

Michael Faraday, Chemist

This icon of modern physics was, in reality, a chemist by training and profession.

Richard A. Pizzi

Many of the great pioneers of modern science in the 18th and 19th centuries have compelling personal stories. Some toiled in obscurity, while others were the toast of fashionable society. The life of the famous English scientist Michael Faraday is particularly interesting, however, as he crossed many different social and economic borders in his career. He knew poverty and isolation as well as fame, and he gained respect in elite social and scientific circles while simultaneously maintaining membership in a small, often disdained religious sect. The man who would plumb the very nature of electricity was one of the most enigmatic of the world's great scientists.

Founding Faraday

Faraday was born on September 22, 1791, in the village of Newington Butts, which is now part of London. Faraday's father, James, was a blacksmith from Yorkshire who had moved south with his wife Margaret looking for work. Michael was their third child, born soon after the family relocated from northern England. These early years were hard ones, as work was difficult to find. James was in poor health and barely made enough money to keep the family together.

In his later years, Faraday recalled that in 1801 when prices were particularly high, he and his siblings were allotted one loaf of bread each, which was meant to last an entire week. His early education was equally meager. He remembered that he learned only the "rudiments of reading, writing, and arithmetic at a common day-school." Most of his time was spent at home or in the streets. The family lived in rooms above a coach-house and struggled for basic sustenance.

Amid all the difficulties of his youth, Faraday took comfort in his family's strong religious faith. He and his family were

members of a Protestant Christian sect called the Sandemanians. Originally established in the early 18th century as dissenters from the Church of Scotland, the Sande-



Michael Faraday, 1791–1867.

manians have been described as a "closed and tight-knit spiritual brotherhood." In Faraday's time, there were approximately 600 Sandemanians in all of Britain, and only about 100 in the London community. This small band of Christians made strict distinctions between themselves and nonmembers, demanding a great deal of personal discipline and commitment from their adherents. All those who were not Sandemanians were considered "unrighteous", and this included other Christians. Faraday's Sandemanian religious beliefs would shape his entire life, including his thinking on questions of science, as he sought to comprehend the "intelligibility, beauty, and symmetry of the divinely constructed universe."

At the age of 14, Faraday began an apprenticeship with the bookbinder

George Ribeau. He had previously run errands for Ribeau to help with the family finances, but by 1805 the family's economic situation demanded that Faraday work regularly. The apprenticeship lasted for seven years, and while he learned the trade of bookbinding, Faraday also began his self-education in science. He read the scientific entries in the *Encyclopedia Britannica* and perused many of the texts that he bound in the shop. He was also particularly taken with Jean Marcet's book *Conversations on Chemistry*, which inspired him to perform rudimentary experiments and build his own electrostatic machine.

Dealing with Davy

In 1810, Faraday joined the City Philosophical Society, a group of men and women who met weekly to hear scientific lectures and debate topics of current intellectual interest. An extension of his efforts at self-improvement, the lectures on electricity, galvanism, and mechanics particularly excited him. While continuing to broaden his understanding of science through intensive reading and debate, in 1812 Faraday was given tickets to attend lectures by the renowned chemist Humphry Davy at the Royal Institution. These lectures would, in more than one way, change his life.

Impressed by Davy's brilliance, Faraday took detailed notes of the lectures and made careful copies of them afterward. He wrote to Davy and gave him copies of the lecture notes, which included meticulous drawings, and asked the prominent researcher for help in establishing a career in science. Davy arranged a meeting with the younger man but had no position to offer him. In fact, he warned Faraday away from science, suggesting that its financial rewards were poor. His apprenticeship complete, Faraday took full-time work as

a bookbinder but continued to hope for a life in science.

Less than a year later, he got what he desired. In early 1813, one of Davy's laboratory assistants at the Royal Institution was fired for fighting with a co-worker. Davy soon hired Faraday to replace the man. For much of the next two decades Faraday would work at the Royal Institution, first for Davy and then under his replacement William Thomas Brande. But between October 1813 and April 1815, Faraday accompanied Davy and his wife Jane on a tour of continental Europe. Davy lectured to appreciative audiences, and Faraday had an opportunity to meet some of the most important scientists in the world. He encountered Ampère in Paris and visited Volta in Milan. Although he was Davy's lowly assistant and was treated as little more than a valet by Davy's wife, this grand tour broadened Faraday's cultural and scientific horizons.

When he returned to London in 1815, Faraday reassumed his position as a chemical assistant at the Royal Institution. Most of his work was that of a technician—performing chemical experiments in the laboratory for his superiors, but he also began lecturing on chemical theory at the Philosophical Society and published his first paper (on caustic lime) in 1816. Faraday worked primarily for William Brande, but he also helped Davy with the development of the miner's safety lamp in 1816–1817, and he assisted surgical instrument maker James Stoddart in his attempts to improve the quality of steel. The laboratory at the Royal Institution was one of the best-equipped in the world, and Faraday benefited from close association with the premier scientists in England.

His Wife and Work

The year 1821 was one of the most significant of Faraday's life, both personally and professionally. In June, he married Sarah Barnard, whom he had met in the Sandemanian church. Later that year, he made his "confession of faith" in the church. He also received a promotion at the Royal Institution, where he was named superintendent of the house.

