Book Reviews

Pioneer Laboratories

Willis R. Whitney, General Electric, and the Origins of U.S. Industrial Research. GEORGE WISE. Columbia University Press, New York, 1985. xii, 375 pp., illus. $29.

The Making of American Industrial Research. Science and Business at GE and Bell, 1876–1926. LEONARD S. REICH. Cambridge University Press, New York, 1985. xvi, 309 pp., illus. $24.95. Studies in Economic History and Policy: The United States in the Twentieth Century.

Wise and Reich have written two books that provide refreshing and complementary perspectives on the origin and early development of industrial research in the United States. The one is an examination of the emergence of industrial research as seen through the career of the first director of the General Electric Research Laboratory, who did more than perhaps any other individual to define and disseminate the concept of industrial research. The other, an exceptional synthesis of technological and business history, is a comparative analysis of the research laboratories at GE and AT&T. Both authors deal effectively with how the laboratories and their managers responded to long-term changes both within and outside the parent corporations.

Willis Whitney was born in Jamestown, New York, in 1868. He graduated in physical chemistry from the Massachusetts Institute of Technology in 1890, earned a doctorate from the University of Leipzig in 1896, and then taught at MIT until he was recruited to head the GE Research Laboratory in 1900. To provide a context for this enterprise Wise devotes a chapter to reviewing early efforts to link science and industry both in the United States and in Europe. At GE Whitney attempted to incorporate some features of a university science environment into the laboratory by holding regular colloquia for the staff and permitting principal members such as Irving Langmuir to publish research findings that lacked immediate commercial value or were protected by patent applications. A national economic crisis that began in 1907 threatened the viability of the laboratory and stimulated Whitney to make significant changes that included devoting more of his energies to research management and less to his own research. He took advantage of a successful effort to produce ductile tungsten at the laboratory to direct research into areas other than lamp improvement, such as electronics and radio. Whitney employed a highly personalized approach to research management by informal and daily tours of the laboratory. He generally controlled the direction of major research efforts through negotiation with his principal associates.

One of Wise's more interesting insights is his classification of styles of management as "exothermic" or "endothermic." He finds that Whitney exemplified the exothermic style in that he sought to energize and inspire others instead of absorbing energy from them to apply to his own investigations. Wise argues that the exothermic style worked well in the early years at the laboratory but became outdated by the 1920's, when endothermic management as exemplified by such men as William D. Coolidge, Whitney's successor as director, became the norm. Wise also believes that Whitney became too conservative during the later years of his tenure and failed to provide leadership into promising areas of research. Whitney's conviction that industrial research would provide GE with insurance against economic disruption proved incorrect with the advent of the Great Depression. His health deteriorated along with the economy, and he stepped down as head of the laboratory in 1932. The same year Irving Langmuir became the first industrial research scientist to receive a Nobel prize.

Reich at the beginning of his book characterizes industrial research as being conducted in laboratories that are separated from production facilities and kept "somewhat insulated from immediate demands yet responsive to long-term company needs" (p. 3). This definition effectively excludes all 19th-century as well as many 20th-century facilities from being considered true industrial research laboratories. Reich does, however, give a careful review of 19th-century developments in science and industry that set the stage for the creation of the two laboratory centers considered in detail in the remainder of the book. Reich devotes three chapters to the early history of GE and to the Research Laboratory, telling a story that agrees generally with that of Wise but places greater emphasis on the role of patents and how the laboratory's activities related to developments elsewhere.

Reich then turns to the early history of the Bell Company and the changes that resulted in the formation of its Research Branch in 1911. Especially provocative is his interpretation of the major reorganization in 1907, when control of the firm passed from Bostonian to New York financiers, the latter led by J. P. Morgan. It was the new management brought in at that time, including Theodore Vail and John Carty, that decided to organize and support the new Research Branch. Reich contrasts the interest and support of top management for the laboratory at Bell with the situation at GE, where the Research Laboratory tended to receive benign neglect from the top.

