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MARY SOMERVILLE (1780–1872), mathematician and writer. Portait by Thomas Phillips (1834).

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The Scottish mathematician and writer shaped the way we think about science and carved a place for herself in the intellectual world of the 19th century.

In 1834 mathematician and author Mary Somerville published *On the Connexion of the Physical Sciences*, a work that was instrumental in the making of modern physics as a discipline. Contemporaries praised the book's clear and lucid survey of astronomy, experimental physics, and chemistry, and it became a classic of Victorian scientific writing. But *Connexion* also posed key questions for a rapidly expanding and largely male-dominated world at a moment of intense intellectual ferment. Could women excel at science? Were the scientific writings of a woman inherently different from those of a man? "Notwithstanding all the dreams of theorists," wrote Cambridge philosopher William Whewell in his review of *Connexion*, "there is a sex in minds"—in other words, Whewell felt that Somerville's sex would always set her writings apart from those of her male contemporaries.[1]

During her long life, Somerville occupied an important place in the physical sciences. Her books brought readers up to date with subjects ranging from astronomy and anthropology to microscopy and geology. She introduced the English-speaking world to Pierre Simon Laplace's celestial mechanics, wrote an outstanding survey of physical geography, and elucidated the common bonds between the sciences at a time when they were being carved up into distinct disciplines. More recently she featured in Mike Leigh's 2014 feature film *Mr. Turner*, which depicts Somerville (brilliantly played by Lesley Manville) taking a prism and a hammer from her handbag to demonstrate an experiment about light. In October she appeared on the new £10 note of the Royal Bank of Scotland (see the box on page 48), an honor she controversially won against such candidates as physicist James Clerk Maxwell.

Yet Somerville remains an enigmatic figure. In contrast with her friend Ada Lovelace, celebrated through her association with Charles Babbage's calculating engines, Somerville seems to have had an implausibly placid life, without crises or tensions. This is undoubtedly because of the continuing

influence of her autobiography, which eschewed any reference to private feelings. But when viewed critically, Somerville's restrained stories of early struggles and eventual success can be used to open up questions about her life and work. To begin with, how did the opportunities available to a gentleman's daughter in Scotland during the final decades of the 18th century contain the possibility of becoming a celebrated mathematician and author?

The divine spark

Somerville believed in family and belonged to a well-connected one. She was born Mary Fairfax on 26 December 1780 in Jedburgh in the Scottish Borders. Her mother, Martha Charters Fairfax, was descended from the most distinguished families in the country. Her father, William George Fairfax, received national recognition for his commanding role in the pivotal naval battle of Camperdown but none of the usual financial rewards associated with such a victory. The family thus had considerable social status but no income other than a military salary.[2]

Young Mary grew up in the seaport town of Burntisland in Scotland, where she was allowed to run wild for the first 10 years of her life. Her father, returning from a long voyage, was alarmed that she had failed to master the skills of reading, writing, and account-keeping that would make her a suitable wife, and he sent her to a boarding school for a year. She also took further lessons in dancing, painting, cookery, music, needlework, and elementary geography—all the accomplishments deemed suitable for a young lady of her station.

In determined hands—and Mary Fairfax was determined—those activities held the possibility of substantial opportunities for learning. For example, she first learned of the existence of algebra by seeing a problem in a fashion magazine. Once she wanted to learn more, teachers and tutors were available to encourage her and provide books, even though study beyond the basics had to be carried out independently and in secret. Although her mother feared she would go mad or become a bluestocking, others in her life saw her as lively, intelligent, and eager to excel.

In 1804, at age 23, Mary Fairfax married her cousin, naval commissioner Samuel Greig, and the couple set up house in London. Her later recollections of the marriage were unhappy; lonely, with few opportunities to meet friends, Mary Greig received no encouragement in following mathematics, languages, and other studies.

