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Michael Faraday and His Contribution to Anesthesia

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Michael Faraday (1791–1867) was a protégé of Humphry Davy. He became one of Davy's successors as Professor of Chemistry at the Royal Institution of Great Britain. Of Faraday's many brilliant discoveries in chemistry and physics, probably the best remembered today is his work on electromagnetic induction. Faraday's contribution to introduction of anesthesia was his published announcement in 1818 that inhalation of the vapor of ether produced the same effects on mentation and consciousness as the breathing of nitrous oxide. He most likely became familiar with the central nervous system effects of nitrous oxide through his association with Davy, an avid user of the gas. Sulfuric ether was a common, convenient, cheap, and easily available substance, in contrast to nitrous oxide, which required expensive, cumbersome, and probably not widely available apparatus for its production and administration. The capability for inhaling intoxicating vapors eventually became commonly available with the use of ether instead of the gas. The first surgical anesthetics were a consequence of the resulting student "ether frolics." The 1818 announcement on breathing ether vapor was published anonymously; however, notations in Faraday's handwriting in some of his personal books clearly establish Michael Faraday as the author of this brief communication. (Key words: Anesthesia: history. History: ether; Faraday, Michael; nitrous oxide.)

THE BICENTENNIAL of the birth of Michael Faraday (1791–1867) was memorialized by special exhibits at the National Portrait Gallery and at the Science Museum in London. Display of photographs, portraits (fig. 1), textual material, and historical scientific apparatus celebrated his life and scientific accomplishments in chemistry and physics and especially his discoveries in the area of electromagnetic induction. Because Faraday also played a small but significant role in the development of anesthesia, it is appropriate that this particular contribution be recalled and noted in connection with his bicentennial year.

The Early Life of Michael Faraday

As a youth, Faraday was apprenticed to a stationer and bookbinder. This occupation gave him access to many books, and he was an avid reader. He also attended scientific lectures whenever possible and performed simple scientific experiments. Despite his advantageous position, he strongly wished to leave commercial trade, which he regarded as "vicious and selfish."[1] He attended several of Humphry Davy's chemistry lectures at the Royal Institution. At these presentations he took detailed notes, which he then carefully transcribed and bound in a volume that he sent to Davy together with a request for employment in science. Thus, in 1812 Faraday was engaged as Davy's assistant at the Royal Institution. In this capacity he assisted Davy in his laboratory experiments and at his lectures and eventually began lecturing on his own.[1]

Michael Faraday accompanied Davy and his wife on a European tour in 1813 despite the war between England and Napoleonic France. Among his duties on this trip was service as Davy's valet (and also as his gunbearer and loader on hunting expeditions). Davy treated Faraday with every consideration, but Mrs. Davy insisted that Faraday maintain his subordinate status and would not permit him to dine with the Davys and their company. However, this trip provided Faraday with the opportunity to improve his knowledge of science vastly through frequent tutorial sessions with Davy and also with the opportunity to meet many prominent continental scientists. He was reengaged at the Royal Institution in 1815.

Faraday was a member of the Sandemanian Church, a dissenting congregation of the Presbyterian Church, and retained deep religious convictions throughout his life. In 1821 he entered a happy and childless marriage with Sarah Barnard.[1]

Faraday soon began to publish some of his own works. Many of these early works appeared as brief anonymous communications in the *Quarterly Journal of Science and the Arts*. By 1825 he had become Director of the Laboratory at the Royal Institution, and toward the end of 1831 he had begun the studies on electromagnetic induction and electrochemistry for which he is primarily remembered today.[1]

Chemical and Physical Discoveries

Faraday has been characterized as "arguably the greatest experimental scientist ever."[2] Initially, he worked with Humphry Davy on the invention of the miners' safety lamp and on a method for retarding corrosion of ships. His subsequent chemical contributions included advances in metallurgy, identification of clathrates, and liquefaction of several gases, including nitrous oxide and chlorine, with enunciation of the concepts of critical temperature and critical pressure. He also studied and characterized several aromatic organic compounds. In addition, he elucidated the laws of electrolysis—the basis of electrochemistry—and conducted investigations in many other areas of chemistry.[2] He introduced the terms "anode," "cathode," "electrode," "anion," and "cation" into the scientific vocabulary.[3]