In a chapter on the research process at AT&T, Reich introduces a sophisticated model of research and development that includes scientific theory, invention, technological theory, and design methodology. He finds that it is almost impossible to distinguish between scientific and technological activity within the industrial research laboratory. He also concludes that distinctions between pure science and applied science are not very useful, at least in historical analysis of such laboratories as those treated in this study. Reich stresses the importance of technological theories that are formulated for the analysis of devices to the understanding of the research process. He points out that these theories could rarely be patented but could be converted into design methodologies and used to cope with complex technical systems. Also a technological theory frequently would stimulate numerous inventions that were patentable. Reich illustrates the usefulness of the concept of technological theory by a careful examination of early vacuum-tube amplifier research conducted at the Bell Research Branch during the period from 1912 to 1920.

In his final chapter, Reich discusses the impact of industrial research in the United States and includes data on the dramatic growth in the number of laboratories and industrial researchers since the 1920's. He finds that the influence of the GE and Bell laboratories was quite important even if later laboratories seldom if ever followed the same pattern. He concludes that "successful industrial research involves every part of a company's organization and that research has to be tailored to corporate structure and needs" (p. 257). Although neither Reich nor Wise claims that these two well-known laboratories necessarily provide an ideal model for an industrial research laboratory, they have furnished excellent models for historical case studies of other such institutions.

JAMES E. BRITTAIN
School of Social Sciences, Georgia Institute of Technology, Atlanta, GA 30332

The Disposal of Nuclear Waste

Geology and Radwaste. A. G. MILNES. Academic Press, Orlando, FL, 1985. xvi, 328 pp., illus. $60; paper, $39.95. Academic Press Geology Series.

Milnes describes this book as "a personal digest of the enormous volume of literature which has appeared on the subject of geology and radioactive wastes in recent years."

His initial interest in the subject "was prompted by a growing concern about the destructive tendencies of modern technology." At this point "even a turning away from the nuclear road requires intensive work toward achieving satisfactory solutions to the problem of radwaste," he writes, and "recognition of this fact provided the main motivation for the writing of the present book."

The book first reviews the nature and sources of radwastes, from conventional, once-through plants to reprocessing plants and other future sources. It is stressed that the health hazards associated with well-contained radwastes are far below those for some other substances routinely in use (for example, ammonia, chlorine, and arsenic). One thing is certain: radioactive materials are easy to detect, and at very low levels.

Chapter 2 reviews the general features of major disposal methods, including deep-well injection, grout injection, shallow land burial, ocean dumping, deep-mine emplacement, immobilization, underground melting, and sub-seabed emplacement. Milnes correctly stresses the importance of managing the large-volume uranium mine wastes. He emphasizes that the sub-seabed environment is at least as viable as the land-based options that are given top priority at present. I would very much agree.

Part 2 of the book is devoted to a summary of present knowledge of those processes that modify the outer few kilometers of the earth on a relevant time scale. For the chemist or engineer associated with disposal problems, the summary is adequate. It is stressed that major changes, a 1-kilometer meteorite crater, a San Francisco earthquake, an ice age, a major submarine slump, are not infrequent on million-year time scales. It is with respect to such processes that the seabed environment is perhaps the most predictable of the disposal sites. Milnes also stresses the complexity of predictive hydrogeology and fluid geochemistry, particularly when organic species are considered. Attention is also given to the behavior and stability of natural vitreous materials, a much neglected topic given the present trend to the use of glass in reprocessing. As nuclear wastes produce energy, the complex problem of describing coupled thermomechanical, hydrogeological, and hydromechanical processes is stressed, and it is suggested that field experiments may be the only way of dealing with such complexity. The problems associated with a glacial event are considered, particularly the possibility of localized deep erosion.

