Bodies Generally Existing as Gases," *Phil. Trans.*, **1845**, *135*, 155-177.

46. It is not possible to list all those who did attend the meeting and participated in the vote, as an attendance register was not kept. There is a record of Fellows who signed in guests, however, and from the appropriate entry in the *Journal Book of the Royal Society* for 1824, we know the following Fellows were in attendance: William Wilkins, James South (*), Alexander Crichton (*), John Knowles, Thomas Young, Thomas Tooke, Graves Haughton, Richard Phillips (*), Edward Troughton, Grant David Yeats (*), Edward Sabine, John Frederick Daniell (*), Temple Chevallier. There is also a record of those who were present for the meal of the Royal Society dining club that followed the meeting. It is likely (but not certain) that they also voted in Faraday's election: Dr. William G. Maton, Wilbraham, T. Murdock, J. F. W. Herschel (*), W. Wilkins (*), W. Marsden, A. Johnston, Lambert, Raper, Branene (probably Brande). The names marked with (*) had signed Faraday's certificate.

The authors thank Dr. Frank James of the Royal Institution for providing the lists of names.

47. Faraday to Warburton, 29 August 1823. Quoted in reference 2, Vol. 1, p. 313.

48. *Ibid.*, p. 340.

49. J. Z. Fullmer, "Technology, Chemistry and the Law in Early 19th Century England," *Technology and Culture*, **1980**, *21*, 1-29.

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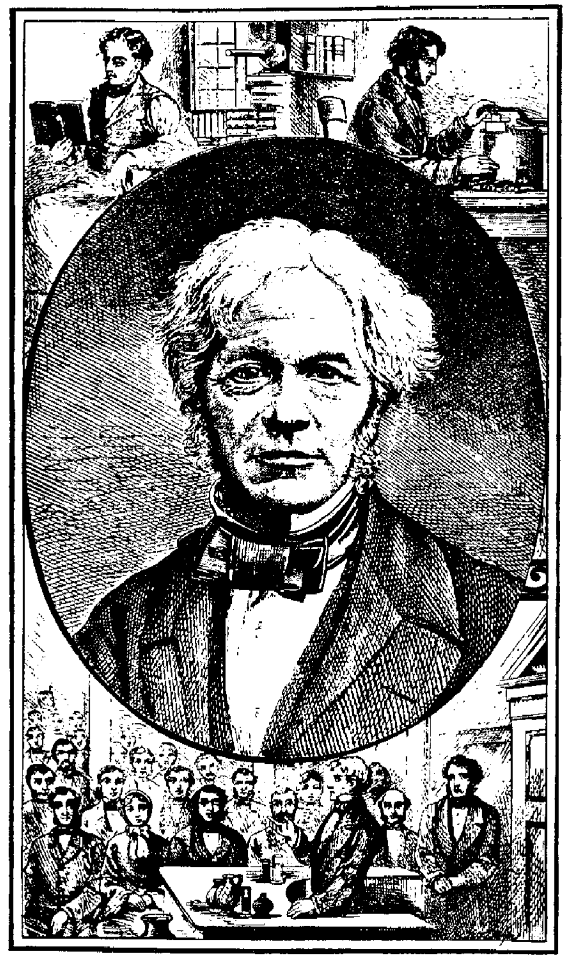
EDUCATING THE JUDGMENT: FARADAY AS A LECTURER

Geoffrey Cantor, University of Leeds

Those who heard Faraday lecture unanimously declared that he was a superb teacher. Moreover, they claimed that attendance at his lectures - whether a Friday Evening Discourse, a series on a specific topic, or a set of Juvenile Lectures - was a memorable experience. While there was consensus on these matters, his auditors differed in their reactions to Faraday and his style of lecturing. This diversity is worth exploring and in the ensuing discussion I shall divide assessments into three categories, starting with references to the specific skills he deployed in the lecture theatre. The second group of comments refer to the personal qualities he projected and particularly to

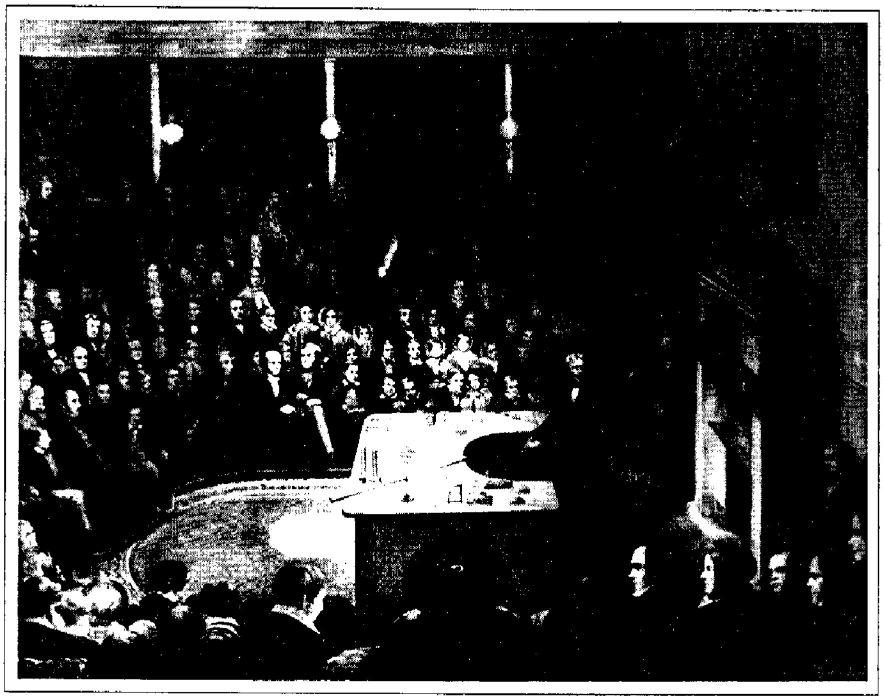


A late 19th-century woodcut of Faraday with scenes from his life in the margins. Note that the bottom scene shows him lecturing. No other scientist has so often been depicted giving popular lectures. In addition to the three illustrations in this article and the view on the front cover, at least two additional period woodcuts of Faraday lecturing are known to exist.