When Greig unexpectedly died in 1807, Mrs. Greig was in a very different position from the one that Miss Fairfax had been in three years before. When she returned to Scotland, she settled into a determined program of mathematical studies and

Was Mary Somerville a scientist?

Mary Somerville's iconic status is often summed up by stating that William Whewell, in his review of her book *On the Connexion of the Physical Sciences*, hailed her as the first "scientist." But almost exactly the opposite was the case. Nowhere did Whewell or anyone else in her lifetime ever call Somerville a scientist, nor is it a word, so far as we know, that she ever used herself. By our current understanding of the term, Somerville can certainly be called a scientist, but for her contemporaries she belonged to a higher and more profound category entirely.

To understand that, we need to see why Whewell invented the word in the first place. At the meeting of the British Association for the Advancement of Science in Cambridge in 1833, poet Samuel Taylor Coleridge had argued that men of science, concerned with mechanical invention and laboratory experiments, were unjustly claiming a higher calling by referring to themselves as "natural philosophers."

Whewell agreed. He replied at the meeting by proposing "scientist," a word formed on the same basis as "artist." The word "scientist," as Whewell well knew, was an unconventional coinage with Greek and Latin roots, a combination potentially offensive to those with a classical education. The term was invented not because of the increasing authority for the role, as has always been assumed, but as a way of maintaining the higher claims of philosophy, which Whewell, like Coleridge, saw as his own true vocation. In publicizing his coinage, he could not resist making analogies with "journalist," "atheist," and "tobacconist," roles scarcely to be emulated in class-conscious Victorian Britain.

ROYAL BANK OF SCOTLAND

Although its utilitarian associations and character as a putdown meant that "scientist" did not catch on in Britain, the word gradually became popular in the more practical climate of the US. The word was reimported in the final decades of the 19th century, although considerable opposition remained: Thomas Henry Huxley quipped that "'scientist' must be about as pleasing a word as 'electrocution.'" [18] The word remained controversial in Britain well into the 20th century.

Whewell did put the term "scientist" into print for the first time in his review of *Connexion*, but he did not apply the word to Somerville herself. In his view, she belonged to a more praiseworthy category. Whewell believed that in the rare circumstance when a woman wrote from deep knowledge, she could do so not with a concern for grubby industrial utility but with lucid metaphysical clarity. Female authorship offered the possibility of direct insight into the laws of nature. His review of *Connexion* quoted from poet John Milton:

> In regions mild, of calm and serene air,
> Above the smoke and stir of this dim spot
> Which men call earth.

In Whewell's view, the precision of language and structure in Somerville's works had everything to do with their authorship by a woman. If men were active, prone to confusing practice and theory, women were above the fray, giving their reasoning clarity and transparency. By those criteria, Somerville was not a scientist, but instead possessed the superior "talents of a philosopher and a writer."[1]

became acquainted with the leading intellectual lights of Edinburgh, particularly astronomer John Playfair, who is today best known as the expositor of James Hutton's pioneering geological theories. Playfair's circle had liberal ideas about the position of women and education in a commercial society that fit well with the young widow's own. Such men saw the widespread encouragement of learning as one way in which the higher classes could reassert their authority to govern the nation. A virtuous widow with an evident taste for science offered an unusual opportunity to display their precepts in action.

Mary Greig soon began to participate in the informal social networks that were characteristic of late Georgian mathematics. Reformers such as Playfair used those networks to encourage existing mathematicians and bring new ones into the fold. In 18th-century England, mathematical publication had typically been in general-interest periodicals such as the *Lady's Diary* and the *Gentleman's Diary*, and involved challenge problems and their solution. By the early 19th century, the reformers had started a new journal, *New Series of the Mathematical Repository*, also devoted to challenge problems but without the miscellaneous information that would also have been found in the older journals.

