EPITOMIZING CHEMISTRY FOR CHANGING AUDIENCES IN BRITAIN, 1820-2020

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Abstract

Chemical texts which are most studied by historians of chemistry are those written by those whose work has made the most impact on shaping the discipline. Books of this kind exist to inform fellow-minded chemists, those who aspire to the same intellectual level of understanding as the authors they study. However, there is a genre of published material which is intended for those curious about the subject and yet do not aspire to become professionals themselves. Their interest in the subject is serious, not simply recreational. Over the past two centuries, when chemistry was sought-after by new audiences, changing forms of literature have been written with them in mind. A fairly well-defined group of students were those who subscribed to night classes in mechanics' institutes. They were from the poorer reaches of society and could not afford expensively produced volumes. A chance discovery has been made of a broadsheet produced by a Glasgow teacher which considers a wide sweep of the subject as it was known in the 1830s. This kind of evidence has built-in ephemerality and it is likely that other printed material of this type once existed. Later books, for a growing middle-class audience, range from a rigorous but simplified description of the science, to a discursive account of the social effects of chemistry. In the cases considered, the chemistry volumes come from a pedagogic series across a wide range of subjects. In the final text considered, one from the Very Short Introduction series, the author offers sympathy to the student because of the popular poor reputation of the subject! Necessarily, the examples chosen are highly selective. They are of a fairly balanced chronological span and hopefully can be considered as being reasonably representative. Finally, there are speculations about what the effect on the subject of the introduction of largely electronic forms of communication will be and hence on the writing of the history of chemistry in the future.

Introduction

A good deal has been published on the important subject of popularization of science in the nineteenth and twentieth centuries (1). These monographs take a broad view of the provision of scientific knowledge. This short paper looks specifically at a small selection of modest, low-priced printed works published in Great Britain (though some with co-editions in the United States) which were intended for students who in the earlier period wanted to understand chemistry through its scientific detail. Some later audiences were attracted by chemistry's role and influence on society in the books written for them.

Until the mid-eighteenth century, teaching texts covering the full breadth of chemistry, as then known, were largely published with scholars, practicing chemists, pharmacists or students attending institutional courses, and libraries, in mind. Examples are works by teachers such as Nicolas de Lemery (1646-1715), *Le Cours de Chymie*, first edition 1687; or of Herman Boerhaave (1668-1738), *Elementa Chemiae*, first edition 1732.

These were fat, expensive, textbooks, with woodcuts or engravings and often bound by the purchaser in luxurious leather bindings with gold tooling. They were soon translated into other languages. The audience for chemical knowledge had expanded through the second half of the eighteenth century and it became a fashionable social pursuit in some centers, especially Paris (2) and London (3). Contemporary printed images show both men and women of the genteel classes enjoying spectacular demonstrations being performed by their chemistry lecturers. This very occasionally led to individual long-term obsessions but by and large the courses offered were ends in themselves and publication for these wider audiences was not usual. At the beginning of the nineteenth century a few textbooks were written for other types of audience, for instance for young persons who were just starting chemical studies. One of these was Samuel Parkes' *A Chemical Catechism for the Use of Young People* of 1806, written for the education of his daughter. There were 14 editions published in England (the title was simplified to *The Chemical Catechism* for the second edition of 1807); two of them were edited by others after Parkes had died. There were also American editions. Parkes claimed that in his approach "the catechetical form, which was first chosen for this work, has been found to possess at least all the advantages that any other mode of instructing youth in chemistry can claim" (fourth edition of 1817, page vii). In the same year Jane Marcet's *Conversations on Chemistry, Intended More Especially for the Female Sex,* was first published. Its similar, though simpler catechistic style, more conversational in nature, was intended for a respectable middle-class readership, the three textual personages being a mentor ("Mrs. Bryant") who taught two young women ("Emily" and "Caroline"). The book proved to be extremely popular, passing through 16 editions published in England, and 23 American ones (4), the later ones pirated and published under the authorship of John Lee Comstock (from 1822) and Thomas P Jones (from 1831, the latter with a slight change in the title).