his ability to relate to his audience. Thirdly, and most importantly for the purpose of this paper, will be his appeal to ideas and values that transcended the particular scientific topics he discussed.

Turning first to Faraday's lecturing skills we find that many of his auditors praised his eloquence and the clarity of his exposition. For example, one lay member of his audience noted that he was "Always clear in his statements and explanations" (1). Others, especially men of science, were particularly attracted to his judicious use of illustrative experiments. Thus the American electrician Joseph Henry was impressed by Faraday's "inimitable tact of experimenting" while William Crookes described Faraday's virtuosity as "a sparkling stream of eloquence and experimental illustration" (2). Likewise the Genevan scientist Auguste De la Rive commented on Faraday's ability to "combine animated and often eloquent language with a judgment and art in his experiments which added to the clearness and elegance of his exposition" (3).

However impressive the quality of Faraday's lectures it must be remembered that he had to acquire his lecturing skills through hard work and, moreover, his practiced verbal delivery and his "inimitable tact of experimenting" were developed over a long period of time. We can identify some of his steps in this direction. While still an assistant in the Royal Institution's laboratory in the 1810s he reported to his friend Benjamin Abbott on the strengths and weaknesses of the lecturers he heard and on the responses of their auditors. He noted the appropriate shape and illumination of the lecture theatre, the best method of delivery of a lecture, its speed and duration (4). He later trained himself by taking elocution lessons and by asking his friend Edward Magrath to audit his lectures and note any faults in his delivery (5). Further evidence of his attempts to improve his style are the many notes in his own hand that contain rules on how to deliver lectures - for example, he cautioned himself "Never to repeat a phrase" (6). He likewise spent much time preparing his experiments which were an integral part of his performance and he rehearsed them carefully beforehand. Faraday was a performer of consummate skill.



Faraday giving one of his Christmas lectures to an audience that includes Prince Albert and his two sons.

The second type of response to Faraday's lectures evoked his personal qualities. He paid great attention to his appearance and deportment, and his manners were correct and congenial. Thus Richard Owen's wife, who attended a number of his lectures, reported that Faraday was charming and humorous. She also commented on his tact when he rebuked some of the male members of the audience who had invaded the ladies' gallery (7). Another female auditor was impressed by "his great talent, great goodness, and the wonderful simplicity of his nature" (8). Despite (if not because of) his humble background and his membership of a Christian sect that set him apart from polite Victorian society, he appeared as a polished gentleman before his audience.

Several contemporaries also noted that Faraday created a bond with his listeners. For example, one woman auditor felt that "he was full of sympathy with his audience" and that his "lectures were '*mind addressing mind*'" (9). Despite his acknowledged expertise in science, he strove to set aside social differences and to appeal directly to the individual. We also see this emphasis on *ad hominem* communication in his juvenile lectures. At the commencement of one series he stated that "I will return to second childhood and become, as it were, young again amongst the young" (10). His series on the chemical history of a candle likewise opened with the assertion that he claimed "the privilege of speaking to juveniles as a juvenile myself" (11).

Faraday's public persona is a complex subject but suffice it to say that it was partially shaped by his religion which emphasized how a true Christian should deport him/herself in public. For example, the Sandemanians' concern with love and fellowship is a counterpart to Faraday's interpersonal skills which helped him relate directly to his audience.

The third reaction by his contemporaries drew attention to Faraday's evocation of feelings that transcended the strict subject matter of science. Thus one auditor reported that she found his lectures spiritually uplifting and noted that he managed to convey "the *deepest* sense of religion" (12). Cornelia Crosse, the wife of the electrician Andrew Crosse, likewise considered that "No attentive listener ever came away from one of Faraday's lectures without having the limits of his spiritual vision enlarged, or without feeling that his imagination had been stimulated to something beyond the mere exposition of physical facts" (13). Auguste De la Rive, who was less prone to hyperbole, also claimed that Faraday generally ended his lectures "by rising into regions far above matter, space, and time, [and] the emotion which he experienced did not fail to communicate itself to those who listened to him" (14).

From extant versions of Faraday's lectures it appears that De la Rive was correct in claiming that Faraday often ended his lectures on an hortatory note. For example, the six lectures on the chemical history of a candle concluded with an appeal to young people in the audience to "shine as lights to those about you" and to make "your deeds honourable and [to be] effectual in the discharge of your duty to your fellowmen" (15). In these finales he often ruminated on the nature of science and on its theological significance. Thus his eight-lecture series on physico-chemical philosophy, delivered in 1847, ended with a train of speculation about how all particles of matter work in harmony and for a purpose. These considerations, asserted Faraday (16):

> ... should lead us to think of Him who hath wrought them; for it is said by an authority far above even that which these works present, that "the invisible things of Him from the creation of the world are clearly seen, being understood by the things that are made, even His eternal power and Godhead" (Romans 1:20).

