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EDITORIAL

Chemicals, Chemistry and Molecules

Judicial pronouncements have an air of finality. In India, we now turn to an overburdened judicial system to resolve failures of governance in everyday life; ranging from major national issues to minor and often, petty local controversies. Lawyers thrive in an intensely litigious environment. Courts oversee investigations into an ever increasing number of scams and misdeeds, by those who have been charged with the responsibility to govern. If one adds the vast number of criminal and civil cases that require judicial attention, we cannot but marvel at the diversity of problems that must confront judges. Judgements on matters of great public interest are awaited with considerable expectation, with press coverage that heightens interest. Judgements on highly arcane matters rarely evoke any mention. I was therefore, nonplussed to read a news item announcing that the Bombay High Court had ruled that 'steam was not a chemical'. The status of steam was a contentious issue, with a company manufacturing sulfuric acid, selling steam as a by-product. The issue before the court was not a judgement on chemistry, but one of interpreting tax laws. There is nothing more bewildering than regulations, periodically promulgated and frequently modified, which govern the imposition of taxes on materials and services. The interpretation of laws can be debated, but in this instance the judges were in no doubt: 'In common sense, the steam is treated as a by-product of water and for preparation of steam the process is just to boil water. Therefore, the common man always treats steam as part and parcel of water. It is a fact that in taxing statute the words which are not of technical expressions or words of art but are words of everyday use, must be understood and given a meaning, not in their scientific sense, but in a sense as understood in common parlance' (Shibu Thomas, *Times of India*, April 17, 2010). The judgement meant a great deal to the company, which was then required to pay 10% sales tax instead of 4%, for the years 1988–1991. One cannot but help feel a tinge of regret that after two decades an appeal to chemistry would be overturned by a vote in favour of common sense. An alert colleague of mine drew the attention of the news magazine of the American Chemical Society to this striking (at least for chemists) judgement of the Bombay High Court leading to an article that begins provocatively: 'Steam is just water. Right? And water is the most abundant chemical on Earth. Right? So when is steam not a chemical? When the Bombay High Court says so' (Ritter, S. K., *Chem. Eng. News*, 2010, **88**, 56).

The court verdict, delivered in the special context of a tax dispute, may have been of little general interest, except to those concerned with chemicals and chemistry. Having been drawn into a career in science by the promise of chemistry, resisting the apparent stability of the administrative services or the uncertain world of journalism, the High Court's pronouncement turned my attention to a discipline that has rarely been viewed as glamorous, in public perception. Chemistry is a common word. Journalists wax eloquent about the 'chemistry' between Prime Minister Manmohan Singh and American Presidents as diverse as George Bush and Barack Obama. Reviews of cinema and theater often highlight favourable or, sometimes, unfavourable chemistry between actors and actresses. In common usage 'chemistry' is a word used, more often, to describe human interactions, than to refer to the science itself. 'Chemicals' is a term that instantly conjures up visions of poisonous, harmful substances that are hazardous to human health and damaging to the environment. Toxic wastes, pollutants of every kind, gaseous, liquid and solid seem to be invariably associated with chemistry. In agriculture, so central to our existence, the dramatic increase in productivity following the industrial synthesis of ammonia and its conversion to the fertilizer, urea, has faded from memory. The story of the rise of DDT as a pesticide has long been supplanted by the chronicle of its fall from grace, as a toxic despoiler of the environment. While the first half of the 20th century has been hailed by historians of science as the age of physics, the second half has been heralded as the age of biology. The glamorous and widely appreciated triumphs of these sister disciplines, often inextricably linked to chemistry, have undoubtedly relegated the subject to the position of the Cinderella of the sciences. It is indeed hard to conjure up an image of chemistry that would enhance its public standing. Even when the Nobel prizes are announced annually, chemistry arouses a heightened public interest only when the award recognizes an advance that makes deep inroads into biology. This year's awards provide an example, with the public interest in 'test tube babies' and the promise of graphene in 'nanotechnology' clearly scoring over the subject of making carbon–carbon bonds using 'palladium catalyzed cross-coupling in organic syn-

thesis'. Carbon is central to organic chemistry, but its elemental forms are increasingly associated with physics and the seductive world of nanoscience. Graphene, a single layer of carbon, a truly two-dimensional material, is not referred to in the press as a chemical; it is a wondrous 'material' that may be a harbinger of many technological advances. The build up of expectation is remarkable: 'Imagine a machine that can test the same physics that scientists test, say, CERN, but small enough to stand on top of your table. Graphene allows this to happen. . .' (Andrew Geim, 2006 interview, quoted in *Frontline*, November 19, 2010, p. 105).

