# Chemistry in the 21st Century: Death or Transformation?

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For some time now, the author has been concerned about the future of chemistry. A concern –as for many chemists– stemmed from the closure of several chemistry departments in the UK over the last decade and attempts to re-brand chemistry elsewhere as part of the biomedical sciences, forensic science or even heritage research. This paper is a first attempt at an analysis of the possible future for chemistry in the 21st century. In a brief paper such as this it is impossible to cover chemistry across the world and it is also not certain that such a global analysis would give a very clear picture. As a British historian it is realistically only possible to deal only with the situation in the United Kingdom. A study of the USA or Germany would differ somewhat and the position in Asia (China, India, Japan) is very different. It may well be that the Asian situation might even undermine my thesis.

It also has also became clear that it would be too complicated and possibly even confusing to analyse long term series of data. For simplicity and clarity, 1977 –the centenary year of the Royal Institute of Chemistry (RIC)– will be compared with 2006. As it happens, 1977 was also the year the author graduated in chemistry.

This is not just a statistical analysis; it is also a cultural study of what chemists are doing. It is thus argued that the well-being of chemistry is not only a matter of data –how many chemistry degrees taken, how many chemistry papers published– but also the internal and external perception of chemistry, how chemists see themselves and how others see chemistry. To put it another way, is what chemists do in the 21st century actually chemistry insofar as it would have been recognised by chemists living 50 or 100 years ago as being chemistry? This is not a trivial point, is there any point in talking about chemists and chemistry if what they do is no longer recognisable in the *longue durée* as being chemistry? This is one aspect of the debate where historians have a particular role to play.

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In the RIC's centenary year of 1977, there was a special exhibition at the Science Museum based on a major revamping of the chemistry galleries, which then covered almost 12,000 square feet. A book on the history of the RIC written by three professional historians of chemistry at the Open University, Colin Russell, Noel Coley and Gerrylynn Roberts. A special leather-bound copy was even presented to Prime Minister, Jim Callaghan. The Royal Mail even issued a set of stamps celebrating British chemistry to mark this milestone. There was much to celebrate. The total professional membership of the RIC had grown exponentially since 1915 to over 23,000. After steady but moderate growth since it was founded in 1841, membership of the broader-based Chemical Society had also grown rapidly since 1940. There was an average of about 2,500 chemistry degrees awarded a year between 1965 and 1977; 1977 was actually a trough year with around 2,250.

Chemistry was in good shape in this period. Thanks to the expansion of higher education in the 1960s, there were more chemistry departments in universities than ever before including Sussex, Warwick, York, Stirling, Bath, Lancaster and Kent. The number of non-German publications in chemistry per annum had risen from 8K in 1918 to 302K in 1975. There were also many new journals, including *Accounts of Chemical Research* (1968), *Macromolecules* (1968), *Chemical Physics* (1973), *Heterocycles* (1973), *Synthesis* (1974), *Tetrahedron Letters* (1975).

In the modern jargon, chemistry was a strong brand in 1977. It had a clear identity and was seen as successful. Nearly all Nobel Laureates in chemistry in this period were clearly "chemists" and worked in chemistry departments: Barton (1969), Wilkinson (1973), Flory (1974), Prelog (1975) and Lipscomb (1976). Among the successes of chemistry during the previous decade were: the total synthesis of vitamin B12 (Wilkinson and Eschenmoser, 1973) and the prostaglandins (Corey, 1969), the Barton-McCombie reaction (1975), organorhodium catalysis (Wilkinson, 1966), uranocene (Streitwieser and Müller-Westerhoff, 1968) and crown ethers (Charles Pedersen, 1967).

Three decades of research by historians and sociologists of science have shown that this success was a culmination of a century and a half of discipline building, specifically:

– Positioning chemistry as a profession not a craft.
– Restricting entry into the field (only partly successful).
– Emphasising pure science rather than application to problems.
– Invoking the linear model of innovation.
– Protecting the boundaries of chemistry from invasion by physics and biology-medicine.