In 1811 Mary Greig was delighted to learn that she had won the prize question from the *Repository*'s 1810 issue. The problem she had solved was a Diophantine problem with three variables, which required a good knowledge of higher algebra. Her winning solution was characterized by elegance and clarity, qualities that she carried into everything she did. It won her a silver medal with her name engraved on it and also led to her first publication.[3]

Winning a prize medal and having her work published represented a vindication of the unusual path that Mary Greig had been following. Her passion for mathematics, however, went beyond a simple need for recognition. It was in mathematics that she felt most intensely alive and completely herself. Family and friends noted how she would become oblivious to the outside world when engaged in solving problems. Mathematics thus offered a way to ignore, even momentarily, the manifold pressures of domestic responsibility. She became skilled at managing her schedule so that children and visitors could interrupt her work only during certain parts of the day. In later life she developed a settled pattern of spending the entire morning in bed, which gave her a secure time for writing her books.

For Somerville, as for Isaac Newton and Maxwell, the practice of mathematics was also a form of theological engagement. She had been brought up in the stern traditions of Scottish Presbyterianism, with its stress on original sin and damnation, but she rebelled against it at an early age. For Somerville, the divine transcendence of God's power could most fully be experienced by those who, like herself, understood the language of mathematics. As she expressed it in *Connexion*:

> These formulae, emblematic of Omniscience, condense into a few symbols the immutable laws of the universe. This mighty instrument of human power itself originates in the primitive constitution of the human mind, and rests upon a few fundamental axioms which have eternally existed in Him who implanted them in the breast of man when He created him after His own image.[4]

FIGURE 1. *MARY SOMERVILLE (1780–1872), AS A YOUNG WOMAN,* John Jackson. (© Somerville College. Courtesy of the Principal and Fellows of Somerville College.)

It was that divine spark that Somerville had felt as a young girl when she first saw algebraic symbols in a fashion magazine, and it was that spark that some of those around her had attempted to stamp out. She never could find God in formal church attendance, but instead traced his hand in those "few fundamental axioms" that she discovered within herself. Her confidence in a divinely implanted harmony of understanding led her to believe in the right of women to achieve their full potential. Even as a child, she "thought it unjust that women should have been given a desire for knowledge if it were wrong to acquire it."[5]

"We are of the earth"

With a small independent fortune from her late husband's estate, the young widow was not only in a position to pursue mathematics, but she could also pick and choose among suitors; any who showed a tendency to deprecate female learning were quickly shown the door. The only person in her near family who actively supported her independence was her uncle, Thomas Somerville, and it was his 41-year-old son William whose proposal she accepted at the end of 1811.

It was a good match. Both held liberal views on politics, religion, and education. Both had strong scientific interests—William having done groundbreaking natural history and ethnological exploration in the Cape of Good Hope.[6] One early act of their married life was the purchase, with William's encouragement, of a selection of advanced (and very expensive) mathematical books. "I was thirty-three years of age when I bought

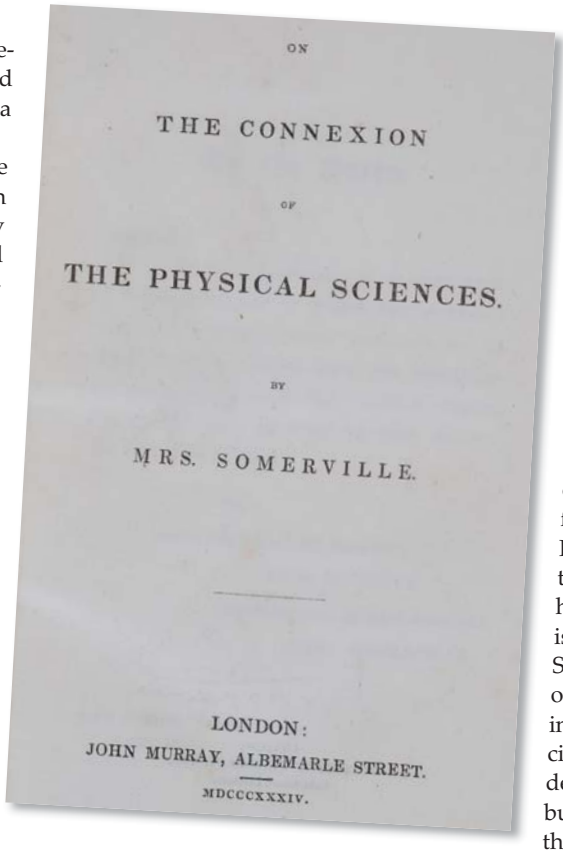
this excellent little library," Mary recalled at the end of her life, "I could hardly believe that I possessed such a treasure."[7]

