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EDITORIAL

Chemists and Chemistry

The J. N. Tata auditorium at the Indian Institute of Science is an imposing lecture theater. On New Year's Day 2011, the hall was packed with nearly 1000 high school children herded in, accompanied by watchful teachers, to witness the Chemical Research Society of India launch the International Year of Chemistry. India's most visible and accomplished scientist, C. N. R. Rao spoke forcefully about the contributions made by chemistry and chemists over the past two centuries. The roll call of honour began with Faraday, now claimed by both physics and chemistry and moved on, inevitably, to Linus Pauling, arguably the dominant presence in 20th century chemistry. This overview of a discipline's historical progress was followed by a lecture-cum-practical demonstration of chemical experiments that produce light, sound and, sometimes, fire. Cold and hot flames, invisible writing that appeared colourfully intense, upon spraying a chemical, and wonderfully luminescent solutions glowing in the dark engaged the young audience. Chemistry seemed a part of magic; an entertaining visual spectacle that hid the image of a subject viewed as boring or intimidating in its detail by most school students. A cursory glance at the chemistry textbooks used by students appearing for the all-India school board examinations (CBSE or ISC) reveals impossibly large volumes, densely packed with information. A mere look at the textbooks must fill the average student with a great sense of foreboding; turning the pages will undoubtedly turn dread into despair. I suspect physics and biology textbooks are hardly more attractive as the volume of information considered necessary at school stage seems to increase in a frightening manner. With both teachers and students struggling to cope with bloated syllabi, it is hardly surprising that 'science' and, particularly, chemistry, are subjects that do not attract many students. In the midst of the captivating demonstration of chemistry's entertainment value, the lecturer paused and asked of the audience: 'How many of you dislike chemistry?' There was little reaction. He then goaded them on: 'Don't worry, your teachers are not looking'. The response was now spontaneous as a sea of hands went up; a resounding vote for the commonly held perception that chemistry is an unpopular subject. The lecturer moved on to play a short video recording of Linus Pauling, iconic and inspirational, speaking of science, at times reflectively. Pauling painted on a very large canvas, moving over the course of a remarkable career from quantum mechanics and crystallography to molecular biology. Chemistry was always his central theme; atoms, molecules and structures were at the core of his forays into immunology and medicine. I am not sure how many of the children were moved by listening to one of the all-time greats of science; but I could not help thinking somewhat sadly, that Pauling's example of viewing the discipline in its broadest sense has never been followed in the development of chemistry teaching and research in India.

The new year provides an opportunity to look back at major events in science in the year gone by. The major journals provide retrospectives and, in following current fashion, rankings of the most significant advances. Just over twenty years ago the journal *Science* introduced a feature that appeared in the last issue of the year, intriguingly entitled 'The Molecule of the Year'. The editorial by the then Editor, Daniel Koshland, explained in captivating fashion the reason for the new feature: 'Historians tend to personalize history. They use political leaders to symbolize war or peace, freedom or slavery, abundance or starvation. Political systems represented by these individuals may be essential but political leaders cannot cure disease without medicine, cannot improve crops without fertilizer, and cannot encourage the literacy on which democracy depends without communications technology. The great advances of the past have been profoundly influenced by science and technology, and our present standard of living depends on them. Political systems can be designed to encourage advances in science and are essential to the fair distribution of its products. Wealth must be created before it can be distributed.' Koshland went on to note that 'in the rush of daily events and the ease of describing personalities instead of analyzing issues, the fundamental causes of progress can be obscured'. He then unveiled the new feature by stating: 'To symbolize . . . scientific progress and to honor the structure that creates it, *Science* has decided to name a Molecule of the Year. The molecule will symbolize a discovery or technique that may actually involve many molecules, but the award will be singular to force us to choose one such discovery each year that is likely to have the greatest influence on history' (Koshland Jr, D. E., *Science*, 1989, **246**, 1541). The choice of the term 'molecule', so central to chemistry, seemed an implicit acknowledgement of the pivotal position occupied by the discipline in science. The first choice in 1989 was the DNA polymerase molecule, the engine that drives the polymerase chain reaction (PCR). This reaction which allows the 'amplification' or copying of DNA has revolutionized molecular biology. However, then and possibly even now, DNA polymerase seemed distant from 'chemistry'. In the period between 1990 and 1996 the term 'molecule' was used to symbolize scientific achievement and progress. Synthetic diamond (1990), the protein p53 so important in cancer research (1993), DNA repair enzymes (1994) and Bose–Einstein condensates (1995) were accorded the honour of being recognized as *Science*'s 'molecule of the year'. Biology, materials science and physics seemed to dominate. There were two exceptions. Buckminsterfullerene (C_{60}, 1991), the 'celestial sphere that fell to Earth' in the words of one of its discoverers, H. Kroto, captured the imagination by its sheer symmetry and beauty. Chemistry reigned briefly. The following year, 1992, saw a surprising choice, nitric oxide (NO), a chemical so simple and common that chemists may hardly give it a second thought, outside an undergraduate classroom. Once again it was a nod to biology, with the recognition of its production and role in signalling within living cells. It was increasingly evident that the term 'molecule' with its strong association with chemistry may be inadequate to symbolize the broad advance of science on many fronts. From 1996, *Science* began to title its annual year end feature as 'Breakthrough of the Year'. Over the past fifteen years many fields and topics ranging from 'understanding HIV' (1996) to the 'first quantum machine' (2010) have been featured. None appear to directly relate to the discipline of conventional chemistry. From 2002 a scientific body with an improbably long acronym, the International Society for Molecular and Cell Biology and Biotechnology Protocols and Researches (ISMCBBPR), based in Berlin has begun announcing a 'molecule of the year'. The 2009 choice of the jumping gene or 'sleeping beauty' transposon is hardly like to enthuse chemists practising what is often termed 'mainstream chemistry'.

