HYLE Essay

Popularizing Chemistry: Hands-on and Hands-off*

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Linus Pauling said, "Chemistry is wonderful. I feel sorry for people who don't know anything about chemistry. They are missing an important source of happiness" (Gaither & Cavasos-Gaither 2002, p. 118). Most people do not feel that. What might be done, and what used to be done, to make chemistry popular? I had thought that 'hands-on' might distinguish those active in chemistry from 'hands-off' supporters, interested but not participating: but now I am not sure.

I happen to sit on the Royal Society of Chemistry's Committee for Promoting Chemistry to the Public. I have been a member of the society since I was a student reading chemistry forty-five years ago (before it was Royal), but was invited (I suppose) to join that committee in the hope that an historian might advise on restoring the reputation of the science to where it was in the long-distant past. The traditional model of popularizing was that one took a little chemistry, diluted it, and added sugar to make it go down: but this has not worked. There is a famous book-review by a child: 'this book told me more about elephants than I wanted to know'. That is how many people feel about being told what professors and academicians are up to: but with chemistry they may also feel alarm. They think of pollution, slow poisoning, and weapons of mass destruction.

I am (like that committee) puzzled about the nature of 'the public' – no doubt they are and were really publics. Recently the 'SciPer' project at Leeds and Sheffield has been sampling the science in popular periodicals, mostly from Britain, in the nineteenth century – and this has resulted in three books,[1] in which chemistry duly features (though not very largely). So I hope now to share some uncertainties, hoping for clarification.

There seem to be three questions that we can profitably have at the back of our minds:

1. Who is chemistry being popularized to, and perhaps why and where?
2. How was it done in some supposedly heroic better past?

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3. How do popularizing and professionalizing fit together?

On the first one, the RSC committee tried to identify publics. One was the elite: graduates, opinion formers, journalists, members of parliament. This was a group not unlike the Cambridge undergraduates who flocked to Bishop Watson in the eighteenth century (Archer & Haley 2005), or the wealthy intelligentsia who heard Michael Faraday at the Royal Institution in the nineteenth. The problem is that these are a critical group, with interests and preconceptions, looking perhaps for a good story rather than sober science.

Then there are children. School science is difficult and dogmatic (Thomas Kuhn [1963] thought necessarily so) and chemistry is not very excitingly taught in these days of 'health and safety' legislation. Such manual skills as boring corks, bending glass, and handling concentrated acids, the experience of smelling and tasting (on purpose or by accident) unpleasant gases and fluids, and making flashes and bangs are denied to children today. So ways are needed to arouse enthusiasm and direct curiosity, so that some will become chemists, hands-on people, and others sympathetic, hands-off adults.

The interested but unsophisticated are another group, reading newspapers that avoid long words and long sentences, and who may pick up the personal rather than the abstract. They should not be despised as unfit to learn about so arcane a science as chemistry, which can and has been made accessible through obituaries and biographies, and the writings of great communicators, like Justus Liebig in his *Familiar Letters.* And finally there are the taxpayers and the consumers, who pay one way or another for chemistry; and are thus essential for its future.

So to the next question: what happened in the past? In the nineteenth century, chemistry was in the useful category of 'entertaining knowledge'. Public lectures attracted big audiences, Antoine Fourcroy in Paris and Humphry Davy in London being notable – they made professing a performance art, competing with metropolitan theatres and concert halls (Knight 2002). There were black markets in tickets and one-way traffic arrangements to ease congestion. Chemistry could appeal to body, mind, and spirit (Knight 2004): an experimental science, it was a craft or 'art' that required manual skills (Faraday's only formal book was *Chemical Manipulation,* 1827), an exciting body of knowledge in the throes of theoretical upset, and momentous in its promise to cast light on matter and mind, elective affinities (Goethe 1971, Richards 2002), God and nature. Chemistry like surgery was both hands-on and hands-off, a science of the secondary qualities (colors, tastes, and smells), where thinking had to be done with fingers, nose, and eyes as well as in the armchair. It was a part of high culture, making Davy in great demand at salons and dinner parties; but also promised to be useful, for example in cleaning up smoky London:[2]

O Chemistry, *attractive* maid,
Descend in pity to our aid!
Come with thy all-pervading gasses,
Thy crucibles, retorts, and glasses
Thy fearful energies and wonders,
Thy dazzling lights and mimic thunders!
Let Carbon in thy train be seen,
Dark Azote, and fair Oxygene,
And Woolaston, and Davy guide
The car that bears thee, at thy side.
If any power can any how
Abate these nuisances, 'tis thou.