A cartoon from the 14 March 1857 issue of *Punch* showing Faraday charming an audience of young ladies with one of his popular lectures.

To understand Faraday the lecturer we will need to look beyond the comments of his contemporaries since they are limited to Faraday's performance and therefore do not adequately disclose what might be called his philosophy of education. However, we are able to pursue this topic since Faraday recorded his views on science education in several places. The foremost source is his famous "Observations on Mental Education" which he delivered at the Royal Institution on the afternoon of Saturday 6 May 1854 before Prince Albert and other dignitaries. This was the second of a series of seven lectures which Faraday helped to organise at the Royal Institution. The series seems to have been the brainchild of Henry Bence Jones, the Secretary of the Royal Institution and later Faraday's biographer, who was "full of a project for getting seven great guns to lecture on education" (17). Faraday did not intend contributing to the series but asked the polymathic William Whewell (Master of Trinity College, Cambridge) to deliver a general lecture "shewing the idea of education as needed for all classes of men & minds" (18). However, although he did not consider himself competent to lecture on education, he claimed that he overcame his reservations when the Managers pressed him to speak on the subject (19).

Six of the seven lectures in the series were concerned with the educational significance of specific subjects - the history of science, languages, chemistry, physics, physiology and economics. Faraday chose the most general subject and, according to E. Ray Lankester, who brought out an edition in 1917, Faraday's was the "most interesting and in many respects the most valuable" of the series (20). The impact of the lecture is difficult to gauge but seems to have been rather slight. While it has been printed on six occasions (1854, 1855, 1859, 1867, 1917 and 1991), it was not reported in the contemporary press. *The Times*, *The Athenaeum* and *The Illustrated London News* remained silent on the subject. Moreover, as I shall argue, it was generally ignored by Victorian educationalists.

The other main source for Faraday's educational views is the evidence he gave in 1862 to the Royal Commission on colleges and public schools chaired by the fourth Earl of Clarendon (21).

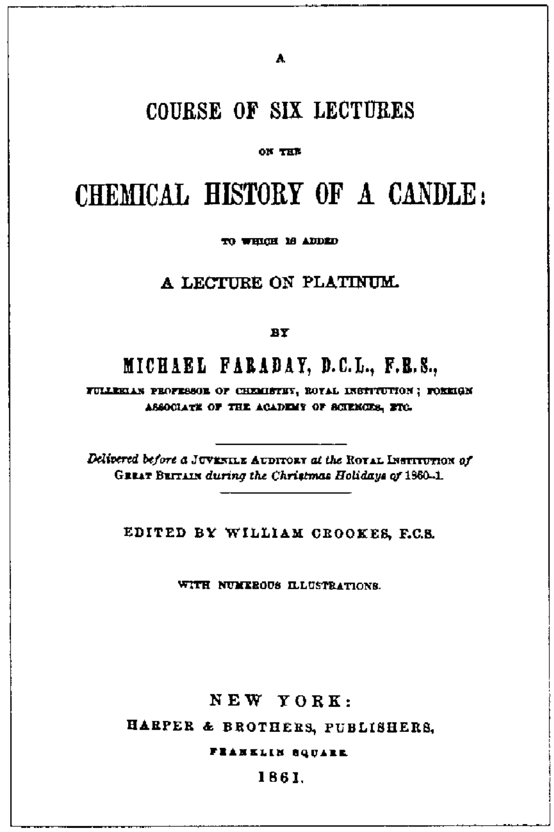
Faraday's "Observations on Mental Education" was a direct response to spiritualism, especially table-turning, which had been imported from America in the early 1850s and had rapidly become both popular and fashionable (22). As the spiritualist craze spread through all classes of society Faraday's views were frequently sought by an insatiable public. As a result of this clamour he conducted some simple experiments in the summer of 1853 and concluded that the table's movement was due to an involuntary muscular motion by the participants pressing down on the table. He publicised this conclusion in both *The Times* and *The Athenaeum* but failed both to arrest the craze and to prevent further solicitations from proponents of table-turning. In response to the continuing popularity of spiritualism, a recurrent theme in his "Mental Education" lecture of 1854 was the need for the public to become better educated in science since an adequate education would not leave the public susceptible to the influence of the table-turners. He considered that a properly trained mind would have no truck with table-turning and would readily be able to distinguish legitimate science from such imposters. However, since most people lacked an education in science they were easy prey to mesmerists, spiritualists and other charlatans. As he wrote to a scientific friend in uncharacteristically vituperative style (23):

> What a weak, credulous, incredulous, unbelieving, superstitious, bold, frightened, what a ridiculous world ours is, as far as concerns the

mind of man. How full of inconsistencies, contradictions and absurdities it is. I declare that taking the average of many minds that have recently come before me ... I should far prefer the obedience, affections and instinct of a dog.

Although Faraday's objections to spiritualism were both religious and scientific, he limited his public opposition to the latter and remained silent on the former (24).

It would be incorrect to read Faraday's "Observations on Mental Education" solely as an attack on spiritualism since the lecture was of far broader significance. In addressing his audience, Faraday's primary concern was with the nature of mind, particularly the judgmental faculty, and how it should be educated. The centrality of this theme can be gauged from the frequent recurrence of the noun "judgment" and its associated verb which appeared 59 times in the lecture - an average of more than twice a page in the printed version. Moreover, an edition published at about the time of Faraday's death bore the title "Observations on the Education of the Judgement", although it is not known whether Faraday approved this change (25).


