Mary Somerville helped to unify science intellectually at a time of specialization.

THOMAS PHILLIPS/*MARY FAIRFAX, MRS WILLIAM SOMERVILLE*/ SCOTTISH NATL PORTRAIT GALLERY

IN RETROSPECT

On the Connexion of the Physical Sciences

Richard Holmes finds Mary Somerville's breakthrough science best-seller thrillingly fresh, 180 years on.

Less than two centuries ago, popular science barely existed. In 1830, astronomer John Herschel wrote to natural philosopher William Whewell about the urgent need for "digests of what is actually known in each particular branch of science … to give a connected view of what has been done, and what remains to be accomplished".

The remarkable writer who first achieved that "connected view" and arguably launched popular science writing was a self-taught Scottish mathematician, Mary Fairfax Somerville (1780–1872). Her book, *On the Connexion of the Physical Sciences*, published by John Murray in 1834 alongside works by Walter Scott, Lord Byron and Jane Austen, contains no equations, few diagrams and little mathematics. But it is a masterpiece of descriptive explanation and analogy that unveils a complete scientific world view, covering everything from stars to insects. It was Murray's best-selling scientific publication until Charles Darwin's *On the Origin of Species* in 1859; it eventually ran to ten editions in Britain, and was published in France, Italy, Germany and the United States.

On the Connexion of the Physical Sciences
MARY SOMERVILLE
John Murray: 1834.

The book appeared at a critical moment for science. The disciplines were beginning to define their territories and societies were starting to coalesce, including the Geological Society in 1807 and the Zoological Society of London in 1826. For Whewell, who scrutinized Somerville's offering in depth in the *Quarterly Review* of March 1834, the work was a "masterly" survey that performed the crucial task of intellectual unification at a moment when science threatened to become like "a great empire falling to pieces".

Somerville, the daughter of admiral William Fairfax, grew up near Scotland's Firth of Forth wandering the seashore, collecting shells and studying seabirds. Her father described her as a savage. At 15 she saw a mysterious reference to algebra in a women's fashion magazine, and began to devour the theorems of Euclid and Newton. She would lie in bed at night, listening to the sea and solving equations in her head.

She was launched into Edinburgh society at 18, a notable beauty; to her parents' dismay she continued her study of maths, as well as painting and the piano, describing herself as "intensely ambitious to excel in something, for I felt in my own breast that women were capable of taking a higher place in creation than that assigned to them in my early days". A disastrous first marriage to glamorous naval attaché Samuel Greig was cut short by his early death in 1807.

In 1812 she met and married her soulmate and cousin, the scientifically minded, globe-trotting physician William Somerville. Moving to London in 1816, and now the parents of four children, the couple entertained leading scientists such as William Herschel, Michael Faraday, Charles Babbage and Charles Lyell. In 1830, at the invitation of the Society for the Diffusion of Useful Knowledge, she translated French astronomer Pierre-Simon Laplace's highly technical *The Mechanism of the Heavens*. In a parliamentary debate on scientific education, she was referred to as "one of the only six persons in England who understands Laplace".

Somerville began writing *On the Connexion of the Physical Sciences* in 1832,

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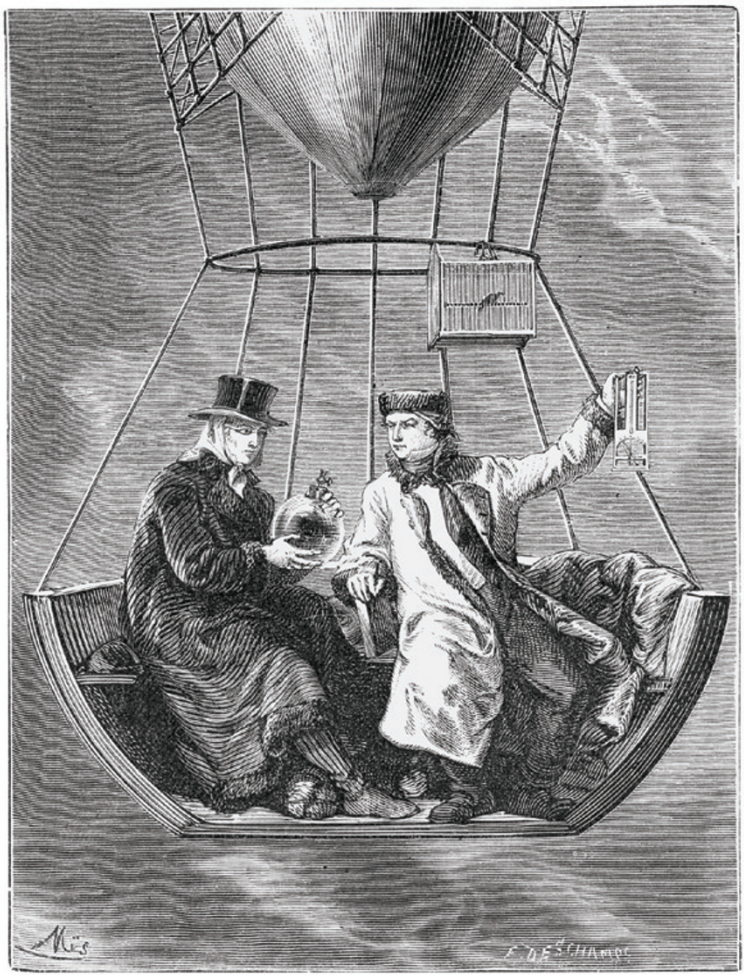
during a long visit to Paris. She effectively became an expert reporter on the latest developments in European science. Taking full advantage of social networking, she contacted Laplace's influential widow and dined with the physicists François Arago, Jean-Baptiste Biot and Joseph-Louis Gay-Lussac. She had privileged status at sites from the Paris Observatory to the National Museum of Natural History, and in the laboratories of electrical-theory pioneers André-Marie Ampère and Antoine César Becquerel.

