because of the structure of the educational institutions and industries of Britain, France, and Germany. Although Guédon may be faulted for seeking to prove a modal negative, his provocative essay does much to clarify why chemical engineering followed different paths of development in America and Europe. In Europe, and especially in Germany, industry adapted itself to the products turned out by universities and technical schools; in America, the universities were sufficiently flexible to adapt their curricula to the demands of business. "It was," Guédon concludes, "easier to move industries in Germany and universities in the United States."

Guédon's intriguing essay is alone enough to make this volume worthwhile, and, though the other contributions do not all attain this standard, several are especially deserving of notice. H. C. Weber relates several colorful and revealing anecdotes about the founders of the influential program in chemical engineering at MIT, and H. C. Lewis's piece on Warren K. Lewis succeeds both in bringing the man to life and in explaining the devotion of his former students. Karl Schoenemann's essay on the development of chemical engineering in Germany explores in some detail the differences between the chemical engineer's role in German and American industry, and Vance E. Senecal has written a valuable summary of the history of chemical engineering at DuPont. Perhaps the real sleeper in the collection, however, is Gianni Astarita's sparkling sketch of the development of chemical engineering in Italy. Astarita weaves a biting critique of Italian government and institutions into his account, and his essay reminds us that it is important to study cases of retarded development as well as success stories if we are to understand the conditions that breed intellectual and industrial accomplishment.

History of Chemical Engineering is on the whole a rewarding book. Although several of the contributions are very amateurish and a few read like government reports, many others are of considerable value both to historians interested in the history of the applied sciences and, I would imagine, to chemical engineers concerned to learn more of their heritage.

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Science and Government in Britain

Scientists in Whitehall. PHILIP GUMMETT. Manchester University Press, Manchester, England, 1980 (U.S. distributor, Humanities Press, Atlantic Highlands, N.J.), x, 246 pp. $38.

The present high level of interaction and mutual dependence between the scientific and political communities has been achieved through a variety of institutional devices, including the recruitment of scientists into the bureaucracy, the proliferation of science advisory committees, and the organization of bureaus and laboratories to administer or perform public R & D programs. As those who follow the fortunes of science and public policy in the United States are aware, the evolving relationship has not always been a smooth one, with multiple misunderstandings, recriminations, and often the need for painful accommodations on both sides.

That these developments and the attendant difficulties are by no means confined to the American experience is well illustrated by Philip Gummett, who in *Scientists in Whitehall* offers a guided tour of the inner recesses of British public administration most closely associated with the scientific community. In the process, he gives us the most comprehensive and informative account now available of the organized relationship between British science and government.

Two features of the book are particularly noteworthy. First, the author is careful to place contemporary developments in historical perspective. By reaching on occasion as far back as the 19th century, Gummett demonstrates that, though attempted solutions may change, the problems of reconciling the forces and prerogatives of science with those of politics and administration remain remarkably constant. American readers may derive some consolation in discovering that a generally earlier and greater public awareness of the need to balance scientific autonomy with public control, to support research stimulating industrial innovation, and to coordinate departmental programs has apparently not enabled the British to devise more durable and satisfactory arrangements for achieving these often conflicting objectives.

Second, the author makes a welcome attempt to identify the ways in which more general features of British public administration have shaped the relationship of science and government. We learn in particular how the existence of a professionalized civil service dominated by "generalists" has, despite successive reforms, limited the recruitment and stature of scientists and engineers in public service. Similarly, the principle of ministerial responsibility has acted as a constant and insurmountable barrier to the formulation of an overarching, coherent science policy.

The book's most persistent shortcoming is the failure to go beyond the institutional forms of scientists' public involvement to discuss the character and impact of their activities. Permutations in the organization and composition of advisory committees and in the division of responsibilities of the departments are presented in detail; given the importance that such matters have had in British discussions of science policy, the emphasis is not entirely unwarranted. But in the absence of an analysis of the effects of these transformations on specific policy choices or on the performance and direction of British science and technology, one is left wondering what is at stake in the debate.

The chapter on the scientific civil service, for example, gives no indication of the diversity of tasks that scientists can perform as public employees. The chemist doing sample analysis, the nuclear engineer inspecting power plants, the biologist administering a research grant program, and the physician advising on worker health policy merge their scientific, administrative, and policy-making roles in quite different ways. To treat them as an undifferentiated class of somewhat oppressed public functionaries does not greatly enhance our knowledge of the value and limitations of scientific training in public employment.

More surprising is the lack of substantive detail concerning the responsibilities, special concerns, and influence of top-level science advisers. The most prominent and presumably most influential emissaries of the scientific community in Whitehall, figures such as Lord Zuckerman and Lord Flowers, are given brief career sketches, but we do not learn to what extent or in what instances these individuals play decisive roles in shaping public policy.

