How workers learnt chemistry

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Most of the time when historians study chemistry the subject dealt with is what might be called élite chemistry. This is chemistry at the cutting edge, chemistry which makes a difference to how we come to understand the properties of matter, molecules, reactions, and so on. Other associated matters which may be explored by historians of chemistry concern social, economic or political relationships with élite chemistry. By far the greatest part of the chemistry investigated has been that carried out by élite chemists. They became élite because they had advantages, often of birth, which led to an excellent and specialist education. Naturally, there are exceptions. Elite chemistry could also be carried out by those who had to struggle to gain their qualifications, because they came from poor, disadvantaged backgrounds and were self-taught. We can think of a number of such chemists: Michael Faraday and Edward Frankland are British examples of the kind of struggles referred to in Samuel Smiles' classic work of 1859, *Self-Help* . These chemists are in the small minority, however: until recently, very few of those born into the working class managed to cross-over the intellectual, economic or social divide.

In this Debus Lecture I want to consider what possibilities there were that the working-class would be able to learn about chemistry in the earlier part of the nineteenth century, and how and why this was achieved. I shall mainly be talking about the situation in Great Britain though I shall make a few references to other parts of the world. But before I turn to workers' education I want to talk a bit about the diffusion of scientific knowledge which was occurring with increasing momentum from the start of the eighteenth century. This involved the wealthier and more educated classes. Going to courses of lectures became a fashionable pastime for the leisured populace, for whom there was no obvious practical advantage in gaining knowledge of science. But for others there could also be practical reasons: chemistry was being increasingly taught at some universities, and at teaching hospitals, as an adjunct to medical education, though of course this too mainly benefited the children of the middle, or merchant classes.

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There has been a good deal written about why and how science became much more widely known at the beginning of the eighteenth century, than at earlier periods. The explanations for this are many and various, but most of them cite the influence of Isaac Newton.

After the publication of his *Principia* of 1687 and *Opticks* of 1704, a number of authors, s'Gravenzande amongst them, made efforts to simplify the ideas contained in them for those who would find the originals too daunting. This also led to the development of demonstration experiments which would make the ideas contained in these works more easily understandable, and indeed enjoyable. The orrery, a mechanical device to show the relative motion of the sun, moon and planets, was first devised in 1704 in a simple form, called a tellurium, by the London clockmakers, George Graham and Thomas Tompion. The orrery got more mechanically complicated as the century wore on and planets were added. This kind of device joined others such as the air pump and electrical machine to provide almost theatrical effects in the teaching of natural philosophy. Joseph Wright of Derby's two famous paintings of 1766 and 1788 show diverse audiences clustered round an orrery and an air pump, and display a range of responses. They indicate very clearly how instruments could be used to make points which would be difficult to do simply by reading from a text.

Returning to my main theme, from early in the eighteenth century, lecturers placed advertisements inviting the public to subscribe for courses, often held in London coffee houses. However, the market was not confined to the capital city: lecturers needed to be peripatetic to make a living, moving around the country to set up demonstration courses in provincial towns. Presumably their apparatus would travel with them on carts on rutted roads, but I have heard of no past or current research which tells me how this was done and how lecturers managed to arrive at their destination with their fragile effects in one piece.

I have not yet mentioned chemistry as a subject for lecture courses. To some extent, a small section on chemistry might be included with the natural philosophy. In some cases it was presented as a specialism of its own, though at this time there seem to have been fewer courses in chemistry than in natural philosophy. But there certainly were some. One of the earliest that is known of was given by the chemist and physician, George Wilson, who in 1690 was lecturing to medical students in London. Little is known about what was actually being taught, but some guesses can be made from his 1691 treatise, *A Compleat Course of Chemistry.* He was followed by others. Peter Shaw was a London physician, who with Ephraim Chambers in 1727 had translated an unauthorised version of Hermann Boerhaave's Leiden University chemistry lectures under the title *New Method of Chemistry.* In 1731 he published his *Proposals for a Course in Chemistry* and also *An Essay for the Introduction of a Portable Laboratory*. He went into public teaching with a vengeance and he gave courses in London in 1731 and

1732.Then in 1733 he moved to the north of England, to a fashionable spa town by the sea, called Scarborough. There he developed a wealthy *clientèle* and returned to medicine, but meanwhile in London, William Lewis advertised a course of lectures in January 1737. A well-known engraving shows a very well equipped laboratory where he said he would demonstrate his chemical experiments to a subscribing audience. In 1746 he published *A Course of Practical Chemistry*, so from this we can make judgments about the syllabus of the course he was teaching, as well.

