CURRENT SCIENCE

Volume 83 Number 8 25 October 2002

EDITORIAL

Oxygen, Lavoisier and Revolution

Sune Kallstenius: You always complain about the time spent on Nobel Committee business.
Bengt Hjalmarsson: All I seem to be doing is reading other people's papers.
SK: How else can we come up with a list of candidates?
BH: What about my important work?
SK: Most Swedes would be proud to pay that price.
BH: I'm tired of paying it! No wonder Swedish chemists don't win the real Prize!
.....
SK: So resign.
BH (Grins): From the committee? I like the power... and the gossip.
SK: Now you have double power: Picking regular Nobel prize winners as well as retro-Nobelists. First the living... now the dead.
BH: The dead don't repay favours.

Oxygen
A play in 2 acts
C. Djerassi and R. Hoffmann

October is the season for the Nobel prizes. For a brief period of a week, the daily announcement from Stockholm focuses attention on science and scientists. The Nobel awards for physics, chemistry and medicine have a degree of credibility, unmatched by the prize for literature and the award for 'peace', announced from Oslo, which quite often is conferred on politicians of questionable merit. The economics prize, an after thought instituted by the Bank of Sweden, has not gained in prestige by continual awards to American economists, for work in an area which has been characterized as a 'dismal science'. The Nobel prizes in the sciences, however, have acquired an enormous distinction in the century that has passed, since the first awards were handed out in 1901. As Harriet Zuckerman notes: 'At the outset before the prizes had acquired their present standing, the Nobel Foundation honoured itself in the course of honouring scientists of great stature. In effect, the Nobel prizes received annual infusions of prestige borrowed from the esteem long accorded the eminent scientists who agreed to accept a prize. This process of prestige accumulation by the Nobels meant that later, when awards were occasionally made to scientists of considerably lower standing, they would acquire a worldwide eminence largely derived from their having been named Nobel laureates' (*Scientific Elite*, The Free Press, New York, 1997, pp. 35–36). Today the awards instantly elevate their recipients to an 'aristocracy in science'. Last year the Nobel Foundation marked the centenary of the prizes, whose stature has remained undimmed by the passage of time. The Swedish government, which evidently considers the Nobel awards as its most distinctive export, even used the celebration as an occasion to promote Swedish business overseas.

In thinking about the Nobel centenary, I chanced upon an extraordinary play, *Oxygen*, authored by two of the most distinguished chemists of our times, Carl Djerassi and Roald Hoffmann (Wiley-VCH, Weinheim, 2001). Djerassi, the moving spirit behind the steroid oral contraceptive, a prolific contributor to the chemistry of natural products, is the recipient of both the National Medal of Science and National Medal of Technology. Hoffmann, a leading theoretical chemist, was a Nobelist in 1981 for his work on the conservation of orbital symmetry in certain classes of chemical reactions. Djerassi and Hoffmann are also distinguished by their literary talents; the former authoring as many as six novels in addition to poetry, drama and serious works on science and policy, while the latter has written three books of poetry and has been at the forefront of efforts to enhance the public perception of chemistry. In their short and gripping play, *Oxygen*, Djerassi and Hoffmann suggest an interesting way of celebrating the Nobel centenary—have the Nobel Foundation award retro-Nobel prizes for the science of the 18th and 19th centuries. The prefix *retro* is an old favourite with chemists; retrosynthesis, for example, signifies the process of deconstructing a target molecular structure, as the first step in devising a strategy for its construction from simple building blocks; the process of synthesis. But, in pondering about retroactive awards, the task of choosing the first recipients appears impossibly complicated. Djerassi and Hoffmann imagine the predicament of a Nobel committee in 2001, worrying about the possible recipients of the first retro-Nobel in chemistry. In thinking about the origins of modern chemistry one name must spring to mind, Antoine Lavoisier (1743–1794), who led the revolution that established modern

chemistry as a quantitative science. Lavoisier's *Elementary Treatise on Chemistry* was published in February 1789. On 14 July 1789, the Parisian mobs stormed the Bastille, signalling the beginning of the French Revolution. A month later, almost in the early weeks of the revolution, Lavoisier was nearly 'lynched by an angry mob of Parisians, during the course of his duties for the government of the times. Lavoisier ignited the sparks of the chemical revolution in the midst of one of history's most dramatic political and social revolutions, in which he was centrally involved. On 8 May 1794, Lavoisier was guillotined at the Place de la Revolution during the infamous Reign of Terror that ruled Paris in the frenzied days of revolution (*Antoine Lavoisier, Science, Administration and Revolution*, A. Donovan, Cambridge University Press, 1993). Several decades later Adolph Wurtz extravagantly claimed: 'Chemistry is a French Science; its founder was Lavoisier of immortal fame'. (quoted by D. Knight in the preface to Donovan's biography).

