Book Reviews

Studies of Science

Science, Technology and Society. A Cross-Disciplinary Perspective. INA SPIEGEL-RÖSING and DEREK DE SOLLA PRICE, Eds. Sage, Beverly Hills, Calif., 1977. xii, 608 pp. $29.95.

The study of the relations of science, technology, and society (SSTS in the shorthand used by one of the editors of the present volume) was generated by the massive growth of science and technology that began with the Second World War. Scholars in both capitalist and socialist countries have contributed to this new academic enterprise, which, at first haltingly but with increasing confidence and commitment, has been emerging from a diverse range of scholarly disciplines since the 1960's.

Not surprisingly, much of the scholarship has been fragmented, growing within and drawing upon the differing traditions of history, philosophy, sociology, political science, economics, and psychology. The development of two fronts—science policy studies, promising solutions to political and organizational problems of science and technology, and social studies of science, seeking insights into the internal and external operations and dimensions of science—posed the problem of building interdisciplinary bridges. This volume sets out to effect this integration. The undertaking had its genesis in the formation of the International Commission (now Council) for Science Policy Studies in Moscow in 1971; and the plan to produce "a cross-disciplinary mode of access to this entire spectrum of scholarship" has been implemented under the aegis of the Council. The 17 key scholars who have contributed to the volume have been drawn from Britain, France, the United States, and West Germany. Their reviews of their respective disciplines, however, call on wider international perspectives, although the editors acknowledge that it was not possible to include extensive reviews of the corpus of literature from the socialist world.

Within this ambit, the book provides an encyclopedic overview of the state of development of the various SSTS disciplines, supported by literature surveys. Despite its more ambitious aims the book's most important achievement lies in its provision of coherent interpretative accounts of the present body of research in the individual SSTS disciplines, in its clarifying introduction to these disciplines for scholars, students, scientists, administrators, and policy-makers, and in its pointers to future research. There is evidence of some exchange of ideas among the contributors, but the sections remain fundamentally independent. Most readers are not likely to slog their way through the book from beginning to end, but they will be able to use the subject and name indexes to track concepts and case studies (the Mohole project, the atom bomb, public interest science, the Rothschild, Pearson, and Brooks reports, and the Velikovsky affair, to name a few, though, surprisingly, not the Oppenheimer episode with its far-reaching implications for science policy advice) and, with the help of the extensive bibliographies, to locate fuller explication elsewhere.

At the heart of the book are the central questions of what is science? how singular is the nature of scientific knowledge? how do differing historical and cultural conditions affect science? how do creativity and innovation develop within it? what are its rules, manifestations, and divergencies? how do research and development, with their differing organization, contribute to the achievement of national and industrial goals? how does technology govern economic development? how deeply is scientific and technological knowledge entwined with political purpose and power? what are its international interconnections? how does the model of Western science and the transfer of technology impinge on the Third World? and, important in the light of this institutionalized new discipline, how do we make judgments about the place of science in society in comparison with other intellectual and cultural components? To go further, as Spiegel-Rösing puts it, will SSTS research itself come to influence the criteria of scientific research and the ideology of science?

There are many more questions than answers. In the intellectual search definitions are essential, but, as this work indicates, it is difficult to obtain consensus in transdisciplinary studies. Nonetheless, each chapter yields important insights. Mulkay's overview of the sociology of the scientific research community, for example, indicates that much of our knowledge of that community rests on studies of physicists and that new evidence being gathered reveals a difference of attitude among biologists. Mulkay also notes that the lack of direct data on commitment to the social norms of science (universalism, communality, disinterestedness, organized skepticism, and more latterly originality and humility) enunciated by Merton some 30 years ago, is "astonishing" given their long presence in the literature and the frequency with which they have been mentioned. Despite the groundwork, our knowledge of the scientific community and its values is rudimentary. "We need to know much more" writes Mulkay, "about ways in which scientists define problems as 'interesting' and worthy of sustained research . . . and whether differences in social processes are associated with cognitive variations." For this we require reliable information on a wide-ranging and comparable set of issues for a variety of scientific fields.

Similarly in the social history of science, the goals and challenges are substantial. MacLeod, in a commanding analysis, illustrates the valuable perspectives offered by history both in "defining the cultural sources and conditions of scientific creativity and the nature and consequences of that activity" and in its contribution to science policy studies through the examination of institutions, the growth of professionalism, research programs, and the diverse external and social influences on scientific and technological development. Governments and those concerned with promoting economic interests, he warns, may believe that policies pertaining to science and technology may not require historical criticism or justification; but "the social historian can introduce a degree of realism into public affairs which sets the function of science in perspective."

Similar adjurations on the special importance to science policy studies of particular disciplines also come from economists, political scientists concerned with the nexus between technology and political power, and Third World scholars. Freeman, director of the Science Policy Research Unit at Sussex University, argues that not only are some of the most interesting problems in science policy concerned with R & D in society, including management of innovation, technology and program assessment, and the scale and direction of R & D investment related to national goals, but economics holds a potentially integrative role in its present swing back to seeing itself as a policy science rather than a positive science. Nowhere, Freeman concludes, could such a trend be "more welcome and more fruitful than in the area of science policy."