Although chemistry may have been a strong brand, it did have its weaknesses even in the 1970s, namely:

– Loss of biochemistry and molecular biology only partly counterbalanced by the creation of physical organic chemistry and bioorganic chemistry.
– Only a minority of chemists belonged to the RIC.
– Chemistry had a poor image of long-standing, which was increased by the explosions at Flixborough in England in 1974 and Seveso in Italy in 1976.
– Chemists to most people in the UK were pharmacists not chemists.

So we could sum up the situation in 1977 by saying that while chemistry had its problems, both chemists and the public had a clear sense of what chemistry was about and most people accepted that –at a minimum– chemists did more good than harm, a view that was promoted by advertising campaigns by the major chemical companies including Du Pont, ICI, BASF and Bayer.

Turning to 2006, the situation at first glance does not look bad at all. The total Corporate Membership of the Royal Society of Chemistry (RSC) was 37,970 compared with 27,850 in 1980 when the RSC was formed by a merger of the RIC, Chemical Society and Society for Analytical Chemistry. The number of chemistry graduates in 2004 was 2,735 roughly comparable with 1977 although the figures are calculated differently.

But these good numbers look different when considered as a trend…

After a long period of stability thanks to a slow decline in Fellows being counterbalanced by a growth in Members, the number of all corporate members began to fall slightly from 2003. Similarly the number of chemistry degrees awarded fell from 4,144 in 1996 to 2,735 in 2004. This fall in the number of chemistry students was paralleled by the closure of six chemistry departments between 2003 and 2005 including King's College and Queen Mary's in London, Lancaster, Kent and Swansea although Queen Mary's has since reopened.

However the most striking change is the changing nature of the subject. Whereas chemistry in 1977 was very much physical, organic and inorganic chemistry, by 2006 it had become biomolecular science, materials and nanotechnology. Many recent Nobel Laureates in chemistry have not been traditional chemists. Of the nine Nobel Laureates in chemistry since 2003, six have come from biomedical faculties or institutes not chemistry departments.

One major change in chemistry over the last three decades has been the relative decline of the chemical industry relative to the pharmaceutical industry in the United Kingdom. It is worth reflecting that the chemical industry in 1977 had a

strong historical continuity with the past –all the major companies could easily trace their history back to the mid-19th century– and the larger chemical companies were a major economic power in their native countries –such as Du Pont in the USA, ICI in the UK and BASF in Germany. Indeed it is even noteworthy from the perspective of 2008 that most chemical companies in 1977 were still associated with specific countries. Above all these companies were household names, who had not heard of BASF tapes, Dulux paint (associated with ICI in Britain rather than Du Pont), nylon or Perspex? It was only when the workers at Grangemouth refinery in Scotland recently went on strike, that the author discovered that Ineos –the owner of Grangemouth refinery– was one of the largest chemical companies in the world.

As the chemical industry faded from the public gaze, the pharmaceutical industry –important even in 1977– has become crucial to the survival of chemistry. The number of R&D scientists employed in the UK pharmaceutical industry doubled between 1978 and 1999 whereas it remained static in the chemical industry. Furthermore more and more academic organic chemists were working on pharmaceutical topics. This shift has come however at a price. Whereas the chemical industry was a standard-bearer for chemistry, the pharmaceutical industry is increasingly coy about its links with chemistry. For instance, prescription medicines are never described as chemicals even though, for example, pantoprazole tablets contain povidone, titanium dioxide, methacrylate-ethacrylate copolymer and even sodium lauryl sulfate (oddly enough this information is only given in the Italian labelling, not the English). Perhaps more importantly the pharmaceutical industry stresses the role of biomedical sciences as a whole –and rightly so– rather than just chemistry.

To meet these challenges from other scientific fields, the RSC has been re-branding itself in recent years as "largest organisation in Europe for advancing the chemical sciences" broadly defined, rather than a British chemical society. But as we have seen that chemistry is itself changing. Will this re-branding work or will chemistry as it was understood it back in 1977 disappear?