In India chemistry is highly visible in both industry and academia. Whenever statistics on publications and scientometric indices are compared with those of the advanced countries, chemistry does better than many other disciplines. Among the national laboratories, those devoted to chemistry are extremely well regarded. Despite the apparent health of the subject in our institutions there appears to be a sense of disquiet; a feeling that the discipline seems less attractive to students than biology or physics. Chemistry in the West, particularly the United States, has transformed over the last quarter of a century, with traditional academic departments broadening their scope to encompass newly emerging areas of chemical biology and materials science. The dramatic advances in chemical analysis over the past few years have really been catalysed by the needs of biology and the requirement to address complex molecules and assemblies in atomic detail. Mass spectrometry and imaging technologies of diverse kinds are commonplace in biology. The impact of the transformation that has swept chemistry elsewhere is yet to be really felt in India. Biological problems have served to unite the traditional sub-disciplines of chemistry in the best of institutions world-wide. Unfortunately in India tradition still seems to rule. Organic, inorganic and physical chemists continue to go their separate ways. Biochemistry, despite the name, seems to have little to do with chemistry. This lack of unity limits the appeal of the discipline. Sharply defined boundaries are irrelevant in today's science. Nevertheless, high and, sometimes, impenetrable barriers ('tunneling' seems improbable) exist between the various sub-disciplines of chemistry in our institutions. Natural products chemistry, once a thriving area of research in many university departments, has virtually become extinct, even as advances in chromatography and analysis have revolutionized the field. Biology offers a fertile hunting ground for natural products chemists, but our institutions lack the technical expertise to exploit the explosive growth of structural analysis. Chemical ecology, a subject that unites wondrous biological phenomena with marvellously sophisticated chemistry, needs practitioners who speak an interdisciplinary language. We can hardly exploit biological diversity to discover new pharmaceutical leads if there are almost no trained chemists comfortable with the analysis of natural products. In teaching, a great disservice is done to students when 'secondary metabolites' are divorced from proteins and nucleic acids, so central to all of biochemistry.

Chemistry, worldwide, has indeed had a crisis of identity even as biology and materials science have exploded. A feature in a prominent chemistry journal raised an interesting question: 'Is the Nobel Prize in Chemistry Still Relevant?' (Mukhopadhyay, R., *Analytical Chemistry*, 2009, **81**, 7866). This is an oft discussed issue, especially when advances in what is perceived as 'biochemistry' or 'biology' are recognized. The commentary quotes the Nobelist, Roald Hoffmann: 'Academia is stodgy and stuck in disciplines'; a judgement that undoubtedly applies to chemistry in India. In attempting to convey the excitement of chemistry on New Year's day the enthusiastic lecturer told his large audience: 'Virtually all human activity requires chemistry'. He was understating his case. Indeed, all human activity requires chemistry.

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