leagues, who focused instead on hazards to communities outside the laboratory.

Second, the effects of the growing competition for development of genetic engineering (which from the late 1970's onward was being experienced at every level from the executive offices of government and corporations to the research laboratory) and of the assault on regulation by the Thatcher and Reagan administrations are addressed only fleetingly and ambiguously in this account, as, for example, in references to the "important industrial, medical and agricultural benefits to be gained from the eventual application of genetic manipulation techniques." "Interests" are defined mainly in terms of the immediate commitments of members of GMAG to their reference groups rather than in terms of the larger pressures shaping both the goals of those groups and the behavior of GMAG as a whole.

As a result, a picture of the forces affecting British policy for genetic engineering at the macro level of global competition for the development of new technology remains to be developed. At the micro level, however, this book provides a detailed and valuable account of committee process and decision making and of the effects of a participatory committee structure on policy.

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Science and Entrepreneurialism

Biotechnology. The University-Industrial Complex. MARTIN KENNEY. Yale University Press, New Haven, CT, 1986. xviii, 306 pp., illus. $23.95.

University scientists have played a more pervasive role in biotechnology than they have in any other fledgling industry, according to Martin Kenney. The events and issues associated with this role are presented in a book in which a scholarly study vies for primacy with a populist tract.

The book is divided into two main sections. The first recounts the highly publicized exodus of prominent academic scientists to new biotechnology firms and the signing of long-term research contracts between firms and universities, such as the agreement between Massachusetts General Hospital and Hoechst. The section assesses the issues associated with these developments—the assignment of intellectual property rights; conflicts of interest that arise when faculty conduct research in university laboratories under financial support from firms in which they hold an equity interest; the potential disparity between the mutual benefits that accrue to universities and firms when the "traditional prerogatives and customs of the university . . . can be sold to the highest bidder" and the public interest. The second section, which contains substantially more information not already available to readers of *Science*, describes the genesis and evolution of biotechnology firms, their financial and organizational characteristics, and their "business plans," particularly with respect to the extent to which they will operate as vertically integrated suppliers of both R&D and final products or as contract researchers for established multiproduct firms.

A separate chapter discusses the challenge to the prominence of land-grant colleges of agriculture posed by the emergence of molecular biology as the scientific base from which new agricultural technologies may derive. Private universities and, to a lesser extent, colleges of life sciences within land-grant universities have been the leaders in molecular biology research. This role strengthens the case for a competitive grants program in preference to formula funding of state agricultural experiment stations, a recurrent issue within both Congress and the U.S. Department of Agriculture.

New university-industry relationships are presented as organizational experiments impelled by a relatively inelastic short-run supply schedule for the research expertise needed to realize the commercial possibilities envisioned for biotechnological techniques. A central role is assigned to venture capitalists who have financed the exodus of university researchers into new firms. This exodus is held not only to have precipitated many of the more publicized conflict-of-interest situations (the case of Calgene, for example) but also to have stimulated established chemical and pharmaceutical firms to acquire the services of specific academic researchers. From this perspective, acceptance of long-term research contracts with private firms and changes in internal policies concerning consulting and patents are necessary if universities are to retain faculty who have the option of joining private firms or relocating to "second-tier" institutions willing to enter into agreements less bound by traditional limits.

Kenney's opening thesis, that events in biotechnology represent "the shattering of the ideology of pure science under the impact of economics," may have an element of hyperbole, but it is a point of view that warrants attention, particularly at a time when national, state, and university officials and faculty are moving rapidly to the drumbeat that universities are engines of economic growth. It is possible to present a tightly argued brief for this position, as David Dickson did in *The New Politics of Science*, and indeed as Kenney does in an epilogue. But Kenney obviously is seeking more—a comprehensive study—and in this he fails.

The book is marred by serious scholarly problems. Kenney explicitly rules out any "conspiratorial" theory concerning university-industry relationships. His descriptions show the complexities of and differences among the behaviors and emerging strategies of universities and firms with respect to contractual relationships. The explicit conclusions of his analyses are usually quite open as to long-term outcomes. Yet the tone of his presentation and the manner in which he presents evidence are permeated with both pessimism and mistrust of the parties involved.

Kenney relies heavily on lists to make his arguments. Subversion of pure science is demonstrated, for example, by lists of faculty who hold equity interests in private firms, of individuals who have held professorships and corporate executive positions simultaneously, and of university consultants to specific biotechnology firms. Assertions about evolutionary processes in the life cycle of the biotechnology industry are supported by tables describing the amount of venture capital raised by selected firms and the potential capital gains that result from premiums above initial offer prices.

There are several problems with this approach. From these lists it is never possible to answer basic research questions—how many? how frequent? how important? There are few totals to any list and no denominators at all. Probably not since Charles Beard's *An Economic Interpretation of the Constitution of the United States* has a scholarly study advanced such casual associations among property holdings, values, and behaviors. Table 5.2, for example, identifies 13 individuals from eight universities who have held professorships and corporate executive positions simultaneously. These are not the same individuals involved in the more highly publicized conflict-of-interest situtations nor have they been identified, as is implicit in Kenney's blanket charge, with exploiting or otherwise pressuring graduate students. They represent an unknown fraction of the faculties in their respective institutions and disciplines. Similarly, the data Kenney has compiled on the characteristics of new biotechnology firms (for example, dates and prices of stock offerings) are useful beginnings but, as he notes, provide little basis for predicting the future structure of the biotechnology industry.

