The Militarization of Physics

Historical Studies in the Physical Sciences, vol. 8, part 1. Papers resulting from a symposium on cooperative research in government and industry organized by Robert Seidel. University of California Press, Berkeley, 1987. vi, 229 pp., illus. Paper, $9.50; to institutions, $11.50.

American physicists, when asked whether they have ever received support from the military or its nuclear weaponeer—the Atomic Energy Commission and successor agencies—will usually respond with a "yes." But when asked whether such funding has shaped their physics, they will typically respond with some kind of "no." For years, most historians of science took this conventional wisdom about the physicists' independence from their military patrons at face value. Recently, however, a growing number of historians have been taking a fresh look at the whole issue. A few have come to the position that, as Harvey Brooks succinctly put it at the 20th anniversary of the Office of Naval Research in 1966, "Even in a system of complete scientific freedom the cumulative effect of the small biases placed in the mind of the investigator by his sponsor can have a profound effect on the direction and impact of his research" (quoted on p. 214 of the present volume).

Drawn from meetings held in 1985 and 1986, this set of six papers provides an excellent introduction to recent historical work on the military-physics relationship in postwar America. Stuart Leslie analyzes how Stanford's electronic engineers and physicists used military funding to propel their university into academia's front ranks. David DeVorkin examines how a semiofficial panel promoted high-altitude research from rockets by serving as a liaison between the military and a medley of physicists. Allan Needell shows that two university-based physicists—John Simpson and James Van Allen—were nicely positioned for jumping into space research after Sputnik, thanks to prior military patronage of their work in cosmic-ray and upper-atmosphere physics. Robert Seidel describes how physicists, working at the behest of numerous military patrons, pursued the elusive goal of high-power lasers during the 1960s and 1970s. Lillian Hoddeson, in a study that at first sight does not exemplify this volume's theme (but see below), tells how physicists at Fermilab succeeded in doubling their accelerator's energy. And in a final paper that is a tour de force, Paul Forman not only assesses the military's role in the early development of quantum electronics but also develops a comprehensive framework for thinking about the relationship between military patronage and physical research in America since 1940.

After World War II, Forman reminds us, the armed forces and the AEC rapidly replaced foundations as the chief patrons of physical research in the United States. Abundant evidence indicates that the military's largess was not motivated by a disinterested enthusiasm for the advancement of physical knowledge. Many officers and bureaucrats, DeVorkin and Forman show, came away from the war convinced that the services should use research patronage as a means of maintaining contact with the physicists. They anticipated that such support would assure cooperation whenever it was needed. Although important, the desire for a cooperative clientele soon became, in Forman's view, a secondary motivation for patronage. With ONR in the lead, the military patrons began making a concerted effort to foster the development and refinement of techniques, including apparatus, having immediate or long-range relevance to service missions—atomic clocks, for example. It was this quest for techniques, Forman insists, that emerged as the military's primary motivation for supporting physical research.

If the Department of Defense and AEC wanted cooperation and techniques from the physicists, what did the physicists want from the military and its nuclear provisioner? First and foremost, as all the papers show, they wanted the wherewithal to pursue ever larger and more costly investigations. In addition some wanted, as Leslie's fine study of developments at Stanford demonstrates, resources with which to maintain or improve their institutions' standing within the academic pecking order. However, funds were not all the physicists wanted. As Forman forcefully argues and DeVorkin and Needell illustrate, they also wanted the feeling that they had scientific freedom—that they, not their military patrons, were setting research and institutional priorities. Accordingly, they had little patience for detailed relevance statements and heavy-handed security regulations.

Despite the physicists' desire for and sense of independence, DOD and AEC/ERDA/DOE patronage has, Forman maintains, deeply influenced physics in postwar America. It transformed the quality of life of

academic physicists, provoking laments from seasoned hands, such as Merle Tuve, who observed in 1959 that "a professor's life nowadays is a rat race of busyness and activity, managing contracts and projects, guiding teams of assistants, and bossing crews of technicians, plus the distractions of numerous trips and committees for government agencies, necessary to keep the whole frenetic business from collapse" (p. 196f.). Military patronage also affected the direction of research. The intensity with which many fields—for example, solid-state physics and quantum electronics—have been cultivated has depended much more on their perceived relevance to service missions than on their prospects of contributing to fundamental understanding.

Besides influencing the physicists' lifestyle and interests, military patronage has profoundly shaped the character of the knowledge they have sought and produced. This is likely to be the most controversial part of Forman's paper. Yet the case that he builds is strong. He has no trouble adducing evidence that, just as the military funding agencies wanted, physicists have substituted a preoccupation with novel and refined technique for their former concern with new understanding. This instrumentalism, he believes, has permeated the entire discipline. It is manifest not only in such mundane areas as nuclear, atomic, molecular, and solid-state physics but also in elementary particle physics. Here Forman invokes recent studies by Sylvan Schweber and Andy Pickering to argue that the triumph of phenomenological theories "reflected both a general militarization of the social purposes of physics in the U.S., and a particular mental posture fostered by the application of brain-grease to military matters" (p. 223). He might also have invoked Hoddeson's study of Fermilab's development of the energy doubler. Forman concludes that American physicists have been self-indulgent to think that they have been using the military. Quite the contrary, it is the military that has used them.

