Theo James presenting a bouquet to HM The Queen on the occasion of her bicentenary visit, 7 December 1999. The Director, Susan Greenfield, looks on

Front page: Façade of the Royal Institution added in 1837. Watercolour by T.H. Shepherd

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Guides to the Royal Institution of Great Britain: 1

HISTORY

by Frank A.J.L. James

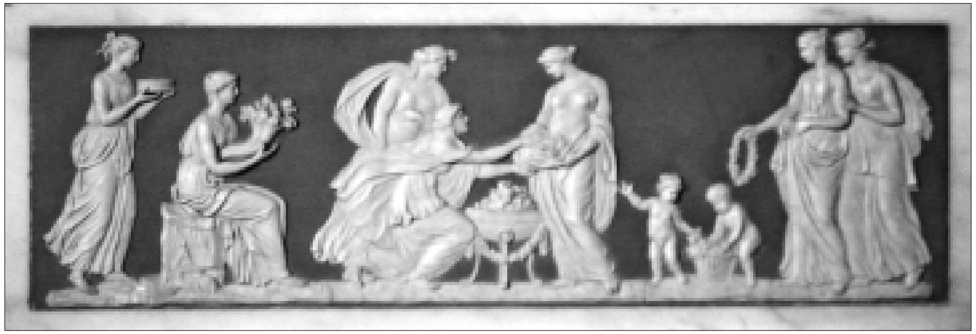
For more than two hundred years the Royal Institution of Great Britain has been at the centre of scientific research and the popularisation of science in this country. Within its walls some of the major scientific discoveries of the last two centuries have been made. Chemists and physicists - such as Humphry Davy, Michael Faraday, John Tyndall, James Dewar, Lord Rayleigh, William Henry Bragg, Henry Dale, Eric Rideal, William Lawrence Bragg and George Porter - carried out much of their major research here. The technological applications of some of this research has transformed the way we live. Furthermore, most of these scientists were first rate communicators who were able to inspire their audiences with an appreciation of science. This guide provides a brief outline about how a medium size Mayfair townhouse became a major centre for scientific excellence.

The historical background to the founding of the Institution in 1799 was the war with France and the increasing industrialisation that had occurred in Britain during the preceding century. The war, which would continue for a further sixteen years, meant that Britain had very restricted access to Continental markets and was forced to rely on its own resources. To help overcome this problem, it was initially envisaged that the Institution would provide access to scientific and technical knowledge, through lectures, to a lay audience with the aim of applying that knowledge for practical purposes. Furthermore, the Institution was seen as a place where scientific knowledge could be practically applied to agricultural improvement, industrialisation and the consolidation of the Empire. These aims, in turn, encouraged those who had such interests to join and the early membership of the Royal Institution shows a strong presence of large land owners, military men and those who worked in the colonial service such as the East India Company.

The Royal Institution was founded at a meeting on 7 March 1799 at the Soho Square house of the President of the Royal Society, Joseph Banks (1743-1820). A list of fifty-eight names was read of gentlemen who had agreed to contribute fifty guineas each to be a Proprietor of a new

> Institution For diffusing the Knowledge, and facilitating the general Introduction, of Useful Mechanical Inventions and Improvements; and for teaching, by Courses of Philosophical Lectures and Experiments, the application of Science to the common Purposes of Life.

Fifty guineas was a substantial sum of money: one needs to multiply it by at least a hundred to give an impression of its modern value. Only the wealthy could afford such a sum and the list of the original Proprietors reads like a who's who of late eighteenth century British society. It included the Member of Parliament and anti-slavery campaigner William Wilberforce (1759-1833), the substantial landowners William Cavendish, 5th Duke of Devonshire (1748-1811)



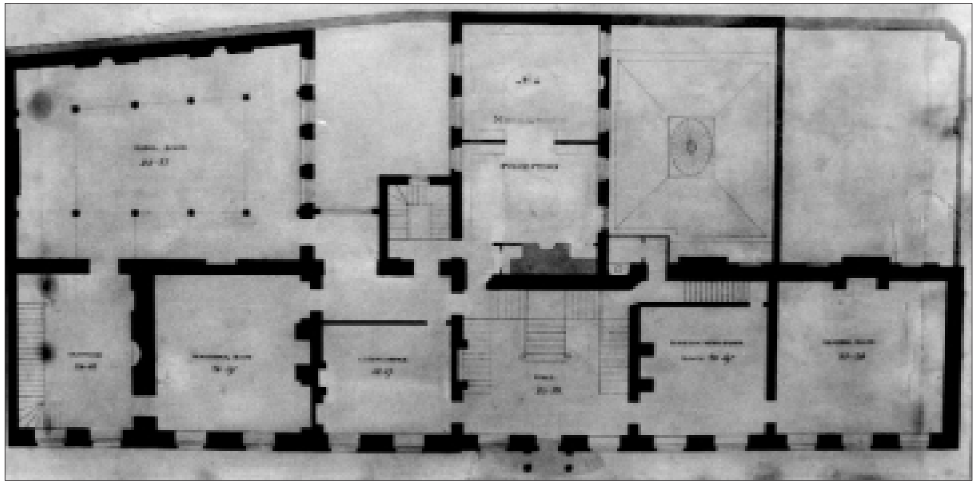
Wedgwood plaque from the fire place of Joseph Banks's house

and George John, 2nd Earl Spencer (1758-1834), the naval officer George Elphinstone, Lord Keith (1746-1823); among these was just one individual who could be fairly described as a man of science, Henry Cavendish (1731-1810) and he would leave much of his apparatus to the Royal Institution where it remains today.