A

COURSE OF SIX LECTURES

ON THE

CHEMICAL HISTORY OF A CANDLE:

TO WHICH IS ADDED

A LECTURE ON PLATINUM.

BY

MICHAEL FARADAY, D.C.L., F.R.S.,

FULLERIAN PROFESSOR OF CHEMISTRY, ROYAL INSTITUTION; FOREIGN ASSOCIATE OF THE ACADEMY OF SCIENCES, ETC.

Delivered before a JUVENILE AUDITORY *at the* ROYAL INSTITUTION *of* GREAT BRITAIN *during the Christmas Holidays of* 1860–1.

EDITED BY WILLIAM CROOKES, F.C.S.

WITH NUMEROUS ILLUSTRATIONS.

NEW YORK:

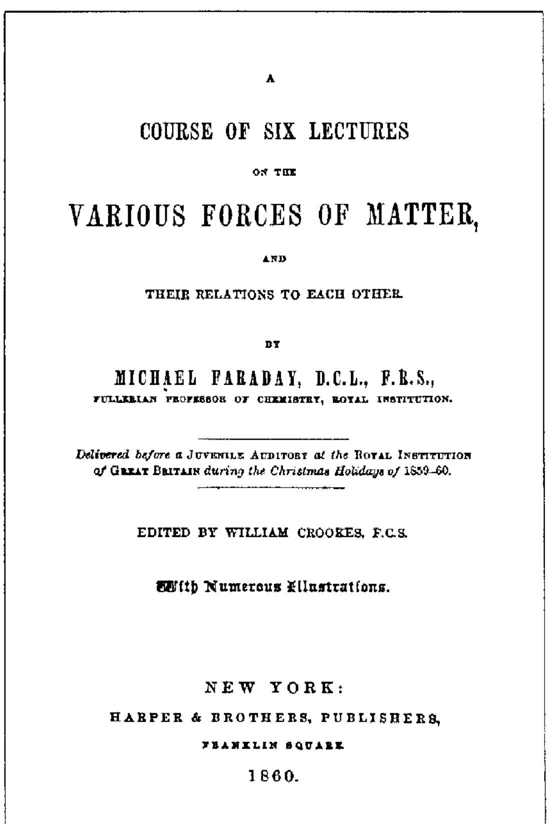
HARPER & BROTHERS, PUBLISHERS,

FRANKLIN SQUARE.

1861.

Faraday understood the judgment to be that faculty which enables a person to discriminate between truth and error, right from wrong, good from evil and, of course, between the valid claims of science and the fantasies perpetrated by table-turners. As he emphatically stated near the opening of his lecture, the major defect in the human mind can be expressed in just "three words ... deficiency of judgment" (26). This declaration established the theme for the remainder of the lecture.

Before proceeding it will be necessary to comment briefly on the word "judgment" and how it was used by earlier and contemporary writers. A classic discussion of the judgment occurred in John Locke's *An Essay Concerning Human Understanding* (1690). For Locke the judgment operates when we lack certain knowledge but need to make a decision based on an inductive inference from the available evidence. In making such a judgment, Locke considered that the mind forges links of agreement or disagreement between the idea under consideration and ideas already existing in the mind. Such comparisons are based on our experience of previously observed conjunctions (27). According to this theory the judgment operates by inductive reasoning and many commentators have classified the judgment as one of the mind's *reasoning* faculties. In an early essay dating from 1818, Faraday adopted a Lockean view by aligning the judgment with rational thought (28). However, it is important to notice that he implicitly rejected Locke's theory in 1854 since he did not conceive judgment as a rational act. Moreover, the comparison of ideas, which was central to Locke's account, found no place in Faraday's discussion.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By contrast, Faraday's analysis bears a closer resemblance to the moral sense theories propounded in the early 18th century by Francis Hutcheson and subsequently extended by such writers as David Hume, Samuel Taylor Coleridge and William Whewell. For these authors the moral sense is an internal sense which judges between right and wrong. Indeed, it has sometimes been related to the conscience which acts as a touchstone when we are faced with making moral decisions. Moreover, for many of the philosophers who supported this theory, the judgment was not a rational faculty but operated intuitively although its ability can be refined by our experience (29). Faraday was closer to these authors who considered the judgment to be an internal moral sense than to Locke and his followers who propounded more rationalist theories.

Although Faraday may have been familiar with some of the authors in this moral sense tradition, there is another and more plausible source for Faraday's account of the judgment. The role of judgment figures prominently in several biblical passages that were familiar to Faraday the Sandemanian. For example, the Psalmist speaks of the king judging "thy people with righteousness, and thy poor with judgment" (Psalm 72:2). Again, on gaining the throne, Solomon did not ask for riches or honour but for "an understanding heart to judge thy people, that I may discern between good and bad". God then expressed His pleasure with Solomon for wisely requesting an "understanding to discern judgment" (1 Kings 3:9-11). Solomon appears to have been Faraday's exemplar as he urged his audience to become wise through the exercise of their judgment. Indeed, Faraday's lecture on "Mental Education" possesses an exhortatory quality and reads like a sermon. Its style and Faraday's rather idiosyncratic use of the term judgment indicates that he was drawing on the Bible at least as much as, if not more than, on contemporary moral theories.