At the beginning of the nineteenth century science teaching became more accessible to those with limited means. In Great Britain organizations recognized this new market. In particular, the Society for the Diffusion of Useful Knowledge, was founded in 1826 largely at the instigation of Lord (Henry) Brougham and acted to encourage the spread of knowledge by making books much cheaper to produce. This arose largely from changes in printing technology and long print-runs. For these less well-off parts of the community, special colleges, or mechanics institutes were established independently from the 1820s for subscribers who had very little money to spare, but whose limited resources were compensated for by a great deal of enthusiasm to learn about scientific, and allied, subjects. All such institutes had libraries, most with lending facilities. Few books or papers today have attempted to survey the widespread printed material available, though the American chemist and historian, Edgar Fahs Smith in his *Old Chemistries* of 1927, considered books published from 1545 to 1837 (5). This brings me to the start of the period where the main focus lies, 1830 to 2012.

The stimulus for this was the discovery of a scarcely-known (perhaps even unknown) publication of the 1830s produced for poor students studying chemistry at a mechanics' institute in Glasgow. Its distinctiveness is that it presented an overview of all chemistry known at the time, printed on the single side of a broadsheet. This minimized the cost of paper and eliminated the cost of binding. It led to more general thoughts about modestly priced publications aimed at those who were less well-off but who were curious about the subject of chemistry, and at the same time lacked the background to be able to study the subject systematically and in detail. Rather little attention has been paid by historians of chemistry on textbooks of a relatively simple form, of which this is an extreme example. I shall briefly survey these from the date of my nineteenth century broadsheet, through basic chemistry texts, up to the present day, my final example being the 2012 book in the *A Very Short Introduction* series published by Oxford University Press. In the limited space I have available I shall not be able to review two other sources of serious scientific information which includes chemistry, periodicals such as *Mechanics Magazine* (from 1823*)*, *Scientific American* (from 1845) and much more recently, *New Scientist* (from 1946*)*, together with the current surfeit of books published to assist students to pass public examinations in chemistry.

William Grier

That many developments in chemistry education occurred in Scotland is not surprising. Education there was more readily available to those of non-established religious beliefs and practices. Moreover, medical education flourished, and it was necessary to take a course in chemistry before the M.D. could be granted. Oxford and Cambridge would not award degrees to those who did not subscribe to the Anglican persuasion (the 39 Articles of Religion), while the ancient universities in Scotland, St. Andrew's, Aberdeen, Glasgow and Edinburgh, offered no impediment to those whose religious beliefs differed from those of the established Church of England. As a

subject connected to medicine, chemistry flourished in comparison with the languid situation south of the Border (6). As well as rigorous teaching taking place, at least in Edinburgh and Glasgow, there was a flourishing contingent of private lecturers teaching chemistry extramurally, and if these teachers were qualified, their courses could count towards fulfilling degree requirements.

In addition to the four ancient universities in Scotland, a new institution of higher education, largely to teach scientific and technical subjects part-time, was established in 1796 with a legacy from a former professor of natural philosophy at Glasgow University, John Anderson (1726-1796). The Andersonian Institution existed to teach those of modest means who had not had the benefit of traditional education, and it is very likely that the author of the broadsheet under discussion, William Grier, attended its classes. Amongst the early teachers at the Andersonian was George Birkbeck who, more than anyone else, was responsible for establishing mechanics institutions from the 1820s.

William Grier was clearly active as a teacher in Glasgow. It is known that he taught mechanics and chemistry at the Gorbals Popular Institution for the Diffusion of Science in the session 1838-39 (7). His sole contribution to chemistry publication was the Chart and he was publicly better known as being the author of books on engineering and arithmetic which went through multiple editions in Great Britain and the United States. These are *The Mechanic's Calculator* (first edition Glasgow, 1832, 18th edition Glasgow, 1856, American editions all from the Glasgow 5th edition of 1838: Philadelphia 1839, New York 1853, Hartford, 1867); *The Mechanic's Pocket Dictionary* (second edition 1837, 14th edition 1861); *The Modern Mechanic* Boston 1857 and 1861. The *Mechanic's Calculator* and *The Modern Mechanic* appear to be the same work but with the Boston editions retitled. Like the *Chart of the Science of Chemistry*, nearly all the Glasgow editions of Grier's books on engineering were published by W G Blackie & Son of Queen Street, Glasgow. The exception is the very first edition of *The Mechanic's Calculator* of 1832, published by Andrew Lottimor and James Lumsden of Glasgow. This may imply that the *Chart* was published post-1832 but by 1835.