At the meeting in Banks's house a group of Proprietors met to discuss the *Proposals* for such an Institution that had been drawn together in the previous weeks by Benjamin Thompson, Count Rumford (1753-1814). The outcome of the meeting was that a committee of Managers was elected to run the "Institution", the *Proposals* were published to gain more support for the "Institution" and a petition for a Royal charter would be submitted. The name "Institution" was probably chosen in imitation of the famous *Istituto delle Scienze e delle Arti* founded in Bologna in the early eighteenth century. A material link between Banks's house and the Royal Institution exists in the mantelpiece in the Long Library which was presented to the Royal Institution by Robert Hadfield (1858-1940) in 1937 after the Soho Square house was demolished.

The development of the "Institution" was rapid. The Managers first met, again in Banks's house, on 9 March 1799, two days after their election. George Finch, Earl of Winchilsea (1752-1826) was elected President in June and through his influence with the King, George III (1738-1820), the Institution acquired its Royal handle the same month, although the charter was not granted until 13 January 1800 by which time the unifying and patriotic 'Great Britain' had been added to the end of the name. In the months immediately following its foundation finding a suitable home was a major priority. Negotiations for the purchase of 21 Albemarle Street were commenced in April 1799, but not completed until the end of July. Nevertheless, the first meeting of the Managers took place there in June. Unlike most other London learned societies, the Royal Institution has remained in its founding location ever since. Builders, under the superintendence of Rumford and Thomas Webster (1773-1844), who designed the lecture theatre, quickly turned what had been a gentleman's town house into a fully functioning scientific institution. Laboratories, lecture theatres, meeting rooms, libraries, display areas as well as living quarters were built and in March the following year Thomas Garnett (1766-1802), the first Professor of Chemistry at the Royal Institution, delivered the first lecture.

Much of the early effort of the Royal Institution concentrated on strictly utilitarian work, for instance using chemistry to improve agriculture. Indeed, the Royal Institution undertook so much of this sort of work that it was referred to in an 1803 will, in which it was left forty guineas, as the 'New Society of Husbandry ... lately established



Early 1800s architectural drawing of the ground floor of the Royal Institution

in Albemarle Street'. Although this kind of work remained a consistent feature of the Royal Institution during both the nineteenth and twentieth centuries, the Managers quickly realised that the Royal Institution's programme needed to have a broader public appeal. Following the strong eighteenth century tradition, the Royal Institution began to stage spectacular and entertaining, not to say dangerous, demonstrations of scientific experiments. For this work the Royal Institution obtained, in 1801, the services of the twenty two year old Humphry Davy (1778-1829) who had made his name by discovering the physiological action of nitrous oxide (laughing) gas. Davy, born in Penzance, the son of a woodcutter, had made his way to the Pneumatic Institute in Bristol (run by Thomas Beddoes (1760-1808)) where he had made his discovery. Davy tried the gas out on some of his friends in Bristol including the poets and philosophers Samuel Taylor Coleridge (1772-1834) and William Wordsworth (1770-1850), whose *Lyrical Ballads* Davy edited. On one occasion while under the influence of several litres of laughing gas Davy wrote in one of his notebooks 'Newton & Davy' in one inch high letters. Full of youthful confidence Davy apparently believed that he was going to do for chemistry in the early nineteenth century what Isaac Newton (1642-1727) had done for natural philosophy a century before. Davy's discovery made his name in England. Evidence of the way it captured the public imagination can be found in the famous caricature by James Gillray (1757-1815). In it Garnett is portrayed administering the gas to the Manager John Hippisley (1748-1825), with somewhat unfortunate results, while a slightly demonic Davy watches with a pair of bellows poised for further action.

Garnett lecturing in 1801. Cartoon by James Gillray

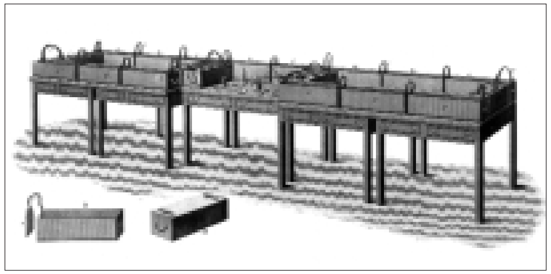
Following Garnett's resignation (June 1801), Davy became Professor of Chemistry (1802) and firmly established the Royal Institution as a popular venue for first rate lectures. The large attendance created the necessity for the first one way street in London. Moreover, the Royal Institution's premier position for undertaking utilitarian work

was strengthened by Davy through his lectures on agricultural chemistry, his invention of the miners' safety lamp in 1815-1816 and (somewhat less successfully) in the mid 1820s, his efforts to protect the copper bottoms of naval vessels by electro-chemical means.