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Perhaps Faraday's most prominent area of endeavor was in electromagnetic induction, the phenomenon wherein changing magnetic or electromagnetic lines of force oriented about a coil of wire induce an electric current in the coil. Faraday's observations in electricity and electrochemistry lay the foundation for much of others' subsequent work in theoretical chemistry and physics as well as the operation of many electrical and electromechanical devices, such as dynamos and electric motors, that have become indispensable in our own time.[2]

Probably no other individual in the history of science has bequeathed his name as the root of so many scientific terms in use today as did Michael Faraday. Examples include the farad (unit of capacitance), faradaic (or faradic) (a distinctive epithet of inductive electricity), and faradism (induced electricity including its therapeutic application). Additional similar words include Faraday (used attributively in the Faraday effect and Faraday's law and also as an electrochemical unit indicating the quantity of current

FIG. 1. Michael Faraday (1791–1867). Painted in 1842 by Thomas Phillips. National Portrait Gallery, London. (Reproduced with permission of the National Portrait Gallery, London.)

EXPERIMENTAL RESEARCHES

IN

CHEMISTRY AND PHYSICS.

BY

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REPRINTED FROM THE PHILOSOPHICAL TRANSACTIONS OF 1821—1857; THE JOURNAL OF THE ROYAL INSTITUTION; THE PHILOSOPHICAL MAGAZINE, AND OTHER PUBLICATIONS.

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RED LION COURT, FLEET STREET.

1859.

FIG. 2. Title page of Faraday's 1859 book, *Experimental Researches in Chemistry and Physics.*

required to deposit or liberate one mole of a substance during electrolysis), Faradization (application of faradic current), and still other terms.[4]

Faraday's Later Life

Faraday was a superb lecturer, and certain of his public scientific lectures delivered at the Royal Institution, some of which were designed for young audiences, are still read and admired today. In 1841 he suffered an episode of physical and mental exhaustion, from which he recuperated in Switzerland, and soon returned to London for many more years of scientific productivity. In recognition of his contributions he received a generous pension from the government, and in his last years he was granted a "grace and favor"† house at Hampton Court, where he

† Government-owned living accommodations granted at the discretion of the Sovereign to worthy subjects.

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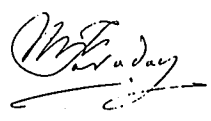

Faraday's own copy containing his own memoranda of such of his articles as are not printed either in this volume or in the volume of Experimental Researches in Electricity.

EXPERIMENTAL RESEARCHES

IN

CHEMISTRY AND PHYSICS.

FIG. 3. Half title page of Faraday's book bearing his signature and on the opposite page, the inscription of Sylvanus P. Thompson, "Faraday's own copy containing his own memoranda of such of his articles as are not printed either in this volume or in the volume of Experimental Researchers on Electricity."

died peacefully on August 25, 1867. Michael and Sarah Faraday are buried at Highgate cemetery in London.[2]

Faraday's Contribution to Anesthesia

Michael Faraday's small but important contribution to the development of anesthesia is detailed in a brief and unsigned communication published in a "miscellania" section of the *Quarterly Journal of Science and the Arts* in 1818:

> v. Effects of Inhaling the Vapour of Sulfuric Ether. When the vapour of ether mixed with common air is inhaled, it produces effects very similar to those occasioned by nitrous oxide. A convenient mode of ascertaining the effect is obtained by introducing a tube into the upper part of a bottle containing ether and breathing through it; a stimulating effect is at first perceived at the epiglottis, but soon becomes very much diminished, a sensation of fullness is then generally felt in the head, and a succession of effects similar to those produced by nitrous oxide. By lowering the tube into the bottle, more of the ether is inhaled at each inspiration, the effect takes place more rapidly, and the sensations are more perfect in their resemblance to those of the gas.
>
> In trying the effects of the ethereal vapour on persons who are particularly affected by nitrous oxide, the similarity of sensation produced was very unexpectedly found to have place [*sic*]. One person who always feels a depression of spirits on inhaling the gas, has a sensation of a similar kind produced by inhaling the vapour.
>
> It is necessary to use caution in making experiments of this kind. By the imprudent inspiration of ether, a gentleman was thrown into a very lethargic state, which continued with occasional periods of intermission for more than 30 hours, and a great depression of spirits; for many days the pulse was so much lowered that considerable fears were entertained for his life.[5]

The important influence of this communication by Michael Faraday on the eventual introduction of anesthesia was to suggest substitution of ether for nitrous oxide when alteration of mental function was desired. This change would make the inhalation of intoxicating vapors safer and more widely available to anyone who wished to try

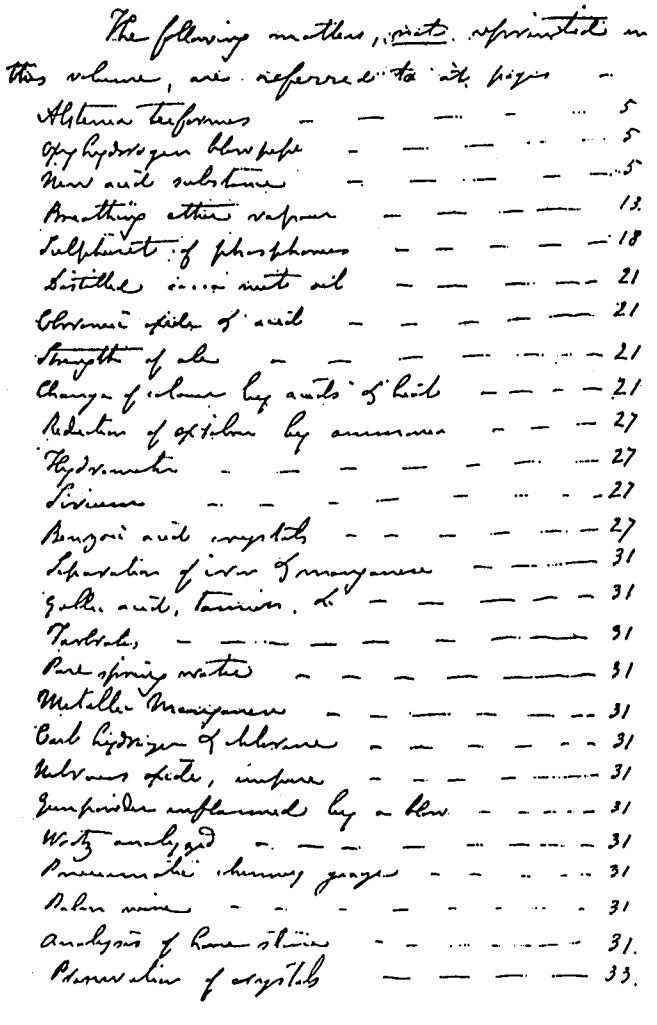

FIG. 4. Table in Faraday's hand listing: "The following matters not reprinted in this volume, are referred to at pages—" The fourth item in the list is "Breathing ether vapour" at page 13.

