space. Theories of how the Universe evolved in the first few moments after the Big Bang can be profoundly influenced by this concept of energetic nothingness.

In 1992, John Barrow wrote *Theories of Everything: The Quest for the Ultimate Explanation* (Clarendon). It is curious that a decade later the ultimate questions can be explored from the point of view of nothingness rather than everything. ■

John O'Connor is in the School of Mathematics and Statistics, University of St Andrews, St Andrews KY16 9SS, UK.

Dispelling the boredom

Stimulating Concepts in Chemistry
edited by Fritz Vögtle, J. Fraser Stoddart & Masakatsu Shibasaki
Wiley-VCH: 2001. 414 pp. $50, £29.95

The New Chemistry: A Showcase for Modern Chemistry and its Applications
edited by Nina Hall
Cambridge University Press: 2000. 493 pp. £30, $49.95

G. M. Whitesides

Each discipline in natural science has a popular reputation. Biology concerns itself with life and is intrinsically fascinating; physics does something very difficult and unfamiliar; astronomy looks at far-away objects and provides amazing pictures; chemistry makes paint and is boring. For those of us who know and love chemistry, this last view is a painful one. Our opinion is quite the opposite: that everything that one touches or sees or tastes is chemistry — that, in fact, all of perceptible reality involves conversations among atoms and molecules — and that an appreciation of chemistry is an essential and endlessly engaging component of an appreciation of the world.

Occasionally, groups of us gather our strength and try to explain why it is that molecules, and their behaviours and idiosyncrasies, are so fascinating. These two books are the fruits of such endeavours. Although both books are efforts to 'explain' chemistry, they have different scopes and styles. Both succeed — in the style of many multi-authored collections — by assembling a collage rather than painting a picture. In looking at a collage, of course, what you see depends on how far back you stand. And in a collage, although the edges can be rough and colours missing, there is often a sense of vigour. Both books convey that sense of vigour for chemistry.

Stimulating Concepts in Chemistry is exclusively focused on organic chemistry and its borders with neighbouring fields, especially biology, materials science and chemical engineering. Its chapters are in the style of reviews in technical journals, rather than essays intended to give a broader view. It is not concerned with the philosophy of its subjects — more with their nuts and bolts.

Organic chemistry is currently in a phase of change and expansion. For a number of decades, it has been focused on the art of organic synthesis. Its accomplishments in developing synthetic pathways to natural products — the often staggeringly complex molecules that are the odd offspring of metabolism — have been some of the great triumphs of the discipline. The utilitarian rationale for this area of research was that it developed methods that made possible the synthesis of drugs, as indeed it did. It was also intellectually very interesting — a grand game of strategy and logistics.

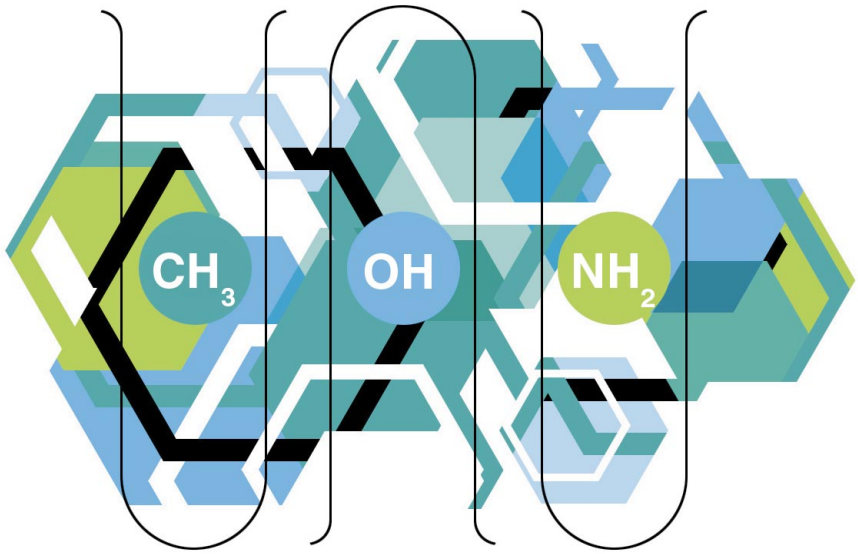
It is striking that very little of this classical genre is represented in these chapters. Their authors instead represent four different groups striking out across the marches. One develops synthetic methods — that is, refines important classes of reactions or processes — and traffics across the busy border between chemistry and chemical engineering. A second designs and fabricates organic molecules possessing new kinds of function: as wires for conducting electrons, molecular-scale machines, antennae for collecting light or molecular sponges that selectively adsorb other molecules. The authors of these chapters are collectively in the vanguard of those who believe that chemistry is a natural centre for nanoscience, as molecules are, in fact, exquisitely engineered and eminently manufacturable nanostructures.

