Communicating Chemistry

The Frontier between Popular Books and Textbooks in Britain during the First Half of the Nineteenth Century

DAVID KNIGHT

Chemistry, in the half-century after 1789, enjoyed a popularity which it has not had subsequently. It was exciting, with its bangs and stinks and color-changes; there was great debate over theory, beginning with Lavoisier's; the science seemed dynamical and fundamental, unlike mechanics, which just dealt with clockwork and billiard balls; and it was accessible. For a small outlay, the apparatus necessary to prepare the new gases, or "factitious airs," could be purchased; while not perhaps quite suitable for the drawing room, small-scale chemistry did not yet require purpose-built laboratories. There had been in the eighteenth century numerous itinerant lecturers in science; with the setting up of Literary and Philosophical Societies, lecturing became a more established activity.[1] In London, the Royal Institution was the most eminent center for research and lecturing; and without the possibility of a *grand tour* on the continent, those in search of culture flocked there. Chemistry also promised to be useful. Francis Bacon had written that experiments of light must lead on to experiments of fruit; but this model of pure and applied science was not realized for many years, and chemistry was one of the first sciences whereby current knowledge was turned to the relief of man's estate.[2]

All this was reflected in chemical publications. It may be best to look at chemistry as a professional, a liberal, and a useful activity as we seek a path to follow through the writings that form a continuum from research papers and reviews, through textbooks, to popularizations. We shall find that the frontiers between these different aspects of chemistry, and between textbooks and more popular works, are hazy, especially at first, but that perhaps by about 1850 these categories are much clearer.

Chemistry and Medical Students

In Britain, the pharmacy or the apothecary's shop is still called "the chemist's," not only in popular use but more formally. Here as everywhere, chemistry became a kind of profession by clinging to the skirts of medicine. The medical school at Edinburgh was modelled upon that at Leyden, where Boerhaave had made chemistry an important part of the course: both the pirated and the official version of his textbook were translated into English. At Edinburgh, which soon became the leading medical school in Britain, and at Glasgow, medical students had to attend lectures and pass examinations in chemistry whether they liked it or not.[3]

Pharmacists, apothecaries, and surgeons in England learned their trade by apprenticeship, as did the young Humphry Davy and Edward Frankland.[4] Physicians such as William Hyde Wollaston and Thomas Young went to Oxford or Cambridge to gain a gentlemanly education, and then perhaps went on to somewhere more active like Edinburgh, where surgeons and physicians trained together. General practitioners in medicine were as a rule apothecaries or surgeons; some took a break from practice, and upgraded themselves by going to Edinburgh for a time. By 1800 the London hospitals were training large numbers of surgeons, and apprenticeship began to give way to a more formal teaching, perhaps in a private medical school like that run by John Hunter. After 1815, students of pharmacy or medicine were required to pass examinations, and therefore found themselves (like their Scottish contemporaries) having to attend courses in chemistry. With these went textbooks.

Lavoisier's *Elements* had been translated into English by the surgeon Robert Kerr, and was published in Edinburgh in 1790.[5] Lavoisier's terms, "oxygen," "hydrogen" and so on, were retained in this translation and subsequently, which makes chemical English unusual among the Germanic languages.[6] Ever since 1066 and the Norman Conquest, English has been very permeable to French. There were some rather pedantic disputes about language, but phlogiston disappeared very rapidly from English chemical writings, and there was no chemical counter-revolution.[7] Lavoisier's is not exactly a textbook; but there were soon both English translations from the French of Antoine de Fourcroy and of Jean Antoine Chaptal, and the German of Friedrich A. C. Gren, as well as textbooks written by native English speakers.[8]

It is not entirely clear what readership William Nicholson (translator of these French texts) had in mind for his *First Principles of Chemistry*. He dedicated it to Henry Cavendish; it has a single fold-out copperplate, and a series of tables at the back; and its tone is highly empirical. In the true Baconian manner, theory is left to the end of the chapters; but in that on sulphur, we find "the modern theory, which rejects phlogiston" duly given credit in a book which (as we might expect from the dedication) is old-fashioned in its language.[9] He took credit in the preface for a work of great compression (getting into one volume what would have been easier to put into three) by judicious selection and the use of side-notes, and for avoiding "system" in nomenclature and theory. The book went well; it appeared in 1790, and there was a third edition by 1793. Nicholson's writings and Lavoisier's (in French) were used by the young Davy in his chemical self-education.

In 1795, Nicholson published a *Dictionary of Chemistry*; this was a genre of some importance in our period.[10] A later famous example was Andrew Ure's "in which the principles of the science are investigated anew, and its applications to the phenomena of nature, medicine, mineralogy, agriculture, and manufactures, detailed."[11] This had begun as a full revision of Nicholson's, but became in effect a new publication; Ure sought to combat the "listlessness" with which readers perused chemical books and to make the reader appreciate "the optical revelations of Newton, and the electro-chemical magic of Davy." This was a great age of encyclopedias and dictionaries, but actually to learn science from one is a rather desperate enterprise. Mere book learning can never be enough, especially in an experimental and empirical science like chemistry: we need a teacher.