Davy also established scientific research as a crucial feature of the Royal Institution, something that was never envisaged, or indeed intended, by the founders. But because the Royal Institution wanted to put on spectacular demonstration lectures it needed to possess a good laboratory. As a result, the Managers allocated money and support so that the laboratory quickly became the best equipped in Britain and one of the best in Europe. In this laboratory Davy, during the first decade of the nineteenth century, developed the first coherent theory of electro-chemical action following the invention of the electric battery by Alessandro Volta (1745-1827) in the late 1790s. In the course of this work Davy isolated the chemical elements sodium, potassium, barium, calcium, magnesium, strontium and later showed, contra the French chemists, that chlorine and iodine were indeed elements.

Prototypes of the Davy lamp showing the evolution of his ideas

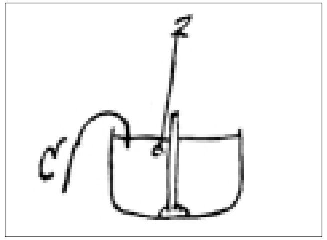
In 1812 Davy was knighted and married Jane Apreece (1780-1855), a wealthy widow, and he decided to retire from his professorship

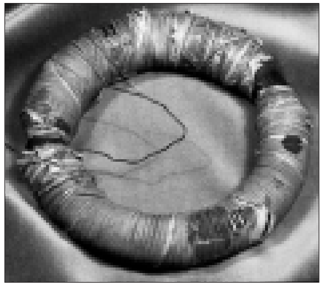


Battery which Davy used to discover elements such as sodium and potassium. Contemporary print at the age of thirty four. He was succeeded by William Thomas Brande (1788-1866). Brande is a little known figure today, mainly because he did not make any major scientific discoveries. But he played a critical role for more than forty years in developing the Royal Institution until his retirement in 1852. In 1816 Brande established chemical lectures for medical students from St George's Hospital (then at the western end of Piccadilly), edited the Institution's journal and continued with the practical application of scientific knowledge, particularly in his case, in water analysis and coinage.

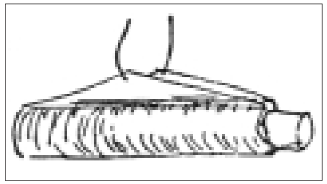
Davy's other successor is better known. One of Davy's listeners during his final course of lectures at the Royal Institution was a twenty year old apprentice bookbinder with a strong interest in chemistry, Michael Faraday (1791-1867). Faraday, the son of a Sandemanian blacksmith who had moved from Westmorland to London, had a typical working class education. Then, two weeks before the Battle of Trafalgar in 1805, the fourteen year old Faraday was apprenticed to learn the trade of bookbinding for the next seven years. The Sandemanians were a very small literalist sect of Christianity to which Faraday was fully committed throughout his life. He made his confession of faith in 1821 (the same year he married into another Sandemanian family), was a Deacon in the church between 1832 and 1840, an Elder between 1840 and 1844 and Elder again between 1860 and 1864. There was a close connection between Faraday's religion and his scientific career. This can be summed up as his search for the laws of nature that God had written into the universe at the time of the Creation and the use of that knowledge for the betterment of humankind.

During his bookbinding apprenticeship Faraday had developed an overriding interest in science, particularly chemistry. He read many books on the subject including *Conversations in Chemistry* by Jane Marcet (1769-1858) and attended lectures in various places, most importantly the City Philosophical Society. A customer at the bookshop gave Faraday tickets to attend Davy's final course of lectures at the Royal Institution. The lectures dealt with a problem then at the cutting edge of chemistry, namely the definition of acidity. Faraday took detailed notes of the lectures, and sent them to Davy asking for a job in science at the Royal Institution. After a complex set of circumstances, Faraday was appointed Chemical Assistant at the Royal Institution in the spring of 1813. Six months later he was touring the Continent with Davy and Lady Davy, as Davy's assistant, secretary and reluctant valet. They went through France, Italy and parts of Germany. In Paris they experimented on iodine; in Florence Davy used the burning glass of the Grand Duke of Tuscany to show that diamonds were made of carbon; they climbed Mount Vesuvius; and in Milan they met Volta who gave Faraday one of his batteries (now on display in the Faraday Museum).