I don't want this part of the lecture to turn into a list of chemistry courses available to the public in London, but I do want to mention a phenomenon which in some ways is the chemistry equivalent similar to the boost which was given by Newton to the public presentation of natural philosophy. This was the work which the very public figure of the chemist and theologian, Joseph Priestley, who had been conducting researches on the chemistry of gases from the 1760s. One of those influenced by Priestley's work was the energetic public lecturers Adam Walker, who in 1766 purchased demonstration apparatus and went to teach in the north of England and the south of Scotland, also spending four years lecturing in Ireland. Later, he gave lecture courses in London. To begin with his teaching tended to be in natural philosophy but from 1774, following Priestley's *Observations on Air*, he taught at York about fixed, mephitic and inflammable airs as well, that is, carbon dioxide, nitrogen and hydrogen. In 1778, he visited Priestley in London and was given pneumatic apparatus to use in his displays. Walker was not a showman but was praised "for the simple but animated manner in which sublime ideas are explained." Another significant figure with Priestley connections was John Warltire, who started giving natural philosophy courses in 1763 all over England, including Bath, Bristol and Birmingham. It is important to point out that there were audiences to be tapped outside London. He added chemistry to his curriculum from 1769.

Warltire had been an assistant when Priestley was at Calne experimenting with dephlogisticated air whilst working for Lord Shelbourne. Priestley was very sympathetic to the idea of teaching through demonstrations, which he himself used to undertake. In a letter of 1774, he wrote: "I have not yet found any person, though ever so good a philosopher, and has read my paper ever so carefully, but is surprised to see me actually make experiments."

So far, I have **not** been talking about the working classes and their taking up of chemical knowledge. The reason is that the basis of the institutions which developed for them in the nineteenth century lies in the rise of public science in the eighteenth century. I believe that it is quite possible that some mechanics, artisans and servants did actually manage to attend the courses which were priced for the middle classes. There are indications that for a much smaller price, the lower orders of society could sit at the back of the rooms in which lectures were being given. For example, a broadsheet

advertising a popular science course in Newcastle-upon-Tyne in the north of England in 1798 states that a course of twelve lectures would cost one guinea (that is one pound and one shilling), but it also stated that servants were admitted to the back seats for one shilling per lecture. (For those not conversant with pre-decimal currency, I should say that one shilling was the equivalent of one twentieth of one pound, now five pence.)

There is also some evidence that workers were pressing for admission to other forms of cultural activity. When the Society for the Encouragement of the Arts set up a free exhibition of paintings in London in 1760, the rooms were overwhelmed by crowds of the general public, to such an extent that the Society decided that future exhibitions would practice crowd control by slapping on an admission charge. At about the same time in London, the British Museum, which had opened its doors in January 1759, it was reported to the trustees that many of those attending were mechanics and "servants-out-of-uniform", unlikely though that may seem.

I mentioned earlier that possibly we could detect two strands in the early teaching of chemistry, the fashionable public lecture, and the teaching of chemistry as an adjunct to medical education. In the eighteenth century, the greatest progress in chemical education in Britain came not from Oxford or Cambridge Universities, or from the London teaching hospitals, but from Scotland, where there were already four universities by the end of the sixteenth century, all of which had the authority to award medical degrees. It was Edinburgh which led the way in chemistry teaching. In 1713 the University appointed its first professor of chemistry, James Crawford, and in 1724, four young men, who had all studied under Herman Boerhaave at Leiden in The Netherlands, established a private course in chemistry. Then in 1726, Edinburgh decided, largely for economic reasons, to establish a medical faculty at the University, and these four men were all appointed professors. To be able to take a medical degree it was compulsory to study chemistry, and the first professor to establish such a course was Andrew Plummer. A laboratory was established and demonstrations were given in the preparation of medicines. The course was a long one, of more than one hundred lectures per session. Meanwhile, in Glasgow, in 1747, a lectureship was established with William Cullen as the appointee. Cullen had studied under Plummer and he was very critical of the course, which had little to do with chemistry other than pharmacy. He strongly believed that chemistry should be based on Newtonian principles, which would make the subject more theoretical, but conversely, he also considered that chemistry should be of relevance to the emerging industries of Scotland. He also believed – very unusual for the time – that students should perform their own experiments in the laboratory. One of the few students who took up the offer was a young Irishman from Ulster, Joseph Black. After Plummer died in 1755, Cullen took over the Edinburgh chair of chemistry, while Black was appointed to the Glasgow

lectureship. Black was an obvious genius and moreover a brilliant teacher. Edinburgh lured him back from Glasgow while Cullen created the necessary vacancy by moving to a purely medical chair.