Nicholson also edited a journal, and has an important place in the history of chemistry because of his electrolysis of water in the course of refereeing Volta's paper with Anthony Carlisle.[12] Another eminent author, whose *Chemical Pocket-Book* was manifestly directed at "the professional student," was James Parkinson, the left-wing London surgeon best known for his description of "Parkinson's disease," the shaking palsy. His book was used by the practical dye-chemist John Mercer.[13] The frontispiece shows Guyton's "economical laboratory," and also the symbols of Jean Hassenfratz and Pierre Adet—which do not seem to be used anywhere else in the book, but which expressed the French antiphlogistic system.[14] The book really would fit into a pocket; and the preface has some charm: the author like the bee (a Baconian topos) has roved freely in search of materials, and tried to imitate its skill in arrangement of them. He hoped his little compendium would

> lead fresh admirers into the delightful walks which are to be found in this department of science, where wide scenes of interest and amusement are constantly opening upon the mind. May it point out the indispensable connection between Chemistry and most other sciences; and the vast advantages a knowledge of its principles may yield to those who are engaged in the most useful and profitable arts; and thereby induce those who are not of the medical profession, to seize the opportunity of obtaining fuller information, by the pleasing and expeditious mode of Public Lectures.

The type is very small, there are abbreviated references to books and papers in the text, and some of the descriptions of explosions and processes are vivid. The book would be useful to the liberal or philosophical student, and to the industrialist, as well as to the medical man.

The *Epitome of Chemistry* of William Henry, Dalton's friend and a pharmacist, was published in 1801.[15] It is noteworthy for its outright avowal of the new system. He believed that everyone who attentively compared it to the phlogiston theory, with its confused order and illogical inferences, would prefer it; and that the "revolution in this science" made learning it much easier. He was also unusual in resolving to omit the history of chemistry from his treatment, partly because it contributed little to information or amusement. He also detailed a series of experiments; in my copy, some of these have been annotated in the light of the reader's experience. They are chiefly of a mineralogical and pharmaceutical nature.

All these books were perforce addressed to a miscellaneous rather than strictly medical audience; but at Guy's Hospital in London, dedicated to the treatment of desperate diseases, courses of lectures were given to students; and in 1811 a *Syllabus* was published.[16] Mine is an interleaved copy, and on the blank pages the owner has made some notes. What is perhaps surprising is how liberal this course was, though clearly medical applications lay behind it; and less surprising is the Baconian aversion to theorizing:[17]

> Chemical Science, though making daily progress, is not yet sufficiently advanced to admit of a perfect arrangement of its parts, and as the new Nomenclature, though admirably contrived, seems from Professor Davy's late brilliant discoveries,[18] to have in some instances been at variance with facts, it has been deemed desirable in this Course of Lectures to guard against too strict an observance or hasty adoption of systematic views of arrangement.

This preface also informs us that students had free access to an extensive laboratory where they could see chemical processes conducted upon "a scale corresponding with the the expenditure of a large Hospital" and thus become "familiarly acquainted with every step," which could not be learned in the lecture room with its demonstrations. It is not clear how far the student would actually carry out experiments himself; and demonstrations by a teacher can be uncomfortably like conjuring-tricks. Certainly there was little formal laboratory instruction, offering the student "hands-on" experience, as an essential component of courses in Britain before the middle of the century.

This syllabus, like those that Davy prepared for his courses at the Royal Institution, enabled the hearer to remember and organize what he (or she at the Royal Institution) had heard.[19] But it would be little help to someone who was attending another institution and did not hear the course. Real textbooks have to be fuller; and to accompany classes taken by a variety of teachers in various places, they have to cover a kind of agreed syllabus, which most people would see as appropriate. Thomas Thomson, at Edinburgh and then as Professor at Glasgow, wrote the first really successful English chemical textbook of the nineteenth century.[20] It received the accolade of a French translation, and it was in a later edition of this book that Dalton's atomic theory was first presented to the world. By 1831 inorganic chemistry alone filled two portly volumes of 700 pages each; students must have longed for Nicholson's compression. The book is clearly but not attractively written, and is sparingly illustrated with woodcuts. For Britain, this textbook must be seen as one of the first steps in chemistry becoming a mature European science, in which national differences become less and less important in the presentation of facts organized in terms of generally accepted theory.[21]

Davy's lectures had been, and Faraday's were to be, delivered to a liberal audience; but after 1815 Davy's immediate successor at the Royal Institution, William Thomas Brande, began formal courses for medical students. The prospectus for these lectures was published in the Institution's journal, and the textbook was specifically mentioned as such.[22] The journal also carried hostile reviews of Thomson's and Henry's rival works, and of a rival lecture course at the Surrey Institution. Brande's textbook was more attractively printed and illustrated than Thomson's.[23] It contains a long (150 pp.) history of chemistry, culminating in the work of Davy, by 1810 established as "the first chemist of Europe"; and it also has various affinity diagrams and tables for converting English weights and measures to French ones. Despite his connections with Davy (who had rather little respect for his abilities), Brande is not always clear about the relationship between muriates and chlorides, made by using our hydrochloric acid and chlorine respectively, which Davy's researches had cleared up. Once again, it is a book to be worked through in order to pass an examination rather than relished.