After their wedding the couple moved first to Edinburgh and then in 1816 to London. In both cities they participated in a lively intellectual culture centered on informal gatherings that involved both men and women. They collected minerals, made observations, discussed new books, and welcomed visiting foreigners. "All kinds of scientific subjects were discussed," she recalled, "experiments tried and astronomical observations made in a little garden in front of the house."[8]

When William's army position was abolished after the Napoleonic Wars, he and Mary travelled to the Continent to save money while they waited for a new post to turn up; they were welcomed to similar gatherings in the best scientific circles of Paris and Geneva. The Somervilles were not aspiring amateurs, nor did they have the money to be potential patrons; rather, they were valued participants in a common enterprise. The scientific world did not necessarily place publication at the core of its activity, but it depended on other forms of communication, including correspondence, conversation, and connoisseurship. In mineralogy, for example, the couple focused their efforts on what all really serious practitioners considered as the science's core activity: They gathered a cabinet, an impressive collection of superb specimens given by friends and purchased on their travels.

In physics, Somerville (painted as a young woman in figure 1) began a series of experimental investigations. Working with advice from physicists William Wollaston and John Herschel in the long summer days of 1825, she carried out delicate experiments to show a connection between magnetism and sunlight. Like most experiments in British science at the time, these relied on simple materials readily at hand or borrowed from friends, rather than on an expensive, specially furnished laboratory.

William Somerville communicated the results of his wife's experiments to the Royal Society of London, just as he managed her other public affairs. Her paper was read on 2 February 1826 and published in the society's *Philosophical Transactions* soon afterwards.[9] To appear under her own name as an author was a big step; this was the first time a woman had ever published an experimental paper there. In the wake of Hans Christian Oersted's discovery of a connection between magnetism and electricity, the results announced in the paper were exciting: Somerville had found that prolonged exposure to sunlight induced magnetism in needles. The relationship between magnetism and light that Somerville proposed was widely discussed among European savants, and her experiments were successfully repeated. She was even awarded a government pension by Parliament, a financial honor reserved for those who contributed to knowledge.


ON

THE CONNEXION

OF

THE PHYSICAL SCIENCES.

BY

MRS. SOMERVILLE.

LONDON:
JOHN MURRAY, ALBEMARLE STREET.
MDCCCXXXIV.

FIGURE 2. TITLE PAGE OF *ON THE CONNEXION OF THE PHYSICAL SCIENCES*. (Courtesy of the Donald F. and Mildred Topp Othmer Library of Chemical History, Chemical Heritage Foundation.)

Yet three years later Peter Riess and Ludwig Moser in Berlin provided a convincing alternative explanation. Using a greater number of controls and a different method for measuring magnetic intensity, Riess and Moser found that even the supposedly crucial violet rays had no substantive effect on magnetism after many hours of exposure. Somerville's results, and the results of those who had replicated her work, in retrospect seemed due to insufficiently cautious technique. It was a devastating outcome and Somerville burned all her remaining copies of the paper. Critics in Parliament complained that her works, however learned, had not "added anything to the stock of human knowledge or enlarged the bounds of science."[10] Although Somerville did publish later experimental papers, her greatest ambition had been crushed. At the end of her life she recalled her shame:

> I was conscious that I had never made a discovery myself, that I had no originality. I have perseverance and intelligence but no genius. That spark from heaven is not granted to the sex, we are of the earth, earthy, whether higher powers may be allotted to us in another state of existence God knows, original genius in science at least is hopeless in this.[11]

Her frustration is palpable. Somerville had aspired to be a great discoverer, like Oersted or Laplace, and she had failed. And with that failure—given her sense of herself as a symbol—she felt she had pulled all women down with her.