Kenney is inconsistent in the use he makes of comparison with other enterprises in expounding the uniqueness of linkages between academic research and the rise of the biotechnology industry. In places comparisons are made to highlight how emerging events in biotechnology differ from past experience—for example, the role of faculty in the early history of biotechnology firms is contrasted with their less important role in computer hardware, and biologists who have resigned their faculty appointments to go into business are contrasted with electrical engineers who have not. In other places, however, portentous implications are attributed to events in biotechnology that appear to be little different, for good or ill, from longer-standing or quite commonplace occurrences in academic life, business history, or university-industry relationships. For example, Kenney concludes that because molecular biology has an emphasis on hardware and machines it "was well prepared for commercialization," observing in a footnote that the cost of equipment for a molecular biology laboratory may total $1 million. Yet the amount he cites is less than is required in other departments, chemistry for example, which, however commercialized they may be, have not exhibited the same linkages. As represented by Kenney the ability of (some?) molecular biologists to secure financial gain through consulting arrangements does not appear strikingly different from that of professors of finance with expertise in new forms of stock-index futures tradings. That premiums may be gained by promoters and insiders when forming new "high-flying" firms is an outcome noted in accounts of many other industries.

These would be matters merely for methodological cautionary notes were it not that the book is pervaded by editorializing, unproven assertions of causal linkages, and other unsupported statements. Empirically testable propositions are presented as self-evident; cause-and-effect relationships are blurred; use of data is erroneous (figure 1.1 shows declines in real levels of NIH funding of DNA research after 1968, not the "atmosphere of growth" associated with current dollar levels); rumor is given equal status with findings; only one side of identified debates is presented; and citations do not always, as implied, provide support for statements in the text (for example, Conrad's paper, which is a call for encouraging graduate students to be allowed to publish their thesis work by themselves, is not empirical support for the statement, "It has been standard practice for professors to exploit graduate students"). Throughout the text Kenney's depiction of the "chaos and opportunity" that prevail as firms explore the possibilities of strengthened in-house capabilities, equity interests in start-up firms, and long-term research contracts with universities is contradicted by judgments such as, "The emphasis on proprietary molecules, etc. by American corporations indicates that they are interested in receiving monopoly returns and not in competing in the sphere of production" (p. 77).

Alternative treatments (speaking perhaps more softly but certainly more soundly) of the issues Kenney examines are available in Sandra Panem's *The Interferon Crusade* and in the article on university-industry relations in biotechnology published in *Science* (**231**, 242 [1986]) by David Blumenthal and his colleagues.

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Solar Wind Phenomena

Collisionless Shocks in the Heliosphere: A Tutorial Review. ROBERT G. STONE and BRUCE T. TSURUTANI, Eds. American Geophysical Union, Washington, DC, 1985. viii, 115 pp., illus. $18. Geophysical Monograph 34.

Collisionless Shocks in the Heliosphere: Reviews of Current Research. BRUCE T. TSURUTANI and ROBERT G. STONE, Eds. American Geophysical Union, Washington, DC, 1985. vi, 303 pp., illus. $36. Geophysical Monograph 35.

Most of the universe is filled with ionized gas so tenuous that for many purposes two-body collisions can be ignored. Despite this the electromagnetic couplings between the charged particles and the many collective plasma modes allow the plasma to behave in many ways like a normal collision-dominated fluid. One of the most dramatic manifestations of this is the formation of collisionless shocks in close, but not exact, analogy to normal gas shocks.

Collisionless shocks in the solar wind were the subject of the Chapman conference held in Napa, California, in February 1984. The papers in the two books reviewed here are based on talks presented at that conference. However, the books have been produced to a far higher standard than the usual conference proceedings; the text and equations have been properly set in an attractive typeface, the papers have all been refereed, and the books are well bound.

The first volume contains four tutorial reviews: a general retrospective account of collisionless shocks in the heliosphere by Kennel, Edmiston, and Hada; a description of the macroscopic gas-dynamic aspects of shock formation in the heliosphere by Hundhausen; a survey by Papadopoulos of the microscopic plasma processes responsible for dissipation in collisionless shocks; and an introduction by Forman and Webb to particle acceleration at shocks. These are intended to provide a graduate student or a scientist from another field with the necessary background to understand the 19 topical reviews in the second volume and should fulfill this function well. I particularly enjoyed the paper by Kennel *et al.*, which, despite its retrospective character, contains some new material and could in itself provide a complete introduction to the field.

The second volume gives a reasonably complete survey of the field as it was in about 1983 from a predominantly American perspective but with substantial contributions from the Federal Republic of Germany. The emphasis is very much on experimental observations and their confrontation with theory. Thus rather oddly, but quite consistently, there is no discussion of what must be the biggest (but as yet not directly detected) shock in the heliosphere, the solar wind termination shock. Planetary bow shocks and traveling interplanetary shocks are treated in great detail, however. Were the conference to be held now the only major change would probably be a much more extensive coverage of cometary shocks inspired by the success of the International Cometary Explorer mission to comet Giacobini-Zinner and the Planet-A, Vega 1, Vega 2, and Giotto missions to comet Halley. However, this is a rather specialized area and probably deserves a monograph to itself.

When one considers that the existence of collisionless shocks was first proposed by T. Gold in 1955, the progress made in the intervening 30 years is remarkable and a tribute to the value of space research in allowing us to investigate in situ plasma processes that it would be almost impossible to recreate in terrestrial laboratories. As well as providing an excellent test of our understanding of plasma physics, these processes are of direct relevance to solar physics and astrophysics. For example, although the idea is still rather controversial, it seems probable that at strong quasi-parallel shocks in the heliosphere we see in miniature the same basic Fermi acceleration process that in supernova remnants accelerates the galactic cosmic rays. For anyone wishing to enter this fascinating field or already working in it these two volumes can be strongly recommended.

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