When in the 1820s the London University was founded, medical courses were a very important part of it, and Edward Turner came from Scotland to teach particularly analytical chemistry there. At first this secular institution was merely a self-styled university, having no charter.[24] A rival body, sponsored by the Church of England and called King's College, was also set up; and the federal University of London, able to grant degrees, did not officially come into being until into the 1830s, by which time it was the fourth in England, little Durham having been chartered just before. Turner's textbook, a single bulky volume of 900 pages, has woodcuts in the text and two pages of copperplate illustrations at the end.[25] Turner's analyses had confirmed Berzelius's in his controversy with Thomson, who had believed with William Prout that all atomic weights were simple multiples of that of hydrogen.[26] In his book, theory rather curiously precedes information; but the difference between fact and theory is frequently dilated upon, and the tone of the book is highly empirical. In particular, while Turner believed that matter was atomic, he was chary of expressing the facts of chemistry in atomic terms because he was uncertain how many atoms were contained in any particular compound.[27] Such caution was typical of textbooks in our period, and helped make them rather dull: they were, after all, tools to help students pass examinations and graduate into the medical profession, or perhaps go into industry.

Relations between the Royal Institution and University College (as the godless institution was now called) were poor for many years, but at King's College the Professor of Chemistry was John Frederic Daniell, a friend of Faraday's, whose own research was in electricity. His textbook looks therefore much less directed to the medical students, who must in fact have provided bread and butter; and indeed its subtitle is "a preparatory view of the forces which concur to the production of chemical phenomena."[28] We would say, with benefit of hindsight, that the viewpoint is that of physical chemistry; and this makes a much less indigestible and fact-clogged text. The woodcut illustrations are in the footnotes, so that the text is unobstructed; the dedication is to Faraday, who in his lifetime was seen as a chemist, and the origin of the book "was a desire to present to students of chemistry an elementary view of the discoveries of Dr. Faraday in Electrical Science." Daniell also hoped to lead the student into chemistry "by a more natural method,—that is more gradually from the known to the unknown—than that which is generally adopted in our elementary books." The result of this was an unusual textbook for its time; but while it makes chemistry seem a very interesting science, with connections to sound, optics and magnetism as well as to heat and electricity, it must have seemed far from immediately relevant to the needs of the average medical student.

The final standard text which belongs to this professional medical tradition is Robert Kane's; his object was "to present to the student an account of the general principles and facts of Chemistry, and of its applications to pharmacy, to medicine, and to the useful arts."[29] The book is almost a cube, being 1200 pages long: it was written by an Irishman and published in Ireland, far therefore from the center of things; but it became a great success not only in Britain but also in the USA, because of its full coverage and clear style. It is well-illustrated with woodcuts, and uses modern-looking formulas and even something like a modern equation:

$$N_6C_{16}H_8O_{11} = N_5C_{16}H_4O_{10} + NH_4O$$

But it would have been a daunting business to settle down and read the book unless one had a professional qualification in mind.

Chemistry and a Liberal Education

It was not possible until well after 1850 to take a degree in chemistry in Britain, and therefore the scope for formal teaching of the pure science at an advanced level was limited. Davy's *Syllabuses* were designed to attract a general audience to his courses, and thus keep the Royal Institution going.[30] It may be that some subscribers annotated their copies; but Davy's own text, *Elements of Chemical Philosophy*, did not appear until 1812, when he had just given up lecturing because of his marriage, knighthood, and impending departure for France.

It was dedicated to his wife, "as a pledge that I shall continue to pursue Science with unabated ardour," and "as a proof of my ardent affection, which must be unalterable, for it is founded upon the admiration of your moral and intellectual qualities."[31] In the event, cohabitation with Jane and chemistry proved unhappy; and the book was not a great success, because it was uneasily neither a textbook nor a monograph. The aspects of the science described were those in which Davy had played a particular part; and for his peers these had been described fully in his research papers in the Royal Society's *Philosophical Transactions*. The science was therefore not fully covered, and while the student might be stimulated he would not have been taken through a standard syllabus. The "Advertisement" (a term then used for introductions) at the beginning is interesting because of its remarks on nomenclature; in the light of his work on chlorine, Davy believed that the language of chemistry was "composed of shreds and patches; innovation will be censured even when it is absolutely necessary, and neology a constant reproach."[32] He was careful to talk about proportions and numbers rather than hypothetical Daltonian atoms.