Grier's *Chart* is a curious survival. The copy found at a London book fair in the 1990s may be the only one still to exist. Ephemeral material of this nature is not generally beloved by librarians and even specialist libraries may have decided to disregard this form of publication over the years. Mechanics' Institutes issued significant quantities of pamphlets—this is proved by the annual reports which they issued but it is not unusual for only a single, or a few of them to be preserved. It is quite possible that Grier's publication was one of several of the type which lecturers handed to their students. Nevertheless they can be valuable to historians. As an example, the (now rare) first annual report of the Edinburgh School of Arts (8) lists the occupations of its first tranche of 25 students as being cabinet-makers, gardeners, a weaver, an iron-founder, and a fishing-rod maker—and several others. The report provides much further information about its first year of operation, including the syllabus of Andrew Fyfe's chemistry course, the catalogue of the library, the accounts, and a long list of the many subscribers.

Compared with a good number of other contemporary teachers in Scottish mechanics' institutes, William Grier is a little-known figure, and his dates of birth and death still remain to be discovered. What little is now known of Grier comes largely from the substantial introductions he wrote for his published works and in them he makes some interesting points, though perhaps they are not unexpected from one who started off from a modest background. He presages the philosophy of Samuel Smiles's *Self-Help* of some twenty years later, in a passage

> The man who would relinquish scientific pursuits because he had no hope of reaching the eminence of a Newton, a Watt, or a Davy is no better than him, who, in despair of ever obtaining a share of wealth equal to that of the rich inheritor of the land, would cease to make any honest exertion to raise himself from a state of the most squalid wretchedness. [*Calculator*, p 5]

There is an indication that he may have attended classes at Anderson's Institution:

> In the museum of the mechanic's class founded by the venerable Anderson of Glasgow, there is preserved the model of a machine to procure a perpetual motion … But had [its maker] been acquainted with the first principles of mechanics … he would have seen the utter folly of his enterprise. [p 10]

Grier declares the reason for his publication:

> This book has been written with the view of assisting the young workman in obtaining a knowledge of the calculations connected with machinery. [p 11]

Grier praises the Society for the Diffusion of Useful Knowledge: "The treatises published [by the SDUK] cannot be too warmly recommended; and are easy of access from their cheapness and mode of publication." He suggests that self-education is a duty:

> The diffusion of scientific knowledge among the working classes becomes thus not only a duty which every man owes to his country, but, besides this, it is an act of benevolence, as it tends to administer pleasure to a class of most useful men, who, in a multitude of cases, suffer grievous privations. [p 16]

The title pages of his books describe him as he wished to be known: his recurring appellation is "Civil Engineer." But in the 3rd edition of *The Mechanic's Pocket Dictionary* of 1838 he additionally refers to himself as "Lecturer on Natural Philosophy, Author of 'The Mechanic's Calculator,' 'A Chart of the Science of Chemistry,' &c, &c."

Figure 1. *Grier's broadsheet, "Chart of the Science of Chemistry," illustrating how densely packed with information is the 24 × 18 inch (61 × 47 cm) sheet.*

A Chart of the Science of Chemistry

The title of the broadsheet is: A CHART OF THE SCIENCE OF CHEMISTRY, / EMBRACING A VIEW OF THE LAWS OF CHEMICAL ACTION, AND OF THE COMPOSITION AND PROPERTIES OF INORGANIC AND ORGANIC SUBSTANCES / BY WILLIAM GRIER, / AUTHOR OF THE MECHANIC'S CALCULATOR, &c., &c.

At the bottom of the chart are production details: it was published by Blackie & Son of Queen Street, Glasgow (who published practically all of Grier's output) and it was printed by W. G. Blackie & Co. It is undated. Another similar teaching publication, originating in Glasgow and printed on a single side of paper, dealt with the Linnaean System of botany (9).

The Grier broadsheet is printed on one side only, the printed area being 24 × 18 inches (approx. 61 × 47 cm). The size of the type is very small, probably 6 point and it is difficult to read without a magnifying glass (a limitation, one might think, for middle-aged Glasgow workmen). The chart is divided into seven vertical columns (not all of the same width). The first five are labelled "General Principles" and the last two "Organic Substances." The rows themselves are headed (1) Chemistry, Chemical Properties, Chemical Nomenclature, Of the Properties in which Bodies Unite and Chemical Conservation, Affinity, Of the Atomic Theory and Theory of Volumes. (2) Caloric, Light, Electricity, Magnetism. (3) Simple Substances. (4) [A very long list of chemical substances in alphabetical order, from Acetic Acid to Zirconium, Sulphate of; the next three sub-columns give compositional details]. (5) Properties and Preparations. (6) Organic Substances, &c. (7) Organic Preparations. Row 7 also includes four line-engravings showing Crucibles, Distillation apparatus using a retort, Demonstration gasometer, and Woulfe's Apparatus.