Black's annual course in Edinburgh attracted vast numbers – in some years, more than 300 people subscribed to the course. These were by no means not all medical students, because only a small proportion of the audience were students who had matriculated and would become doctors – we know this from the numbers graduating n medicine. Anyone in the city could sign-up whether or not they had matriculated at the University, so a large proportion of those attending Black's lectures were the general public. In theory, this cohort could have included members of the working class, but in practice, as Black charged the audience three guineas – that is three pounds and three shillings – to attend, it is unlikely that the working class would be there, as an ordinary worker would scarcely be able to afford that much. It is interesting that the names of all those subscribing to these chemistry courses are recorded and preserved in the University archive, and one day someone with a great deal of patience might be able to determine what the backgrounds of the attendees was. I do know the occupation of one subscriber who attended for two consecutive years – he was Archibald Geddes, who was in charge of a glassworks in the nearby town of Leith. I suspect that he, and most of the other non-university students, came from the comfortable middle classes.

The real change in workers' education in science came in Glasgow, and it resulted from the wishes of a professor of natural philosophy at Glasgow University, John Anderson. He was concerned about the elitist quality of universities and wanted to make education possible for those who had previously been excluded. He established a special class every Tuesday and Thursday for those whose pursuits did not allow them to follow the routine of academic study. To make courses more accessible, some were taught with syllabuses which specifically avoided mathematics. As a substitute, his lectures were illustrated with numerous experiments. He died in 1796 and his will stipulated that the whole of his property was to be bequeathed "to the public, for the good of mankind, and the improvement of science, in an institution to be denominated Anderson's Institution."

Someone else thinking on the same lines was George Birkbeck. He came from Yorkshire and had graduated as a doctor at Edinburgh University in 1799. Afterwards he was appointed to the professorship of natural philosophy at Anderson's Institution in Glasgow. In his four years there he held free Saturday evening public lectures on the 'mechanic arts'. These proved to be very popular and it was clear that something else was needed for those workmen who could not attend the ordinary courses he was giving on weekdays. This was reinforced when one day he went to the university

workshop to get a centrifugal pump repaired and the workmen crowded round him asking questions. He later wrote of the incident,

> "I beheld through every disadvantage of circumstance and appearance, such strong indications of the existence of unquenchable spirit ---- why are these minds left without the means of obtaining that knowledge which they so ardently desire and why are the avenues of science barred against them because they are so poor?"

Birkbeck proposed to the trustees of Anderson's Institution that a variant of it be set up, an institution, open in the evenings, specifically for the poor, but keen, working classes. The trustees were initially cautious but the response made it clear that the demand was real, even if there was a small fee. The first lecture attracted an audience of 75, but by the fourth lecture demonstration there were 500 in the lecture hall and ticket sales had to be restricted from then on. After this successful experiment, Birkbeck left Glasgow in 1804 but continued to lecture on science in Birmingham, Liverpool and Hull. The chemist, Andrew Ure, took over his post in Glasgow and he was to teach there for the next 26 years. He would also teach in the Glasgow Mechanics Institute when it was eventually established in 1823, though the regular chemistry teacher was John Steel. Ure taught to a mixed audience of men and women at the Andersonian; women had previously attended the fashionable lectures in the eighteenth century but they were barred from attending universities. Some of the mechanics' institutes did allow women to participate in their activities, but this was not universal. A caricature of the time compares the audiences: the rather rough, all-male Glasgow Mechanics Institute with Anderson's Institution where the *clientèle* is rather more genteel, and mixed.

Another major figure who needs to be considered was Thomas Garnett, who was appointed professor of chemistry at the Andersonian in 1796. Just three years later, he went down to London to be the professor of chemistry at the newly founded Royal Institution of Great Britain. This had been founded by a number of scientific philanthropists with the intention of: "Diffusing the knowledge, and facilitating the general introduction, of useful mechanical invention and improvements, and for teaching, by courses of philosophical lectures and experiments, the application of science to the common purposes of life."

