centers and laboratories stretching across the country, India maintains a science and technology establishment of considerable proportions.

How did this situation arise? What moved a poor country where scanty funds, old equipment, a difficult climate, and the indifference of students and scientists militated against a lively research tradition to a position where its theoretical and experimental work is recognized around the world?

Important aspects of the answer to these questions lie in Robert Anderson's small book, based substantially on interviews with Indian and other scientists between 1967 and 1975. The author selects the lives of two preeminent but strikingly different scientists, Meghnad Saha (1893–1956) and Homi Bhabha (1909–1966), with well-established international reputations in astrophysics and in cosmic-ray and elementary-particle theory, respectively, and examines the social, educational, political, and philosophical influences that caused them to impart distinctive and determining influences to the development of Indian science. In doing so, Anderson sets up a biographical model for studying the growth of scientific institutions and the play of personality and power in molding a scientific community, and suggests the pertinence of comparative studies of scientists and scientific-institution building in other countries. These, he writes, "could provide an empirical basis for understanding the characteristics of the entire scientific community."

Saha and Bhabha represent distant ends of the social and organizational spectrum of science. Saha, the son of a small shopkeeper from East Bengal, rose scholastically by way of Dacca College and Presidency College Calcutta and the universities of London and Berlin, became a fellow of the Royal Society, and, in the impecunious period of Colonial science in India in the 20's, began to influence the establishment of scientific academies and journals, encouraged university-based research, notably in mathematics and astrophysics at Allahabad and Calcutta, established the Saha Institute of Nuclear Physics (1950), and entered Parliament in 1951 for the purposes of planning national industrial development and relating science and technology to "the problem of living for India's millions."

Bhabha, contrastingly, was a member of a wealthy Parsi family. He studied at Cambridge, trained in theoretical physics at the Cavendish Laboratory, won a fellowship in the Royal Society, and began a prestigious career in wartime India, where he put his thrust not in the universities but in the Tata Institute of Fundamental Research, which he founded in 1945, in building close and "indispensable" relations with Nehru, and in shaping the Indian Atomic Energy Commission. Essentially Bhabha personified the scientific aristocracy of Big Science. He was "a career science organizer" who worked closely within government, donning a variety of official hats yet managing to retain a necessary measure of scientific autonomy. At his death in an air crash in 1966, he held a formidable array of official posts including secretary to the government of India in the Department of Atomic Energy, ex officio chairman of the Atomic Energy Commission and director of the Atomic Energy Establishment of Trombay, director and professor of theoretical physics at the Tata Institute, and chairman of the Scientific Advisory Committee to Cabinet. Bhabha's influence lay behind the Canada-India Reactor Agreement of 1956; his "policy of flexible nuclear development," writes Anderson, "had been skillfully woven into the agreement in such a way that it was impossible for Canada to later insist on adequate safeguards." His drive and initiative laid the ground plan for the complex of India's atomic reactors and laboratories. From differing standpoints, Bhabha and Saha both sought self-reliance for Indian scientists, Bhabha seeing this in the adaptation of imported models to gain time and ensure training and Saha preferring an independent science and technology tied to socialistic economic development. Their separate influences in fact produced institutes that "have promoted an expert-dependent or specialist-dependent pattern of social development."

Anderson's contrapuntal biographical analysis is a novel approach to the sociology of science. Yet the method is not entirely successful. There is considerable fragmentation and repetition, and an amount of indigestible detail is scattered through the text. What does emerge, however, is a store of information on India's scientific arena across the formative years from the '20's to the mid-'60's, and some fertile evidence for historians and sociologists of science in other countries of the pervasive and dynamic influence of highly motivated individuals on the formation of national policy in science.

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Chemical Communication

Animal Communication by Pheromones. H. H. SHOREY. Academic Press, New York, 1976. viii, 168 pp., illus. $16.50.

Twenty-five years ago, when Nikolaas Tinbergen's influential work *The Study of Instinct* summarized the state of a newly emerged ethology, chemical communication still was an obscure phenomenon relative to the visual and auditory systems on which the discipline had been based. Virtually no pheromones were then chemically known, and no attempt had been made to formulate principles concerning their transmission and reception. The key literature comprised fewer than 50 articles.

The situation has since been radically altered as a result of three lines of technical advance: the introduction of gas chromatography, and subsequently gas chromatography coupled with mass spectrometry, permitting the identification of secretory products in microgram quantities; the invention of special neurophysiological techniques, such as the electroantennogram, that led to a better understanding of the chemoreceptor systems; and the development of physical models by which transmission of odorants through water and air could be analyzed. The study of chemical communication now ranks as a small discipline in itself. Investigators have identified hundreds of pheromones and continue to discover new ones at an accelerating rate. General principles of the evolution of the communicative systems have begun to emerge with clarity. In fact, far from being obscure, pheromones are the dominant signals of communication in animals and microorganisms. They are generated, transmitted, and received as precisely as visual and auditory systems that serve equivalent functions.