Faraday's 1821 sketch in his laboratory notebook of his electro-magnetic rotations apparatus


Faraday's electro-magnetic induction ring - the first transformer

Returning to England just before the Battle of Waterloo, Faraday resumed his position at the Royal Institution where he remained for the rest of his life becoming in 1821 Superintendent of the House (in which capacity he oversaw the erection of the columned façade in the late 1830s), in 1825 Director of the Laboratory and in 1833 Fullerian


Faraday's 1831 sketch in his laboratory notebook of his electric generator

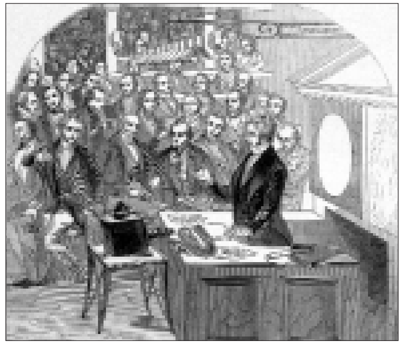
Professor of Chemistry, a post that was especially created for him by the eccentric philanthropist John Fuller (1757-1834). Fuller also endowed a Professorship of Physiology which has been held by such eminent people as Peter Mark Roget (1779-1869), Thomas Henry Huxley (1825-1895), Charles Sherrington (1857-1952), Andrew Huxley, Max Perutz and now the current Director, Susan Greenfield.

Faraday is rightly remembered for his many fundamental contributions to chemistry and physics, made mostly in the basement laboratory of the Royal Institution. Following the discovery of electro-magnetism in 1820 by Hans Christian Oersted (1777-1851), Faraday turned his attention to the subject. The following year he discovered electro-magnetic rotations, the principle behind the electric motor. Ten years later, in August 1831, he discovered electro-magnetic induction and made the first transformer and generator to produce electric current from the movement of a magnet in a coil of wire. (The originals of both these devices are on display in the Faraday Museum). The impact of these discoveries is still felt today. No matter what primary source of energy is used, *all* power stations generate electricity based on the fundamental principles Faraday discovered in 1831. On the occasion of the centenary of Faraday's discoveries in 1931, and coinciding with a period of increasing electrification, large scale celebrations took place, including the hiring of the Royal Albert Hall.

A view of the Faraday centenary exhibition in the Albert Hall, 1931

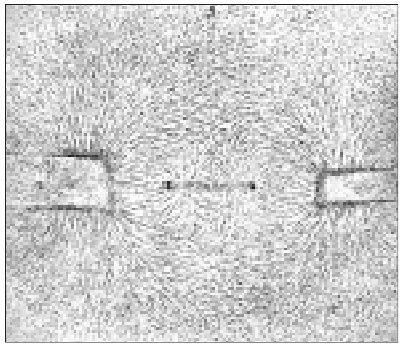
Later in the 1830s Faraday studied electro-chemistry, discovering his laws of electrolysis and coining the nomenclature (electrode, anode, cathode, ion etc) of electro-chemistry with which we are so familiar today. In 1836 Faraday built a cage, a twelve foot cube covered in metal gauze, for which only the lecture theatre provided the necessary space. The results of his experiments in the cage enabled him show that electricity was a *force* rather than an imponderable fluid, as had been argued up to that time. In 1845 Faraday discovered that light was affected by magnetism and that all matter possessed magnetic properties, not just iron. These experimental discoveries allowed him to develop his field theory of electro-magnetism. Later mathematised by his younger contemporaries William Thomson (Lord Kelvin, 1824-1907) and James Clerk Maxwell (1831-1879) this theory became, and remains, one of the cornerstones of modern physics.

The technological application of many of these discoveries of Faraday's and others, such as his liquefaction of gases (1823) and his discovery of benzene (1825), have radically altered the way we live. But Faraday was also



Faraday lecturing on the magneto-optical effect, 23 January 1846. From Illustrated London News, *1846*

Faraday's assistant, Charles Anderson, working in the basement laboratory. Harriet Moore watercolour, 1852



Iron filing diagram showing the structure of space near a magnet. Made by Faraday, early 1850s directly involved with technology through the normal utilitarian role of the Royal Institution. In the late 1810s he worked on a project to improve steel and, in the latter part of 1820s, on a tedious, time consuming and ultimately unsuccessful project to improve optical glass. Outside the building, in 1844, he conducted, with the geologist Charles Lyell (1797-1875), the enquiry on behalf of the Home Office into the explosion at Haswell Colliery, County Durham, in which ninety five men and boys had died. The report he and Lyell produced so embarrassed the government that they resorted to political manoeuvring to suppress it. Faraday was appointed scientific adviser to the Admiralty in 1829 and he gave them advice until at least the Anglo-French war against Russia of the mid 1850s when he suggested that one of the proposed plans of attack against the Baltic naval fortress of Cronstadt would probably not be effective. Between 1830 and 1852 he taught chemistry to the cadets of the Royal Engineers and Royal Artillery at the Royal Military Academy, Woolwich. Faraday's most sustained piece of utilitarian work was undertaken for Trinity House, the English and Welsh lighthouse authority, where he was scientific adviser from 1836 to 1865. Part of his work for them was done in the Royal Institution, part in Trinity House itself and part in Faraday visiting lighthouses round the country and in France. In this role he helped make great improvements to the lighthouse service including overseeing the experimental introduction of electric light at the South Foreland lighthouse in the 1850s and 1860s.