We shall now examine his theory of judgment. One of his basic premises was that we all possess the judgmental faculty. However, in most people it is a crude and unrefined instrument and therefore many of the judgments we make are incorrect ones. An untrained judgment would not readily be able to distinguish truth from error, or a piece of legitimate science from a manifestly false claim about spirits moving tables. However, just as we can train our voices by frequent practice or learn to discriminate between different types of wine, so the judgment can be trained. Educating the judgment is not rapidly achieved but "will require *patience* and *labour of thought*" (30). Moreover, as part of this training we must frequently and consciously reflect on the workings of our own judgment.

In his "Mental Education" lecture Faraday offered many general hints on how to educate the judgment. For example, he suggested that we should take full cognizance of the information supplied by our senses but treat this data with caution since the senses can deceive. Likewise, we should not make judgments too hastily. Instead, we should frame our ideas with precision and clarity. Moreover, we must learn from our errors. The judgment thus emerges as a ringmaster trying to

A cartoon entitled "Faraday giving his card to Father Thames" which appeared in the 21 July issue of *Punch*. As with his criticism of spiritualism, this was the result of a letter written by Faraday to the editor of the *Times* deploring the extent of the river's pollution.

keep in check the senses, the intellect, the imagination and language. Each has its rightful place in the ring but any one of them is likely to press forward, gain control and consume the others, including the ringmaster. The judgment therefore requires proper education in order to perform its task effectively.

In training the judgment, an education in science is particularly useful. "I am persuaded", wrote Faraday, "that all persons may find in natural things an admirable school for self-instruction and a field for the necessary mental exercises" (31). While the judgment was to be used in all other fields (except possibly religion), the sciences offered the best ground for training the mind and increasing our self-awareness (32). The several examples offered throughout Faraday's lecture were to confirm this point. Thus a scientific training provides the mental discipline to weigh evidence with care - this exercises the discriminatory power of the judgment. Through the practice of science we also become aware of our own ignorance and the deficiency of our judgmental power. Science teaches us not to be seduced by our pet hypotheses or by our imagination but to subject these honestly and critically to the outcome of experiments. We must also pay due attention to the laws of nature which cannot be suspended at our whim but provide touchstones against which to judge facts. Furthermore, science trains us to withhold our judgment unless the evidence is compelling. It also teaches us to frame our ideas with precision and to use language with clarity. Most importantly "This education has for its first and last step *humility*" - a term which was often applied to Faraday and possesses strong religious connotations (33).

Before the Public Schools' Commission in 1862, Faraday again stressed the importance of science education in training the mind. He claimed that there cannot be a better school for educating the mind than the study of natural science which encompasses "the laws impressed on all created things by the Creator and the wonderful unity and stability of matter and the forces of matter" (34).

These claims about the value of a scientific education were illustrated by several examples taken from the experience of Faraday and his contemporaries. Thus he claimed that some of his early hypotheses were proved wrong and had to be abandoned. In other cases, such as his theory of electrolytic conduction, he accepted the criticisms of his fellow scientists but, while holding his hypothesis in abeyance, became increasingly convinced of its validity (35). He also cited the example of D. F. J. Arago who, while describing the phenomenon which has come to be known as Arago's disc, judiciously avoided attributing a physical cause to the disc's rotation (36).

The correct exercise of the judgment was very important to Faraday not only in scientific matters but in all other aspects of life (again with the possible exception of religion). I have argued elsewhere that in many different areas of his life Faraday created strong demarcations between opposing concepts. Thus he sharply distinguished order from confusion, safety from danger and good from evil. His emphasis on the operation of the role of the judgment takes on broader significance in this psychological context. It is clear that he possessed a powerful drive to discriminate between right and wrong, good and evil. For example, as a Sandemanian he was committed to live strictly according to the demanding moral code laid down in the Bible and therefore had to decide the correct action in any circumstance. Imbued with the sect's stern religious values, he was conscience stricken when he thought he had adopted the wrong course of action through the inadequate exercise of his judgment (37).

The notion of judgment is itself one of a pair of opposites, its contrary being prejudice which is the failure to make a balanced judgment, owing to some prior conviction. Throughout his writings Faraday launched attacks on the various forms of prejudice. For example, a scientist who became too attached to an hypothesis would not be able to perceive the facts clearly or be able to appreciate alternative hypotheses. Thus in his 1844 attack on atomism Faraday urged scientists to distinguish fact from theory and he stressed that theories are only assumptions and should be treated as such. However, if scientists "forget that it is an assumption" then the theory "becomes a prejudice, and inevitably interferes, more or less, with a clear-sighted judgment" (38). Likewise in his lecture on "Mental Education" Faraday noted our tendency to deceive ourselves but he then argued that if we are aware of our prejudices we should strive to eliminate them by the proper exercise of the judgment (39). Prejudices also pervaded society. Thus he identified pervasive prejudices propagated by the British school system, and on being asked by the Commissioners why science was so neglected in schools, he answered that "it is only a matter of habit and of prejudice, derived from pre-existing conditions" (40).

Faraday's discussion of the judgment was highly reflexive since in his "Observations on Mental Education" he offered a very personal view based on his own mental development. As he stated in a prefatory note to the 1859 edition, his observations were "immediately connected in their nature and origin with my own experimental life" (41). Moreover, at the end of the lecture Faraday admitted that he had delivered "an open declaration, almost a [personal] confession" based on his own experience (42). What is most striking about these reflections is that Faraday nowhere discussed the role of educational institutions such as schools and universities - even the Royal Institution was not mentioned. Instead he emphasized *self-education*. He was an autodidact and he referred all educational questions to the development of mind and not to institutions. He even annoyed the Royal Commissioners by failing to respond to their questions about public schools (of which he had no experience) and instead insisting on talking generally about educating the mind (43). His comments about teachers were equally robust and individualistic. When the Commissioners pressed Faraday on the question whether boys should receive instruction in science prior to the age of 12 or 13, they received little assistance in being told that schools should not employ a man "who is a pedant in his science, and delights in abstract terms ... You want men who can teach". Moreover, he asserted that lectures "depend entirely for their value upon the manner in which they are given. It is not the matter, it is not the subject, so much as the man" (44). Such advice was of little use to Her Majesty's Commissioners in formulating educational policy on the amount of science to be taught and at what ages.