For those who went to the lectures and "mute . . . on Davy's lips reposed/ And nature's coyest secret's were disclosed," but who emerged dazzled rather than informed, a classic little work was written by Jane Marcet, but published anonymously in 1806.[33] Its title was *Conversations on Chemistry*.[34] In it, Emily and Caroline learn the science from their governess, Mrs. B. No concessions were made to supposed feminine interests.[35] We do learn that the girls were wearing muslin dresses; but the chemistry of cookery or dyeing is not at all prominent. The girls are taken through the science as in more formal textbooks, but with the recognition that "professional" chemistry, concerned with making money, is not for them. The book is well-illustrated (many chemistry books have some illustrations in common) with copper-plates; sometimes the apparatus is supported by disembodied hands, which of course shows how it was used. Experiments are clearly described. The book and its success indicate that chemistry was relatively accessible to women in the early nineteenth century; though Jane Marcet's most famous reader was the young Faraday, who was thus drawn into the science.[36]

In a book which can be dated from internal evidence to the end of 1815, John Webster described mechanics and chemistry.[37] His context was natural theology, a way of making science momentous which was particularly characteristic of Britain at this time:

> The noblest edifice of science ought to be regarded as only the threshold to the temple of the Deity. Natural religion is not sufficient for fallen man; but, like the helm which steers the majestic vessel through the trackless ocean to its destined shore, it guides us to the haven of faith, and introduces us to the consideration and reception of received truth. It shews us that we are surrounded by miracles in the natural world, as incontestable, and yet as inexplicable as those which sustain our belief in the interposition of God, by the revelation of his will. It is thus that our minds are led to repose in the delightful conviction, that the God of nature is the same wise, merciful, and gracious Being that is revealed to us in the pages of inspired truth.[38]

There is much emphasis upon heat, light and electricity, the dynamic science of the time; and thus on the work of Davy "who penetrated the secret elaboratory of nature, and developed some of her hidden laws," and for whom "all chemical affinity is the result of electrical influence." Chemistry for Webster included all the combinations of matter that were not merely mechanical: "the most important phenomena of nature; the causes of rain, hail, snow, winds, volcanos and even earthquakes . . . the vegetation of plants, and some of the most important functions of animals . . . and the arts and manufactories" as well as what we might think of as chemical. The reader would have learned a lot of contemporary science; but we would have to categorize the book as popular science, rather than as a textbook.

Some of Webster's phraseology is indeed not so far from Davy's posthumous dialogues, *Consolations in Travel*, which tells us about chemistry and its relationship to other sciences, within the context of a pantheistic natural theology and the hope of human immortality.[39] While striking and readable, and in its day successful in terms of reviews and sales, it was clearly a popular work rather than a textbook. This is less clear in William Prout's loosely organized *Bridgewater Treatise*, 1834, one of a series of eight prepared in accordance with a legacy from the Earl of Bridgewater to illustrate in various sciences the power, wisdom and goodness of God as manifested in the Creation.[40] Here, the chemistry is fairly heavy going, and the reader would be taken through a good deal of science, especially Prout's somewhat eccentric atomic and molecular theory: but the context makes it clear that this is liberal study, or popularization—natural theology being still a powerful vehicle for this in Britain at this time.

In the same tradition is George Fownes' "Actonian Prize" volume, on Chemistry as exemplifying the wisdom and benevolence of God, published in 1844 by the same publisher as his textbook, *A Manual of Chemistry*.[41] Its particular emphasis was upon animal and vegetable chemistry, in a coherent and interesting attempt to carry the Argument from Design down from the obvious to the imperceptible features of organisms. Among animals, there was not only "exquisite mechanical beauty of contrivance" in individual creatures and structures, but also "a general plan or type of organization." The microscope showed how the individual happiness of the animal, and the permanence of the race, were assured by the great Contriver; but now:

> The recent discoveries of chemistry, more especially in its relations to animal and vegetable physiology, lead to the hope that it may be possible to draw an inference of design from the chemical constitution of the earth and its inhabitants, hardly inferior in value to that derived from their physical study, though not always so obvious and striking.

We might note that the book appeared in the same year as *Vestiges*, the deistic evolutionary that which created an enormous furore fifteen years before Charles Darwin published his *Origin of Species*, and the Argument from design received a heavy blow.[42] As well as edification, the reader of Fownes' book would learn a lot of chemistry pretty painlessly and would encounter some of his rather clumsy chemical equations.

Bridgewater Treatises were substantial publications on good paper; but the 1820s saw "the March of Mind," with greater literacy and a publishing revolution. New printing technology, the use of paper made from wood pulp or esparto grass, and the coming of the "case-bound" hardback, meant that books ceased to be luxury items. Robert Chambers, who wrote *Vestiges*, was a publisher who had seized these opportunities for publishing instructional works. Davy's advice to the starry-eyed young Faraday that he should stick to bookbinding would have turned out to be poor advice; the craft withered. One of the series taking advantage of all this was Dionysius Lardner's *Cabinet Cyclopedia*, a collection of little books which together would form a library of useful and entertaining knowledge.[43] Many subscribers must have signed up for the whole set, and then not read them all; one often finds copies with the pages unopened.