When the author does discuss specific policy decisions or marshals evidence to evaluate the impact of concrete measures, interest gains considerably. Thus, the efforts to diversify the program of the atomic energy laboratory at Harwell and to promote industrial research in other

government laboratories are well described, and the account can be profitably read by those concerned with similar programs in the United States. The limited success of the Rothschild reforms in redirecting the work of the research councils is clarified. And the few paragraphs on the decision to participate in the European 300-GeV particle accelerator do more to reveal the limits of scientific self-government than several pages on the machinery of the Advisory Board for the Research Councils.

The focus on institutional arrangements limits somewhat the book's contribution to the field of science and public policy studies. Much of the material will be familiar to those already acquainted with the general features of British science policy organization. The author's narrow purview also excludes a more far-reaching inquiry into the special status of science and technology in both the processes and policies of modern British government, an inquiry that would have linked organizational features both to the achievements and failings of British science and technology and to underlying transformations in British society, government, and the economy. Though Gummett chronicles and comments upon the involvement of scientists in the administrative apparatus with considerable competence and good judgment, one regrets that he did not more often step back from his subject to gain a position of broader perspective and deeper insight.

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A Prospectus of Knowledge

Knowledge. Its Creation, Distribution, and Economic Significance. Vol. 1, Knowledge and Knowledge Production. FRITZ MACHLUP. Princeton University Press, Princeton, N.J., 1981. xxx, 274 pp. $17.50.

This first volume in a projected eight-volume study of *Knowledge: Its Creation, Distribution, and Economic Significance* might best be approached as if it were part of a great formal garden—Machlup's Garden of Knowledge—and not a mere publication. In that frame of mind, the reader will be prepared for a leisurely stroll, with side excursions to study cultivated areas ranging from "a priori knowledge" to "zoology." There will be stops along the way at "peace" and "playing" and a thorough visit to the area one might expect to find in an economist's garden, one planted with considerations of "value" and "marginal utility" and "price."

The guide for this trip, Fritz Machlup of Princeton University, will probably be as interesting to many readers as the garden. They will perhaps be surprised to learn that he is a professor emeritus with the energy and confidence to start such a lengthy project—no blue hills of retirement for this man. They will find it interesting that he ignores the "rules" of his own professional culture, with its high degree of specialization; in my own university we have separate departments for history, for the history of science, and for the history of medicine, but Machlup turns his back on these petty professional distinctions and declares his domain to be simply "knowledge." The reader should put aside any fears this might arouse and spend the day seeing what this learned guide and his garden have to offer.

Machlup makes the tour enjoyable with his careful analyses of knowledge, with his asides, and with his evaluations of others and of himself. When he stops a bit too long in that part of the garden reserved for reviews of his previous work—and you should be familiar with the fact that this project builds on Machlup's one-volume study *The Production and Distribution of Knowledge in the United States* (1962)—you may get impatient. But you will probably find engaging his recognition that some distinctions he has just made were "not very entertaining" or his acknowledgment that all he has been able to do is make something "less obscure." As these asides and other evaluations make clear, the author feels no acute pressure of either time or space. With seven volumes to go, he can afford to explore dead ends, probe alternative modes of explanation and categorization, play with an idea just because it is interesting.

That is why it is best for the reader not to be in a great hurry to get on with it. Machlup has not built an interstate highway designed to get you from A to B to C with dispatch. In his type of garden you can turn aside to look at the two-cultures controversy made famous by C. P. Snow. You will learn that in Machlup's judgment his own specialty, economics, "is equally far removed from the ready grasp of most molecular biologists as it is from the ready grasp of most Romance philologists" (pp. 80–81). After having narrowed Snow's argument substantially (and bolstered the ego of the Romance philologist), Machlup strolls on to look at the humanities and social sciences. Why do this or that particular subject? The author explains: Because it fascinates him. Whether your particular fascination is with business machines, with pornographic materials—yes, he stops in that part of the garden too—or with the proper definition of scientific knowledge, Machlup will provide you with interesting insights and a good sense of how each particular type of knowledge relates to the whole.

When you finish, say, the section on "scientific knowledge," you will know more. You will know, for instance, something about the different ways different societies over the centuries have defined science. I, for one, did not know that Descartes thought that " 'any knowledge that can be questioned ought not to be called science' " (p. 63). Nor did I recall that Kant had had something very important to do with creating our modern concept of what science is. Of particular interest to me was the manner in which English-speaking peoples during the 19th century came to restrict the use of the word "science" to the study of natural phenomena. As Machlup points out, however, in other societies science kept its broader, less restrictive meaning and referred to "systems of knowledge acquired by sustained study" (p. 67). Thus if I were a German or Japanese or Russian historian, instead of an American one, I would be recognized as a scientist and could, I guess, ignore the two-cultures controversy entirely.

This bit of semantic lore may not interest you, and I doubt that it will be of great practical value to me. You just may not care to know what science or history or humanism means and how the meanings have changed over the years. For those who love interstate highways of the mind, I recommend a shortcut through the garden. You will want to race past a good bit of the first two parts of the book, Types of Knowledge and Qualities of Knowledge. For you it will be part 3, Knowledge as a Product, that will be of greatest interest. It is this part