallace and the Introduction of Continental Calculus to Britain: A Letter to George Peacock', in: *Historia Mathematica* 14 (1987), pp. 119–32, p. 124; Guicciardini, *Development*, pp. 132–3.

[172] Warwick, *Masters of Theory*, pp. 67, 76; cf. Johnson, 'Contributors', p. 96; Enros, 'The Analytical Society', pp. 24, 26; Guicciardini, *Development*, p. 135.

[173] Guicciardini, *Development*, p. 136.

[174] Guicciardini, *Development*, p. 138.

[175] David Philip Miller, 'The Royal Society of London 1800–1835: A Study in the Cultural Politics of Scientific Organization', PhD thesis, University of Pennsylvania 1981, p. 119, citing a review by Herschel in *The Monthly Review* 81 (1816), p. 393.

were being assimilated by a roll call of teachers including Wallace, Ivory, Hellins, John Brinkley, Woodhouse, Bonnycastle, and William Spence.[176]

In 1840 the use of Hutton's *Course* was discontinued at the RMA.[177] The last textbooks of fluxions to be reprinted were those of William Dealtry in 1816 and Vince in 1818.[178] There thus came to be a generation of British mathematicians who never learned fluxions, but acquired analysis directly from French works: to whom, therefore, older British works were inaccessible. Arguably, it would take the foundation of the Astronomical Society in 1820 and the London Mathematical Society in 1865 to bring the process of professionalizing British mathematics to anything near completion. But by then Georgian mathematics and its culture were, like Hutton's library, quite gone.

[176] Guicciardini, *Development*, p. 135.
[177] Jones, *Records*, p. 102; cf. Panteki, 'William Wallace', p. 124; Crosland and Smith, 'The Transmission of Physics', p. 18.
[178] Craik, 'Mathematical Analysis' p. 240.