In contrast to the vague speculations of eighteenth-century natural philosophy, her 500-page book covers a tight field of hard sciences — astronomy, physics, chemistry, geography, meteorology and electromagnetism. Its groundbreaking style, clear and logical, occasionally opens out into passages of sublime perspective, such as the description of universal gravity as a force equally present "in the descent of a rain drop as in the falls of Niagara; in the weight of the air, as in the periods of the moon". Somerville ranges over subjects from stellar parallax to terrestrial magnetism, from comets to giant seaweed.

Her handling of acoustics is characteristically brilliant, based on the observations of John Herschel, Arago and naturalist Alexander von Humboldt. Comparing the propagation of sound to "a field of corn agitated by a gust of wind", she goes on to describe phenomena from birdsong to thunder. She also suggests a connection between waves propagated in water, the atmosphere and sunlight, writing: "Any one who has observed the reflection of the waves from a wall on the side of a river ... after the passage of a steam-boat, will have a perfect idea of the reflection of sound and of light."

Her exploration of the solar spectrum contains one of the earliest descriptions (derived from work by William Herschel, chemist William Hyde Wollaston and physicist Johann Wilhelm Ritter) of infrared and ultraviolet rays at the extreme ends of the known light spectrum, "too extensive in their undulations to affect our optic nerves". She speculates that such rays might have many possible functions in the animal kingdom: "We are altogether ignorant of the perceptions which direct the carrier-pigeon to his home ... or of those in the antennae of insects which warn them of the approach of danger". She also mused about climate change, the cause of earthquakes and the existence of planets beyond Uranus.



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French scientists making high-altitude measurements in 1804.

The most original sections deal with electricity and the new science of electromagnetism. Somerville thrillingly describes Faraday's latest work with the horseshoe magnetic generator, establishing that magnetism and electricity must have complex links in what he was beginning to define as 'fields'. These sections clearly predict the connection between all electromagnetic phenomena, established in four equations a generation later by physicist James Clerk Maxwell (see nature.com/maxwell).

Somerville's work contextualized the sciences as an ongoing global project. The book emphasized, in a wholly new way, the communal nature of science as shared discovery, referring to John Franklin's Arctic expeditions, the high-altitude balloon flights of Biot and Gay-Lussac (pictured), the geographical explorations of Lyell and Humboldt, and the teams of European astronomers who observed the return of Halley's comet, among other feats.

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For Richard Holmes on science biography, see:
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On the Connexion of the Physical Sciences was widely praised by journalists and scientists in Britain and abroad; both Arago and Humboldt deeply admired it. The popular, large-circulation journal *Mechanics' Magazine* urged its audience: "read it! read it!" Somerville dined at the male stronghold of the University of Cambridge, invited by its science professors; received honorary membership of the Royal Astronomical Society among others; and, although barred from the Royal Society, is commemorated there in a formidable marble bust.

Such was her celebrity that she wrote, "I am a kind of tame Lioness at present." Her friend the novelist Maria Edgeworth, however, noted that "while her head is up among the stars, her feet are firm upon the earth". Somerville, privately unorthodox and witty, sceptical but still believing in a creator, lived up to that estimation throughout her long life. She supported women's suffrage (her signature was the first on philosopher John Stuart Mill's petition to Parliament); campaigned against vivisection, and against slavery in America; and believed in Darwinian evolution.

Like the great poets of her era, Somerville brought a new vision into the world, and one that a broad, educated public could grasp. Seven years after her death, a new women's college at the University of Oxford was named in her honour.

Looking back almost 40 years after the publication of her magnum opus, Maxwell reflected: "It was one of those suggestive books which put into definitive, intelligible and communicative form the guiding ideas that are already working in the minds of men of science". In fact, the book prompted the creation of a new professional concept, and a new umbrella word to define it, coined by Whewell in his review of 1834: "scientist". ■

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