The question is, who were Grier's influences when he was putting his broadsheet together? The most likely candidate would seem to be Andrew Ure (1778-1857), who taught chemistry at the Andersonian from 1804 to 1830. However, Ure did not publish a chemistry textbook of the kind which would allow comparisons to be made.

Precursors

Two chemistry books in rather different styles, whose texts were clearly intended for workers rather than middle-class young ladies, were provided by Andrew Fyfe (1792-1861) and John Joseph Griffin (1802-1877). Both had strong ties to the mechanics' institute movement in Scotland though their careers followed different trajectories. Fyfe graduated in medicine from the University of Edinburgh, later also becoming a fellow (later President) of the Royal College of Surgeons. He started his career by teaching as a private lecturer in Edinburgh (10), and tried for several academic jobs. It took him 30 years before he was able to secure a post as Professor of Chemistry in Aberdeen. An early publication of his makes reference to his extra-mural teaching, *Elements of Chemistry ... Comprising the Principal Part of a Manual of Chemistry for the Use of Pupils of Mechanics Institutions* (Richardson and Lord: Boston, 1827).

John Joseph Griffin's audience for chemistry may have had similarities yet his chemistry focus was fundamentally different (11). He, too, started his chemistry study at the Andersonian Institution, later teaching in its mechanics class. But then he became involved in the supply of chemical apparatus and in publishing, in 1823, the first of six editions of *Chemical Recreations.* In 1829 he travelled to Heidelberg in Germany to improve his knowledge of chemistry. Returning to Glasgow he continued to publish texts which closely connected with his increasingly burgeoning apparatus and instrument business. The second edition of *Chemical Recreations* of 1825 is composed of two parts, "First Lines of Chemistry," and then, "On Chemical Operations and Processes." The former starts by asking the questions which a student at Griffin's mechanics' class might well ask: "What is Chemistry?—Is it interesting?—Is it useful?—How am I to proceed in studying it?" The answer Griffin wants to hear is of course, yes. A couple of pages further on is a section Make Experiments, and here Griffin writes,

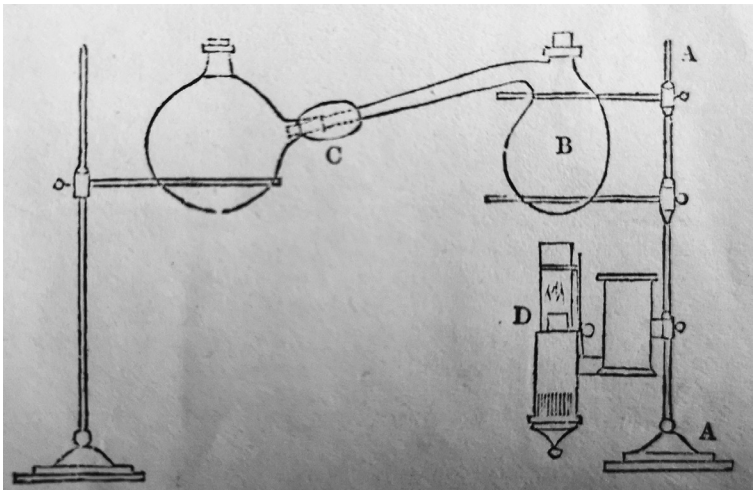

Figure 2. *Detail from Grier's broadsheet depicting a "distillatory apparatus."*

> It has been found that all the marvelous diversity of appearance under which bodies are presented to the eye, and the changes of state to which they are incessantly subjected are occasioned by the reciprocal actions and combinations of a few unchangeable primary bodies. The properties of these bodies, and the nature of the laws which regulate these actions, are therefore the object of which the chemical student is to enter into an investigation.

Griffin's company could supply the necessary simple apparatus. Some copies of *Chemical Recreations* (for example the tenth edition of 1854) have bound in the back of them copies of *Griffin's Scientific Circular* of December 1850, a catalogue advertising its wares. These included complete sets of chemical apparatus in various forms enabling students to repeat some or all of the experiments described in the front part of the book. The question has to be asked, was all the apparatus listed in the extensive catalogue immediately available, did it have to be ordered, and who in fact constructed it if it were not Griffin's own firm?