A recent editorial in *Nature Chemistry*, a relatively new addition to the constantly expanding portfolio of *Nature* journals, raised a question: 'Where are the champions?' The essay argues that 'chemistry lacks the easily articulated grand challenges associated with physics or biology and it generally gets a rough ride in mainstream media' (*Nature Chemistry*, 2010, **2**, 599). Indeed, I have heard the phrase 'grand challenge' only from physicists (invariably, theoretical) and biologists. Understanding quantum gravity or dark matter or the tantalising prospect of a theory that unifies all particles and forces is clearly in the realm of 'grand challenges'. So too are problems that address the understanding of brain function, the task of winning the never ending war against infectious and metabolic disease and the translation of genome sequences into predictors of biological fate. While chemistry and chemicals are central to all of biology and a great deal of physics, there is little to suggest that this fact is commonly known. The *Nature Chemistry* editorial notes that the 'negative perception of chemicals permeates through large sections of society and seems to influence how some consumer products are marketed. Perhaps the most stark example of this is a particular brand of compost that boldly proclaims to be "100% chemical free". That certainly would be some kind of miracle. Examples such as these have even prompted the Royal Society of Chemistry to offer a £ 1-million prize to anyone who can provide them with a sample of a material that is chemical free'. Curiously, the word 'material' is used even in science in a manner that places it apart from its poor cousin, the humble chemical. In naming journals, *Materials Chemistry* or *Chemistry of Materials* sound both scholarly and sensible. *Chemicals Chemistry* or *Chemistry of Chemicals* offend the ear and our sensibilities. Simply put, in popular perception, even amongst scientists, the term 'materials' seems to refer to substances that are 'good and useful'. 'Chemicals' appear to be best avoided. The *Nature Chemistry* editorial notes that the most common misconceptions about chemicals, 'include the idea that an individual can lead a chemical free life, and the notion that synthetic chemicals are dangerous, whereas natural ones are not'.

Even as I wondered about the public perception of chemicals and chemistry I received, as an unexpected gift, a beautifully illustrated, coffee table book: *Molecules that Changed the World* (Nicolaou, K. C. and Montagnon, T., Wiley-VCH, Weinheim, 2008). The book is subtitled, 'A Brief History of the Art and Science of Synthesis and its Impact on Society'. The authors state their intentions clearly in the preface: 'The inspiration for this book arose from the desire to enlighten and instill a greater appreciation in society at large about a difficult subject – chemistry. . . Many people remember chemistry as one of the most challenging subjects in college, or the class in which they struggled. For others, the mere mention of the word chemistry conjures up images of explosions, poisons, and pollution (toxic waste and dangerous fumes). The reality of chemistry, however, is far more exciting and rewarding, once these unfortunate and distressing images are dispelled'. In presenting a view of the heart of chemistry, the authors attempt to dispell common prejudices: 'Indeed, beyond this curtain, there lies a beautiful world of molecules with a glorious history and myriad wondrous applications'. Chemical synthesis, a creative activity which over two centuries has produced most of the chemicals that we need and use, but love to hate, is an underappreciated discipline. Nicolaou and Montagnon present a superbly illustrated tour through a world of molecules as familiar as glucose and aspirin, as feared as strychnine, as valuable as penicillin, cyclosporin, erythromycin, taxol and vancomycin and as exotic and unfamiliar as thiostrepton and the monstrous marine natural product, palytoxin. While structural complexity has provided the intellectual challenge for organic synthesis, modern drug discovery has remained rooted in the more mundane world of medicinal chemistry. Most widely used pharmaceuticals are small molecules, despite the oft repeated claims of biotechnology. In a chapter entitled 'Small Molecule Drugs', the authors bring to life the history of omeprazole and the drugs used to treat gastric ulcers, sedatives like valium and the barbiturates, antidepressants of which prozac has become widely known, antivirals and antibiotics that provide the main line of attack against invading viruses and bacteria. The complexities of chemistry are lightened by the authors' foray into history, bringing chemists and their discipline to life. Chemistry, biology and medicine are intertwined in ways that are not commonly appreciated. In attempting to take readers on a guided tour through a world of molecules, that have transformed our existence, Nicolaou and Montagnon may have indeed provided the justification for an old slogan that used to proclaim, 'better living through chemistry'. The coming year, 2011, has been declared by UNESCO as the 'International Year of Chemistry'. In celebrating chemistry as a discipline we might take heart in the fact that in stripping stream of its status as a chemical, the Bombay High Court did not address the issue of what constitutes a molecule. Truly, chemicals have changed the world.

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