While Faraday acknowledged that "any useful education must be of the *self*", he considered that "society, as a body, must act powerfully in its cause" (45). Moreover, he informed the Commissioners that the "first thing to do is to give scientific teaching an assured and honoured place in education" (46). There was, he asserted, plenty of scope for Britain to encourage scientific education, which had been sorely undervalued. One telling comparison was with France where science was better appreciated and understood by all ranks in society.

Since education was of the self, ignorance and lack of judgment were manifest in all classes. Faraday found not only British workmen deficient in science but also the army officers he taught at Woolwich and his auditors at the Royal Institution, who were drawn principally from the higher ranks of society (47). He was particularly critical of the prevailing emphasis on teaching Latin and Greek to the upper classes who were manifestly ignorant of science. Indeed, men and women highly educated in the classics were, he claimed, the most ignorant in natural knowledge. They pestered him about mesmerism and table-turning and were so convinced of the truth of these soi-disant sciences that they could not be dissuaded by informed argument. "They are ignorant of their ignorance at the end of all that education", Faraday noted sadly (48).

In his scientific research Faraday employed no mathematics beyond simple ratios and was on several occasions hostile to the increasing deployment of mathematics, especially algebra, in the inductive sciences. Not surprisingly, this opposition to mathematics is also found in his educational views. Although he recognised that mathematics was the only branch of science generally included in the public school curriculum, he told the Public Schools' Commissioners that mathematics offered only a very limited training for the mind since it dealt with logical relationships and not with the behaviour of physical objects in the world. Hence those who were trained in mathematics could often "make no useful judgment at the sight of a machine". Moreover, perhaps with Augustus de Morgan in mind, he chastised those "excellent mathematicians" who were prejudiced in favour of table-turning and mesmerism (49). In his opinion the study of mathematics did not significantly improve the faculty of judgment (50).

Mathematics was one of the two subjects well represented in the curriculum of public schools. The other was classics and the Commissioners were particularly interested whether the scientists called to give evidence considered that science should be taught at the expense of classics. Faraday's comments were rather equivocal since his questioners pressed him on the educational value of classical learning - a subject outside his experience. Yet he was clearly dubious about the role claimed for classics in educating the mind and instead argued for the importance of the physical sciences.

The question whether science should be taught in schools was one of several educational issues hotly debated at the mid-century. At that time a number of science-related innovations were implemented, such as the Cambridge Natural Sciences Tripos in 1848 and the School of Natural Science at Oxford two years later. Much controversy centered on the ancient universities and both were subjected to examination by Royal Commission. Other major foci for science education were the Great Exhibition and the foundation of the Government School of Mines (1851), the Royal College of Chemistry (1853) and the Department of Science and Art (1853). Science teaching in schools was a politically fraught issue with arguments raging over whether, and to what extent, it should replace classics in the public schools, how it should be examined and whether it should be introduced to the lower classes. Moreover there was much debate over whether science should be taught as a pure, morally-elevating form of knowledge or whether its utilitarian value should be emphasized (51).

Some of these issues were aired in the 1854 series at the Royal Institution but were more central to the centenary celebrations organized in the summer of the same year by the Society of Arts. These celebrations included both a large educational exhibition containing displays of school books and apparatus, pupils' work, maps, scientific apparatus, etc., and a series of lectures which opened with William Whewell speaking "On the Material Helps of Education" (52).

Faraday's intervention on the topic of science education was thus part of a much broader educational debate and many of his general comments on the importance of science should have been welcomed by a wide range of educational reformers including radicals and utilitarians. However, I want to end this paper by drawing attention to two ironies implied by Faraday's lecture on "Mental Education".

First, as I have shown, his lecture was fundamentally concerned with moral values and with the role of the judgment; as such, it was principally an exercise in moral philosophy. As far as it engaged questions of education, it was about self-education. These subjects existed outside the main arena of educational debate in the 1850s and 1860s. Indeed, no other commentator engaged questions about the judgment and the issue of self-education was very low on the educational agenda.

Similarly, Faraday paid no attention to the leading issues of the day. For example, while he ignored the issue of social class, the British educational debate was fundamentally concerned with the question of determining which aspects of science should be taught to each class. Thus all the other six lectures delivered in the same series at the Royal Institution were addressed specifically to the upper classes, while the series organized by the Society of Arts was concerned with science for lower echelons of society. Furthermore, as I have already noted, Faraday's evidence to the Royal Commissioners did not assist them in framing a science policy for public schools - how much should be taught, to which age-groups, and how it should be examined.

Although Faraday's "Mental Education" lecture was an impressive tour de force, it was an idiosyncratic performance and it proved largely irrelevant to the main educational concerns of the 1850s and 1860s.

The second irony connects the above with my opening comments. Although Faraday's views on education were out of key with those of his contemporaries, he was nevertheless the foremost science lecturer of the day. He could excite his audience and convey science so eloquently, yet his views on education were idiosyncratic and found few resonances among contemporaries. This second irony underscores Faraday's paradoxical position in Victorian science and emphasizes the contrast between the public Faraday and the private Faraday. Against our image of the successful researcher and the renowned lecturer must be set the very private world of Faraday the Sandemanian (53).