Audiences, men and women, watched for the most part, as the lecturer (often very near the front row) did the experiments, which might be spectacular – as when potassium, and miners' safety lamps, were the subject. Anna Laetitia Barbauld, in her poem '1811', wrote how, for American tourists in decayed London, some future antiquarian might (Barbauld 1995):

Call up sages whose capacious mind
Left in its course a track of light behind;
Point where mute crowds on Davy's lips reposed,
And nature's coyest secrets were disclosed;
Join with their Franklin, Priestley's injured name,
Whom, then, each continent shall proudly claim.

In 1811 the coyest secret was that chlorine was an element, but the sexy imagery takes up some of Davy's pantheistic rhetoric about Nature.

Some of these audiences went into hands-on chemistry. S.T. Coleridge wrote to his friend Davy (Knight 2005a) for advice about setting up a laboratory in the Lake District with his fellow-poet William Wordsworth, and for anybody thus tempted 'portable laboratories' were available, wooden boxes fitted up with apparatus, used in schools and at home, suitable for both serious and recreational chemistry. John Dalton's friend William Henry sold various sizes, at fifteen, eleven, or six and a half guineas – James Watt junior bought one of the expensive ones.[3] They might be devised to accompany a chemistry book. Then photography became a craze by the middle of the nineteenth century, requiring expertise in handling apparatus and chemicals. Hands-on chemistry included the spice of danger. But for those who remained hands-off, it was the dynamical character of chemistry that seemed most attractive. Priestley had prophesied that natural philosophers working in chemistry, optics, and electricity would eclipse Newton himself, getting below the surface, and exploring the underlying forces (Priestley 1966, p. xv). This excited poets and artists, as we see in recent studies of Percy Shelley and of Coleridge, both well-read in chemistry and medicine (Ruston 2005, Vick-

ers 2005), and of Joseph Turner (Hamilton 2001); chemistry, the leading science of the day, was moving away from a clockwork universe.[4]

Working men (skilled artisans and craftsmen rather than laborers) could also get to lectures, at Mechanics' Institutes lit (chemically) by gas making evening classes possible, and at peripatetic meetings of organizations like the British Association for the Advancement of Science, founded on a German model, and itself the model for societies in the USA, France, and Australia. Gradually museums, originally intended for ladies and gentlemen, were opened to a more general public – even on Sundays, after a struggle, in Sabbatarian Britain. Exhibitions illustrating science, technology, and general progress attracted huge audiences and generated vast enthusiasm. Sometimes, as in London's 'Crystal Palace' in 1851, the building housing the exhibition was itself a marvel of high technology. Many of the exhibits there were broadly chemical, and international juries compared them in various classes and awarded prizes. Davy had been the apostle of applied science, making big promises (blank checks on the future); by the mid century, science (especially chemistry) was delivering utility. Ballyhoo was appropriate.

Reading remained the major way into chemistry for those fired by lectures or displays. Jane Marcet, excited by Davy's lectures but needing something more systematic, wrote for girls in the same position her *Conversations on Chemistry,* 1806, a best-seller which turned the young Faraday (a bookbinder's apprentice) towards the science. Hers was not a chemistry of 'separate spheres'; the girls do experiments, doubtless with a portable laboratory, and learn the latest science. In the second quarter of the nineteenth century, the price of books in Britain dropped sharply by about a half, so that they ceased to be a luxury – new technology, longer print runs, and (temporary) collapse of the copyright system all played a part (St Clair 2004). Categories of chemistry books were fuzzy: there were some formal textbooks, for students of medicine and pharmacy, but in the first half of the century many were aimed at general readers keen on self-help (Lundgren & Bensaude-Vincent 2000). They had to be accessible and attractive, unlike textbooks efficiently and systematically covering the syllabus for an examination that students had to pass.

There were from the late eighteenth century informal scientific journals, in Britain published by Alexander Tilloch *(Philosophical Magazine),* William Nicholson *(Journal of Natural Philosophy)*, and Thomas Thomson *(Annals of Philosophy):* Nicholson and Thomson were both chemists with substantial publications in the science. 'Taxes on knowledge', which inhibited periodicals, were not lifted until the mid century, and postage was expensive until then also. But nevertheless in their heyday these journals, offering speedy publication, had published some original papers, reprinted papers from elsewhere, reviewed books and meetings, and included correspondence (some-

times contentious). The editors sought to build up a community of regular readers, who could feel that they were part of the great enterprise of advancing knowledge. They were predominantly, but not exclusively, concerned with chemistry: Thomson wrote that "our *Annals* must contain a greater proportion of Chemistry, which is making a rapid progress, than of those sciences which are in a great measure stationary" (*Annals of Philosophy*, 1 [1813], p. iv).