Experiments in authorship

During the second decade of the 19th century, scientific authorship began to undergo significant changes. While original work of the kind evidenced in Somerville's *Philosophical Transactions* paper was increasingly valued, the dissemination of existing knowledge became central to campaigns for political change in the years leading up to the first Reform Act in 1832. Those circumstances led to a vast expansion in the types of and audiences for scientific writing. It was Henry Brougham, the leading figure in this transformation, who suggested that Somerville contribute an account of Newton's *Principia* and Laplace's *Mécanique céleste* to the publishing program of the Society for the Diffusion of Useful Knowledge (SDUK), a pioneering group in making science available to the public.

FIGURE 3. SOMERVILLE COLLEGE. Oxford University's first women's college was named after Mary Somerville in 1879. (Photo by Philip Allfrey.)

As an experiment in authorship, however, Somerville's *Mechanism of the Heavens* proved a dead end. The SDUK recognized that her manuscript had not fulfilled the (impossible) task of providing ordinary readers with a mathematically grounded introduction to what Laplace had accomplished. Instead, London publisher John Murray agreed to issue it. During the mid 1830s, she completed two full-length books on topics involving higher mathematics, including a second volume of *Mechanism of the Heavens*, but both remained in manuscript, as Murray was unwilling to publish further mathematical works.

The failure to have those books published was the major turning point in Somerville's career as an author. The "Preliminary Dissertation" to *Mechanism of the Heavens* was widely praised as a concise nonmathematical essay accessible to suitably prepared readers. Somerville developed the introductory discourse into *On the Connexion of the Physical Sciences* (figure 2), which would become her most famous work. The book sold exceptionally well, with 10 editions and 17 500 copies sold. They made their way to schools, colonial outposts, and specialist scientific libraries. As Maxwell said, *Connexion* was among those "suggestive books, which put into a definite, intelligible, and communicable form, the guiding ideas that are already working in the minds of men of science, so as to lead them to discoveries."[12] Among those discoveries was the planet Neptune, the orbit of which John Couch Adams had calculated after following a prediction in *Connexion*.

In 1838 the Somervilles left England and spent the rest of their lives moving from place to place in Italy. The immediate reasons were medical, for William was in poor health; but the Continent also offered the opportunity of living well on reduced receipts, as poor financial decisions had led to a drastic reduction in their income. They were hardly destitute, but they felt trapped in an exile of genteel poverty, unable to return to England and live in the style that they believed befitted their status.

Somerville continued to write, and in 1848 she published *Physical Geography*, which sold nearly as many copies as *Connexion* and was widely admired by readers from Herschel to naturalist Alexander von Humboldt. By the 1870s the rise of geography as an academic subject gave the book a new lease on life as a textbook in the US and throughout the British empire. Somerville never considered her authorship as motivated primarily by profit; given the family's improvident expenditure, royalties were bound to be a welcome supplement rather than a way of keeping bread on the table. Rather, Somerville wrote because she believed in the importance of what she had to say and in her significance as a symbol of self-education, liberalism, and women's rights.