Since his early days at the Institution, Faraday had worked primarily on chemical experiments. But in 1821, this changed, as he returned to one of his early interests: electricity. In 1820, the Danish

natural philosopher Hans Christian Oersted had discovered electromagnetism and opened a new field of research that was growing in popularity. Faraday was an enthusiastic participant in these explorations. Working in his basement laboratory in the late summer of 1821, Faraday commenced a series of experiments that led to his discovery of electromagnetic rotation. This had great practical significance, as it would prove to be the principle behind the development of the electric motor. Faraday published his findings in the October 1821 issue of the *Quarterly Journal of Science*.

During the decade following his discovery, Faraday worked principally in the field of chemistry. His most important achievements during this period were the liquefaction of chlorine in 1823 and the isolation of benzene in 1825. He also worked extensively on the production of optical glass. As important as any research project to Faraday's public reputation, however, was his founding in 1826 of two lectures series: the *Friday Evening Discourses* and the annual Christmas lectures for adolescents. He lectured more than 140 times in these two series from 1826 to the early 1860s and was considered the premier scientific lecturer in Britain. Both lecture series continue to this day.

Electrifying Progress

In August 1831, 10 years after his discovery of electromagnetic rotation, Faraday discovered electromagnetic induction. He demonstrated that a magnet could induce an electrical current in a wire, and he was able to convert mechanical energy into electrical energy. This discovery was truly revolutionary, for it paved the way for the creation of the electric transformer and generator, practical technologies that would profoundly change modern life.

Faraday continued his work on electricity for the remainder of the decade. He developed a theory of electrochemical action and coined, with William Whewell, now-familiar words like electrode, electrolyte, and ion. He also worked on a new theory of static electricity and electrical induction. Faraday ultimately rejected the old theory that electricity was a fluid. He concluded that electricity was a force that passed from particle to particle of matter.

In February 1833, Faraday was named Fullerian Professor of Chemistry at the

Royal Institution. He was awarded an honorary degree from the University of Oxford and received two awards from the Royal Society. Faraday had been previously elected to the Royal Society in 1824 over the objections of his mentor Humphry Davy, who was then president of the Society. It seems Davy could not imagine his former assistant and “valet” as a colleague. Although opposed by Davy, Faraday never expressed hostility toward his mentor and held him in high esteem for the rest of his life.

As Faraday’s fame spread, he took more prominent positions in British scientific and public life. In 1836, he began a lifelong association with Trinity House, the institution responsible for safe nautical navigation around the British Isles. Faraday helped to improve the efficiency of lighthouses by inventing a chimney for oil-burning lamps. In the 1830s and 1840s, Faraday also served as a professor of chemistry at the Royal Military Academy.

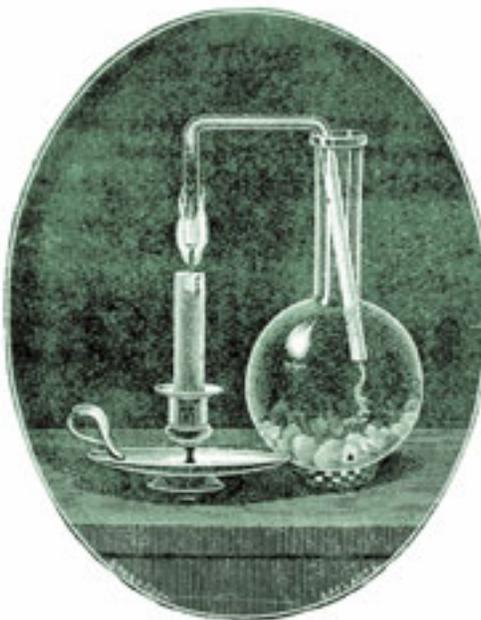


FIG. 33.—Faraday’s experiment for investigating the different parts of a candle flame.

Along with professional prominence, the 1840s brought ill health to Michael Faraday. He endured a nervous breakdown

in the first part of the decade, but he recovered enough to renew his research on electricity.

The Faraday Effect

As a result of new mathematical developments in the field by William Thomson (Lord Kelvin), Faraday attempted to determine if light was affected when passing through an electrolyte. He tried the experiment twice but noticed nothing. Then, on September 13, 1845, he placed a piece of glass on the poles of an electromagnet and passed polarized light through the glass. When he turned the electromagnet on he discovered that the light’s polarization had changed.

This experiment determined that light was affected by magnetic force. This “magneto-optical effect” was later termed the Faraday effect. After discovering that glass could be affected by magnetic force, Faraday experimented with other substances that yielded similar results. The resultant effect he termed “diamagnetism”. Concluding that magnetism was an inherent property of matter, Faraday asserted his conclusions in an 1846 lecture entitled “Thoughts on Ray Vibrations”. This lecture became the basis for the field theory of electromagnetism. The theory was extended mathematically by Thomson and, most importantly, by James Clerk Maxwell, who developed it into one of the cornerstones of modern physics.

The discovery of diamagnetism was the apex of Michael Faraday’s intellectual career. His health began a steady decline through the 1850s and early 1860s, although he did continue to work with Trinity House and perform the annual Christmas lectures. Beginning in 1860, Faraday became an elder in the Sandemanian Church, that small group of believers to whom he remained loyal throughout his life. He died on August 25, 1867, and was buried in Highgate Cemetery, an acknowledged giant of European science.

Suggested Reading

Cantor, G. N. *Michael Faraday: Sandemanian and Scientist*; St. Martins Press: New York, 1991.
Williams, L. P. *Michael Faraday: A Biography*; Basic Books: New York, 1965.

Richard A. Pizzi is a freelance writer based in Washington, DC. ♦