BOOK REVIEWS

Concerns About Risk

Public Reactions to Nuclear Waste. Citizens' Views of Repository Siting. RILEY E. DUNLAP, MICHAEL E. KRAFT, and EUGENE A. ROSA, Eds. Duke University Press, Durham, NC, 1993. xvi, 332 pp., illus. $49.95; paper, $24.95. Based on a symposium, San Francisco, CA, 1989.

For many scientists, engineers, and regulators, the public controversy over siting a repository for high-level nuclear wastes exemplifies the clash between rational scientific judgment and irrational public attitudes. Even many who are more sympathetic to public concerns about risk and management believe the controversy is exacerbated by incompatibilities between good science and public participation in regulatory decision-making. Understanding the incompatibilities, however, is crucial to managing science and technology in a democratic society and provides an important motivation to study the relationship between public opinion and nuclear waste policy. In this book, Dunlap and his colleagues present a solid base of empirical research on the subject, and the strength of the collection is the careful unraveling of social factors and context to explain the overwhelmingly negative public view of nuclear waste and its management.

What can we expect to learn from a deeper understanding of public views about nuclear waste policy? One expectation, possibly held by those who hope to move the process forward, is that we might uncover insights to help "repair" the current U.S. approach to nuclear waste management and eventually complete the siting of a long-term repository in Yucca Mountain, Nevada. Taken as a whole, the studies give little reason to expect that the existing conflict can be resolved consensually. Public sentiment across many sociological and political boundaries is strongly against a repository. Reasons for this view cannot be explained by simple models of self-interest, not-in-my-backyard (NIMBY) irrationality, deficiencies in technical expertise, or visceral reactions to the term "waste." Unacceptability of the repository is most significantly related to strong concerns about risk (health and environmental) and lack of trust in those who will manage the facility (most notably the Department of Energy). Options for waste management in this case seem limited to (i) stop the current plans and completely rethink the approach; (ii) determine whether there are socially acceptable bribes at local and national levels; or (iii) decide to override the democratic process.

The book presents many perspectives on the "publics" involved in the debate. The contributions report empirical analysis of local, rural, urban, site-specific, touristic, and national opinions on nuclear waste management. Not included in the book is an analysis of the technical and regulatory communities and their own beliefs about the efficacy of the current management approach. Empirical analysis of the non-technical concerns of scientists, engineers, and regulators, particularly a better understanding of their perceptions of the social and political dimensions, would be enlightening in the context of citizens' views and the nuclear waste debate.

An important but far more subtle lesson of the book has to do with the kinds of science and methods the national state brings to bear on a problem that generates significant public controversy. In this case, we have to question to what extent the U.S. management approach for nuclear waste unintentionally "engineered" the current environment of animosity by responding to an inherently political problem with an inappropriate technocratic decision process. Would a management strategy based on a deeper understanding of and respect for democratic processes have resulted in less social conflict? Dunlap and his colleagues cannot answer this question, but their historical analysis of nuclear waste reveals a management process for incorporating public input that was dismally unscientific and unbalanced in its treatment of technical and social data.

The concluding chapter summarizes the individual empirical studies and presents the cumulative wisdom. It then considers currently suggested technological, judicial/legislative, and knowledge fixes for the waste management program in the light of the cumulative wisdom. Advocates of the current plans for Yucca Mountain will not find this discussion particularly encouraging. Notably, some issues it raises demand much more study and analysis, especially if we hope to integrate insights from social science with the traditional technocratic approach. Two immediate examples come to mind: how the site-selection criteria might be modified to recognize social and political factors explicitly, and the extent to which public distrust in a managing organization should elicit major changes in program authority and responsibilities. More generally, the book underscores that these issues call for rigorous natural and social science consideration of how technology and its management can best meet the demands of our democratic society.

Robin Cantor
Division of Social, Behavioral, and Economic Research, National Science Foundation, Arlington, VA 22230, USA

Magnetics for Chemists

Molecular Magnetism. OLIVIER KAHN. VCH, New York, 1993. xvi, 380 pp., illus. $95.

The title of this book begs several questions. Is there such a thing as molecular magnetism, distinguishable from other kinds that have different adjectives attached (such as personal magnetism or animal magnetism)? Is "magnetism" to be construed as a property of a molecule, or is it inherently a property of an ensemble? The questions are important because the central theme, unstated at the outset but becoming ever more evident as the book proceeds, is to establish principles that will enable chemists (and the book is addressed principally to chemists) to assemble clusters or arrays of molecules whose collective properties are governed by interactions between the constituents and then to rationalize these properties through fundamental theories. The principal interaction mechanism considered is magnetic exchange, of course, and the microscopic mechanisms of superexchange and double exchange are exhaustively gone into. However, other, less well known sources of cooperativity also receive attention, such as the way in which the change of metal-ligand bond length accompanying a high-spin to low-spin transition on one molecule transmits its effect to its neighbors.

The starting point, though, is the individual molecule, almost exclusively in the form of the classical Werner-type of coordination complex in which a transition metal or lanthanide ion is embedded in a coating of organic ligands but in which the unpaired *d*- or *f*-electrons are only modestly delocalized away from the central metal. The magnetic behavior of crystals made up from such molecules, considered in the first

Vignette: Induction

Being a methodical as well as a suggestible person, and having spent the morning reading Francis Bacon, she decided to test the inductive method of reasoning by making lists of former friends and looking for a characteristic common to all of them by which she might arrive at a general law of friendship gone awry.