They were with others all swallowed up in due course by the increasingly formal *Philosophical Magazine*, as science became more specialized and less widely attractive, and the scientific community more self-conscious. In the second half of the century we have William Crookes' *Chemical News* and his *Quarterly Journal of Science*, Norman Lockyer's *Nature*, the *Mechanics' Magazine*, and *Science Gossip*, which despite its promising title was mostly a sober work of natural history – but chemistry was much less prominent in these last four. By 1900 it had become forbidding rather than accessible. Original papers were in a compressed style, full of equations, and written for experts. There was no longer room for the interested experimenter with his portable laboratory to make a serious contribution fit to appear in print alongside serious researchers' work.

That brings us to our third question, for chemistry had become professionalized and this had a powerful and continuing effect on its popularity. Undergraduate degrees in chemistry were on offer by the middle years of the nineteenth century, and the Prussian victory over the French Second Empire in 1870 was seen as a vindication of the German educational system. It had an effect comparable to the Sputnik of 1957 in promoting scientific education. In England a Royal Commission headed by the Duke of Devonshire promoted Scientific Instruction in a series of reports. Such things can be an excuse for inaction, but in this case they were acted upon. An unintended consequence was the rise of what have been called 'two cultures', scientific and humanistic, poorly communicating with each other because they have had different and specialized educations (Knight 2004b).

When two or three historians of chemistry are collected together, the conversation tends to turn to 'profession' and what it means in different times and places. For us it is enough that it involves education, jargon, self-regulation, and recognized status and expertise. That seems to have happened to chemists in the later nineteenth century. Professions thus serve the public, but they can also be conspiracies against the public; as the longstanding jokes about, and doubtful popularity of, lawyers, clergy, and doctors indicate. A naval historian (Rodger 2004, p. 201) remarks of officers in Britain's 'Glorious Revolution' of 1688/9 that most "seem to have taken a professional attitude to the revolution, in the sense that they thought first of their careers". We live in a culture of suspicion, where experts are seen as self-interested and

pompous and are distrusted. 'Alternative' therapies, religions, and beliefs about 'chemicals' continue to abound; confusion about the 'organic' is as bad as it ever was in previous centuries.

Suspicion is not new. A journal[5] aimed at artisans, *The Chemist,* was rude about Davy, for whom chemistry had been a vehicle for social mobility, propelling him from provincial poverty into the Presidency of the Royal Society and a baronetcy:

> he professes a sort of royal science […] he has no appearance of labouring for the people. He brings not the science which he pursues down to their level; he stands aloof amidst dignitaries, nobles and philosophers; and apparently takes no concern in the improvement of those classes for whom our labours are intended, and to whom we look for support. Amidst all the great efforts which have been lately made to promote scientific instruction among the working classes, and amidst all the patronage which these efforts have found among opulent and clever men, it has been with regret that we have sought in vain to trace one exertion or smile of encouragement bestowed on such efforts by the President of the Royal Society. [*The Chemist,* 1 (1824), pp. vi-vii]

Davy was indeed snobbish and alarmed at the 'March of Mind', but distaste for pundits on the one hand, and for plebeians and their popularizers on the other, was to become a feature of the science of the later nineteenth century, and lead to the 'dilution' model of getting chemistry across.

Faraday, Davy's disciple and successor at the Royal Institution, lectured brilliantly to children, notably on 'The Chemical History of a Candle', in a tradition that still continues and is now more democratically available, on television. He did not feel that it was in any way beneath him to popularize, but the next generation did often think that way, and their successors often do. Serious science, to be noted in university promotion committees, does not include popular writing or lecturing.

We can ask what did interest people who went to hear Faraday or his contemporaries, and it was clearly not only ideas but also facts. Lectures at the Royal Institution included much on explosives and weapons – the 'military-industrial complex' of Eisenhower's famous speech went back a hundred years or so. Poisons, like explosions, have also always drawn audiences, who might not have gone to hear August Hofmann talk about molecular structures, even though he had croquet balls and rods as his visual aids. In the mid twentieth century, young Oliver Sacks delighted in chemistry, practical and factual, which helped him focus his life in wartime London (Sacks 2001). He, and people like me a little later, learned chemistry not so very different from that of the late nineteenth century, and often in laboratories of that date; definitely hands-on.

In the professionalizing Victorian age, popularizers also began to be professionals, people with a foot in both camps, of science and of journalism and

other writing; and like other Grub Street hacks, made a living out of it (Fyfe 2005). But they were tolerated rather than much admired by the scientific community; and indeed popularizing science (and its history) is still problematic – we see it as simplifying, dumbing-down, sensationalizing, and often simply misreporting (Laszlo 2005), and all too often that is what it is. We must have all groaned over amateurish histories which ignore recent scholarship.

