pursue conventionally described science. Examples of the cyanide process for gold extraction and of uses of microbiology link the scientific work to particular economic, geographical, and demographic characteristics of the southern continent. By the 1880s Australian scientists produced results that were recognized abroad and gained institutional and public support at home. A somewhat similar case is made for technology by George Bindon and David Philip Miller. Their paper "Sweetness and light" discusses the ways in which the Colonial Sugar Refining Company, using experienced chemists from Scotland and Germany, adapted milling and refining processes to Australian conditions. In this instance, experts established technical control over floor control, which the authors argue represents one evidence of an industrial research orientation.

The third and last section, entitled Passage to Modernity, moves toward and emphasizes science since the 1940s, with the exception of the paper by H. Hamersley on the Sydney Cancer Research Committee in the 1920s. Home describes the rapid advancement of the physical sciences, and the simultaneous shift away from agriculture, during World War II. Australians were brought into British work on radar and established facilities that could be used after the war as well. Woodruff T. Sullivan's excellent essay on Australian radio astronomy documents the value of Australian work as well as the problems facing those who tried to collaborate with scientists on the other side of the world. Sullivan also points out the difficulties faced by women, such as Ruby Payne-Scott, who had to keep her marriage a secret from 1944 to 1950 because the Commonwealth Scientific and Industrial Research Organization forbade married women on permanent staff. S. C. B. Gascoigne documents in detail the way postwar astronomy benefited from the equipment, staff, and facilities that, in turn, allowed Australians to take advantage of their location in the Southern Hemisphere and collaborate with scientists elsewhere in the world. According to Ron Johnston and Jean Buckley, in the period since 1945 sponsorship by government agencies has undergirded unprecedented growth and status for science. The price for that support has been a process more bureaucratized and, increasingly in recent years, politicized as well.

Geographical location influenced the work of plant and medical scientists just as it had the research of some astronomers. R. L. Burt and W. T. Williams review the extraordinary problems and possibilities opened by the acclimatization of plants on their long-isolated continent and observe with regret how slowly (only since the 1930s) botanists have been able to gain reasonable oversight of plant imports and exports. The in many ways unique environment provided unusual opportunities in the medical sciences as well. F. C. Courtice argues that the scientists who earned international recognition were often those who concentrated on indigenous species or local problems and could thus produce results distinct from those of foreign scientists. His examples include Charles James Martin, whose work on snake venom led to antitoxins, to an international reputation for the young Sydney physiologist, and to subsequent research on the toxic components of venoms at the Walter and Eliza Hall Institute in Melbourne.

Taken together, these essays reflect the range and level of current work on the history of biological and physical sciences in Australia. Historians are still mapping terrain and prominent features. No one here, for example, explores in any detail the pervasive and persistent public concern for the resources and ecology of the continent, the role of women and amateurs in a population at once highly urbanized yet widely dispersed, and the impact of the difficult transition years after federation in 1901.

Like the United States a century earlier, Australians have sought independence from British and European (and recently even American) dominance, an effort seemingly at odds with the simultaneous goal of acceptance as equals by foreign colleagues. In these essays we discover the paradox that Australian scientists have often gained independent recognition at precisely the moment they merge into an international network.

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An Internationalist Focus

Nature in Its Greatest Extent. Western Science in the Pacific. ROY MACLEOD and PHILIP F. REHBOCK, Eds. University of Hawaii Press, Honolulu, HI, 1988. xiv, 288 pp., illus. $43. From a symposium, Berkeley, CA, 1985.

The social history of scientific development has typically taken the nation as its focus. But this volume reawakens us to other historiographical possibilities: the interaction of nations in the exploration, scientific development, and exploitation of a major geographical region. Elegant surveys by O. H. K. Spate and Alan Frost capture well the early European fascination with the Pacific, its peoples, and the harnessing of science to political and economic designs. Miranda Hughes's sensitive and witty account of the Baudin expedition (1800–1804) analyzes the ways in which the assumptions of European philosophy and anthropology manifested themselves in Bau-

"Giving Hawaii the Scientific Once Over," newspaper cartoon, 29 August 1920." [From P. F. Rehbock, "Organizing Pacific science," in *Nature in Its Greatest Extent*; courtesy of Bishop Museum, Pacific Science Congress Scrapbook]

din's and François Péron's encounters with the Tasmanian Aborigines.