Successors

A later Scottish initiative for helping students from modest backgrounds to study and understand chemistry was that developed by a medical graduate who had a taste for chemistry rather than medicine, George Wilson (1818-1859) (12). He taught at the Edinburgh School of Arts (a very early, perhaps the first, mechanics' institute, founded 1821). In 1854 he was appointed director of the newly established Industrial Museum of Scotland whose origins lay in the Great Exhibition of 1851. His predilection was to teach industrial chemistry and he set about garnering materials for his museum from friendly local industrialists, even though an exhibition building did not yet exist (he had to store his burgeoning collection in a warehouse and a disused chapel (13)). He did teach, however, and he toured his students round local industrial works. His 1850 pedagogic textbook, *Chemistry*, whose opening paragraph declares,

> It would be of great advantage to the beginner in Chemistry if it were possible to give a simple but sufficient definition of the nature of the science on the study of which he is about to enter…

was published in the Chambers Educational Course series, and is more traditional in structure than Wilson's innovative teaching methods might have indicated. It appeared in only one edition, perhaps because he died in 1859, at a relatively young age and he had no successor as editor.

Another, rather different way of teaching, though also by using material objects, was developed by Thomas Twining (1806-1895), a wealthy merchant of the tea-importing family, who was obsessed with teaching applied science to socially and financially disadvantaged students. He did this through the medium of his Economic Museum at Twickenham, situated just outside London. He wrote in the heavily pedagogic text, intended for teachers who were expected to follow his instructive text (14),

> …this Course, besides supplying to the Working Classes in an easy and familiar style the Elementary

> and Applied Science they constantly require for their guidance in Daily Life, is intended to afford the Artisan Students a stepping-stone to further Scientific and Technical Studies…

In his teachers' text, Twining recommends chemical apparatus and glassware which were available from J. J. Griffin and Sons, and other firms.

Post-Mechanics Institutes and New Publications

Mechanics' institutes could be said to have been a great success over the first twenty or thirty years of their existence, when it has been estimated that between 400,000 and 600,000 attended some course or other in the period from 1820 to the middle of the nineteenth century. But for a number of reasons they were not sustainable. Their existence was financially precarious and philanthropy could divert their purpose, with gentrification becoming a threat to the purity of their initial aims. More access to public education by the state establishing elementary schools meant that learning moved towards different institutions. The large initial numbers may have been due to the slack being taken up from previous unavailability of courses. The nature of the earlier body of mechanics and artisans was changing. Working Men's Colleges, backed by the Christian Socialist movement, were set up from 1854 (with F D Maurice and John Ruskin heavily involved). Half a century later in 1903, An Association to Promote the Higher Education of Working Men, shortly afterwards renamed the Workers Educational Association, became an informal middle-class movement of evening classes (it still exists today). Then in 1969 the Open University was founded which has developed a vast quantity of chemistry teaching material (which it is impossible to survey here). With these changes, the nature of associated literature also changed. In this final section I shall consider three series of books which covered a very wide range of topics (chemistry amongst them) and which were printed in very large numbers. These are Benn's Sixpenny Library, the Teach Yourself Books and the Very Short Introduction series developed by Oxford University Press.

Benn's Sixpenny Library, through its very title, emphasized the cheapness of its literature. The series was produced by Ernest Benn Limited, with most of the volume titles, about one hundred of them, appearing between 1927 and 1930 at a rate of one per fortnight. *Chemistry* was published in 1927 and is numbered 104 (though it was one of the first twelve titles). The author was Percy F. Spielmann, who immediately declared pessimistically in his Foreword,

> The presentation of a comprehensive survey of a vast subject, compressed into a very limited space, and addressed to a public that is, in a great measure, unfamiliar with scientific matters, is a task of some difficulty.

Spielmann's survey occupies a mere 80 pages. However, the book is not so much about the science of chemistry, rather than about the place of chemistry in society. For example, Chapter 5 (of 7) bears the title "The Application of Chemistry to Human Affairs." In this chapter, Spielmann sees his subject as an élite calling, writing,

> It should be needless to state that the development of science as a whole and chemistry in particular is so difficult and arduous that only the fully trained are fit to attempt it…

And later,

> at the moment of writing, the demand for the services of chemists is such as to require that boys shall take up chemistry only if their bent is so strong that they cannot be kept away from it … It is very undesirable for an ill-educated individual to take chemistry.