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FIG. 5. Contents of a sheet of paper pasted in the book over page 13: "Breathing ether vapour 1818 Quarterly Journal iv 158."

it. Rather than invest a large sum in equipment and chemicals to embark on a hazardous experiment with nitrous oxide one merely had to purchase the desired quantity of ether from the chemist's shop. Nitrous oxide *per se* was not expensive—Davy had calculated that it could eventually be produced for about two pence per dose[6]—but the apparatus required to generate, store, and administer nitrous oxide was very costly and well beyond the means of most people. This equipment was available from the firm of Boulton and Watt of Birmingham and would have cost from about £10 for a large apparatus to £3 15′ for the small portable apparatus including the necessary accessories.[7] (This was at a time when a working man's family could subsist on £30–40 per year[8]). Also, to prepare nitrous oxide for inhalation, considerable skill in chemical manipulation was required to obtain gas of high quality, free from the toxic higher oxides of nitrogen. Recreational inhalation of ether became an increasingly popular pastime as the first half of the 19th century progressed. The earliest administrations of ether for pain relief during surgery by Crawford Long[9] and William Clarke[10] were inspired by student "ether frolics."

Faraday no doubt became well versed in the effects of nitrous oxide inhalation through his association with Humphry Davy. During 1799 and 1800 at Thomas Beddoes's Pneumatic Institution in Bristol, Davy breathed nitrous oxide with enthusiasm, and sometimes to excess, and administered the gas to many others. He described its effects in great detail.[6,11] Administration and inhalation of nitrous oxide by Davy continued after his appointment to the Royal Institution in 1800. The famous 1802 cartoon by Gilray depicted a wild inhalation session at the Royal Institution presided over by Davy and witnessed by a large audience of contemporary dignitaries.[12] An 1806 account related that a group of distinguished men became quite drunk on the "gaseous oxyd of azote" and called it "Philosophical Brandy." It was noted that on this occasion, "Professor D—Y" acted quite silly while Count Rumford fell asleep in accord with his phlegmatic personality.[13] These activities were no doubt continued into the time of Faraday's early career at the Royal Institution, and it is no mystery how Michael Faraday learned about the effects of nitrous oxide inhalation. The means by which Faraday became familiar with the properties of sulfuric ether that he described are not known. However, in Faraday's time ether was a common, readily available, and widely used medicinal substance. Others, such as R. J. Thornton, had commented on the ether's peculiar cerebral effects, which they had encountered during its medicinal use.[14]

Authorship of the 1818 Suggestion

Although the brief article on the effects of ether vapor quoted above was unsigned, it is easy to establish Michael Faraday as its author. Jeffreys indicated that an annotated copy of Faraday's *Experimental Researches in Chemistry and Physics* exists at the Institution of Electrical Engineers in London, which confirms Faraday's authorship[15] (fig. 2). Inscribed on the half title page of this particular book is Faraday's name in his own handwriting, confirming that it was his personal copy (fig. 3). On the opposite page is an inscription by Sylvanus Phillips Thompson‡ (1851–1916), President of the Institution of Electrical Engineers in 1899 and a biographer of Faraday.[16] In his inscription, Thompson wrote, "Faraday's own copy containing his own memoranda of such of his articles as are not printed either in this volume or in the volume of Experimental Researches in Electricity" (fig. 3).

A list of articles written in Faraday's hand on a thin sheet of paper is pasted in the book over the table of contents. This list presents the pages where particular references are located and is headed: "The following matters not represented in this volume are referred to at pages" (fig. 4). The fourth item of the list indicates that some type of notation is to be found by page 13 concerning "Breathing ether vapour." Opposite page 13 is pasted another sheet of thin blue paper with the notation, again written in Faraday's hand, "Breathing ether vapour 1818 Quarterly Journal iv 158" (fig. 5). Similar confirmatory material verifying Faraday's authorship of the 1818 memorandum is said by Jeffreys to be located at the Royal Institution in London.[15]

Thus, by publicizing the observation that inhalation of the vapor of sulfuric ether produced the same mental effects as nitrous oxide breathing, Michael Faraday took his place in the sequence of distinguished individuals whose collective observations ultimately resulted in the introduction of clinical anesthesia in 1846.[17]

The author is indebted to Mrs. Lenore Symons, Archivist of the Institution of Electrical Engineers, Savoy Place, London, WC1R OBL, England for information on Faraday and his associates and for permission to examine and reproduce materials from the archives of the Institution.

‡ Symons L.: Personal communication.

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