Much of its funding was provided by the Society for Bettering the Conditions and Improving the Comforts of the Poor. A Scotsman, Thomas Webster, who was an architect, was employed as Clerk of Works to design a lecture theatre in Albemarle Street in the West End of London. He was anxious to establish a school for mechanics, as had already been done in Glasgow, and as part of that scheme, his design of the

lecture theatre included a gallery which was intended "for those who either wished to be less observed, or who, for obvious reasons, would not like to sit down by their employers." This gallery was accessed directly from the street so that the artisans and mechanics could come and go without meeting their betters and causing embarrassment all-round.

This did not go down well with the Managers who formed the Board of the Royal Institution. Webster later wrote in his autobiography,

> "I was asked rudely what I meant by instructing the lower orders in Science? I was told… that this plan must be dropped as quickly as possible. It was thought to have a dangerous political tendency. I was thus told that if I persisted, I would become a marked man! … From what appeared to me to be very erroneous reasoning my mechanics' stone staircase was pulled down at considerable expense."

Thus the Royal Institution lost its opportunity to take a lead in the scientific education of the working classes, becoming the most fashionable place of its kind for the wealthier strands of society to experience scientific experiments. A famous print by Gillray of 1802, 'Scientific Researches! New Discoveries in Pneumatics! Or… an Experimental Lecture on the Power of Air', shows an experiment with laughing gas, conducted by Thomas Garnett, which has gone somewhat wrong, The dark-haired, coiffed, young Humphry Davy grins from behind the laboratory bench, bellows in hand. But equally interesting is the audience which Gillray depicts. It is clearly intended to show a wealthy and fashionable group of lecture-goers, the ladies wearing huge hats. Not a worker can be detected amongst them.

In fact, at this time, the initiative to teach science to the working classes had passed to Paris. The Conservatoire des Arts et Métiers, a teaching institution for science and engineering, was established as one of the post-Revolution initiatives in education in 1794. It created a collection of models, machinery and scientific apparatus which was placed at the disposal of working men for the purpose of visual instruction to complement lecture courses. The key figure in the development of working class education at the Conservatoire was a naval architect called Charles Dupin. After the end of the Napoleonic era, he was determined to pay a visit to the British Isles to investigate the state of its industry, and in the end he made five journeys, between 1816 and 1824. A key visit was made to Glasgow in 1817 where he met Andrew Ure, who by that time had taken over chemistry from Andrew Garnett. Here, Dupin witnessed cheap evening lectures for workers on geometry, mechanics, physics and applied chemistry. He recorded in his report that "The Andersonian Institution has produced astonishing results. It is a wonderful thing to see today, in many Glasgow workshops,

simple workman possess, and develop when necessary, the principles of social harmony." In 1819 he devised a programme based on what he had observed in Glasgow, and he and two others were appointed to professorships at the Conservatoire: he would teach mechanics, Jean-Baptiste Say would teach industrial economy, and Nicolas Clément would teach chemistry. Later, in 1824, Dupin devised a programme of teaching for mature adults in Paris based on what he had seen in Glasgow. He obtained support to build a new and rather grand lecture theatre at significant cost, provided of course by the State.

Dupin's work was much admired by George Birkbeck, who wrote a glowing Introduction to Dupin's 1827 treatise, *Mathematics Practically Applied to the Useful and Fine Arts*, referring to the "important results of the recent attempts to extend Science to the labouring classes." Birkbeck also used the opportunity to criticise Britain for its lack of State sponsorship. He wrote:

> "If in the case of improvement Great Britain should appear to have been outstripped by her active and ingenious neighbours, it ought in justice to the people, to be recorded, that all has been affected by themselves: that not one name in connection with the government of this country… has lent its influence, or its encouragement to accelerate the progress of Mechanics' Institutions: and that in France, public functionaries of every description, local and general, have vied with each other in extending this intellectual impulse."