References and Notes

1. B. Abbott, "The Late Professor Faraday", *The Friends' Quarterly Examiner*, **1868**, *2*, 122-8. Quotation on p. 125.

2. N. Reingold, et al., *The Papers of Joseph Henry*, 5 Vols., Smithsonian Institution Press, Washington, 1972-1985, Vol. 3, p. 255; M. Faraday, *A Course of Six Lectures on the Various Forces of Matter and their Relations to Each Other*, Griffin, London and Glasgow, 1860, p.v.

3. A. De la Rive, "Michael Faraday, His Life and Work", *Philosophical Magazine*, **1867**, *34*, 409-37. Quotation on p. 411.

4. M. Faraday to B. Abbott, 11 June 1813 and 18 June 1813 in L. P. Williams, ed., *The Selected Correspondence of Michael Faraday*, 2 Vols., Cambridge University Press, Cambridge, 1971, Vol. 1, pp. 54-7.

5. S. P. Thompson, *Michael Faraday, His Life and Work*, Cassell, London, 1898, p. 231.

6. H. Bence Jones, *The Life and Letters of Faraday*, 2nd ed., 2 Vols., Longmans, London, 1870, Vol. 2, p. 446.

7. Reference 5, pp. 236-7.

8. M. L[loyd], *Sunny Memories, Containing Personal Recollections of Some Celebrated Characters*, 2 Vols., Women's Printing Society, London, 1879-89, Vol.1, p. 67.

9. *Ibid.*

10. Faraday, reference 2, p. 2.

11. M. Faraday, *The Chemical History of a Candle*, Hutchinson, London, 1907, p. 2; A. Yarrow, "An Incident in Connection with Faraday's Life", *Proceedings of the Royal Institution*, **1926-8**, *25*, 480.

12. Reference 8, p. 67.

13. C. Crosse, "Science and Society in the Fifties", *Temple Bar*, **1891**, *93*, 42.

14. Reference 5, p. 238.

15. Reference 11, p. 113.

16. Reference 6, Vol. 1, p. 225. This biblical passage is discussed further in Herbert T. Pratt's contribution to this volume.

17. Tyndall's journal, Royal Institution, Tyndall papers. Entry for 4 February 1854. Quoted in D. Layton, *Science for the People: The Origins of the School Science Curriculum in England*, Allen & Unwin, London, 1973, p. 128.

18. M. Faraday to W. Whewell, 10 March 1854, reference 4, Vol. 2, pp. 723-4.

19. M. Faraday to W. Whewell, 14 March 1854, *ibid.*, p. 726.

20. M. Faraday, "Observations on Mental Education", in M. Faraday, *Experimental Researches in Chemistry and Physics*, Taylor & Francis, London, 1859, pp. 463-91. All subsequent quotations are from this edition.

21. "Report of H. M. Commissioners Appointed to Inquire into the Revenues and Management of Certain Colleges and Schools and the Studies Pursued and Instruction Given Therein", *Parliamentary Papers*, **1864**, *4*, 375-82. Hereafter cited as *Report*. Part of Faraday's evidence is reprinted in E. L. Youmans, ed., *Modern Culture; its True Aims and Requirements*, Macmillan, London, 1867, pp. 412-5.

22. J. Oppenheim, *The Other World. Spiritualism and Psychical Research in England, 1850-1914*, Cambridge University Press, Cambridge, 1985; L. Barrow, *Independent Spirits. Spiritualism and English Plebeians, 1850-1910*, Routledge & Kegan Paul, London, 1986.

23. M. Faraday to C. Schoenbein, 25 July 1853 in G. W. A. Kahlbaum and F. V. Darbishire, eds., *The Letters of Faraday and Schoenbein, 1836-62*, Schwabe, Basle and Williams & Norgate, London, 1899, pp. 214-6.

24. G. Cantor, *Michael Faraday, Sandemanian and Scientist: A Study of Science and Religion in the Nineteenth Century*, Macmillan, London & St. Martin's, New York, 1991, pp. 148-50.

25. Youmans, reference 21, pp. 192-230.

26. Reference 20, p. 465.

27. J. Locke, *An Essay Concerning Human Understanding*, [1690], reprinted 2 Vols., Dent, London, 1961, Vol. 2, pp. 247-9 & 277-8.

28. M. Faraday, "On Imagination and Judgement", in "A Class Book for the Reception of Mental Exercises", ff. 22-7, Royal Institution, Faraday papers.

29. F. Hutcheson, *An Essay on the Nature and Conduct of the Passions and Affections. With Illustrations of the Moral Sense*, Knapton, London, 1728; D. Hume, *A Treatise of Human Nature*, Noon, London, 1739; W. Whewell, *The Elements of Morality, including Polity*, 2 Vols., Parker, London, 1848, Vol. 1; S. T. Coleridge, *The Friend*, ed. B. E. Rooke, 2 Vols., Routledge & Kegan Paul, London & Princeton University Press, Princeton, 1969, Vol. 1, p. 153.

30. Reference 20, p. 484.

31. *Ibid.*, p. 473; cf p. 479 and *Report*, reference 21, p. 381.

32. E. Crawford, "Learning from Experience" in D. Gooding and F. A. J. L. James, eds., *Faraday Rediscovered: Essays on the Life and Work of Michael Faraday, 1791-1867*, Macmillan, London, 1985, pp. 211-27.