This pressure for integration is exerted from another standpoint by Sardar and Rosser-Owen from London's Muslim Institute, whose chapter "Science policy and developing countries" calls attention to the narrowness of the economic base of the research so far conducted on developing countries and underscores the need for wider cultural interpretations of science policy and technology transfer. Such criticism questions the "occidentalizing dynamics of development and development policies"—which finds expression, for example, in the prestigious aerospace and atomic programs of a country like India—and presses the need for science policy in developing countries to provide systematic analysis of "actual domestic development needs." The real problem, the authors sum up, would appear to be "not so much inappropriate development programmes as inappropriate decision-makers."

The chapters contributed by the political scientists, Lakoff, Nelkin, and Sapolsky, which deal with aspects of the political experience of scientists, the advisory and adversary systems, the role of expertise and its relations to government, and the part played by scientists at all levels in military science, bring us closer to the user audience for this volume. It is perhaps on these subjects that the literature and scholarship are the most diffuse. The bias is substantially American. The discussion, however, and the recommendations for further case studies of conflicts among scientists and between scientists and government agencies, of the social and political conflicts involving science, and of the decision-making process concerning domestic and military policy are as relevant for Australia, Israel, Japan, India, Canada, Brazil, or Nigeria as for Britain, Europe, and the United States.

This work stands as a landmark that no student of the social relations of science and technology can afford to ignore. Additionally the editors see it as bridging a gap between researchers and policy-makers. As Salomon of the Organization for Economic Co-operation and Development points out, "There exists a real gap between decision-making and the studies devoted to science policies," a point amply borne out by the book's own referenced case studies of decision-making. In the past, communication, as the editors admit, has not been good. It is to be hoped that this compilation will both influence researchers to think about the practical implications and applications of their work and encourage policy-makers and administrators to make increasing use of the scholarship that is available.

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Photobiology

Primary Processes of Photosynthesis. J. BARBER, Ed. Elsevier, New York, 1977. x, 516 pp., illus. $71.50. Topics in Photosynthesis, vol. 2.

About 15 years ago, Martin Kamen wrote a small book called *Primary Processes in Photosynthesis*. Softbound, Kamen's book cost only $2.45, but it was a treasure chest of insight and humor. To appreciate the sweep and grandeur of photosynthesis, Kamen said, one must think of time in exponential units, so that the interval of time between, say, 10^{-15} and 10^{-14} second is just as significant as the interval between 1 and 10 seconds. From the absorption of a quantum of light, which takes about 10^{-15} second, to the growth of a field of beans, there are more than 20 orders of magnitude of time—a greater span than the age of the universe measured in years. Kamen argued that the really interesting intervals of time, however, were the ones between 10^{-9} and 10^{-4} second. He called this the era of photochemistry, the time when photosynthetic systems capture the energy of the quantum in the first, fleeting products of a chemical reaction. The earlier era of photophysics and the later eras of biochemistry and physiology seemed reasonably well understood, but of the initial photochemical reactions of photosynthesis very little was known. As Kamen put it, the photochemical era marked a strong maximum in the spectrum of our ignorance.

The photochemical reactions of photosynthesis have increasingly provided a meeting point for scientists with widely different interests, from physicists to biologists and from theoreticians to gadgeteers. This collection of articles edited by J. Barber illustrates the outcome of this convergence. The topics included range from theories of exciton migration through details of instrumentation to the effects of *p*H gradients.

Most of the chlorophyll or bacteriochlorophyll in the membranes of photosynthetic organisms is not involved directly in photochemical reactions. Instead it acts as an antenna that absorbs light and funnels the energy in about 10^{-10} second to special sites called reaction centers, where the photochemistry begins. A small fraction of the excitations fail to be trapped and are emitted as fluorescence. A polished chapter by J. Lavorel and A.-L. Etienne discusses measurements of the fluorescence yields and lifetimes, covering recent work employing picosecond excitation techniques as well as measurements of the fluorescence yield during continuous illumination.

The question of how energy can move to the reaction centers so rapidly has intrigued theoreticians for many years. R. S. Knox discusses recent theoretical work on this subject in a chapter that will be heavy going for more biologically inclined readers. He concludes that exciton motion in the antenna becomes incoherent within about 10^{-14} second after excitation and that a diffusive, random-walk process describes the movement of excitons to the traps adequately after this point.

The primary chemical process that occurs in the reaction center is the oxidation of a special complex of chlorophyll or bacteriochlorophyll molecules. In photosynthetic bacteria, the initial electron transfer occurs in about 10^{-11} second. An account of recent picosecond and nanosecond spectrophotometric studies of the primary reactions is given by P. Mathis in a chapter on fast absorption spectroscopy. Mathis's chapter is rich in technical details on photomultipliers, light sources, signal averaging, and related topics.

Photooxidations of chlorophylls also can occur in solution. Photooxidation in vitro, however, almost invariably proceeds by way of a triplet state, whereas the primary reactions in vivo appear to involve excited singlet states. Electron transfer occurs from excited singlet states in vitro, but it generally is followed by a rapid back reaction that returns the system to the ground state. The spectroscopy and photochemistry of chlorophyll in vitro are discussed authoritatively by G. R. Seely.

The photosynthetic systems of chloroplasts and algae contain two types of re-