Thus it ever was. I now want to return to Great Britain from France. In 1821, after a long period of incubation, the first true mechanics institute in Great Britain was founded, and there are arguments to say that it was the first in the world. The essence of a mechanics institute was that it was self-governed, with at least some true mechanics involved on the committee, and that teaching was held in the evenings, after work. Birkbeck's adult education doctrines had inspired Leonard Horner, a wealthy Scottish merchant and geologist, to establish the Edinburgh School of Arts in 1821. The word 'Arts' used here implies industrial arts, not fine art. Its first prospectus declared that "This association has been formed for the purpose of enabling industrious tradesmen to become acquainted with the principles of Mechanics, Chemistry and other branches of science as are of practical application to their various trades." The School of Arts was not free but it was cheap enough for certain classes of worker to attend. Its funding was also assisted by middle-class sponsors and a long list of them is printed in the prospectus. There is also a revealing list of who the first 25 students were who attended the first mechanics class, together with their occupations. Most common were gardeners and watchmakers, three of each. Interestingly, a further three of the 25

were blind. Chemistry was taught from the very start, the teacher being Andrew Fyfe, who had trained as a surgeon (and it should be remembered that surgeons who were members of a guild were usually required to have studied chemistry). Fyfe's course was a rigorous one, quite closely mirroring that of the university professor of chemistry in Edinburgh, Thomas Charles Hope, though much shorter in duration. We know more of Fyfe's programme than appears in the prospectus because he published a textbook in 1827, the American edition bearing the explicit title *Elements of Chemistry for the Use of Schools and Academies, comprising the Principal Part of a Manual for the Use of Pupils of Mechanics Institutions*. The Preface makes the point:

> "In compiling a work on Chemistry, for the Use of pupils of Mechanics' Institutions, and who have not had the benefit of a Classical Education, I have not only studiously avoided the most abstruse part of the science, but I have endeavoured to explain its laws and operations in language as simple as the nature of the subject will admit."

It was this which led to an almost explosive expansion of worker education in Britain, which expanded rapidly to Ireland, the United States, Canada, Australia and New Zealand.

The London Mechanics Institution was one of the earliest to be founded, along with those in Edinburgh and Glasgow. It was started in 1823 by Birkbeck, with the support of an energetic Scottish lawyer and Member of Parliament, Henry Brougham. Chemistry was on the agenda right from the beginning and a laboratory was incorporated in the building. In the first year of operation the subject was taught by Richard Phillips, a talented chemist who would later become Curator of the Museum of Practical Geology. The *Mechanics Magazine* reported the first lecture of Phillips course in ecstatic terms:

> "The attendance was extremely numerous. The sight of eight or nine hundred artificers thus collecting, after their daily toils are over, to listen to the voice of science, is something new in the metropolis, and marks an era in the history of its population that future historians will dwell on with pride… when men can appreciate the abstract truths of science, they can only be governed by reason, and will easily see through the common-place cant of common-place politicians…. The change which is indicated in the manners of our people, by their hastening in the evening to attend scientific lectures must be pregnant with great future improvement."

The article mentions approvingly that both George Birkbeck and Henry Brougham were present at this lecture.

After the early 1820s, the mechanics institute movement took off very quickly. A survey in mid-century indicated that there were 702 institutes in Britain and Ireland in 1851, and it has been estimated that in the thirty years of their existence some 400,000 members may have joined at some time or other. In 1851, the average membership per institute was 171. This figure was much greater in industrial towns than in smaller places, of course, but some of the small institutes were very active. All the heavily industrialised cities in England – Birmingham, Liverpool, Manchester, Leeds – had large and active mechanics' institutes, sometimes several, vying with each other. Scotland had 55 of them by 1851, with membership varying between 20 and 700. There was a good deal of contemporary debate about how successfully the institutes were doing their job. Attendances certainly fluctuated, the nature of their mission changed in some cases, and some were financially precarious and had to close down. It cannot be denied, however, that at least until the middle of the nineteenth century, the mechanics' institutes played a significant role in urban life for the working classes.

To some extent, interest in chemistry had something to do with the theatricality of demonstrations. Chemistry teachers performed experiments with whatever could be purchased. In early periods and outside metropolitan areas, materials were not easily available. Surviving physical evidence for the collections is rather sparse, but clues can be picked up, especially from annual reports of the institutes. For example, annual reports can provide information about their activities. Let me take as an example Kelso, which is a small town in a rural setting, just north of the border which Scotland has with England. At the beginning of the nineteenth century it had a population of around 4000. It possessed a mechanics institute only for a relatively brief period. Chemistry classes were offered by a local minister of religion, the Reverend George Gray. The subscription for a course in chemistry was five shillings. The 1825 report tells us "A proper apparatus having been provided, the room [was] commodiously fitted up and lighted with Argand lamps." At the time there would have been no gas supply to provide artificial light. The course ran with one lecture every week over a period of five months. Gray was aware of the limitations of his rural subscribers, the report reporting, "Mr Gray did not deem it expedient to institute any formal examinations, as the difficulty of fully understanding the technical terms of Chemistry… presents unavoidable obstacles to students unacquainted with the subject." The course closed a few years later when the Reverend Gray moved to another parish and chemistry classes came to an end. Mechanics institutes outside larger towns and cities did depend on local talent being available to provide the teaching.