The volume on chemistry was written by Michael Donovan; it has an attractive vignette on its engraved title page, showing two *putti* performing dangerous-looking chemical operations involving a furnace; but the text is forbiddingly serious.[44] While not strictly a textbook, it was written for readers intent upon self-help and keen to learn hundreds of facts rather baldly presented in small type. The persevering reader would indeed learn a great deal of chemistry from this compact volume, which is conservative and empirical in tone, and discusses contemporary issues such as Avogadro's hypothesis and the relationship of cyanic and fulminic acids. In effect, then, it is a textbook.

Clerks and artisans in the nineteenth century were indeed capable of reading stiff texts, as the libraries of Mechanics' Institutes indicate; but, as at the Royal Institution, their social superiors in the professional and landed classes liked the bitter pill of instruction to be sugared. Perhaps like the poet and philosopher Samuel Taylor Coleridge, they hoped to increase their stock of metaphors; at least they expected to be entertained. Even in papers given to the Royal Society, Davy and his contemporaries were careful about language, introducing vivid description, with appropriate analogy and imagery.[45] In 1841 the Chemical Society of London was founded, the first such national body.[46] By then there was beginning to be a community of chemists, expecting their publications to be in a compressed and exact language free from ambiguity. Thus there was a greater need for explicitly popularizing works in plain language for those who wanted to know some science but were never going to practice it.

In 1842 Thomas Griffiths, lecturer "on chemistry and medical physics" at St. Bartholemew's Hospital in London, delivered four lectures before the young Queen Victoria, on the Chemistry of the ancient elements: Fire, Air, Earth and Water. When they were published, she allowed him to dedicate the volume to her; and its elegant cloth case-binding bears the Royal Arms embossed in gold. Under "fire" we learn a good deal about lamps, including Davy's safety lamp; and the other chapters in effect deal with the three states of matter. The book ends with the statement that

> its object has been to excite feelings of interest regarding the enchanting Science of Chemistry, rather than to give minute information; and if the few treasures which have been displayed from this vast mine of Natural Knowledge induce those who are unacquainted with its resources, to enter upon the pursuit of more, they will find it rich and inexhaustible.

> They will find that, unlike its parent Art of Alchemy, Chemistry is a Science having no narrow range nor selfish aim, but an intimate connexion with the best and highest interests of man, teaching him the just and proper value of the productions of the beautiful globe upon which he dwells, and their practical applications to his wants, his comforts, or his luxuries; and leading him to acknowledge, with reverence and gratitude, the Wisdom, Power, and Goodness of The great God, by Whom all things were Created.[47]

This is followed in the appendix by advice upon performing experiments which will illuminate the text.

In the same vein, but more explicitly for children, John Scoffern published *Chemistry no Mystery* at the same period.[48] The book contains some diagrammatic reaction-mechanisms, and attractive woodcut illustrations; but their enthusiastic didacticism is less fun than Jane Marcet's dialogue-form had been. Scoffern edited some lectures of Faraday's, and was well-equipped to popularize. J. F. W. Johnston, who had worked briefly with Berzelius, taught chemistry (mainly as part of an engineering course) at Durham University, where the examination papers he set can still be seen; but unlike his contemporaries in London, he lacked classes large enough to warrant his writing a textbook. His *Chemistry of Common Life* is an agreeably written popular work, up-to-date especially in its agricultural chemistry which, with isomerism, was Johnston's main interest.[49] It was widely translated, making his name probably better known in Germany and Scandinavia than it was at home.[50] Daniell's was thus perhaps the only example of a liberal textbook of chemical philosophy at this time.

Technical Chemistry

In the eighteenth century, Bishop Watson had taught applied chemistry at Cambridge in what was in effect cameralistics; it was directed at wealthy young men who would have estates to manage.[51] In the hungry years of war, Davy had made agricultural chemistry one of his specialities, and his book on the subject was for long the standard text.[52] The only work his pupil Faraday actually composed as a book was *Chemical Manipulation*, which was unusual in that it described very clearly how to carry out all the practical operations of chemistry without going into the theory of the science.[53] Even more than Berzelius's book on the blowpipe, it was therefore an excellent adjunct to standard textbooks, an antidote to mere book-learning; and it shows Faraday's careful avoidance of waste as well as his great skill and experience. The son of a smith, he delighted in the skill in his fingers; and that comes through in the writing. The description of fractional distillation in a zig-zag tube is particularly striking for the modern chemist accustomed to custom-built apparatus.

Such apparatus was supplied by Frederick Accum, some of it indeed for the Royal Institution; for although throughout the nineteenth century chemists liked to make their own, more and more was purchased, and makers of apparatus and instruments tried to keep apace of researchers. Accum wrote a standard introductory text in two volumes, with a strongly experimental emphasis, but allowing for "those tentative processes of the mind called hypotheses, which in natural science are rendered legitimate by experiment."[54] We can guess at part of the point of the work from the way some of the apparatus illustrated bears prominently the name "ACCUM Compton St., Soho"; a textbook could also be a trade catalogue. Accum also wrote a little book on chemical analysis.[55] The editor of the second edition in his preface remarks that the book is aimed at those who

> having already become conversant with the first principles of the most delightful, as well as the most useful, of all sciences, is desirous of applying his knowledge to practice, but who requires some leading medium to conduct him from the elementary treatises he may have consulted, to the writings of the most distinguished chemical philosophers of this and other countries.

