Although this collection will interest most people working in the area of IT, the papers will be particularly useful for students, researchers and teachers of social and organisational aspects of technological change.

**REFERENCE**

1 Ann Game and Rosemary Pringle, *Gender at Work* , George Allen and Unwin, Sydney, 1983.

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**Prometheus Bound: Science in a Dynamic Steady State** *by John Ziman* (Cambridge University Press, Cambridge, 1994), pp ix + 289, A$49.95, ISBN 0-521-43430-0

Prometheus must sometimes have wondered what he got into. Not only, you recall, did he steal the immortal's fire and deliver it to humankind, for which crime he was condemned to be bound to a rock, his liver eternally being devoured by eagles. In this age he has been adopted as the symbol and representative of human activities in science and technology.

We have not only the title of this serial, linking Prometheus to "Issues in Technological Change, Innovation, Information Economics, Communication and Science Policy". But there are a range of monographs in which Prometheus' state is transformed, being Unbound, Rebound, and in this case, Bound. The author does not make it clear why he has chosen this title, beyond the clue that his first article, in 1978, on the subject of a 'limits to growth' perspective on science, was entitled Bounded Science.

To quote, approvingly, from the blurb, "John Ziman is one of the most influential writers on the practice of science". Together with Derek de Solla Price, who introduced the notion of analysing science at the macro- level in quantitative terms, and who was the first to predict a limit to the growth of science, and Thomas Merton, who opened up the arcane practices of science to sociological analysis, these three might well be considered the fathers of science studies. (Sorry, there were no mothers.)

Ziman, as a well-established physicist, took a considerable career risk in following his interests in what were referred to in the late 1960s as the social aspects of science. He continued this interest when the fashion of ideological critique declined with the cessation of Vietnam hostilities. He headed the Science Policy Support Group in London, which sought to link the emerging social science analytical capability with a better informed understanding of the processes of science. This was pursued primarily through Ziman's own writings, but also by commandeering a small component of the funds of the Economic and Social Research Council to tempt the social scientists to devote some of their energies to examining that crucial element of modern civilisation - science.

For devotees of Ziman's work, 'Prometheus Bound' will come as something of a disappointment. For, as the author states, this book is essentially an enlargement of the picture presented in 1987 as SPSG Concept Paper No.1 , **Science in a Steady State**, "clarified and made more vivid for a wider circle"(p.viii). True, there are many telling illustrations and examples. However, the essential argument is unchanged from the 1987 version, despite the numerous public examinations and critiques of his thesis, and the many changes which have occurred in the science system in the intervening seven years.

Mind you, there is abundant evidence that Ziman's message has yet to be heard in many scientific, research management, and policy circles. That alone suggests there is good reason for the author, and Cambridge University Press, to try to reach a larger audience. For it is a message of considerable importance to scientists, bewildered by the apparent state of siege in which they find their beloved vocation, and to those who seek to shape and steer the research process, and the research investment.

The essence of Ziman's thesis, is that science, like any other human activity, is subject to the inexorable limits to growth. After centuries of expansion, which provided the basis for what its practitioners assumed to be the 'natural' conditions for intellectual inquiry about the material world, science has come up against its resource limits. These conditions induce a range of responses which may appear random, chaotic, or even bloody-minded, but which can be understood as system reactions to limits: "In less than a generation we have witnessed a *radical, irreversible, world-wide transformation* in the way that science is organized and performed." (p.7)

The approach to these limits has been driven , in part, by the very successes of science itself. The economic promise of science has led both industrialised and industrialising nations to train, and provide employment for, ever more scientists. Twenty-five years ago, it was remarkable to reflect that half the scientists who have ever lived were then alive. The same statement applies today!

Other features which drive science to its limits are identified by Ziman as the continually increasing sophistication and cost of research techniques and instrumentation, the pressure of competition leading to the breakneck race to achieve a much-heralded scientific breakthrough, each more elusive and expensive than the preceding one, and the expanding demand for interdisciplinary research on problems of national interest.