Not surprisingly, commercial firms established themselves to supply chemicals and sets of apparatus to those wishing to study chemistry seriously, often in the home. In many cases, manufacturers were aware that there was benefit in supplying the poorer end of the market, where the numbers studying chemistry were greatest, as

well as for wealthier chemists and institutions. One such company which became prominent in Great Britain was that of John Joseph Griffin. It started as a publishing firm in 1795. John Joseph was born in Glasgow in 1802 and interestingly studied chemistry abroad, in Paris and in Heidelberg. He was never a practising chemist himself, remaining a businessman for the whole of his life. Books, which were a mixture of being a catalogue and textbook, started to pour out from the firm from 1823, when the first edition of *Chemical Recreations: a Series of Amusing and Instructive Experiments may be Performed Easily, Safely and at Little Expense* was published. This title reached its 10th edition by 1854, at a time when learning chemistry still remained a popular activity. Griffin specialised in sets of apparatus, and the cheapest he offered was inexpensive – one guinea would buy a small laboratory set of 48 items to enable blowpipe analysis to be undertaken, and another guinea would pay for apparatus allowing experimentation on gases. Well aware of the market he was seeking, the Preface of his *Chemical Recreations*, referred to: "the three great evils of high cost, scarcity and difficulty of management…. That the prevalence of these evils has hitherto repressed the extensive diffusion of chemical knowledge is undeniable". The firm was extremely successful, so much so that the name of Griffin continued as part of the internationally-known scientific instrument company 'Griffin and George' until as recently as 1999, when trading stopped. Griffin was just one of a number of firms which supplied chemical apparatus for home and institutional use. Firms to supply chemical apparatus were soon established in France, mainly in Paris, and in America, in Boston, Philadelphia and New York. One of the first in America was a partnership in Boston between Josiah Holbrook and the English émigré, Timothy Claxton, who started to make apparatus for schools in 1829. Holbrook is also acknowledged as having originated the American lyceum system, which had strong similarities to the British mechanics' institute movement, though was perhaps rather more social and commercial in character. Holbrook drew up a basic plan for a simple village lyceum, where there is provision for a laboratory, a cabinet, where apparatus would have been stored, and a lecture room. Lyceums came in all shapes and sizes. A rather more substantial teaching establishment was formed in Philadelphia in the 1840s, the Wagner Free Institute of Science, which provided lectures on a variety of scientific topics including, of course, chemistry. William Wagner, a wealthy merchant, himself taught geology. The Wagner Institute still exists today and continues to teach science to adults in the evenings.

Mechanics Institutes were founded at about the same time in Australia as the Lyceum movement got off the ground in America. The first was in the Tasmanian town of Hobart in 1827, which is a remarkably early date considering that the first colonists only arrived near what is now Sydney in 1788, but it reflects the strong desire of new immigrants to study science and agriculture in a country which had yet to be tamed. The opening up of the goldfields such as those near Ballarat in the State of

Victoria, and the rush of miners to exploit them led to further and even more remote, institutes springing up, many of which taught chemistry. The Ballarat Institute still exists. It is in a sophisticated building with part of its nineteenth century library still intact, though many others were simpler and smaller, such as the Burke and Wills Mechanics Institute of 1863 in Fryerstown, Victoria, typical of many of the small homespun buildings which were constructed in Australia. Large numbers of these buildings still exist, though the teaching ambitions they once held have been dropped and they exist today as general libraries and social centres.

For the last part of this talk, I want to deal with what chemistry teachers in higher education could offer to those students who wished to study chemistry, but who were not enrolled in universities. There is evidence that professors of chemistry not infrequently taught popular classes which lay outside their mainstream responsibilities. It is certain, for example, that Joseph Black in Edinburgh gave courses of chemistry to lawyers in the later eighteenth century which had nothing to do with his normal classes. This is known because one of those who attended these extra-mural classes was the lawyer and friend of Dr Samuel Johnson, James Boswell. He recorded in his diary that Black's lectures bored him, though he took some interest when the subject of gold came up (lawyers usually are interested in gold).