33. Reference 20, p. 485.

34. *Report*, reference 21, p. 381.

35. Reference 20, pp. 474-5.

36. *Ibid.*, pp. 483-4.

37. Reference 24, p. 267.

38. M. Faraday, *Experimental Researches in Electricity*, 3 Vols., Taylor & Francis, London, 1839-55, Vol. 2, p. 285; J. Agassi, *Faraday as a Natural Philosopher*, Chicago University Press, Chicago, 1971.

39. Reference 20, p. 475.

40. *Report*, Reference 21, p. 375.

41. Reference 20, p. 463.

42. *Ibid.*, p. 491.

43. *Report*, Reference 21, p. 380.

44. *Ibid.*, pp. 378-9.

45. Reference 20, p. 473.

46. *Report*, Reference 21, p. 380.

47. *Ibid.*, p. 376.

48. *Ibid.*, p. 381.

49. *Ibid.*, pp. 377 and 381.

50. Reference 20, p. 480.
51. Reference 17.
52. D. Layton, "The Educational Exhibition of 1854", *J. Royal Soc. Arts*, **1972**, *120*, 183-7 & 253-6.
53. This world is explored in reference 24.

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THE MILITARY CONTEXT OF CHEMISTRY: THE CASE OF MICHAEL FARADAY

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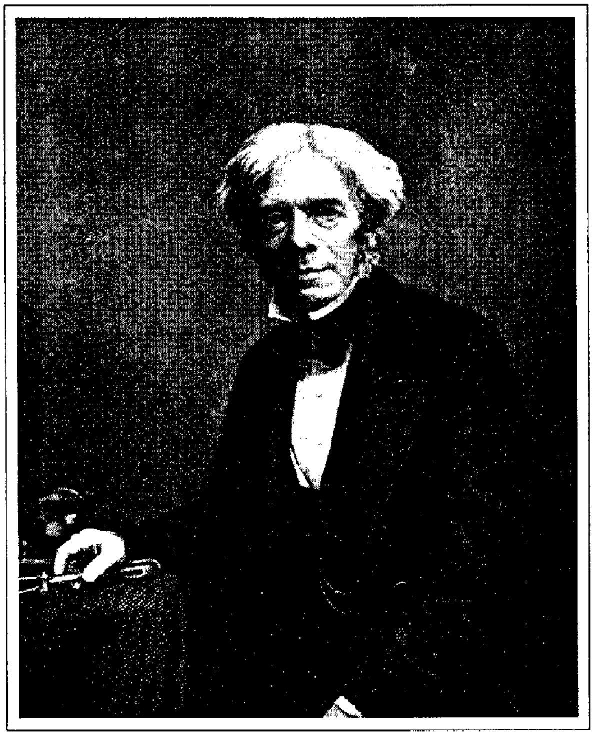
There are many essential requirements for a person to become a successful scientist. One of them is the availability of sufficient time to perform research. Michael Faraday (1791-1867) was perfectly well aware of this and frequently commented that, lacking property, time was his "only estate" (1). However, as I shall show, for various institutional and personal reasons time for research was in short supply during the latter part of the 1820s.

Faraday's opportunity to do original research, while he was still Laboratory Assistant in the Royal Institution, occurred following the discovery in 1820 of electromagnetism by the Danish natural philosopher Hans Christian Oersted (2). Men of science all over Europe conducted many further experiments in the subsequent months and advanced theories to understand this phenomenon. In the summer of 1821 Richard Phillips (3), a close friend of Faraday's, asked him to survey this activity for the *Annals of Philosophy* which Phillips edited. This Faraday did, writing up his conclusions in his only anonymous paper, "Historical Sketch of Electro-magnetism" (4). During this process he discovered electro-magnetic rotation - the principle behind the electric motor (5). He quickly published this discovery and promptly got into a priority dispute involving William Hyde Wollaston (6), the interregnum President of the Royal Society for a few months in 1820 between the death of Joseph Banks (7) and the election of Humphry Davy (8), Faraday's patron at the Royal Institution. It was claimed that Wollaston had predicted the existence of such a phenomenon, that Faraday had known this, but had not acknowledged it. However, Wollaston did not press the claim and the dispute was short lived, not at that time reaching the press (9).



Faraday in his later years.

However, it resurfaced over a more serious priority dispute in 1823 after Faraday had liquefied chlorine. He had been conducting an experiment suggested by Davy, the unexpected result of which led to the liquefaction of chlorine under pressure (10). When Davy demanded a share of the credit, Faraday demurred. A published report claimed that Davy, speaking from the Presidential Chair of the Royal Society, had stated that Faraday had been following Wollaston's suggestion when he discovered electro-magnetic rotation (11). Although Davy quickly said he had been misreported (12), the damage was done and Faraday was forced to declare his authorship of the "Historical Sketch" so as to defend his priority in public (13).

Worse was to follow. Faraday was nominated, without Davy's prior knowledge, to be a Fellow of the Royal Society (14). Davy opposed Faraday's election, since otherwise, because of their close association, it might be assumed, by members of various factions within the Royal Society, that he had prompted it. He did not want to be seen as continuing the Banksian tradition of supporting his friends and opposing his enemies irrespective of their scientific merit (15). The reason why Davy wanted to distance himself from the Banksian tradition was his hope that a firmer relationship would develop between the Society and Government, particularly the Admiralty. He wanted to encourage the state to ask for scientific advice from the Society and also to provide support for science. Davy was firmly committed to this policy and thus it was