If this is a strange thing to write in a book which might be expected to encourage readers to become interested in the subject, it is difficult to understand why Benn's Library chose Spielmann as their author. True, he was possessor of a Ph.D. and an Associate of the Royal Institute of Chemistry. His publications reveal his main interest as being bitumen and asphalt (15). A consuming interest was collecting miniature books and he published a catalogue of them (16). In his Benn's Sixpenny Library, Spielmann's approach fulfilled less of a particular need for the facts of chemistry rather more about how chemistry fitted into society.

This is in contrast to the *Teach Yourself Books* approach, which attempted to epitomize the major aspects of chemical knowledge of the day. The *Teach Yourself Books: Chemistry*. A *Practical Book of Self-Instruction in Chemistry, Based on the Work by James Knight, M.A., B.Sc., Completely Revised and Enlarged by G. Bruce MacAlpine, B.Sc*. is derived from *The Self-Educator in Chemistry* of 1901 written by James Knight (1860-1936), a Glasgow schoolmaster (though one who in fact had been awarded a D.Sc). The rationale for writing the work is clarified in the Introduction, where the author is critical of the lack of science teaching in schools, writing (17),

> This book is intended for all who wish to keep abreast of their daily reading and daily tasks. and who, by

> reason of a one-sided system of culture in youth, have felt themselves in matters relating to the outside world as the stranger within or even outside the gates.

The book filled a gap, according to a review in Durham University's *The Northerner*, which made the point, "Books on chemistry for the general reader are almost non-existent" (18). In the 1962 edition, within 240 pages, there are nineteen short chapters, two of which could be considered biochemistry (Food and Vitamins) and one on Photography. The first chapter dives right in, treating the atomic theory, followed by chemical nomenclature. From then on, most chapters are based on the chemistry of particular elements. The text is discursive; mathematics and chemical equations are used sparingly. The final chapter deals with the elements as set out in the periodic table. The overall feel of this Teach Yourself book was worthy, but presentationally dull, the dullness not being overcome by the unsubtle, garish yellow and black cover. In recent years the *Teach Yourself* series has had a rebirth (19) and is now published in a somewhat different form and with new titles, deriving from the original concept, by the publisher Random House.

As a final example of texts developed for the non-specialist, curious amateur there is the *A Very Short Introduction* (VSI) series. Here, the card covers are colored with bands of color, each one different for each title. The program of developing a multi-volume series was devised by Oxford University Press in 1995. Its success has been phenomenal—by the end of 2021 there will be about 680 volumes in the series, and in the long-term, it is expected that there will be 1,250 titles. Currently about 8 million copies have been sold. Translations have appeared in 45 languages. Most books in the series contain about 100 pages, though some are significantly longer (*Organic Chemistry*, by Graham Patrick, is 175 pages long.) It should be noted that there is a *History of Chemistry* volume in this series by William H. Brock, published in 2016 (20). The *Very Short Introduction* volumes are today's intellectual *livres de poche* for a long air-flight. The chemistry volumes need to be seen in the context of the VSI project, and its public reception, as a whole.

The author of *Chemistry: A Very Short Introduction* (numbered 417), which appeared in February 2015, is Peter Atkins, professor emeritus at the University of Oxford, who has done much to popularize his subject. There are several other *Very Short* volumes which concern chemistry, and *Physical Chemistry*, also written by Atkins, was published earlier, in 2014. Atkins starts off in a jauntily pessimistic style:

> I hope to open your eyes and show you a fascinating, Intellectually and economically, world, that of chemistry. Chemistry, I have to admit, has an unhappy reputation. People remember it from their school-days as a subject that was largely incomprehensible, fact-rich but understanding-poor, smelly and so far removed from the real world of events and pleasures that there seemed little point in coming to terms with its grubby concepts, spells, recipes and rules.

The jaunty style continues through the book, making the text attractive and non-threatening for the layman (though there are a few fairly tough passages). There are no chemical equations to intimidate (and no diagrams), not even in the "Its [Chemistry's] Reactions" chapter. Much of the text is not so much an epitome of the science of chemistry but more of an explanation of its culture. Where does this lead the reader who yearns for more? In the Further Reading section, the first four (of seven) books recommended are works of Atkins himself—on Thermodynamics, Physical Chemistry, Atoms and Chemical Principles. This is not unfair as he is aware of writing in a sympathetic style for his uninitiated readership. Writing about the power of quantum mechanics, Atkins admits,

> that it remains largely incomprehensible is admittedly an irksome deficiency, but in due course I shall do my best to distil from it what is necessary for understanding the behaviour of atoms… [p 4]

He is being realistic; not all authors of popularizing texts are.