That is, it is a kind of advanced textbook, but probably to be studied by those who are not taking a formal course of instruction and who will be engaged in industry or in consultancy.

The elementary text readers might well have used was Samuel Parkes' *Chemical Catechism*, a very successful work in which the text is in the form of questions and answers; a dogmatic kind of teaching, but intended as "a kind of text-book for the student."[56] It begins with an essay upon the utility of chemistry (particularly addressed to middle-class parents), and then takes the form of a catechism with extensive footnotes, to which the reader may return—they are in a smaller type, and refer to sources; frequently also they breathe an enthusiastic natural theology, for Parkes was a keen Unitarian. At the back are additional notes, where on Davy and the alkalis we find

> These discoveries will certainly form a new æra in the history of Chemistry, and render the name of Davy ever dear to those who delight in the investigation of nature.
>
> *Immortal Newton thus with eye sublime*
> *Marked the bright periods of revolving time;*
> *Explor'd in Nature's scenes the effect and cause,*
> *And, charm'd, unravell'd all her latent laws.*

Davy was always delighted to be thought the Newton of Chemistry. Parkes, himself an industrial chemist writing from the Haggerstone Chemical Works in London, also set out a series of experiments which he urged all readers to pursue, again turning to verse:

> To read or practice the foregoing experiments merely for the sake of amusement, may occasionally have its advantages; but a resolution to repeat them, and examine all the phænomena, for the sole purpose of receiving instruction, is what the author would principally inculcate. Let it never be forgotten, that no *effect*, however extraordinary, or even trivial, it may appear to us, can ever happen but in consequence of some previously established law of unerring nature. The following apostrophe of Dr. [Erasmus] Darwin to the Fountain of all Goodness, may possibly tend to impress this important truth upon the student's mind;—
>
> *Thus, at thy potent nod,* effect *and* cause
> *Walk hand in hand, according to thy laws;*
> *Rise at Volition's call, in groups combin'd,*
> *Amuse, delight, instruct and serve mankind.*

Here as elsewhere, the frontier between textbooks and popularization is hazy, though there is no doubt which side of the line Parkes would like to be on. The frontispiece to his first three editions were chemical curiosities: pictures of apparatus etched onto glass with fluoric acid—perhaps the glass kept breaking, for the fourth edition has a engraving on copper of the laboratory at the Surrey Institution instead. For really splendid illustrations of chemical equipment, including coke ovens, a steam train, and a domestic hot water system as well as ordinary apparatus, we have C. Mackenzie's *One Thousand Experiments in Chemistry*; but he saw British chemistry in 1822 as run of the mill, with only Davy raising it above mediocrity; his discoveries had not only "fixed on him the admiration of every man of science," but also "thrown around him the halo of scientific philanthropy."[57]

Indeed, in 1843 an English translation of Fresenius and Will's little book on determining the commercial value of alkalies, acids and manganese appeared; this would follow on well from books such as Accum's.[58] It was dedicated to Liebig, whose English reputation was becoming very high: his books on agriculture and on animal chemistry had just come out in translation, and his *Familiar Letters on Chemistry*, a masterpiece of popularization, was also published in 1843.[59] In new editions it grew from a slim volume to a fat one. Boussingault's *Rural Economy* was translated about the same time, with its equal emphasis upon application and practical value, which produced a ready response in early Victorian Britain.[60] But the new generation of chemists would have to look chiefly to Germany; and indeed the major step in the development of the science around 1850 was the invitation to August Wilhelm Hofmann to come to London and direct the Royal College of Chemistry.[61]

By this time the principle of conservation of energy was uniting the sciences of optics, heat, mechanics, electricity and magnetism into classical physics; chemistry had thus lost outlying (or, to Davy and Daniell, central) provinces of its empire, and no longer seemed the fundamental science. Physics was now the dynamical science; and from 1859, with the publication of the *Origin of Species*, evolutionary biology became the most exciting science. So the time we have been looking at was particularly apt for readable works conveying a world-view, before chemistry became too advanced for the general reader and specialized textbooks were the order of the day. It was in some ways a golden age, an innocent and happy youth; but it makes publications hard to classify.

Notes

1. See the special issue, "Science Lecturing in the 18th Century," *British Journal for the History of Science*, 28 (1995), part 1.
2. See Brian Dolan's chapter on experiments; Brian Gee, "Amusement Chests and Portable Laboratories: Practical Alternatives to the Regular Laboratory" in

Frank A. J. L. James (ed.), *The Development of the Laboratory* (London: Macmillan, 1989), pp. 37–59; and my paper, "Portable Laboratories in the Early 19th Century" presented to an ESF workshop in Lisbon in November 1996.