Faraday also supported innovation at the Royal Institution. He was instrumental in founding and sustaining two series of lectures which continue to this day. The Friday Evening Discourses, founded in 1826, became, by the 1840s, the very formal affairs which they remain. The lecturer commences as the clock strikes the hour and is supposed to finish as the clock strikes the next hour. Discourses are addressed to members and their guests, attired in evening dress.

More than 3000 Discourses have been delivered since their foundation, and have covered a broad range of both scientific and non-scientific subjects. In addition to those who have worked in the Royal Institution, Discourses have been delivered by such diverse figures as the scientists Charles Wheatstone (1802-1875), A.R. Wallace (1823-1913), William Thomson, Thomas Huxley (1825-1895), James Clerk Maxwell, Peiter Zeeman (1865-1943), Ernest Rutherford (1871-1937), Guglielmo Marconi (1874-1937), Alexander Fleming (1881-1955), Kathleen Lonsdale (1903-1971), Dorothy Hodgkin (1910-1994), Jane Goodall, Patrick Moore, Fred Hoyle and Max Perutz; the art and architectural historians John Ruskin (1819-1900), Joan Evans (1893-1977, the first woman to deliver a Discourse in 1923), Nikolaus Pevsner (1902-1983), Kenneth Clark (1903-1983) and Neil MacGregor; churchmen such as Nicholas Wiseman (1802-1865, Archbishop of Westminster) and Arthur Stanley (1815-1881, Dean of Westminster); writers such as George Du Maurier (1834-1896), H.G. Wells (1866-1946), Walter De La Mare (1873-1956), John Buchan (1875-1940) and C.P. Snow (1905-1980); historians and archaeologists such as G.M. Trevelyan (1876-1962), Mortimer Wheeler (1890-1976), Arthur Bryant (1899-1985) and Kathleen Kenyon (1906-1978); others such as the athlete Roger Bannister, the naval officer and last Viceroy Earl Mountbatten (1900-1979) and the violinist Yehudi Menuhin (1916-1999). Of all the Discourses delivered in the Royal Institution two might be picked out for special mention: Faraday's on 25 January 1839 when he publicly announced for the first time the existence of photography and J.J. Thomson's (1856-1940) on 30 April 1897 where he first announced the existence of the fundamental particle later called the electron.

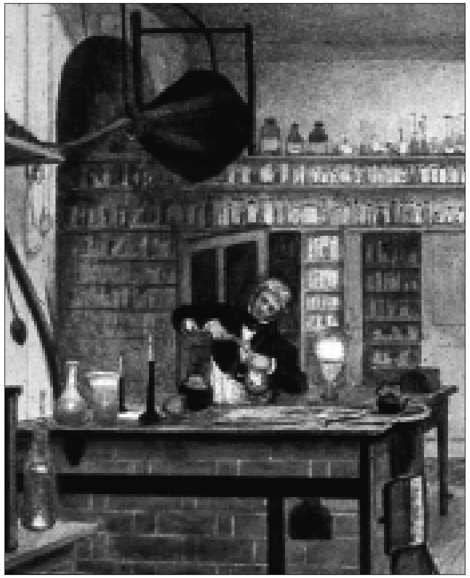
The other series which Faraday initiated were the Christmas Lectures for young people of which Faraday gave nineteen series including his famous *Chemical History of a Candle*. Faraday gave this series twice in 1848-1849 and 1860-1861. In 1861 the lectures were

Faraday delivering a Christmas lecture on 27 December 1855 in the presence of Prince Albert and the Prince of Wales. Painted by Alexander Blaikley

published and became a highly successful book which has hardly been out of print since; the book has also been translated into several languages including Polish and Japanese. The Christmas Lectures have been televised since 1966 and now reach an audience of

W.L. Bragg delivering a 1961 Christmas lecture on electrostatics chaired by Lord Brabazon and aided by Bill Coates. Painting by Terrance Cuneo

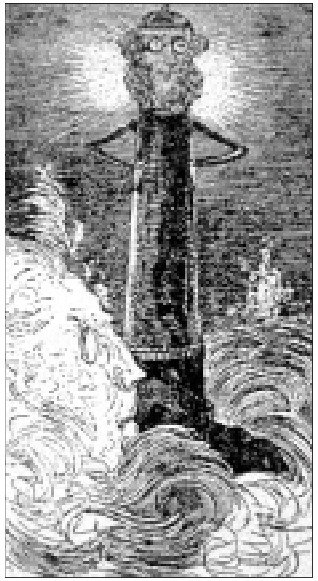
millions each year. Furthermore, in recent years they have been repeated in Japan each summer where they are also broadcast. Like the Discourses, Christmas Lectures have been delivered by distinguished scientists including Robert Watson-Watt (1892-1973), Frank Whittle (1907-1996), Eric Laithwaite (1921-1997), Carl Sagan (1934-1996), Bernard Lovell, Colin Blakemore, David Attenborough, Richard Dawkins and Richard Gregory.



