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EDITORIAL

# Where has chemistry gone?

A review panel recently suggested changes in the way that the National Research Council (NRC) the operating arm of the US National Academy of Sciences (NAS) functions (Lawler, A., *Science*, 2000, **289**, 1443). Since a major function of the NRC is to produce reports, most often for US federal government agencies, the review recommended an administrative reorganization of divisions. The new structure would be based on broad themes: 'education and social matters; physics, astronomy, engineering and energy; food and health; biology, earth sciences and environment policy; and transportations'. According to the news report, such a grouping 'will allow greater synergy among disciplines'. In reading this rather prosaic news item, I was suddenly struck by the fact that 'chemistry' as a discipline was conspicuously missing from the list of distinct 'themes' envisaged for the NRC. Physics, astronomy, engineering, biology and earth sciences find a specific mention; agriculture and medicine appear disguised as 'food and health'. Mathematics is absent and probably, rightly so. But where has chemistry gone? After all, the American Chemical Society is supposedly the professional body with the largest number of members in America. Is the absence of an explicit reference to the chemical sciences as a 'theme' for the NRC, a commentary on the present status of the discipline?

There was a time when 'chemistry' was a well-defined subject; its practitioners clearly marked the boundaries of their sub-disciplines. Organic chemistry confined itself to the study of compounds of carbon. The rest of the periodic table, with the exception of the few elements that bonded to carbon, were hardly of concern. But even here, the boundaries were sharply drawn; natural organic polymers, proteins, nucleic acids and polysaccharides were generally excluded from the ambit of 'organic chemistry'. In its early, developmental stages, life was indeed 'banished' from organic chemistry. Edvard Buchner's epoch-making discovery in 1896, of cell-free fermentation by yeast juices may have marked the beginning of biochemistry; but it drew from Adolf von Baeyer, his mentor and one of the pillars of German chemistry, the scathing comment: '. . . he (Buchner) has no real chemical talent'. The remarkable ability of academic organic chemists to construct high barriers around their discipline, well into the second half of the 20th century, prompted the biochemist Arthur Kornberg (noted for his seminal contributions to the emerging discipline of molecular biology) to note: 'The problem was that organic chemists placed arbitrary boundaries on their science. Although in their pursuit of natural products, they might still eagerly seek the challenge of an Amazonian butterfly pigment, they would not accept nucleic acids, proteins and enzymes as proper natural products.' (Kornberg, A., *Biochemistry*, 1987, **26**, 6888).

Inorganic and physical chemistry, the other main subdivisions of the science were also substantially insular, although the influence of physics was always strong on the latter. For a while, beginning in the 1920s, it appeared that the quantum revolution had breached chemistry's borders, but it was quickly adapted to create a new branch, theoretical chemistry. In recent times in many laboratories computers are more evident than shelves of chemicals. Analytical and polymer chemistry were always poor relatives, important in industry but low down in the academic hierarchy.

While in the public perception the first half of the 20th century belonged to physics, the second was undoubtedly dominated by biology. Chemistry which made steady progress throughout the last one hundred years has always been a Cinderella amongst the sciences, with no fairy godmother in sight. Chemical knowledge forms the basis for much of the improvements in our standard of living; pharmaceuticals, fertilizers, pesticides, polymers and refrigerants are among the many products of chemistry. Nevertheless, chemistry has been closely associated in the public mind, with many of the widely perceived ills of modern life – environmental pollution by chemicals being amongst the most widely discussed public concerns. Chemistry, thus, has an unfortunately poor, public image despite its widely acknowledged utility. Even in academic circles physicists and biologists appear to be asking fundamentally important questions which apparently pose greater intellectual challenges than the more mundane questions of chemistry. Who would not like to be told of quests that seek to probe the origins of the universe or the

origins of life? Chemistry, however, seems to address matters of detail, at a level of complexity that generally appears unappealing.

Chemistry is, undoubtedly, a central science. It borders biology on a very broad front, ranging from molecular biology to behavioural biology. Chemical ecology is rapidly developing as an important field, dependent exclusively on the most sensitive and sophisticated tools of analytical chemistry. The tools for probing the structure of matter, developed by physicists, most notably X-ray diffraction, nuclear magnetic resonance, mass spectrometry and a whole range of spectroscopic and microscopic techniques, have invariably been refined on the more tractable problems of chemistry, before their more glamorous applications in biology or medicine. That chemistry occupied a central position in the 19th century is borne out by Alfred Nobel's will, which ignores biology but awards prizes for physics, chemistry and physiology or medicine. But the first sign of the widening scope of the definition of chemistry was visible, when in a remarkable feat of alchemy, the Royal Swedish Academy of Sciences, transformed Ernest Rutherford into the laureate for chemistry. In more recent times, biologists and physicists have routinely been awarded prizes in chemistry. The frequency with which molecular and structural biologists have been recognized is a clear sign that perceptions about what constitutes chemistry are rapidly changing. Chemistry baiters might enjoy the uncharitable comments of John Maddox, the former editor of *Nature*: 'Chemists have done wonders in losing their identity in the rest of science. . . . the practice of what still passes for chemistry seems to have been largely preempted by outsiders – physicists, quantum theoreticists, computer mavens, statisticians, instrument designers, laser experts, genetic engineers, medical researchers, psychiatrists, astronomers, materials specialists and a host of other species. Truly, the science of chemistry has lost its identity'. (Maddox, J., quoted in, Seebach, D., *Angew. Chem. Int. Ed. Engl.*, 1990, **29**, 1321). But, chemistry has its defenders. In his perceptive essay written a decade ago, Seebach noted: '. . . that discrete boundaries no longer exist between the various natural sciences (mathematics, physics, chemistry, biology, medicine) and especially between related subdisciplies (in this case inorganic, biological, organic and physical chemistry). This has been the case for a long time in the world of applications, and it is just as true along the frontlines of research. Chemistry has not lost its identity: it has instead gained important footholds within the domains of other disciplines – albeit rarely at the initiative of chemists'. There is a distinctive side to chemistry which Seebach emphasizes in a quote attributed to Marcellin Bertholet (1860): 'chemistry creates its own object. This creative power, similar to that of the arts distinguishes it fundamentally from the natural and historical sciences'. In recent times, the flame of chemistry flickered briefly and brightly in the public eye, when the wonderfully symmetric $C_{60}$ molecule, literally a 'celestial sphere', appeared to fall from the heavens.

In reflecting on chemistry, one cannot but note that in India also, the discipline faces a crisis of identity. Hemmed on its frontiers by biology and materials science, chemistry needs to become more broad based. Biology is a religion, that has always welcomed converts. Chemistry departments, on the contrary, have invariably been more puritanical in their outlook. But, in excluding chemistry as a 'theme' the NRC review is not alone. Close to home we have a major institution, the Jawaharlal Nehru University, Delhi which finds place for a spectrum of disciplines ranging from Political Science to Physical Sciences, but chemistry is well disguised, if not absent. In improving the image of chemistry and emphasizing its importance, the discipline needs a new generation of practitioners, who will redefine the borders of the science. The richness of chemistry clearly lies in its role as a central science. Traditional chemists must recognize that disciplinary boundaries are porous. Only then will public perceptions about chemistry improve. Maybe we will then rediscover the science.

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