A third group focuses on the synthesis of molecules relevant to biology. The molecules they describe mimic, inhibit or modify enzymes — all of these are activities that will be increasingly important as biology turns from cataloguing the genome to understanding the proteins whose structures it encodes. A fourth group simply makes new structures — exotic constructions containing only carbon atoms, multiply branched and rebranched molecules called dendrimers, and molecular crystals with designed structures. Chemists have always enjoyed making new molecules, and these chapters are baby pictures of new members of the molecular family.

The New Chemistry is a quite different book, and is intended, I think, for a more centrist audience. It is more classical in its coverage: it has a broader scope within chemistry and includes more history, but is less concerned with trade at the borders between chemistry and other disciplines. Its contributions span the full range of atomic and molecular behaviour: from the search for new elements to the production of energy, and from discussions of the nature of metals to discussions of chaos. It is surprisingly unconcerned with the intersection of chemistry and biology.

Is its title, *New Chemistry*, an accurate description? Well, yes and no. The fact that the essays cover a wide range of topics suggests, accurately, that the traditional subfields of chemistry are amalgamating. Some of the subjects — the chemistry of compounds held together by weak physical interactions rather than by covalent bonds, molecular electronics, materials, the production of energy, processes far from equilibrium, surfaces — are probably all, for different reasons, in for long runs. Others, such as the synthesis of complex organic structures, the study of the chemical bond and the chemistry of inorganic ions, are so fundamental that they will certainly always be part of the field, but may not be where most of the students go. The virtual absence of contributions from areas such as biochemistry and environmental chemistry reflects the fact that every collage is made with the materials available, and some colours and textures are always missing.

So neither book provides a broadly accessible, poetic view of chemistry. Both require



DAVID NEWTON

that the reader understands the periodic table and can interpret organic structural formulae. I will give my graduate students the reviews collected by Vögtle, Stoddart and Shibasaki. They provide an excellent, if idiosyncratic, view of new directions in organic chemistry — a field that has become actively evangelical, and is spreading the gospel of organic synthesis and synthetic nanostructures to all who will listen. Hall's book I will keep for myself. It covers a sufficiently broad scope that even those who have spent too many years thinking about atoms and molecules will find that its essays contain surprises. I will not trouble my wife with either: neither book is really suitable for explaining chemistry to those who are not chemists, although much of Hall's book should be easily understandable by other natural scientists.

Both books do a good job of describing chemistry to chemists in ways that catch the imagination. That is a good start in escaping the dread adjective 'boring'. ■

G. M. Whitesides is in the Department of Chemistry, Harvard University, 12 Oxford Street, Cambridge, Massachusetts 02138-2902, USA.

A constructive scheme unravelled?

The Collapse of the Kyoto Protocol and the Struggle to Slow Global Warming
by David Victor
Council on Foreign Relations/Princeton University Press: 2001. 169 pp. $19.95, £12.95

Michael Grubb

The Collapse of the Kyoto Protocol is a serious, detailed, but ultimately paradoxical book. Apart from the introductory chapter — which contains some misleading caricatures about the Kyoto Protocol, the international agreement that set targets for greenhouse-gas emissions — it is written with an authority and detail that few can muster. It is also an absolutely independent assessment, beholden to no one. Yet the core conclusion reveals a fundamental inconsistency in the analysis.