After European settlement local scientific cultures gradually emerged. Crude models of colonial science depicting forelock-tugging fact-gatherers at the periphery providing grist for the mills of grand European systematizers receive short shrift here. Barry Butcher examines the careers and contributions of three Australian Darwinists in an institutional environment engendered by a creationist old guard in Britain. He argues that these Australian Darwinists were able to operate both as collectors and as theorists on a more or less equal footing with European "masters." We are reminded that the institutional development of science in a colonial setting can create an impression of uniform dependency and deference that deeper sociocultural inquiry dispels. MacLeod makes a related point about the Funafuti expeditions of 1896–1904, which were designed to test, by deep bore sampling, rival theories of the origin of Pacific atolls. Of these expeditions, the one launched from Australia was the most successful. To the Australians this was a victory for Australian geology and colonial nationalism. To the British, and the Royal Society, of course, it represented a triumph for British imperial science.

In New Guinea until the 1870s, escaping safely with new birds of paradise to provide plumage for gentlewomen's hats appeared more attractive than settlement or development. However, from the 1880s, Dutch, British, and German territorial claims spurred geographical and scientific exploration. David G. Frodin uses New Guinea as a laboratory to compare imperial scientific styles and demonstrates subtly their interplay with basic economic and practical constraints and individual initiative in determining the rate and direction of inquiry into the natural history of New Guinea.

In this century a major integrating role has been played by the Pacific Science Association. Rehbock finds its origins in the internationalism of the years after World War I, in the Pan-Pacific Union of Alexander Ford, and in the enthusiastic advocacy of the American geologist Herbert E. Gregory. Though a great measure of international scientific cooperation and multicultural harmony was achieved, the PSA was also undoubtedly used for national purposes. An aspect of the super powers' agenda is emphasized in the concluding essays. As Harry N. Scheiber informs us, Wilbert Chapman argued in a decidedly chauvinistic vein that the Pacific Ocean was "the Great Plains of the twentieth-century." After World War II, Chapman tirelessly promoted the new unified oceanography. Government support and industry participation were based largely upon interest in Pacific fisheries. Basic oceanographic research was applied as a crucial tool in U.S. negotiations of fishing treaties with Costa Rica, Canada, and Japan. Marine biology and fisheries development are also the focus of the paper by Robert H. Randolph and John E. Bardach on Soviet science in the Pacific. They recount institutional developments in the far east of the Soviet Union, the impetus given to marine research in the early Stalinist era, its virtual collapse in the late 1930s (in murky circumstances perhaps related to the rise of Lysenkoism), and more recent Soviet attention to marine biological resource protection and management. This account is fascinating and no doubt hard-won. But the claim that Soviet science continues to be affected by political factors and that Soviet activities in the PSA "do not confine themselves to . . . strictly scientific considerations" sits oddly with the rest of the volume, which demonstrates that the pursuit of economic and political objectives through science has been the norm and not the particular failing of the Soviet Union in the modern era.

This is a stimulating book. However, the

story of Western science in the Pacific should be melded with that of Western science in Asia. The Pacific is a meeting ground for East and West in a larger sense, as the editors acknowledge. The scientific history of the Pacific now opens onto an even wider stage with an enlarged cast of players.

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Social Insects

Interindividual Behavioral Variability in Social Insects. ROBERT L. JEANNE, Ed. Westview, Boulder, CO, 1988. x, 456 pp., illus. Paper, $39.85. Westview Studies in Insect Biology. Based on a symposium, Hollywood, FL, 1985.

There has been a quiet but significant renaissance occurring in studies of social insects, in which the role of individuals in the structure and function of insect societies has been receiving increasing attention. It has long been apparent that colonies function as highly coordinated units to perform a wide variety of tasks, but the extreme variability characteristic of individual worker behaviors at any given time has been a significant barrier to the development of a comprehensive theory concerning the control of colony-level activities. The concept that colonies operate as "superorganisms" that are more than the sum of their individual workers was articulated by Wheeler and others during the first half of this century, but has languished in recent years owing to the lack of mechanistic explanations of how colonies could control individual worker activities. The empirical studies collected in this volume represent significant progress in understanding this question.