The names fell into two categories: those she had lost interest in, and those who had lost interest in her. She looked briefly at the column of names of people she had lost interest in, considered calling one or two, then lost interest. The other list, those who had lost interest in her, was baffling, and the only general law she could arrive at was that they were disloyal. This was of course a tautology and surely not what Francis Bacon had been driving at, but then he died of a cold caught while testing his theories of refrigeration by shoving snow into a chicken.

—From *Rameau's Niece*, a novel by *Cathleen Schine* (Plume)

instance as non-interacting, was the stamping ground for armies of theoretically inclined inorganic chemists in the 1960s and '70s, operating under the banner of ligand field theory. One may doubt quite seriously whether any useful purpose is served by going over all this old ground again, and much of the content of the early chapters of Kahn's book is easily accessed through the standard textbooks of Ballhausen and Figgis, not to mention the classic works of Condon and Shortley and Griffith. The contents of most of the extensive appendixes can also be found in these books. Novelty begins to emerge from chapter 4 onward, when interactions between metal ions in dimeric or more extended centers are treated. A wealth of formal cases is considered (binuclear, trinuclear—symmetrical and unsymmetrical—isotropic and anisotropic interactions) that will helpfully guide chemists toward rationalizing properties of the multifarious compounds turned up adventitiously even by what we sometimes call "directed" syntheses.

More penetrating in terms of rationalizing interaction mechanisms are the descriptions of the various approaches starting from molecular orbital or valence bond limits initiated by Anderson 30 years ago and systematized for the use of solid state chemists by Kanamori and Goodenough. Kahn shows convincingly, and in language familiar to chemists, how what he charmingly labels the "rustic" approaches to conjugated molecules like the Huckel model fail completely as a starting point for rationalizing magnetic interactions. He sets out the formalism of two apparently disparate but in the end equivalent models based on "natural" and "orthogonalized" magnetic orbitals and coins some useful phrases such as the "active electron approximation." And yet the nagging thought persists that we have been here before, which brings me back to my original question.

The distinguishing features of molecular magnetism as expounded by Kahn are, first, that the materials in question contain only localized magnetic electrons (that is, the book deals only with magnetic insulators) and, second, that for the most part they have quite low point and space group symmetries as a result of elaborate and often quite beautiful molecular architectures brought about by the tailor-made organic ligands. Physicists often use the word "zoo" in such cases to express their horror at having to search for first principles among such complexity, but in the present case the principles have been available for a long time. Indeed, in his preface Kahn pays tribute to Van Vleck and Anderson, to whose names the others mentioned above should certainly be added. Where then does that leave "molecular" magnetism? In my view there is a seamless web of increasing structural complexity from binary oxides to metal-organic clusters and multi-metallic enzyme active sites. The central themes of molecular magnetism are then (as I just stated) some beautiful and subtle chemistry, enabling coordination geometry and crystal packing to be tuned to a fine degree, and the fact that these compounds are unusual among magnetic materials in being transparent and colored. Two deficiencies of this book are that it says nothing about the way to actually make molecular magnets or about their electronic excited states. Twenty years ago we found a class of organic-soluble transparent magnets that changed color at the Curie temperature—what fun! Kahn's book is Cartesian and didactic: the fun (and there is plenty of it) is mostly left to the imagination.

Peter Day
Royal Institution,
London W1X 4BS, UK

Engineering Lessons

Design Paradigms. Case Histories of Error and Judgment in Engineering. HENRY PETROSKI. Cambridge University Press, New York, 1994. xii, 209 pp., illus. $42.95 or £30; paper, $17.94 or £12.95.

Powerful as today's ubiquitous computational models are for analysis, conceptual design still, as Henry Petroski puts it, "involves the human mind in fundamentally the same way it did for the first builders [relying] more on [mental] pictures than on words or numbers" (p. 11). We may not yet be able to point to a spate of recent writings concerned with the slighting of this cornerstone of design in American engineering education, but the publication of *Design Paradigms* following on Eugene Ferguson's *Engineering and the Mind's Eye* (1992) may well augur such a trend.

For Petroski, professor of civil engineering at Duke University, "The single most fruitful source of lessons in engineering judgment exists in the case histories of failures, which point incontrovertibly to examples of bad judgment and therefore provide guideposts for negotiating around the pitfalls in the design process itself." Sound engineering judgment, he argues, can also be learned from studying the "great engineers, who by their works have demonstrated that they possessed impeccable judgment, which has more often than not come from their critical study of failures or near-failures" (p. 122). In this vein, Petroski makes the case for investigating classic and historical case studies rather than recent design failures, the analysis of which is often complicated by ongoing litigation and distortions or, even more critically, by court-imposed secrecy.

The historical studies, then, are taken mainly from civil or structural engineering, ranging from the pitfalls of transporting large column components in ancient Greece to the failure, from aerodynamic flutter, of the Tacoma Narrows Bridge in 1940. The critiques tend to be rather compact, but they can be augmented by consulting publications listed in the ample bibliography. Succinctness may also account for Petroski's having omitted, in recounting Galileo's description of Renaissance shipbuilders taking extra precautions in launching larger ships because of scale effect (pp. 54–55), that Galileo also lauded these "artisans ... who, through observations [of failures or near-failures] handed down by their predecessors as well as those which they attentively and continually make for themselves, are truly expert and whose reasoning is of the finest" (*Dialogues Concern-*