This applied to all the sciences, and yet chemistry now writhes beneath popular dislike to a greater degree than other sciences. This is partly because, as Lavoisier hoped, its language looks like algebra, but with jaw-cracking long names – the jargon is hard to break into, and nowadays proficiency in mathematics has become more important than manual dexterity. Then, the conflict of 1914-18 was 'the chemists' war', where poison gas particularly struck the public imagination as a horrifying manifestation of the science. At the same time, with Einstein and his contemporaries, chemistry was displaced from its elite and fundamental position. It was plausible to say that it was reduced to physics (though really no truer than to say that architecture is reduced to physics), and that the new Newton would be found among physicists. Chemists had an essential role to play in the new teams and groups which in the twentieth century came to replace the lone genius like Faraday, but in physics or biology it seemed everyone's essential service-science – not very glamorous.

Chemistry seemed to have the cure for pollution like London's, where *Punch* commented in 1862 upon hopes for a clean-up:

> The passenger of Chelsea boat
> Unwonted salmon shall admire,
> Where dogs and cats he used [to] note,
> Defunct that on thy breast did float,
> Emitting exhalations dire. [*Punch,* 15th November 1862, p. 198]

In the event, it was engineers laying a new sewage system rather than Faraday's experiments with chlorine that brought improvement. Chemical industry has since acquired a reputation for polluting, and the pharmaceutical industry for profiteering.

What could be done, if like King Canute we hope to turn this tide? Chemistry was a problematic science for natural theologians, because while astronomers wonderingly contemplated the starry heavens, and natural historians the eye of a fly, chemists busily sought to improve on nature (Brooke & Cantor 1998, Knight 2004c). This led to a rhetoric of conquest (Schummer 2006), deeply unpopular in our 'green' days. The rhetoric of chemistry has long been macho (Knight 2000a), full of images from warfare, but it might be wiser to return to a dynamical picture of revealing the powers inherent in

nature so that we can use them, rather than torturing Nature ('putting her to the question', like a suspected witch), or conquering her.

In his published inaugural lecture of 1802, which Mary Shelley picked up and used in writing *Frankenstein* (Shelley 1999, pp. 17-24), Davy used a sexy rhetoric in which chemistry was a branch of sublime philosophy, and the chemist:

> Not contented with what is found upon the surface of the earth, […] has penetrated into her bosom, and has even searched the bottom of the ocean for the purpose of allaying the restlessness of his desires, or of extending and increasing his power. [Davy 1839-40, vol. 2, pp. 318, 320; Woof et al. 1997]

Once conquered, Nature could be put on a pedestal and worshipped:

> Oh, most magnificent and noble Nature!
> Have I not worshipped thee with such a love
> As never mortal man before displayed?
> Adored thee in thy majesty of visible creation,
> And searched into thy hidden and mysterious ways
> As Poet, as Philosopher, as Sage? [Knight 1998, p. 9]

In our post-Freudian age, we probably could not, with a straight face, write quite that way about the scientific urge, though we should note that Davy's lectures and writings were very popular with women – this was before the prudish Victorian era. But we might be able to make chemistry less down-to-earth and prosy than we often do, maybe giving a new frisson to hands-on and hands-off.

Chemists were culturally active, Davy analyzing colors used in ancient wall-paintings from Pompeii and elsewhere (through his friendship with the sculptor Antonio Canova [Knight 2000b]); while Wollaston wrote, also for the Royal Society's *Philosophical Transactions,* on 'fairy rings' in the grass, and with Sir Thomas Lawrence, President of the Royal Academy, a paper on why the eyes in portraits follow you around. In conservation and restoration, the role of chemists remains essential, and that should be good for the reputation of the science. And we still, like Goethe, use the idea of personal chemistry in analyzing human relationships.

Boundaries between sciences are certainly social constructs, and the science we call 'chemistry', with its inorganic, organic, and physical branches, in institutes and departments is only one way of exploring and describing the world. It might come to an end, as some fear: though materials science, nanotechnology, molecular biology *etc*. would continue under different umbrellas. What if it did come to an end? We might be perturbed, but as historians we need not worry – the Roman Empire still supports a small army of historians investigating its affairs, and there are much fuller records for the Empire of Chemistry.

Notes

[*] This paper was first presented at the *5th International Conference on the History of Chemistry, Lisbon, Portugal, 6-10 September 2005.*

[1] Cantor & Shuttleworth 2004, Cantor *et al*. 2004, Hensen *et al*. 2004, and my essay-review (Knight 2005b).

[2] Luttrell 1993, pp. 530-1; 'Woolaston' was William Hyde Wollaston, metallurgist.

[3] Henry, 1801, pp. 3, 14; 3rd ed., 1803, p. vi. A guinea was one pound, one shilling (£1.05), the unit used for gentlemen's fees, prizes, and luxuries.

[4] William Paley's *Natural Theology* (1802), the classic statement of the clockwork metaphor, will be published in a new edition, ed. M.D. Eddy and D.M. Knight, Oxford UP, 2006.

[5] The editor's name was Montgradieu (possibly Montgradien); Martyn Berry, personal communication, 19/8/05.

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