Approach and Conclusions

The production of texts to make chemistry, which has always been a complicated, complex subject, comprehensible to a willing but not scientifically sophisticated audience goes back well over two hundred years. In London, Edinburgh and Paris chemistry courses for an enthusiastic public (including women) were a fashionable, serious diversion for the middle classes. The audience for its study developed significantly with an upwardly shifting demographic and access to basic education of working men and women, and this provided potential for authors to develop new ways of providing for the changing readership. Early teachers at mechanics' institutes struggled to teach in a non-mathematical way, but the breadth of the scientific agenda was not compromised. This is demonstrated by Grier's broadsheet. However, authors appreciated that the developing science had to be pruned for non-specialists, and ultimately in their popularizing publications, the notion of what chemistry was

became more socially based. This occurred particularly in the twentieth century and now today, Peter Atkins in his *Very Short Introduction,* has been realistic about what has been possible, and though he only hints at it, what is better left out.

What can be learned from the texts which have been used to compile this paper? It is clear that even in the earliest production, Grier's broadsheet, the content had to be highly selective in what it incorporated, even if the impression Grier may have wished to suggest to his mechanics' class was comprehensiveness. One only has to consult the earliest chemical journal, August Crell's *Chemisches Journal*, an abstracting publication, to realize that the subject had spread its wings widely even by the late eighteenth century. Crell was responsible for a total of 31 volumes over 20 years (the titles changed several times between 1778 and 1791) (21). So those who were teaching and popularizing the subject, even at this early stage, had to be highly selective in what they could teach and write. For later periods, one only has to be confronted by groaning shelves of 8000 volumes of *Chemical Abstracts* (1909 to the present) to be totally intimidated by the impossibility of the task. An important issue arising from this comparison is the level of understandability which might be expected even from the highly curious, but non-specialist seeker after knowledge. The sheer quantity of specialized chemical knowledge today is staggering and even highly competent professionals in one field are unlikely to have a grasp in areas outside their areas of expertise.

Creators of epitomizing texts have to think a great deal about how they approach the process of selectivity. It could be argued that the tendency has always been to over-consider "classic" publications and papers. The backgrounds to these inevitably have been developed by their own authors' selective readings. There is bound to be distortion about what the subject of chemistry comprises. The significance of published papers can certainly change with time. Some works now seen as seminal were ignored until many years after they had been first authored. On the other hand, some chemists of the past have become today's heroic figures and may be over-represented by compilers in how much attention they pay to them. It could be argued that the Nobel Prize holds a responsibility for some of this distortion.

The few examples I have chosen to consult and write about can only be representational of a considerable publishing phenomenon. An effort has been made to balance the chronology of these popularizing texts from the early nineteenth to the early twenty-first century, the books chosen being published in English in Great Britain, with co-editions later appearing in the United States.

The Future

Where to next? Chemistry has become a hot potato for many members of society, with its strong social and political connotations. A major current example is global warming caused by fossil fuel emissions which are the concerns of many individuals, while governments struggle with the problem which has economic as well as scientific and social consequences and which cannot be ignored (22). Teaching chemistry through publications in earlier days, by ploughing through the properties of elements one by one, is no longer a viable approach. And yet writing about chemistry while leaving out its science is fatuous and does not lead to an understanding which underlies the issues. Some compromise between the approaches is needed. To understand today's chemistry, as well as the part it plays in daily life, a willingness is needed to confront concepts which for most are unfamiliar. But this has always been the case ever since chemistry entered the domain of the curious and studious amateur two centuries ago. It seems unlikely that the reading public will ever be able to keep up with the changes in concepts and content in the future. Chemists may be able to make sense of each others' work, but even the most curious of the curious public will lag further and further behind. Chemistry historians are confronted with this problem now and will face the problem increasingly in the future. Practically no papers in history of science journals deal with near-contemporary subjects, for several reasons. Those with training in history are unlikely to have knowledge of modern or contemporary science, while scientists who take an interest in history may find it difficult to satisfy historians (who control history of science journals) (23). It is interesting that some nations have societies both for chemistry historians and also for chemists with strong historical interests. In Great Britain, the Society for the History of Alchemy and Chemistry (SHAC) belongs to the former category, while the Historical Group of the Royal Society of Chemistry represents the latter.