Faraday working in the basement laboratory. Harriet Moore watercolour, 1852

Faraday's researches, lecturing and public scientific work made him into one of the most famous men of the day. He was awarded an annual Civil List pension of £300 in 1836, albeit after some difficult political manoeuvring in the course of which the Prime Minister, Lord Melbourne (1779-1848), was forced to write to Faraday apologising for calling scientific pensions 'humbug' (with a theological participle as Faraday put it) in the course of an interview in Downing Street. Doubtless at the instigation of Prince Albert (1819-1861), who was a frequent visitor to the Royal Institution, Queen Victoria (1819-1901) provided Faraday with a grace and favour house at Hampton Court in 1858. From then on Faraday spent an increasing amount of time there as his health deteriorated. In 1864 he was offered the Presidency of the Royal Institution in succession to Algernon Percy, 4th Duke of Northumberland (1792-1865), whose health was failing. Faraday refused on the grounds that he was the servant of the Royal Institution rather than its master. From 1865 his health declined sharply and he died at Hampton Court on 25 August 1867 and was buried five days later in the Sandemanian plot in Highgate Cemetery.

None of Faraday's work would have been possible without access to the laboratory of the Royal Institution. This is especially so in the case of his scientific work for the state and its agencies. Such necessity is further confirmed by the fact that Faraday's successor at the Royal Institution, John Tyndall (1820-1893), also succeeded him, in 1865, at Trinity House. Tyndall was born in Ireland and was originally a railway surveyor. He then taught mathematics at Queenwood College in Hampshire, a boys school, before going to Marburg where he studied under Robert Bunsen (1811-1899) receiving his PhD in 1850. Tyndall took a strong interest in magnetism and thus attracted Faraday's attention. In 1853 he delivered a highly successful Friday Evening Discourse which led to his appointment, at Faraday's suggestion, as Professor of Natural Philosophy to succeed the recently retired Brande. Tyndall became Superintendent of the House following the Faraday's death. However, Faraday was succeeded as Fullerian Professor of Chemistry by William Odling (1829-1921) for five years and then by John Hall Gladstone (1827-1902) for three years.

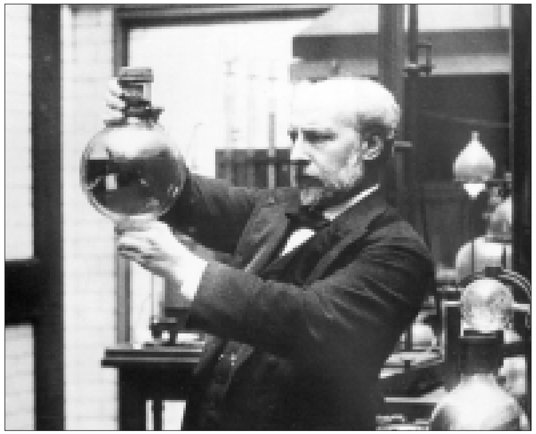


Tyndall as a lighthouse. From Moonshine, *1884*

Tyndall's scientific work included showing why the sky is blue, establishing a theory of glaciers and attacking theories of spontaneous generation. But his most notable work was in the popularisation of science. He coined the phrase 'the scientific use of the imagination' which Arthur Conan Doyle (1859-1930) had

Sherlock Holmes use in *The Hound of the Baskervilles* (1902). Tyndall delivered a large number of lectures (including twelve series of Christmas lectures) and wrote many books on popular scientific subjects. In his 1874 Presidential address to the Belfast meeting of the British Association for the Advancement of Science, Tyndall made the most famous/notorious statement of his view that the world should be studied from a naturalistic viewpoint rather than a theological one. The public impact of this address was still being felt in 1903 when George Bernard Shaw (1856-1950) had Mrs Whitefield say 'Nothing has been right since that speech that Professor Tyndall made at Belfast' in his 1903 play *Man and Superman*.

