CURRENT SCIENCE

Volume 95 Number 5 10 September 2008

EDITORIAL

Analytical Chemistry: Resurrection of a Discipline

Chemistry is a subject characterized by well-defined boundaries, that separate the major sub-disciplines of organic, physical and inorganic chemistry. More recently, theoreticians who have little taste for the sounds and smells of a chemistry laboratory, have carved out a kingdom of their own. The organic chemists focus their attention on a few elements; carbon occupying centrestage. The inorganic chemists range farther afield. The borders are well demarcated, although organometallics and materials chemistry have, at least in part, breached barriers that seemed as impregnable as the Berlin Wall, in the years before its dramatic dismantling. Physical chemists appear wedded to areas that have their roots in physics; sometimes labelling themselves as chemical physicists, an acknowledgement of their distance from the heart of chemistry. The fierce loyalties of the practitioners of these sub-disciplines resemble those observed in religious sub-sects. The other sciences seem less divided by such clear boundaries. Analysis of substances, pure and mixtures of several components, forms the core of chemistry. Curiously, analytical chemistry, which once seemed a respectable term, is now largely shunned; a Cinderella amongst the various sub-sects of chemistry. For most people of my generation, who have had chemistry in college, the term conjures up visions (most often, nightmares) of being asked to separate and identify the constituents of an unknown mixture in a practical examination. The task was often aided by the goodwill of laboratory attenders who knew the right answers. Analytical chemistry, as I learnt it decades ago, always seemed to teach you more about practical human skills than about the subtleties of identifying molecules. Flame tests, gravimetry, titrations, colour reactions, precipitates that must appear and later dissolve, mirrors that permanently scarred clean test tubes and coloured and colourless gases that miraculously appeared under gentle chemical coaxing are memories that remain.

Analysis and synthesis constitute the heart of chemistry. Chemical analysis is, of course, as old as chemistry itself. The roots of modern analysis can be traced to the early years of the 19th century. Chemistry's origins coincide with some of history's most dramatic moments. Lavoisier's book, *Elements of Chemistry*, appeared in French in 1789 and a year later in English, sparking off the chemical revolution. Ironically and tragically, Lavoisier was caught in the turmoil of the French Revolution and guillotined in 1794. In a book tracing the 'discovery of the molecular basis of life', Graeme Hunter quotes Joseph Lagrange: 'It took them only an instant to cut-off that head, and a hundred years may not produce another like it' (*Vital Forces*, Academic Press, New York, 2000, p. 15). In tracing the path from the 'animal chemistry' of Lavoisier to molecular biology, Hunter pauses to survey early 19th century chemistry. His assessment, that 'chemistry in the first half of the 19th century was dominated by the findings, teachings and personalities of three men: Jöns Jacob Berzelius, Justus Liebig and Friedrich Wöhler', will be shared by many students of the history of the discipline. In many ways, analytical chemistry was truly midwifed into existence in Berzelius' work. Hunter notes that 'Berzelius was above all a classifier, the Linnaeus of chemistry'. In looking back at two centuries of progress since Berzelius' *Textbook of Chemistry* appeared in 1808, one can immediately see that analysis pervades every corner of chemistry. The pace of advance in chemical analysis has been spectacular in the second half of the 20th century; a diverse portfolio of spectroscopies permit identification and quantitation of chemicals, with a degree of sensitivity that is simply astounding. Molecular size and complexity are not a bar to analysis; mixtures of the most complex nature are resolved and analysed with relative ease today. Chemical analysis is the essence of forensic science and medical diagnosis. Paradoxically, analytical chemistry has become a victim of its own spectacular success, slowly disappearing as a well-defined sub-discipline of chemistry.

I must confess that writing a column on analytical chemistry would not have occurred to me if a book had not appeared on my desk, with a little note from the journal office asking me to suggest a potential reviewer. This is a routine chore for an editor and I usually have only a passing glance at the book. Over the years I have learnt that titles and publishers are a useful guide in assessing whether a review is merited. This time I was intrigued by the title and a quick glance at the contents persuaded me to retain the volume, which was the *Annual Review of*