3. A. L. Donovan, *Philosophical Chemistry in the Scottish Enlightenment* (Edinburgh: University Press, 1975).
4. D. M. Knight, *Humphry Davy: Science and Power* (Oxford: Blackwell, 1992); 2nd ed. (Cambridge: Cambridge University Press, 1998); chap. 2. Colin A. Russell, *Lancastrian Chemist; the Early Years of Sir Edward Frankland* (Milton Keynes: Open University Press, 1986).
5. A. L. Lavoisier, *Elements of Chemistry [1790]*, facsimile, intr. D. McKie (New York: Dover, 1965). Earlier, P. J. Macquer's book had been translated, *Elements of the Theory and Practice of Chymistry*, 3rd ed., tr. A. Reid (London: Nourse, 1775).
6. B. Bensaude-Vincent and F. Abbri (eds.), *Lavoisier in European Context* (Canton, MA: Science History Publications, 1995).
7. D. M. Knight, "Lavoisier; Discovery, Interpretation and Revolution," *Redconti della Accademia Nazionale della Scienze*, 112 (1994), 251–59.
8. D. M. Knight, *Natural Science Books in English 1600–1900*, 2nd ed. (London: Portman, 1989), p. 142.
9. W. Nicholson, *The First Principles of Chemistry*, 3rd ed. (London: Robinson, 1793), p. 153.
10. W. H. Brock, *The Fontana History of Chemistry* (London: Fontana, 1992), pp. 273–75. Cf C. Hutton, *A Mathematical and Philosophical Dictionary* (London: Johnson, 1796–5) (sic).
11. A. Ure, *A Dictionary of Chemistry*, 3rd ed. (London: Tegg, 1828).
12. M. P. Crosland, *In the Shadow of Lavoisier: The* Annales de Chimie *and the establishment of a new science* (Faringdon: British Society of the History of Science, monograph 9, 1994), pp. 255ff.
13. I owe this information to Dr. Agustí Nieto-Galan.
14. J. Parkinson, *The Chemical Pocket-Book*, 2nd ed. (London: Wittingham, 1801); quotation from p. VIII.
15. W. Henry, *An Epitome of Chemistry*, 3rd ed. (London: Johnson, 1803), pp. xlii, xvii.
16. W. Babington, A. Marcet, and W. Allen, *A Syllabus of a Course of Chemical Lectures Read at Guy's Hospital* (London, 1811).
17. ibid., pp. 5–6.
18. This is a reference to Davy's work on chlorine and on acidity, *Philosophical Transactions*, 100 (1810), 231–57.
19. H. Davy, *Collected Works*, ed. J. Davy (London: Smith Elder, 1839–40), vol. 2, pp. 327–436, and 437–66.
20. T. Thomson, *A System of Chemistry* (London, 1802); 7th ed. (London and Edinburgh: Baldwin & Craddock, Blackwood, 1831).

21. See my chapter in P. Corsi and C. Pogliano (ed.), *Storia della Scienze*, 4 (Torino: Einaudi, 1993), pp. 98–135.
22. *Quarterly Journal of Science*, 10 (1821), 215–16; cf 18 (1825), 199–200, where Faraday's name has been added.
23. W. T. Brande, *A Manual of Chemistry [1819]*, 3rd ed. (London: Murray, 1830).
24. N. Harte and J. North, *The World of University College, London, 1828–1978* (London: University College, 1978); M. Sanderson (ed.), *The Universities in the Nineteenth Century* (London: Routledge, 1975), pp. 58ff.
25. E. Turner, *Elements of Chemistry; Including the Recent Discoveries and Doctrines of the Science*, 3rd ed. (London: Taylor, 1831).
26. W. H. Brock, *From Protyle to Proton: Wiliam Prout and the Nature of Matter 1785–1985* (Bristol: Adam Hilger, 1985), chaps. 5 and 7.
27. ibid., p. 177.
28. J. F. Daniell, *An Introduction to the Study of Chemical Philosophy* (London: Parker, 1839). Quotations from pp. VII and IX.
29. R. Kane, *Elements of Chemistry* (Dublin: Hodges and Smith, 1842). The quotations are from pp. V and 1172.
30. J. Golinski, *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760–1820* (Cambridge: University Press, 1992), chapter 7.
31. H. Davy, *Collected Works*, vol. 4, quotations from pp. IX, XIV.
32. ibid., "Advertisment." Davy is echoing Shakespeare, *Hamlet*, III, 4, I.102.
33. Anna Laetitia Barbauld, "1811," in A. Ashfield (ed.), *Romantic Women Poets 1770–1830* (Manchester: University Press, 1995), p. 25.
34. [J. Marcet], *Conversations on Chemistry*, 11th ed. (London: Longman, 1828). Jane was the wife of Dr. Alexander Marcet of Guy's Hospital; for a biography, see B. Polkinghorn, *Jane Marcet: an Uncommon Woman* (Aldermaston: Forestwood, 1993).
35. Cf Natalie Pigeard's chapter on the situation in France.
36. D. Knight, "Accomplishment or Dogma: Chemistry in the Introductory Works of Jane Marcet and Samuel Parkes," *Ambix*, 33 (1986), 94–98.
37. J. Webster, *Elements of Mechanical and Chemical Philosophy* (Taunton: Poole, nd [1815]), pp. IV, 8, 28, 51.
38. J. H. Brooke, *Science and Religion: Some Historical Perspectives* (Cambridge: Cambridge University Press, 1991), chap. 6.
39. H. Davy, *Consolations in Travel; or the Last Days of a Philosopher* (London: Murray, 1830); and see my "From Science to Wisdom; Humphry Davy's Life" in M. Shortland and R. Yeo (eds.), *Telling Lives in Science; Essays on Scientific Biography* (Cambridge: Cambridge University Press, 1996), pp. 103–14.
40. W. Prout, *Chemistry, Meteorology and the Function of Digestion Considered with Reference to Natural Theology* (London: Pickering, 1834).