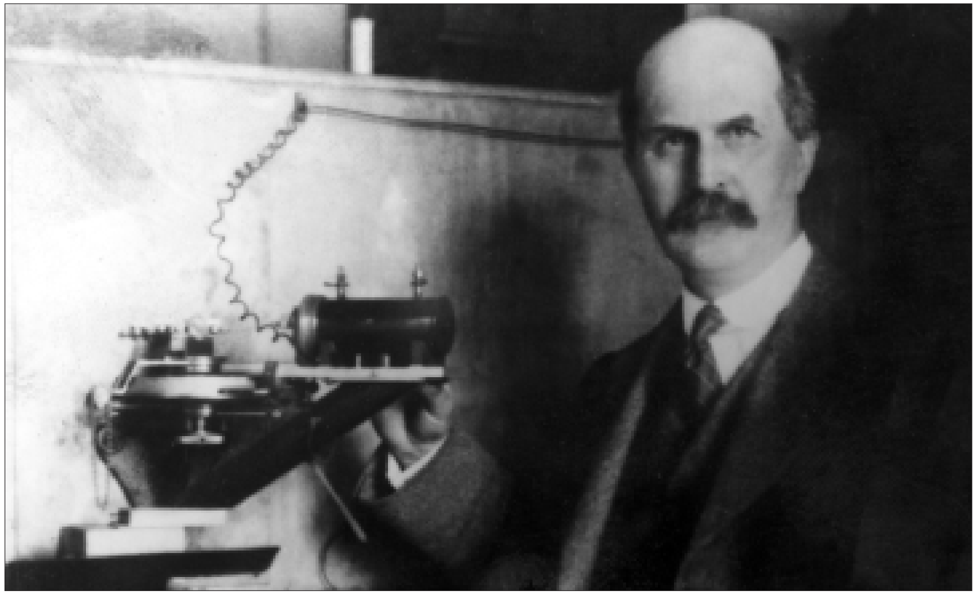
The outstanding record of research by its professors led the Royal Institution to formally adopt research as one of its activities in 1862 following a report by its Secretary, Henry Bence Jones (1814-1873). Indeed research came to have an ever increasing role within the Royal Institution as science in Britain expanded in the late nineteenth century. Following Tyndall's retirement in 1887, John William Strutt, 3rd Lord Rayleigh (1842-1919) was appointed Professor of Natural Philosophy, while James Dewar (1842-1923), who had been Fullerian Professor of Chemistry since 1877, became Superintendent of the House. Rayleigh, who had moved from being Cavendish Professor of Experimental Physics at Cambridge University, was also a Secretary of the Royal Society and had a private laboratory at his house Terling Place near Colchester. In 1896, he too became Scientific Adviser to Trinity House following in



Dewar with flask. Photograph, c.1900

Faraday's and Tyndall's footsteps. Rayleigh, with William Ramsay (1852-1916) at University College London, discovered the inert gas argon, for which he won the Nobel Prize for Physics in 1904. The Nobel Prize had been established in 1901 and this was the first time, but by no means the last, that it was awarded to someone working in the Royal Institution. (Rayleigh's large argon machine is on display in the Ante-Room).

Scientific research at the Royal Institution was given a massive boost in 1896 when the industrial chemist Ludwig Mond (1839-1909) endowed the Davy-Faraday Research Laboratory. Number 20 Albemarle Street was purchased and converted into a large modern laboratory which extended it beyond the two or three basement rooms that had been used hitherto. The Davy-Faraday Research Laboratory was opened by Edward, Prince of Wales (1841-1910) and Dewar and Rayleigh became its joint first Directors. Although Dewar divided his time between Cambridge (where he was Jacksonian



W.H. Bragg with spectrometer. Photograph, c.1920

Kathleen Lonsdale. Photograph by Lotte Meitner-Graf, c.1950

Professor of Natural Philosophy) and the Royal Institution, his important work on cryogenics was located at the Royal Institution. This had been a long term interest of his in the course of which he invented the Dewar flask (now popularly known as the 'Thermos' flask) to minimise heat loss. His work achieved success when on 10 May 1898 he first liquefied hydrogen after many attempts. (See the painting, in the Ante-Room, of Dewar lecturing on the subject).

The comparatively small size of the Royal Institution has meant that the direction of research in the Davy-Faraday Laboratory has followed the scientific interests of the Director. Thus, when William Henry Bragg (1862-1942) became Director in 1923, x-ray crystallography became the chief subject of research. Previously, Bragg had been educated at the University of Cambridge and had then taught mathematics and physics at the University of Adelaide in Australia where his son William Lawrence Bragg (1890-1971) was born. He had commenced working on radiation and x-rays by 1903. In 1909 he returned to England as Professor of Physics at Leeds University where, with his son Lawrence (by now at Trinity College, Cambridge), he worked out how to determine the structure of crystals using their x-ray diffraction patterns. For this work they jointly received the Nobel Prize for Physics in 1915; Lawrence Bragg, at the age of twenty five, remains the youngest Nobel Prize winner ever. It was this diffraction technique that was later used at the Cavendish Laboratory in Cambridge by Francis Crick and James Watson to reveal the double helical structure of DNA in 1953; indeed Lawrence Bragg, who at that time was head of the Cavendish, wrote the preface to Watson's *The Double Helix* (1968).