Analytical Chemistry (Volume 1, 2008). Two hundred years after Berzelius, Annual Reviews Inc had turned to *Analytical Chemistry*, a discipline that I mistakenly thought had been quietly laid to rest. The Annual Reviews is, of course, an enormously influential publishing enterprise. Beginning with the *Annual Review of Biochemistry* in 1932, volumes now appear, yearly, in 33 different fields, ranging from *Genomics and Human Genetics* to *Nuclear and Particle Science*. Indeed, there is even a series on *Law and Social Science*. Fifty years after the first appearance of the *Annual Reviews*, the founder of the series, J. Murray Luck, describes the genesis in Volume 50 of the *Annual Review of Biochemistry*. As a young faculty member at Stanford in the late 1920s he found himself 'knee deep in trouble' while attempting to 'give a course on current research in biochemistry to a group of ten to fifteen graduate students'. The idea of an 'annual review' has proved remarkably successful in highlighting rapidly developing fields in diverse areas of science. Writing a scholarly and readable review is no easy task. Remarkably, the *Annual Review* series has maintained an enviably high quality, over a period of 75 years, even as the range of subjects has expanded. Despite their obvious utility, I have learnt to be wary in choosing reviewers for the *Annual Reviews*. While most scientists are pleased to receive a review copy that they can retain, there are accomplished, busy and impatient colleagues who peremptorily dismiss any idea of reviewing a collection of reviews.

The volume on *Analytical Chemistry* signals the beginning of a new series. Its prefatory chapter sets a tone that places the collection of reviews, right in the centre of the most active and visible fields of science today – medicine, biology and biotechnology. Lee Hood's account of 'A personal voyage of discovery: Developing technology and changing biology' is a story of the development of methods and instruments that permit rapid chemical analysis and synthesis of proteins and nucleic acids, molecules central to cellular biology. Hood begins with a quote from Freeman Dyson that is most apt for modern biology: '*New directions in science are launched by new tools much more often than by new concepts. The effect of a tool driven revolution is to discover new things that have to be explained*' (*Imagined Worlds*, Harvard University Press, 1998). The automated protein and DNA sequencers and the peptide and DNA synthesizers came out of Hood's laboratory at Caltech in the 1980s; rapid commercialization brought the new tools into biochemistry and molecular biology laboratories across the world and fuelled the growth of the biotechnology industry. The genomics revolution and the explosion of biological information is a direct outcome of the new technologies; systems biology, an area highlighted in Hood's overview, appears to be emerging as an integrating discipline. The deep inroads that biology has made into medicine, over the last decade or so, have largely been a result of the rapidity with which detailed and accurate chemical analysis of biological molecules can be performed. The overwhelming majority of the 29 reviews in this volume deal with methods that are directly applicable to biological problems. Old fashioned chemists, longing for a simpler age, may find some satisfaction in the realization that biophysics and spectroscopy now advance under the banner of analytical chemistry. The analysis of biological fluids, most commonly blood and urine, but increasingly others like cerebrospinal fluid, lung aspirates and extracts of biopsy tissue by NMR and chromatography coupled mass spectrometry, is becoming commonplace. Infelicitous terms like metabolomics and metabonomics have entered the world of chemical analysis (J. C. Lindon and J. K. Nicholson, p. 45). Mass spectrometry, whose origins can be traced to the work of J. J. Thompson in the last decade of the 19th century, is now the most rapidly evolving analytical method, applicable to almost every problem of chemical analysis. The reviews in this collection describe some spectacular new frontiers. These include, rapid characterization of microorganisms (P. A. Demirev and C. Fenselau, p. 71) and the use of laser desorption mass spectrometry for imaging biological tissues (K. E. Burnum *et al.*, p. 689). There are distinct advantages to being able to image molecular distributions in biological tissues. Many reviews in this volume describe techniques that have remarkable sensitivity and high spatial resolution. The 'single cell' is now the target of chemical analysis; a tribute to the rapid pace of technological advance. Lasers, specifically ultrafast lasers, are a key to many of the techniques described in this inaugural issue of the *Annual Review of Analytical Chemistry*. As the volume and resolution of chemical analysis of heterogeneous systems increases, the pressure on handling and processing information will grow. Dyson's forecast that we will 'discover new things that have to be explained' will, inevitably, come true.

In reflecting on the resurrection of analytical chemistry, I was drawn to an account of the life and times of Jöns Jacob Berzelius (J. Wisniak, *Chemical Educator*, 2000, **5**, 343). I realized then that Berzelius had indeed even anticipated the need for *Annual Reviews*. Wisniak notes that Berzelius published *Annual Surveys of the Progress in the Sciences* from 1821 to 1848, the year he died. These volumes which totalled 'about 12,000 pages' were 'probably his most important publications'. The appearance of an *Annual Reviews* in analytical chemistry marks the rebirth of an old discipline; an acknowledgement of the triumphant advance of the area of chemical analysis in the two centuries since Berzelius.

P. Balaram