Almost all of the 14 papers were initially presented at a joint symposium of the Entomological Society of America and the North American Section of the International Union for the Study of Social Insects. The contributions are remarkable in their consistently high quality as well as in their uniformity of approach. The latter reflects not only an exceptionally good editorial job by Jeanne but also the sophisticated level of analysis that is being applied to social insect colonies.

Recent studies of social organization have benefited greatly from the techniques and concepts provided by the developing field of behavioral ecology. In this work, the tools of the trade include detailed recording of ethograms, measurement of colony growth and development, analysis of between-task transitions, and some "old-fashioned" natural history. These techniques, when applied in the theoretical contexts of caste polyethism and kin selection theory, have provided some major advances in understanding how social insect colonies function. For example, it is now clear that the extensive variation in what workers do at any age or time has real importance for colony survival, by providing the flexibility to respond to rapidly changing environmental conditions as well as foraging opportunities. Also, there appears to be genetic structure to this variation, so that individuals within the nest have different capacities to perform functions and to develop into reproductives. Finally, specialization by workers to perform particular tasks may be more significant than previously thought. Though few workers are lifetime specialists, those that do specialize for extended periods may provide unique contributions to colony economy, such as the undertaker honey bees, which remove corpses from colonies.

The major criticism I have of this collection has to do with the quality of the book's production. Westview Press has filled an important niche in academic publishing through their series Studies in Insect Biology. Unfortunately, the quality of the content of the books has not been matched in the production; the typeface, paper quality, and printing of this one are so poor as to make reading it a real chore. Also, more rapid publication would have been desirable, as this field is moving so rapidly that some of the contributions in this volume have already been eclipsed by more recent work.

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Atmospheric Chemistry

Chemistry of the Natural Atmosphere. PETER WARNECK. Academic Press, San Diego, CA, 1988. xiv, 757 pp., illus. $85. International Geophysics Series, vol. 41.

In 1963, Christian Junge's classic textbook *Air Chemistry and Radioactivity* defined the emerging field of atmospheric chemistry. For years there has been a need for a revised version. Other fine books have been published in recent years, especially those by Seinfeld and by Finlayson-Pitts and Pitts, but none has replaced Junge's text. Warneck set out to produce such an update and has succeeded admirably. Reflecting the enormous growth of the field since 1963, Warneck's book is twice the length of Junge's, but Warneck maintains Junge's devotion to general principles that are applicable both to natural and anthropogenic phenomena and to local and global problems. In contrast, the other texts noted above have greater focus on local air pollution problems.

The "radioactivity" in Junge's title refers to his inclusion of information about transport and deposition that was gained from the huge "tracer experiments" provided by atmospheric testing of nuclear weapons in the 1950s and early '60s. Warneck covers the use of radium daughters to determine aerosol residence times and occasionally includes results from fallout of fission products or ratios of carbon-14 to total carbon, but radioactivity is a minor feature of his book. The major addition since 1963 is the explosive growth of knowledge of rates of gas-phase reactions resulting from extensive studies of photochemical smog and of the formation and destruction of stratospheric ozone. Although Warneck's coverage of gas-phase reactions is not as detailed as those of the air pollution books, it is quite good, especially as applied to the natural atmosphere. Not only does he treat kinetics in a conventional way, but he demonstrates the use of tropospheric and hemispheric box models to estimate concentrations of radicals that have so far defied direct measurement. Warneck discusses important reaction pathways in groups of about five elementary reactions, frequently bringing these groups together in diagrams that summarize the big picture. Unfortunately for students, he does not do this in all cases. It would have been helpful if he had assigned a number to each elementary reaction and used it throughout. Also, he could have explained more of the tricks, many involving the steady-state approximation, that kineticists and modelers use to simplify the treatment of complex sets of reactions.

Changes in the treatment of aerosols, which Junge covered in depth, are not as extensive. Today better devices are used more routinely for collection of size-segregated particles, and more detailed chemical analyses are now possible with use of x-ray fluorescence, neutron activation analysis, ion chromatography for inorganic species, and techniques such as gas and liquid chromatography and mass spectrometry for organic species. Warneck explains the use of enrichment factors in relation to the crustal abundance pattern; they have been helpful in identifying sources of airborne particles. The aerosol chapter is followed by one that covers the thermodynamics of uptake of water by particles and the subsequent growth of droplets in fogs and clouds, and goes on to treat scavenging and the composition of rain. As is typical of his approach,