Lavoisier brought to chemistry the approach of the experimental physicists of his time; a belief that a rigorous, quantitative, experimental analysis of chemical phenomena would eventually provide the basis for a unifying theory of chemistry. Lavoisier had an extraordinarily successful career in the years preceding the revolution, as a 'tax farmer' and financial administrator. He brought the philosophy of the careful accountant to the study of chemical reactions. Lavoisier, more than anyone else, established the importance of the conservation of mass in chemical transformations. Lavoisier's remarkable insight that combustion involved combination of materials with oxygen, provided the decisive evidence against the 'phlogiston theory', which held that when substances burned, a mysterious entity, 'phlogiston', escaped into the air. To Lavoisier, combustion involved the process of chemical combination with oxygen, a component of air.

Djerassi and Hoffmann, through the fictional retro-Nobel committee ask: 'Who should get the award for the discovery of oxygen'. The candidates are, of course, Lavoisier, Joseph Priestley an English clergyman and Carl Wilhelm Scheele the Swedish apothecary. The play flits back and forth between the Nobel Committee in 2001 and Stockholm in 1777, where the three contenders have assembled at the invitation of King Gustavus III to resolve directly a dispute on the priority for the discovery of oxygen. Even as the drama moves across the centuries, scientists will quickly appreciate the emotions that accompany scientific discovery and the often dominating desire to be first and of course, to be publicly recognized for the achievement. The fictional conversation in *Oxygen* between the Nobel committee members say it all:

Ulf Svanholm: Because science is done by scientists... not machines... and scientists crave recognition.
Astrid Rosenqvist: Science is done by humans... humans are competitive... scientists are even more competitive... and they want to be rewarded for being first.
Sune Kallstenius: Of course! But we still haven't agreed what 'being first' means: is it the initial discovery... the first publication... or full understanding?

Djerassi and Hoffmann have woven a fascinating drama around the discovery of oxygen. Scheele was the first man to make oxygen but did not publish his results, but did write to Lavoisier providing a recipe for its synthesis. Priestley made oxygen in 1774 but, like Scheele, he did not fully recognize the significance of his discovery for chemistry. Lavoisier, integrated oxygen into his view of combustion, discrediting decisively the phlogiston theory, which Priestley espoused for several years after it became clear that it had no basis in experimental fact. As the playwrights note in their foreword: 'Scheele and Priestley fit their discovery into an entirely wrong logical framework—the phlogiston theory—that Lavoisier is about to demolish. How does Lavoisier deal with the Priestley and Scheele discoveries? Does he give the discoverers their due credit? And what is discovery after all? Does it matter if you do not fully understand what you have found? Or if you do not let the world know?' The history of science is replete with examples of independent discoveries making apportioning of credit a difficult and often, contentious process. As the fictional Nobel committee discovers in *Oxygen* the selection of 'retro-laureates' may prove as difficult as deciding on contemporary awards.

But in the end we must return to Lavoisier. In his career as an administrator Lavoisier was a conservative. As a scientist he was a true revolutionary, prepared to vigorously challenge prevailing dogma. Ironically, Priestley, a whole-hearted supporter of the French revolution, while living in royalist England, was conservative in his view of chemistry. Donovan's biography highlights in a footnote a remarkable communication from Lavoisier to Priestley: 'In July 1791 Joseph Priestley organized a celebration in Birmingham to mark the anniversary of the fall of the Bastille. Later that day a Church and King crowd destroyed his home, library and laboratory'. Lavoisier's letter to Priestley evokes a wonderful image of the times: *'As a Citizen, you (Priestley) belong to England and it is for her to atone for your losses; as a Scholar and as a Philosopher you belong to the entire world; you belong above all to those who know how to appreciate you, and it is we, united in agreement, who vow to restore to you the instruments which you have employed so usefully in our instruction. We have therefore resolved to reestablish your Cabinet, to raise again the Temple which ignorance, barbarity and superstition have dared profane. What more important service can we render to science than to place in your hands the instruments necessary for its cultivation?'*.

A study of Lavoisier and his times may benefit all those who try to understand the imperatives that drive both scientific and social revolutions.

P. Balaram