Black's successor as professor of Medicine and Chemistry at Edinburgh from 1799, Thomas Charles Hope, developed a special course for the general public, and at least two complete series of lectures were given in the 1820s, at the very time when mechanics' institutes were being established. Hope's popular lectures were not a gesture of liberality – they can be seen as an attempt to undermine the efforts of others trying to offer public courses, which if successful, would have reduced his income. Hope's first popular course commenced in February 1826. Twenty-two lectures, each lasting for one-and-a-half hours, were delivered three times a week until April, and they were designed to cover 'The General Principles and more important facts of CHEMISTRY'. Hope demonstrated some of his more spectacular experiments to audiences which included women. These popular lectures were maliciously reported by the lawyer and member of the Edinburgh literati, Henry Cockburn, who wrote: "the ladies declared that there never was anything so delightful as these chemical flirtations. The Doctor is in absolute extasy with his audience of veils and feathers, and can't leave the Affinities." The course's content, defined in Hope's carefully preserved notes, was a fairly rigorous one, covering heat, pneumatic chemistry, acids, salts and electricity. Hope signed off the 1826 and 1828 courses, commenting to his class: "You are now aware that Chemistry is an Experimental Science & will readily be convinced that it cannot be pursued by study in the closet alone – It is necessary to engage in the labors of the Laboratory --- Experiments must be performed & processes conducted." So this

links-in with the commercial efforts being made by firms such as Griffin to provide cheap sets of chemical apparatus for home use.

It has to be said that Hope was not a popular teacher – his manner was pompous and some saw him as coming from a former age. Although fulfilling a chemistry course was compulsory for medical students, a remarkably liberal rule allowed them to seek teachers of chemistry elsewhere, and many of them did. A small industry of chemistry-teaching outside the walls of Edinburgh University built up, and many of these classes consisted of mixtures of medical students, surgeon-apprentices and common townsfolk. Being in an extra-mural class did not mean that the facilities or the teaching were second-rate. The facilities offered by one of Edinburgh's extra-mural teachers, David Boswell Reid, whose classroom and laboratory lay close to the University buildings, were clearly sophisticated. He taught large classes and wrote a number of perfectly respectable textbooks for his students. The provision for allowing chemistry lectures to be taken outside universities meant that there became a buoyant market for teachers, and many of them taught in a variety of institutions, including mechanics' institutes.

At the end of the period I am dealing with – up to about 1860 – museums came to be another source of chemical knowledge for the working classes. One of the first science museums to be established in Great Britain was the Museum of Practical Geology, in 1837. It was built in central London between 1846 and 1851. Its purpose was to exhibit the rocks, minerals and organic remains as illustrated by the maps of the Geological Survey. It was also intended that the Museum would indicate to the public the uses to which the inorganic resources of the nation might be put, such as how clay can be turned into porcelain. Along with the displays, lecture courses were given by some of the most talented scientists in the field. The chemist Lyon Playfair lectured in the early 1850s to an audience largely made up of working men, on chemistry as applied to agriculture (from 1858 he became professor of chemistry at Edinburgh University). The later rise of national museums in Britain has much to do with the Great Exhibition of 1851, which was developed with a strong lead given by the husband of Queen Victoria, Prince Albert. As Special Commissioner to the Exhibition, Playfair himself was also deeply involved. The Exhibition, the first truly international one ever held, made a sizeable profit and the government decided that part of this should be spent to set up a new museum system. In 1857, a large estate in west London was purchased on which to build museums and science institutions – the area now known as South Kensington. This was intended to include a science museum. In theory, one did exist as part of the South Kensington Museum, but it was very slow to get off the ground. Again, it was Edinburgh which led the way, with the establishment of the Industrial Museum of Scotland in 1854. It was a chemist who was appointed director, George Wilson. The government was slow to respond to the need for an

actual building but Wilson collected large quantities of scientific and industrial material, storing some of it and using the rest to teach with. The particular subjects he taught are described in his museum's published annual reports and he took his classes on industrial visits, for example to the local glassworks and gasworks. Additionally, he continued to teach chemistry in the local mechanics institute. Edinburgh University awarded him the title Professor of Technology. The word Technology was unusual in the 1850s, and Wilson was always having to tell his audiences what was meant by the term. After his early death in 1859, the Museum's name was changed to the Museum of Science and Art and building started. However, the scientific aspect declined as the institution became gentrified and went socially upmarket. Exactly the same thing happened in South Kensington, as the original purpose of the museum, to explain manufacturing processes and display the products of industry, was subverted towards acquiring Italian Renaissance sculpture and building galleries for paintings. The Science Museum had to wait from 1857 until 1928 before it got its own purpose-built building.