From his physicist's toolbox, Ziman has selected the metaphor of 'steady state' to characterise the new regime of science. This steady state is one in which science is faced with increasing demands from its paymasters to be efficient, and deliver the goods, but within a roughly constant envelope of resources. Dynamic adjustments must occur within the envelope, rather than as has always been the practice in the past, of expanding the envelope.

What are the consequences of the emergence of this regime? Ziman traces the effects in four areas. The first of these addresses the allocation of resources, which is now dominated by higher levels of scrutiny and accountability, a concern with priority-setting, the emergence of formal processes of evaluation beyond the traditional peer review, and a much greater emphasis on the management of research resources.

The second aspect is the institutional responses to these changes. Indeed, Ziman argues that the research institution has largely displaced the individual scientists as the key component of science, and what is more, these institutions are subject to the disciplines of the market-place. This is leading to selectivity and concentration in the allocation of resources, an emphasis on financial efficiency, and Ziman laments, a general growth of bureaucratised procedures.

The third area of transformation is in the scientific career itself, as the notion of the scientific workforce has become firmly established, leading to a shift "from patronage to career management". (p. 185). Finally, the multinational tradition of science is displaced by the globalisation of R&D - each international, but in very different ways.

Perhaps the most significant shift between the 1987 concept paper and the 1994 book is in Ziman's attitudes to the planning and management processes now applied to steady state science. Where in the earlier version, the emergence of these new approaches was dispassionately catalogued, in 1994 Ziman is concerned with "steering through the buzzword blizzard". (p. 249).

"Many of these practices are so ill judged that they could do lasting damage to the health of science and its efficacy as a social institution." (p. 252) The litany of modern science policy - accountability, evaluation, selectivity, priorities, competition and management, are subject to critical attack as too often representing little more than the application of generalised bureaucratic principles without regard to the special creative character of the research process. For Ziman, this amounts to killing the goose that lay the golden eggs.

This last argument deserves serious consideration. It is possible to see at least some of the responses to the significant changes in the perceived value of scientific knowledge that Ziman has characterised by his steady state metaphor as representing an excessive and over-enthusiastic application of managerialism.

Indeed, it is quite remarkable. Currently, general management principles are moving away from 'command- control' models, and towards a more decentralised approach to decision-making, with cohesion maintained by a supportive organisational culture. But at the same time , an exemplar of this approach, the science system, with its quality control maintained by a subtle social dynamic, is being moved in the direction of bureaucracy. Whatever the resource limitations, and the economic potential, means must be found to pursue both efficiency and directedness without threatening individual and institutional creativity.

Ziman has catalogued the changes in the environment of modern science with a clarity and insight that will make this book immensely appealing to those scientists struggling to come to grips with the rationale, and the rhetoric, of science policy. Which is not to say that many of course have not been quite adept at this already.

One could not dispute the magnitude of the changes that have occurred to science in this one generation, or that resource limitations themselves are a factor in this change. However it seems the far greater shift in the conception of knowledge as the central component in generating economic activity, itself a resource which is not subject to conventional depletion, and the evolution of new approaches to its effective management, which is driving the new revolution in ideas. And that revolution has only just begun!

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**Energy Research and Technology in Australia** *by Australian Science and Technology Council* . ASTEC Occasional Paper No. 28, (Australian Government Publishing Service, Canberra, 1994) pp. 81, ISBN 0-644-29665-8,$7.95

This report by the Australian Science and Technology Council [ASTEC] is a serious and considered review of energy research and associated technology. Much of the discussion of energy-related issues in Australia focusses on the economic contribution from the mining and export of energy minerals. While that cannot be ignored, energy plays a much more important role in maintaining the basic fabric of industrial society. If sufficient energy is available, it is possible to rectify shortages in most other areas. Land can be farmed more intensively, poorer grades of ore can be worked for minerals, sea water can be distilled to produce potable water and housing can be allowed to spread further from the centres of urban areas, if energy is plentiful. Without adequate supplies of energy, however, our soci-