David Victor gives short shrift to many of the sacred cows of US opposition to the protocol. Whereas most US criticisms centre on the lack of quantified commitments for developing countries, Victor argues the opposite, that the commitments should have focused only on the rich countries of the OECD. It would then have avoided the institutional difficulties raised particularly by including Russia and Ukraine. Most US economists argue that Kyoto's targets are too close, but Victor says they should have been closer, to minimize the uncertainties. Kyoto's targets cover many different gases; whereas opponents want the effort to focus more on

gases other than carbon dioxide, Victor says the targets should have been restricted to carbon dioxide only, because it is hard to monitor the others properly.

The core of Victor's analysis is thus an institutional critique, particularly with respect to emissions trading — the option for countries to trade their emissions allowances. Trading, he rightly asserts, is an inevitable consequence of adopting emissions targets. Yet he believes that bringing money into emissions control will create incentives to cheat the system that will exacerbate the already difficult problems of monitoring and enforcement. He also claims that, although Kyoto's flexibilities would allow the United States to meet its commitment through investing in emission reduction projects or systems abroad, the foreign institutions concerned may not be able to guarantee that this will really reduce emissions elsewhere.

Victor's book is built on years of experience and commentary on the climate-change regime. He has always been a critic of the targets-and-trading approach, and sees the collapse of the recent talks in The Hague as vindicating his stance. But his final chapter marks an important evolution in his thinking. Previously, he argued for a soft-law approach based on national reporting and review — a climate equivalent of the OECD's economic review process. Here he acknowledges that something stronger is needed. The answer? A mix of targets-and-trading with a tax system that sets a limit on the market price of emission permits.

Putting a cap on permit prices and restricting the system to carbon dioxide in the OECD countries, he argues, would overcome the institutional difficulties he has identified. But one senses an air of desperation. By the end of the book Victor has argued himself into supporting many of the Kyoto Protocol's fundamental principles. The problems he identifies are not unmanageable, and the changes he seeks are relatively minor compared with the prospect of negotiating an entirely new system. But as a long-standing critic, he cannot bear to recognize that. He would rather tear down the house and start again according to his own specifications.

Despite all its important insights, its ultimate negativity — and political naiveté — makes this a depressing book. For example, the difficulty of monitoring methane emissions does not preclude keeping the Kyoto basket of gases for national targets, while domestic policies target carbon dioxide and other gases separately. Monitoring need not involve unacceptably intrusive international inspection; a reasonable degree of democracy and transparency could minimize the scope for abuse. Victor complains that no one compared the benefits of including methane against the costs of (imperfect) monitoring, but he makes no attempt to compare such costs with his own alternative of abandoning the protocol along with the whole idea of cost-effectiveness across the different gases.

Victor's analytical strength and peculiar negativity are nowhere more striking than in his treatment of liability. He knows that emissions trading can do much to solve the thorny problem of compliance, provided that the validity of acquired emission allowances is made dependent on the selling country complying with its commitments ('buyer liability'). The alternative of seller liability "invites disaster ... it will fail because it is a fiction in international law". With buyer liability, however, selling countries would not get a good price unless they could convince the countries interested in buying that they have both the systems and the intent to comply. Indeed, the case Victor presents for such buyer liability is unanswerable and unsurpassed in the whole of the literature. Yet he then meekly notes that the "international debate" (actually the US position) at The Hague conference supported seller liability. He could have castigated the previous US administration for its cowardice and lack of imagination on the issue, and argued passionately that the rescheduling of the suspended Hague talks offers the world a chance to get this cornerstone of international emissions trading on the right footing. Instead, he simply concludes that the protocol is hopeless, but that if the world starts again with his own scheme, it will get the liability rules right.

There are too many such inconsistencies between Victor's critique of trading in the protocol and his endorsement of trading