Society, gender, and science

In the complex social world of Victorian Britain, Somerville presented herself in ways appropriate to her iconic role. In private, she could have a sharp wit and a fine sense of the ridiculous. Having grown up opposing almost everything her parents believed in, she was forthright about her unorthodox religious and political views and enthusiastic in discussing the latest scientific findings. With those not in the inner family circle, however, she held back, maintaining a facade of quiet modesty. Those who visited the greatest woman of the age anticipating

a feast of brilliant talk were disappointed. Celebrated wit Sydney Smith asked the crucial question: "Where is she?"[13]

Over the longer term, Somerville realized that the most powerful way of communicating her message was through the story of her own life. That was the usual means through which women were thought to influence history: shaping the lives of others through individual example. As early as the 1820s, Somerville's stories about her life and early struggles were already widely rehearsed in conversation.

Somerville consistently used her celebrity as a way of supporting causes she cared about, especially women's rights and antivivisection. She signed one of the first petitions for female suffrage in 1868. Shocked by the violence of the Franco–Prussian war of 1870–71, she argued that science was too often harnessed to military purposes. She also foresaw the extinction of large parts of the animal world as a result of human action. "Man, the lord of the creation," she wrote in 1848, "will extirpate the noble creatures of the earth, but he himself will ever be the slave of the cankerworm and the fly."[14] Toward the end of her life, Somerville spoke out more strongly about this, hoping that

> man will endeavour to preserve the equilibrium which exists in the meteorological forces and vital conditions of countries . . . and thus save from extinction the myriad beauteous forms of life which have shared with him the inheritance of this wonderful earth.[15]

Her main lessons for her readers were about self-education, the capabilities of women, and the importance of character; those come through strongly in her autobiography, *Personal Recollections, from Early Life to Old Age, of Mary Somerville*. It was a book with a purpose. Edited by her eldest daughter, Martha, and filled with stories of struggle and anecdotes of the famous, *Personal Recollections* became a classic of late Victorian women's autobiography, widely used as a school prize for exceptional academic achievement. Somerville's advocacy of women's right to education and the vote gave her life story a renewed significance for her contemporaries, particularly women pursuing education. On her death in 1872, her treasured mathematical books were bequeathed to Girton College at the University of Cambridge, and in 1879 the first women's college at Oxford was named in her honor (figure 3).

Unladylike conduct

As inventor Alexander Graham Bell, an advocate of women's rights, wrote with heavy irony in 1875, "Mrs. Mary Somerville was guilty of the *most unladylike conduct* in daring to write works on the Connection of the Physical Sciences. . . . Why should any ambitious woman be allowed to invade man's sacred domains?"[16]

Like Ada Lovelace, Émilie du Châtelet, or many of the other women significant in science, Somerville tends to be considered as an individual case rather than being analyzed in the context of other issues, such as the formation of physics as a discipline or the changing social role of science. In most discussions of such issues, individual women are mentioned once or twice as biographical curiosities, underlining the assumption that female writers are a peculiar anomaly in a world that is otherwise characterized as masculine and under the control of "men of science." Such accounts tend to isolate women from the historical mainstream. Their actual significance is distorted or downplayed, even in fields where they ought to be central to the story.

That situation is symptomatic of a wider problem in the way we often write the history of science. By her own admission, Somerville never made a great discovery and hence is unable to satisfy a focus on novelty and originality as the only measures of significance.[17] The works for which she is best known continue to be marginalized under the catch-all title of "popular science," which in Somerville's case is a misnomer. Works like *Connexion* and *Physical Geography* were not really "popular" in the sense that the term has today. They were weighty, reflective treatises, akin to the best work of philosopher Whewell, geologist Charles Lyell, and astronomer Agnes Clerke. Somerville's career and writings thus suggest the need for a reevaluation of categories like popular science that have been used to chart the development of scientific writing and inquiry in the 19th century and beyond.

For now, Somerville remains an important role model in science and mathematics education. Her writings are central to debates about gender relations in science, the unity of physics, and the relations between science, religion, and empire. Her books gained widespread recognition and acclaim at a time when the status of the sciences as a route to truth was challenged and the possibility of women participating in science was doubted. Although I hope that Maxwell appears on Scottish money soon, Somerville deserves her place on the £10 note.

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