What are the possible outcomes for the future of chemistry? Chemistry may change its nature and become a fusion of biomolecular science, materials and nanotechnology but retain the name. There has been similar changes before –chemistry in 1750 was different from chemistry in 1840 and again from chemistry in 1930– but this is a momentous change… will this new constellation of sub-disciplines and quasi-disciplines stick together?

Whereas the relative importance of sub-disciplines within chemistry and even the rise of new sub-disciplines could be accommodated fairly easily, taking over other disciplines is much more difficult, the more so since they had already "escaped" from chemistry. But the key issue herein is that biomolecular science and biomedicine as a whole and materials science are both more powerful than chemistry itself—and crucially they are both seen as being more relevant than chemistry so this takeover bid is unlikely to succeed.

Although the chemical industry still exists and indeed still employs a large number of chemists, its relative decline (and indeed the decline of manufacturing in general) makes it harder for chemistry to prosper as its relevance is seen to be declining and it lacks the PR boost that a strong high-profile chemical industry could give it as it has done in the past.

If chemistry is unable to re-brand itself successfully, it will either continue to just reposition itself and trust in the preference of some scientists to label themselves chemists –despite the lack of any continuity with the past– or it will just fade away as former would-be chemists identify themselves as biomedical scientists, materials scientist or physicists. Perhaps nanotechnology will be the final refuge of chemists although it is as much physics as chemistry. As all institutions –including scientific disciplines and chemical societies– seek to prolong their existence, I suspect it will be a drawn out "whimper" rather than a "bang". Perhaps in a century from now, chemical societies will have become like the medieval guilds that still exist in the City of London, for example the Salters Company, which however does excellent work in the field of chemical education.

If these conclusions are correct, and they are at present a hunch rather than a rigorously proved hypothesis, this suggests that chemistry over the next half-century will revert back to its eighteenth century origins in medicine (= biomedicine) metallurgy and mineralogy (= materials science) and natural philosophy (= physics). Obvious alchemy as a pseudoscience will have no part to play but it is entirely possible that alchemy as practised today may outlive chemistry! Indeed even now the Science Museum gets more enquiries from the media about alchemy than about chemistry.

Do the conclusions have any relevance to historians of chemistry? It is argued it changes the way the subject is to be viewed. If its history leads ultimately to dissolution it must alter the perception of that history. For instance it surely affects the way one studies the coming together of mineralogy and metallurgy in the eighteenth century if it is known –at some point in the future– that alliance was dissolved. An understanding of the development of chemistry –which is very dif-

ferent from the very limited way most practising chemists view it– enables practising chemists as well as historians of chemistry to better understand why it is unravelling.

But if chemistry does unravel and becomes biomedicine and material sciences, where does that leave the history of chemistry? Will the history of chemistry survive or will it too unravel to become part of the history of medicine and the history of the material sciences? Is there precedence for the history of a "dead" discipline? Certainly the history of alchemy is very healthy, more so than the history of chemistry.

The author does not wish to be unduly alarmist or to claim that the end of chemistry is nigh. Chemistry is not dead or in pieces yet. It is still a major scientific discipline with many professionally trained practitioners. In some countries, notably in China and India, it is still flourishing. So it is probably a bit early to start worrying, but if it does unravel over the next few decades, please remember you read it first in this paper.

## Sources

This is not intended to be a fully referenced paper. Most of the data, with the exception of the number of non-German publications, was kindly supplied by the Royal Society of Chemistry for which I am very grateful, but the conclusions drawn from them are entirely my own. The number of non-German publications was taken from Arnold Thackray, *et al.*, *Chemistry in America* (Dordrecht: Kluwer, 1985), Table 6.8, 400. I had previously touched on some of the themes in this paper in "Between the Living State and the Solid State: Chemistry in a Changing World" in *Chemical Sciences in the 20$^{th}$ Century: Bridging Boundaries* (Wiley-VCH, 2001), ed. Carsten Reinhardt, 193-200. Other papers which deal with this question include John W. Moore, "What's the Future of Chemistry?" *Chemical Education International*, 1 (1) (2000): 8-10 and Stephen W Breuer, "Does Chemistry have a Future?" *University Chemistry Education* 6 (1) (2002): 13-16.