So, is there a future for self-education texts in chemistry? Electronic forms of learning are flourishing today, but the death of the printed book has been much exaggerated by futurologists. Certainly this has not happened in the humanities (which include the history of chemistry). The Covid-19 crisis has meant that traditional libraries have for a large part, been off-bounds from early 2020

and onwards, with distance-learning on screens becoming the norm for universities. But academic study is not the focus of this paper and attitudes taken by a curious public requires inspired guesses based on observable trends. Pure science does not hold a particularly high reputation amongst the general public, and in its place there appears to be no shortage of newly-authored, printed books which address how as-yet unresolved scientific problems challenge society, and how these will impact negatively upon life-styles and living conditions. Those requiring information rather than literary forms are more likely to turn to websites and television rather than printed paper.

Books dealing with the benefits of chemistry for today's public are rarer now than in the past, but then misery has always sold better than warmth. (People settling down to read a book on a long journey get more pleasure from being told about how terrible everything is, as newspapers have long known.) But for the minority who want to learn about serious science and its contemporary development, it is likely that electronic forms of information-provision will be the medium to which they turn. This is for various reasons. It is rapid to place before its audience, it is very easily accessible, it can be exceptionally rich in knowledge-provision, it can be entirely up-to-date. Moreover, it allows questioning, including one-to-one discussion with colleagues, some of whom may be geographically remote. A downside is that the rise of electronic communication through personal e-mails has as its concomitant the decline of traditional correspondence. This will have a major impact for chemistry historians of the future. E-mails are fugitive and tend to be archived only for official purposes. It is almost impossible to imagine how anything will endure in the way of those ideas, proposals, criticisms etc., at times when chemists corresponded with their colleagues, if key letters of the past had not been preserved. Our understanding of the thought-processes which led to major breakthroughs would simply not exist. The papers these chemists published rarely provide a substitute.

It is sensible to regard the printed book and electronic access to knowledge as complementary forms. Books are better at providing carefully considered opinions. They make authors think carefully about these opinions, knowing that once printed they are set in stone (or at least, in non-erasable ink). There are many stories about wild inaccuracies in certain electronic texts, and editorial checking and revision can be lax or non-existent. There can be an indiscipline in electronic forms which is rarer in books, where there is more financial and reputational commitment to producing accurate text for long-term usage. When Wikipedia gets it wrong, it can almost instantly be amended. Earlier versions disappear. Opinions expressed in Wikipedia are not ascribed to their authors. It can be revealing to compare earlier with later editions of printed books when changes have been introduced. If texts in printed form entirely disappear, much will be unavailable for future historians. The use to which they would have been put will change the nature of the history of chemistry for ever.

It must be appreciated that over the past couple of centuries there have been changing reasons why the public has wanted to learn about knowledge new to them. The mechanics who crowded in to the Andersonian Institution had different motives for understanding chemistry from those who were buying cheaply produced copies of the Teach Yourself series a century later, and very different from those readers anxious to find out reasons for climate change and what can be done about it. One thing can be said that is unlikely ever to change: the basic curiosity of serious-minded adults.

References and Notes

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22. Another obvious contemporary example of dilemmas having to be faced by governments is balancing scientific evidence they receive regarding the Covid-19 pandemic against the wish to maintain national economies in as healthy a state as possible. In the extreme, some politicians have ignored or contradicted science, exposing themselves as climate-change or Covid-19 deniers.
23. The roles of chemists and of historians in documenting the history of recent chemistry are discussed in two papers in this issue: S. J. Weininger, "'The Poor Sister:' Coming to Grips with Recent and Contemporary Chemistry," *Bull. Hist. Chem.***, 2022**, *47*(1), 119-123. P. J. T. Morris and J. I. Seeman, "The Importance of Plurality and Mutual Respect in the Practice of the History of Chemistry," *Bull. Hist. Chem.*, **2022**, *47*(1), 124-137.

About the Author

Robert G. W. Anderson made his way in UK national museums, first as a curator, then a director. He had graduated from Oxford in chemistry and for the whole of his career has published in the history of the subject. He won the Dexter Prize in 1986 and the Bunge Prize in 2016. He was President of the British Society for the History of Science, Chairman of the Society for the History of Alchemy and Chemistry, is a fellow of the Royal Society of Edinburgh, and an emeritus fellow of Clare Hall, Cambridge. Most recently, from 2016 to 2020, he has been President and CEO of the Science History Institute, Philadelphia.