41. G. Fownes, *Chemistry, as Exemplifying the Wisdom and Benevolence of God* (London: Churchill, 1844), pp. vii–ix, 170.
42. [R. Chambers], *Vestiges of the Natural History of Creation [1844]*, intr. J. Secord (Chicago: University Press, 1996).
43. There are letters about the series in the Correspondence of William Swainson, a major contributor, preserved at the Linnean Society of London.
44. M. Donovan, *A Treatise on Chemistry* (London: Longman, 1832). This has an engraved, and two different typographic, title pages.
45. D. Knight, "Chemistry and Metaphors," *Chemistry and Industry*, 24 (1993), 996–99; "The Poetry of Science," *Science and Public Affairs*, Summer 1994, pp. 23–25.
46. W. H. Brock, *Fontana History*, pp. 440ff; C. A. Russel, N. Coley, and G. K. Roberts, *Chemists by Profession* (Milton Keynes: Open University Press, 1977).
47. T. Griffiths, *Chemistry of the Four Ancient Elements* (London: Highley, 1842), pp. 197f.
48. J. Scoffern, *Chemistry no Mystery*, 2nd ed., ed. W. H. Thornethwaite (London: Hall, 1848), e.g. p. 169.
49. J. F. W. Johnston, *The Chemistry of Common Life* (Edinburgh: Blackwood, 1855).
50. See the chapters by Barbara Orland and Anders Lundgren.
51. R. Watson, *Chemical Essays*, 5 vols. (London, 1781–87).
52. H. Davy, *Elements of Agricultural Chemistry* (London: Longman, 1813).
53. M. Faraday, *Chemical Manipulation: Being Instructions to Students in Chemistry on the Methods of Performing Experiments of Demonstration or Research, with Accuracy and Success*, 3rd ed. (London: Murray, 1842); reprinted in David Knight (ed.), *The Development of Chemistry, 1789–1914*, 10 vols. (London: Routledge, 1998).
54. F. Accum, *System of Theoretical and Practical Chemistry*, 2nd ed. (London: Kearsley, 1807), vol. 1, p. vii and plate III.
55. F. Accum, *Chemical Re-Agents or Tests; and their Application in Analyzing Waters, Earths, Soils, Metalliferous Ores, Metallic Alloys &c.*, ed. W. Maugham (London: Tilt, 1828).
56. S. Parkes, *The Chemical Catechism*, 3rd ed. (London: Lackington, Allen, 1808), pp. xii, 545, 593. See F. Kurzer, "Samuel Parkes: Chemist, Author, Reformer—a Biography," *Annals of Science*, 54 (1997), 431–62.
57. C. Mackenzie, *One Thousand Experiments in Chemistry: with Illustrations of Natural Phenomena; and Practical Observations on the Manufacturing and Chemical Processes at Present Pursued in the Successful Cultivation of the Useful Arts*, 2nd ed. (London: Phillips, 1822), p. xxvi.
58. C. R. Fresenius and H. Will, *New Methods of Alkalimetry, and of Determining the Commercial Value of Acids and Manganese*, J. Lloyd Bullock, ed. (London: Taylor and Walton, 1843).

59. J. Liebig, *Organic Chemistry in its Applications to Agriculture and Physiology*, 3rd ed., tr. L. Playfair, 1843; *Familiar Letters on Chemistry*, J. Gardner, ed., 1843; *Animal Chemistry*, W. Gregory, ed., 1842 (all, London: Taylor and Walton). W. H. Brock, *Liebig: The Chemical Gate Keeper* (Cambridge: Cambridge University Press, 1996).
60. J. B. Boussingault, *Rural Economy, in its Relations with Chemistry, Physics, and Meteorology: or, an Application of the Principles of Chemistry and Physiology to the Details of Practical Farming*, 2nd ed., ed. & tr. G. Law (London: Bailliere, 1845).
61. R. Bud and G. K. Roberts, *Science versus Practice: Chemistry in Victorian Britain* (Manchester: Manchester University Press, 1984); and D. Knight, *Ideas in Chemistry: A History of the Science*, 2nd ed. (London: Athlone, 1995), chapter 11.