as "an interest group or, more accurately, as a loose confederation of constituencies, operating within the context of a federal (and plural) system. The problems of science that they seek to illustrate are problems of politics" (p. vi).

The volume contains some very important and challenging documents. Much of the administrative and policy history of the World War II agencies for research and development is sensitively and economically told through the use of well-chosen and well-abridged documents and a thoughtful editorial road map for those who have forgotten or never knew OSRD, NDRC, NRC, and the wartime activities of Vannevar Bush, Karl Compton, and Leonard Carmichael. From the pages of the volume the thread of administrative history emerges from the early developments to the Atomic Energy Commission, the National Science Foundation, the Office of Science and Technology, the National Institutes of Health, and the National Aeronautics and Space Administration. Not all the history, to be sure, is here. The great effects of the Eberstadt report and of the many major developments in the national security field on the governmental environment and decisions for postwar research and development are largely missing. The role of Congress is treated rather more heavily in the early part of the history than seems warranted, particularly in contrast to the comparatively limited treatment it is given in the later part. In one place, the history of the NSF, the thread of the story is lost somewhat.

Some documents are simply excellent in typifying an attitude, a problem, or a spirit, and provide both variety and substance to a work which also includes a Truman veto message and Bernard Baruch's historic speech to the U.N. on nuclear disarmament. Excellent examples of such varied selections are a delightful excerpt from testimony by Maury Maverick in which he criticizes scientists for being smug (pp. 79–80), excerpts which show the misconceptions that the natural scientist has about social science research, and a fairly full excerpt from an excellent Harvard University document on the new relationships between universities and government and their implications for public policy and academic policy.

The Rand McNally volume is the most important of the three books reviewed here: first, because it does something well that hasn't been done often enough and, second, because the readings make a real contribution to teaching, public discussion, and the advance of research and education on a vital subject still largely neglected by the appropriate scholarly disciplines. For just as basic physical and theoretical research and the training of teachers and scientists had to precede or accompany the scientific development which produced the political, moral, social, economic, and administrative questions raised in these books, so must higher education develop orderly analysis and train the teachers, scholars, and policy-makers to meet these issues. Surely by now the key problems of science and public policy have been raised with sufficient force and clarity. Solutions wait upon a greatly increased commitment of the intellectual community to basic research and educational programs across the full range of problems encompassed by science and public policy.

The Making of an Elite

The word "technocracy" is associated in American minds with an abortive political movement founded by Howard Scott in 1933 and with its antecedent philosophy in Veblen's *The Engineers and the Price System.* In **The Rise of the Technocrats: A Social History** (Routledge and Kegan Paul, London; University of Toronto Press, Toronto, 1965. 456 pp. $9), W. H. G. Armytage, who is head of the Department of Education at the University of Sheffield in England, briefly refers to these matters, but his aim is vastly broader. The technocrats are those who compose the scientific and technological community, both as it exists in and for itself and as it forms the basis of contemporary industry and government. The implicit theme of the book is the transformation of Europe, North America, and now much of Asia from an agricultural to an industrial economy resting on a scientific technology. The explicit subject matter is the associated rise of scientists, engineers, and a technically trained managerial class to the position of a national decision-making elite. In short, Armytage has written what we might call the institutional history of science and technology. The end product of this revolution is the highly collectivized super-industrial state in which power, as C. Wright Mills effectively showed, is controlled by an interlocking system of the industrial management, the political directorate, and the military establishment. The picture is equally accurate for the United States, the Soviet Union, Japan, and the People's Republic of China.

How did this state of society come into being, one that was astonishingly well predicted in Bacon's *New Atlantis*? By means of a minutely detailed, heavily empirical, and thoroughly documented chronicle, Armytage describes the process as a succession of particular events which compose this institutional development. The sheer volume of his material is attested by an index of about 2700 entries for a text of only 358 pages. He begins his account, for reasons that are not at all clear to me, with the establishment of botanical gardens in the 16th century, then moves with an ever-increasing quantity of data into the mainstream of his history. The 17th century saw the establishment of scientific academies and their associated journals. The first of these proved abortive, permanence coming with the Royal Society in England and the Académie des Sciences in France. The technical school is a French creation of the 18th century, originating with the École des Ponts et Chaussées (1749), although the archetype of the contemporary institution is the enormously influential École Polytechnique (1794). The graduate school of science and the technical institute, primarily German inventions, came with the 19th century, along with an unimaginable proliferation of societies, associations, laboratories, schools, departments, agencies, and finally whole ministries of science and technology. By the beginning of the 20th century the transformation was pretty well complete in England, France, Germany, Japan, and at least the eastern United States. By the time of World War II the process had reached a similar stage in the Soviet Union, as it is now nearing it in China.