Does the perspective developed by Forman apply to the whole of postwar science? It would surely need major modification for those disciplines such as the biological sciences where military patronage is small. It might need modification as well for mathematics and astronomy, two disciplines that have received substantial funding from the military. Still, Forman's trenchant analysis sets a direction for historians of recent American science. No doubt studies examining the validity and applicability of his argument will soon be forthcoming.

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Limits on Adaptation

Genetic Constraints on Adaptive Evolution. VOLKER LOESCHCKE, Ed. Springer-Verlag, New York, 1987. x, 188 pp., illus. $49.50. Based on a symposium, Syracuse, NY, Aug. 1986.

With the decline of the pan-adaptationist view in evolutionary biology, the search has begun for the demons that prevent populations from reaching evolutionary nirvana. If adaptation had its way, every individual would mature instantly, reproduce at an infinite rate, and live forever. No organism meets these criteria, and this motivates the search for the constraints that frustrate adaptation. A logical place to look for those constraints is at the genetic level because selection cannot produce evolutionary change if appropriate forms of genetic variation are lacking. This reasoning is leading a growing number of workers from fields as diverse as genetics, development, morphology, and ecology to examine how patterns of genetic variation limit adaptive evolution. Nine papers on this topic from a symposium of the International Congress of Ecology in 1986 are brought together in this volume. Though interesting insights emerge from some chapters, the book falls short of presenting a synthetic overview of its subject.

Life history characters provide particularly compelling examples of constraints because finite reproductive output and senescence are so clearly maladaptive. Rose, Service, and Hutchinson review the evidence regarding the sources of genetic constraints on life histories in the book's most interesting (and amusing) chapter. Their own work on *Drosophila* shows how constraints can be analyzed with the classical methods of quantitative genetics. The topic of life history evolution is picked up in other papers by Barker and Thomas, by Clark, and by Christiansen. Several of these papers focus on the possibility that the joint action of pleiotropic mutation and selection might determine the genetic correlations that define the constraints. Unfortunately, the theory to which the authors appeal is based on the assumption of weak stabilizing selection and is inappropriate for traits such as life history characters that are under strong directional selection. Little is known either empirically or theoretically about the structure of genetic correlations under these conditions, a lacuna that is one of the outstanding problems in our understanding of the sources of evolutionary constraints.

A theme that recurs in several chapters is the importance of phenotypic plasticity (or reaction norms), the developmental and physiological responses of genotypes to environmental variation. Via's chapter, which discusses implications of phenotypic plasticity using quantitative genetic models, is perhaps the best introduction to this topic available anywhere. Van Noordwijk and Gebhardt discuss the evolutionary consequences of continuous forms of environmental variation, and Scharloo reviews the genetics of developmental buffering against environmental and genetic variation. Schaal and Leverich discuss phenotypic plasticity and other phenomena important in plant populations. A molecular perspective is introduced by Golding, who shows that certain DNA sequences bias the frequency of different classes of mutations.

Despite its high points, the book is disappointing as a whole. Several important approaches to the problem are missing entirely from it. The comparative method, for example, is the only way to study changes in patterns of genetic variation over substantial periods of evolutionary time. Measurements of selection in natural populations can identify characters that are under directional selection but that are prevented from evolving by genetic constraints. Developmental biology is critical in revealing the mechanisms by which genetic constraints are expressed and has been prominent in emphasizing their importance in evolution. These and other approaches receive no attention, whereas quantitative genetics is represented by six of the nine chapters. The book thus presents a somewhat narrow view of an important subject.

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Early Precambrian Terrains

Evolution of the Lewisian and Comparable Precambrian High Grade Terrains. R. G. PARK and J. TARNEY, Eds. Published for the Geological Society by Blackwell Scientific, Palo Alto, CA, 1987. viii, 315 pp., illus. $80. Geological Society Special Publication no. 27. From a conference, Leicester, U.K., March 1985.

This book, the proceedings of the third Lewisian conference, replaces the proceedings of the second, 1971, conference. The editors, J. Sutton, and the late J. V. Watson contribute, together with a host of researchers who had probably never heard of the Lewisian in 1971. Besides the 18 papers on the Lewisian, there are 3 on Greenland and 1 each on Western Australia (Yilgarn), Enderby Land, and northeastern China.

The volume is dedicated to Watson and opens with an appreciation of her work,