At the Royal Institution William Bragg built up a formidable team of researchers into crystallography. Scientists who passed through the laboratory included John Desmond Bernal (1901-1971), William Thomas Astbury (1898-1961) and the only British woman ever to have won the Nobel Prize for Chemistry, Dorothy Hodgkin. Another member of Bragg's team was Kathleen Lonsdale, the first woman to be elected (in 1945) a Fellow of the Royal Society. She worked in the 1920s on the theory of space groups to help determine where possibilities of molecular symmetry might occur. One hundred years or so after Faraday had discovered benzene in the Royal Institution, Lonsdale demonstrated, for the first time, that its ring was hexagonal and planar, and she also calculated its precise dimensions.

Following the elder Bragg's death in 1942 there was a period of three Directors of the Davy-Faraday Laboratory (Henry Dale (1875-1968), Eric Rideal (1890-1974) and E.N. da C. Andrade (1887-1971)) before Lawrence Bragg moved from the Cavendish Professorship to became Director in 1953. Bragg was the first person to be denominated explicitly as Director of the Royal Institution. Previously much of the work now done by the Director had been undertaken by the Secretary of the Royal Institution.

Like his father, Lawrence Bragg built up a strong research team to work on x-ray crystallography in the Davy-Faraday Research Laboratory. Max Perutz and John Kendrew (1917-1997) both remained at the Cavendish Laboratory in Cambridge. However, they were appointed Readers in the Royal Institution and there was close collaboration between the two laboratories. A major piece of work carried out by this team, particularly by David (later Lord) Phillips (1924-1999), was the determination of the structure of lysozyme. This substance, which is a constituent of egg-white, was the first enzyme to have its structure completely determined. The original model and Bragg's drawing of lysozyme are in the collections of the Royal Institution.

Richard Catlow delivering a schools lecture. Photograph, late 1990s.

During his period as Director of the Royal Institution, Bragg established, in 1954, a major programme of Schools Lectures which continue to flourish. In these lectures scientists talk about and demonstrate scientific experiments to young people who come in their thousands each year. This programme has become increasingly valuable in building on and supporting the National Curriculum. On Bragg's retirement in 1966, George (now Lord) Porter was appointed Director, a position he held until 1985 when he became President of the Royal Society. Research at the Royal Institution then switched to investigating high-speed chemical reactions using photochemical methods. Early in Porter's directorship there was a large fund raising appeal based on the centenary of Faraday's death. Money from this appeal was used to renovate some third floor laboratories and build the Bernard Sunley Lecture theatre on the ground floor, the Faraday Museum and archives room in the basement. Porter was also instrumental in founding the Royal Institution Mathematics Masterclasses in 1979, following Christopher

Zeeman's very successful 1978 Christmas lectures on mathematics (the first time the subject had been covered by the lectures). The Mathematics Masterclasses are aimed at extending an interest in mathematics in able young mathematicians, and now run in 39 centres throughout the country attended by about 3000 young people annually; a primary level programme commenced in the spring of 1999 which a year later had twelve centres.

Following Porter's retirement, the dominant topics of research became solid state chemistry under the Directorships of the chemists John Meurig Thomas (Director, 1985-1991) and Peter Day (Director, 1991-1998). In 1998 the directorships of the Royal Institution and Davy-Faraday Research Laboratory were separated. The Wolfson Professor of Natural Philosophy, Richard Catlow, took over the latter and work continues on solid state chemistry using advanced computational and experimental techniques. The neuroscientist Susan Greenfield, who was the first woman in nearly 170 years to deliver the Christmas lectures in 1994, was appointed Director of the Royal Institution in 1998 to lead it into its third century.

The Royal Institution, like so many other durable British institutions, has managed to preserve and indeed enhance much of its original purpose, while meeting the challenges posed over the past two hundred years by immense scientific and social change - change which the Royal Institution played a crucial role in bringing about. It has met these challenges by adapting, when necessary, its structures, where it concentrated its efforts, and in providing innovative programmes. The Royal Institution thus enters its third century still promoting 'the application of Science to the common Purposes of Life'.

Further Reading:

Gwendy Caroe, *The Royal Institution: An informal history*, London, 1985.

Morris Berman, *Social Change and Scientific Organization: The Royal Institution, 1799-1844*, London, 1978.

Henry Bence Jones, *The Royal Institution: Its Founder and its First Professors*, London, 1871.

There are a large number biographical studies and articles on most of the people who have worked in the Royal Institution including the following, in chronological order of subject:

Sanborn C. Brown, *Benjamin Thompson, Count Rumford*, Cambridge, MA, 1979.

David Knight, *Humphry Davy: Science and Power*, Oxford, 1992.

Geoffrey Cantor, David Gooding and Frank A.J.L. James, *Faraday*, London, 1991.

A.S. Eve, and C.H. Creasey, *Life and Work of John Tyndall*, London, 1945.

Gwendy Caroe, *William Henry Bragg, 1862-1942: Man and scientist*, Cambridge, 1978.

John M. Thomas and David Phillips (eds), *Selections and Reflections: The Legacy of Sir Lawrence Bragg*, Northwood, 1990.

The Royal Institution web page, which contains full details of future events, research and much else, is at: http://www.ri.ac.uk