If the reader has the patience to keep his attention fixed on Armytage's outpouring of facts, he is bound to be fascinated by the ever-accelerating expansion and the seemingly uncontrollable momentum of this development. At the same time, he may very well be confused by the author's oversimplified approach to this complex subject. The sudden and arbitrary beginning,

without any introduction, can only serve to puzzle the reader. Why the botanical garden? Perhaps it has a place, but can it be said to have played so important a role? Is it really a social institution in Armytage's sense, or is it, as I believe, a large-scale cooperative experiment? My own view is that this history ought to begin with the late medieval guild and the *quadrivium* of the medieval university. But there are more searching questions. A history that is so narrowly restricted to the empirical data does not really tell the story that we need to know. Without descriptive and interpretive generalizations, without an assessment or evaluation of the main events, we are never brought to the place where we can comprehend the role of the scientific institution, and hence the scientific enterprise itself, in the social and economic systems in which they play this role. The crucial event in the social history of science, for example, is the professionalization of science in the 19th century. What social factors were necessary for this to occur? The beginning, I think, is the succession of radical changes in the manufacturing process following the Industrial Revolution of the 18th century. Through complex developments in the physical sciences a new symbiotic interdependency grew up between science and technology, with the ultimate consequence that science reached a decisive economic importance. The point is that the historian cannot write meaningful social history without inquiring into that intricate pattern of relations existing among science, technology, industry, and economic and social organizations. Armytage has an overabundance of one kind of fact, but he does not present the larger issues, and he does not have a conceptual scheme by which all these elements can be united into a revealing totality.

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Fluorescent-Tracer Studies

Beaches represent one of the most complex natural environments on earth. Movement of beach sediment in response to waves and currents as analyzed by use of tracer particles is the subject of **The Movement of Beach Sand** (Elsevier, New York, 1966. 231 pp., illus. $14.50) by James C. Ingle, Jr. A great resurgence of interest in tracing the path of sediment movement both in rivers and on beaches has developed with the advent of methods for radioactive or fluorescent tagging of natural sediment. Because the field has grown so rapidly within the past ten years much of the basic literature is still in the inconvenient form of mimeographed internal laboratory reports, limited-circulation Department of Defense project reports, and unpublished graduate theses. Ingle has performed a valuable service by identifying these references in an exhaustive 8½-page bibliography.

The book is constructed primarily around the description and analysis of a series of fluorescent-tracer-particle experiments conducted by Ingle in shallow water at five beaches along the southern California coast. An introduction that gives appropriate terminology and history is followed by chapters on field and laboratory procedures, general patterns of foreshore-inshore tracer transport, sand movement seaward of the breaker zone, sand movement around man-made structures, analysis of tracer dispersion, and a summary chapter. Those interested in performing fluorescent-tracer experiments are directed to the first appendix, which lists components of the coating formulations currently being used by coastal investigators other than Ingle.

Even though Ingle has attempted to relate his conclusions to work of previous investigators, many aspects of basic data-collection procedures and methods of interpretation are presented somewhat esoterically, thereby causing potential hardship for many readers having only a general background in sedimentology. A broadened base of readership might have been achieved by deemphasizing the California tests and by adding an incisive examination of the applicable literature relating to statistics of beach-sediment sampling designs, sampling devices, and concepts of hydrodynamic interpretation. However, as presently constituted, the book holds many rewards for those concerned with understanding the dynamics of coastal erosion and accretion.

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Physical Chemistry for Students

Should a course in advanced physical chemistry be offered in a modern curriculum, and if so, what should the content be? Jeff C. Davis, Jr., the author of **Advanced Physical Chemistry: Molecules, Structure, and Spectra** (Ronald, New York, 1965. 642 pp., illus. $12), clearly believes in the need for such a course. His first few chapters, which cover elementary quantum mechanical principles, are followed by one on statistical mechanics. Chapters on the hydrogen atom, complex atoms, and simple molecules follow. The latter half of the book is devoted almost entirely to molecular spectroscopy, including microwave, infrared, electronic, and magnetic-resonance applications. Numerous problems are given at the end of each chapter, many of which appear to be of top quality.

The text is well written and clear, although I wished at times that it were more concise. The early chapters on quantum mechanical principles and applications are on the level of Pauling and Wilson's *Introduction to Quantum Chemistry* or Eyring, Water, and Kimball's *Quantum Chemistry*, and the treatment of many topics parallels the treatment given in these two texts. The one chapter on statistical mechanics is, in my opinion, not adequate for a course in advanced physical chemistry since only the microcanonical ensemble is considered. The latter half of the book offers an excellent introduction to the various branches of molecular spectroscopy.

A course based on this text could easily be incorporated into existing chemistry-department programs. Within this framework it is a decent text if one offers supplementary material in kinetic theory and statistical mechanics. Although there is no doubt that a graduating senior in chemistry ought to be familiar with the material presented, there is some question in my mind whether piling additional survey courses on top of the existing structure is worthwhile. It might be more to the point if the present undergraduate programs in chemistry departments, which have been for the most part frozen for about 20 years, were completely revamped with more emphasis on the general principles and more efficient use of students' time.

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