The final part of the book is devoted to the problem of finding the most favorable repository sites and to the relation between geology and public policy. Milnes concludes that because work on the seabed is the most free from public pressure it is perhaps the most honest. Case histories from Sweden and Switzerland are critically discussed, and Milnes concludes that "it is fair to say that involvement in the site selection process presents the geological profession with a strong challenge to the maintenance of scientific integrity."

I think Milnes has achieved his goal of providing a reasonable overview of the subject. The book provides an excellent basis on which to build a discussion of the options and problems of radwaste disposal.

W. S. FYFE
Department of Geology, University of Western Ontario, London, Ontario, Canada N6A 5B7

Rocky Shores Revisited

The Ecology of Rocky Coasts. Essays Presented to J. R. Lewis. P. G. MOORE and R. SEED, Eds. Columbia University Press, New York, 1986. xiv, 467 pp., illus. $45.

Rocky coasts are among the most intensively studied habitats in the world. This is because patterns in the distribution of organisms are obvious, physical gradients are compressed, processes such as recruitment, competition, and predation are conspicuous, and the size and longevity of dominant organisms are often scaled down to manageable dimensions. Ecologists of rocky coasts, like the communities they study, are a diverse lot who are often isolated, occasionally provincial, and commonly influenced by a few dominant individuals. All of this is reflected in the collection of essays entitled *The Ecology of Rocky Coasts*.

This volume is a tribute to J. R. Lewis, who is best known for *The Ecology of Rocky Shores,* published in 1964. The essays are by former students and colleagues of Lewis's, several of whom are among the most distinguished and prolific researchers in benthic ecology today. Although the essays focus on rocky coasts in nontropical (primarily North Atlantic) regions and are largely limited to a few dominant groups of organisms, they vary widely in approach, scope, scale, and objectives. Such diversity provides a rich international overview of the discipline. For that reason and for several of its superb essays, this volume is a worthwhile addition to the library of anyone interested in the contemporary natural history and ecology of temperate rocky coasts.

The Ecology of Rocky Shores focused on qualitative patterns of intertidal zonation along British coasts. Lewis explained most patterns as resulting from largely physical processes such as exposure, topography, and climate. *The Ecology of Rocky Coasts* considers more broadly the system studied by Lewis. The contributions include studies of biological processes, subtidal zones, and regions far beyond British shores. The volume progresses from zonal dominants to population biology to reproduction, recruitment, predation, and community structure. The planning and organization make it relatively cohesive. Cross-referencing is minimal, but there is little subject overlap. The editors added several nice touches such as quotations, poems, whimsical sketches, and a thoughtful preface expressing their gratitude to Lewis.

The volume opens with a brief, affectionate account of the history of Lewis's career and the academic environment of benthic marine ecology during the early post-war years in Britain (Moore and Powell). This is followed by several excellent reviews on the ecology of some dominant organisms of rocky coasts such as algae (Norton), mussels (Suchanek), and limpets (Branch). These provide background and global perspective to current research on each group. Similar reviews on the ecology of barnacles and littorinids would have made the volume more complete.

Todd reviews reproductive strategies for north temperate shore invertebrates. Other essays on this and topics of population biology are in the form of original studies on selected organisms (primarily barnacles and gastropods) that are largely confined to the British coast. These are descriptive and of limited utility beyond the region of study. In contrast, Wethey's contribution stands out as an elegant example of a recruitment study on a single species that is of general significance. He examined the timing of settlement for *Semibalanus balanoides* in New England and Britain using techniques that yield high-resolution spatial and temporal data. At both sites he observed a periodicity in settlement that he concluded would function to minimize the risk of catastrophic early post-settlement mortality.

Predation is the focus of several essays. Hughes presents an excellent overview of several studies on predation in rocky coast environments that have contributed substantively to general ecology. He reviews optimal foraging theory, the role of predation in structuring communities, the intermediate disturbance hypothesis, and biogeographical patterns in predation as it affects prey morphology. Other essays on predation are more limited in scope and overlap those of Hughes or other contributors.