We have reached the middle of the nineteenth-century and rather than drawing my own conclusions, I want to pose some questions. The first must be about why chemistry became such a popular area of study for people who would be unlikely to find a direct use for it. Were they going to lectures purely for recreational purposes? Did they go to enjoy the smells and the bangs, or did they go to be seen by their smart friends? To what extent could the lecturers be considered to be the personalities or celebrities of their day? A number of contemporary women commented on Humphry Davy's smouldering good looks, and he was not the only chemist of the time to be admired for reasons other than for his prowess in chemistry!

I don't think that my premise, that chemistry became a popular area of study, can be disputed. Towards the end of the eighteenth century, the middle-classes started to attend chemistry courses in significant numbers. Though it would be easy to mislead ourselves by looking at the Royal Institution alone and drawing conclusions from that single example, the Royal Institution was by no means unique in London. There was also the Surrey Institution, where Frederick Accum lectured on chemistry, and the London Institution drew large crowds. Of this latter, it was reported at the time: "In the winter time when the lectures are delivered by leading men of science, the theatre is as full as can be imagined." Additionally, in the regions, newly established literary and philosophical societies, and athenaeums, were springing up and chemistry was nearly always shown on the yearly agenda of talks.

Why, then, was chemistry equally popular with workers? Were they emulating their betters? Did they see practical uses for the subject, perhaps employment? Was chemistry popular because there was less mathematics involved, compared, with, say, the study of natural philosophy? Was it because of the theatrical effects which lecturers

produced, with their flashes and bangs? Or was it the other way round, that because there were plenty of qualified chemists looking for jobs, courses were set up by them, whilst secondarily providing a service for the working class? It is certainly the case that many eminent chemists started their careers by teaching in existing working-class organisations, or quite often, hiring their own premises, buying their apparatus and setting themselves up as extra-mural lecturers.

Another matter we might think about is why medical students, who would go on to qualify as physicians, needed to learn chemistry at all? In the earlier period I have talked about, chemistry mainly meant the preparation of drugs, and one can see the point of that. But as the eighteenth century wore on, the developing chemical world became less and less relevant to doctoring. Some aspects can be understood, for example the study of heat, or of dephlogisticated and fixed airs, but why did Black's medical students need to know about platinum, or about rocks which are flexible, or the temperature at which mercury freezes? In case you are thinking that knowledge of materia medica is an essential for doctors, it should be pointed out that there could be separate professorships on this subject. In Edinburgh, a chair of materia medica was set up as early as 1768, and Francis Home was appointed to it.

Perhaps we also need to consider the reason for the decline of chemistry as an area for popular study in the nineteenth century. If it can be agreed that it is the case, when did that decline start, and why? When Thomas Charles Hope gave his annual course of lectures in Edinburgh in 1823, 575 persons registered for it. In 1843, when he gave his last course, there were only 118 registrations. Consider now the number of medical graduations in each of these two years. There were 93 graduands in 1823 and 87 in 1842, not much difference. The cohort which fell off to a huge extent in the twenty years is that of the general public, and by several hundred. Chemistry no longer seems fashionable by mid-century. Why should that be, and had anything else taken its place?

I want to end by considering the working class and their mechanics institutes. Just as public interest in chemistry had declined by mid-century, so had enthusiasm for the institutes themselves. Some struggled to stay open as subscribers fell away. There are some sad stories. Salisbury Mechanics Institute in the south of England was formed in 1833. It ran into financial difficulties and tried to sell its apparatus to provide some money to keep going, it failed to do so, so sold lottery tickets for the apparatus, and then it closed down anyway in 1841. This was blamed, at the time, on the "indifference of the workmen." What had happened to them between 1833 and 1841? Rather than closing, more usually the institutes changed to offer more popular cultural activities. The two-term rigorous lecture series on the foundations of chemistry was replaced, for example, by a celebrity lecture on exotic foreign travel. I don't think that this can be

explained by other knowledge-transfer systems becoming popular and taking their place.

Before I get too gloomy, and make you gloomy too, I shall stop. The story I have told is really a heroic one. It is likely that a larger proportion of the population knew something about chemistry in the first decades of the nineteenth century than ever before, or than ever since. And that change needs to be thought about.

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