H. H. Shorey has written a useful account of our present knowledge of chemical communication, shorter but better organized and more easily read than the multiauthored *Pheromones* (1974) edited by M. C. Birch. It is in fact a primer of the subject, quickly covering the main principles with well-chosen examples and figures but backed up by a thorough bibliography of 726 titles. *Animal Communication by Pheromones* can be read either as an introductory textbook or as supplementary material in courses on animal behavior. It can also be consulted by scholars as a reference work and guide to the literature.

Shorey, an entomologist, understandably stresses biological aspects of the subject over chemical. But this emphasis is appropriate, since pheromones are typically unexceptional compounds of low molecular weight, while the physiology and behavior evolved to employ them are often unique and surprisingly complicated. The males of certain moth species, for example, can distinguish females of their own as opposed to similar species on the basis of a single optical isomer or even quantitative differences in blends of the same substances. In female *Pachygrapsus* and *Cancer* crabs, molting to the adult stage is mediated by the hormone crustecdysone, which upon being released into the water also serves as a pheromone attractive to males. To take one of a rapidly growing list of mammalian examples, female rhesus monkeys produce volatile aliphatic acids in their vaginas that function as potent sex attractants. These same substances are also produced in the vaginas of young women, reaching their highest levels in the late follicular phase and declining progressively during the luteal phase. Clearly we have much more to learn about pheromones, and there may even be surprises in store as the new understanding is extended to human biology.

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Developmental Neurobiology

Neuronal Recognition. SAMUEL H. BARONDES, Ed. Plenum, New York, 1976. xvi, 368 pp., illus. $27.50.

It is awesome that the neurons of the human brain make orderly connections with each other by means of approximately 10^{14} synapses. The orderliness of synaptic contacts is believed to involve "guidance" of neuronal processes toward the correct targets, followed by "recognition" of the appropriate targets by the processes. *Neuronal Recognition* describes some of the evidence for the formation of selective synapses and several biochemical and cellular models for how it may be mediated.

The book has 11 chapters, grouped into three sections: on specificity in synaptic development and regeneration, on the morphology and biochemistry of synapses, and on the molecular basis of neuronal recognition. The authors of the chapters have chosen between reviewing a field and summarizing their own contributions. Thus Fambrough offers an excellent detailed survey of work on the specificity of nerve-muscle interactions, Bunge a critical review of synapse formation in vitro, Pfenninger and Rees a summary of the anatomical changes that occur during synapse formation, Morgan and Gombos a survey of synaptosome biochemistry, and Toole a detailed view of acid mucopolysaccharides. The chapter by Toole, while pertinent to cell guidance, is not obviously related to the title of the book. The remaining authors—Jacobson; Cotman and Lynch; Moscona; Roth and Marchase; Merrell, Gottlieb, and Glaser; and Barondes and Rosen—for the most part offer summaries of the work in their own laboratories. Among these summaries, we appreciated Cotman and Lynch's discussion of reinnervation in the central nervous system, which stresses the lack of evidence for inappropriate reinnervation. Several of the other summaries give too little discussion of pertinent findings from other laboratories. In particular, the chapters by Jacobson on retinotectal specificity, by Moscona on embryonic cell recognition, and by Barondes and Rosen on cell surface carbohydrate-binding proteins are narrower in scope, and therefore less valuable, than they might have been. In general, literature is reviewed only through 1974.

The impression that remains after reading this book is that the more descriptive approaches of anatomy and physiology have already provided solid information on developmental processes in the nervous system but that the biochemical approach has so far told us relatively little. Much has been learned by observing the development of synaptic contacts in culture (Bunge; Pfenninger and Rees) and by examining the reaggregation of dissociated cells (Moscona). Likewise, we have benefited by studying the recovery of synaptic function and structure after partial deafferentiation in the central nervous system (Cotman and Lynch), after denervation of muscle (Fambrough), and after rearrangement of retinotectal projections (Jacobson). Such clear information has yet to come forth from the biochemical approaches, where the emphasis is still on finding an appropriate model system that embodies the key elements of neuronal recognition. Moscona argues for study of the reaggregation of trypsin-dissociated embryonic cells, Roth and Marchase argue for study of the interactions of dissociated retinal cells with intact optic tectum, Merrell *et al.* prefer to study membrane-neuron interactions, and Barondes and Rosen are willing to forgo neurons altogether and investigate aggregation of slime mold cells. While the experiments are often elegant and clever, their pertinence to neuronal recognition is not always apparent. Nor is it easy to compare one laboratory's data with another's. For instance, "adhesion" may be measured as an on rate or as an off rate; as an energy-independent phenomenon or as an energy-dependent one; immediately after mixing or after prolonged incubation at 37°C; with respect to the cell membrane or the extracellular matrix. The title of the last section of the book, Toward a Molecular Basis of Neuronal Recognition, is apt, since we still lack much specific information and have a great deal to look toward.

Though this book lacks a single author to organize the data and reconcile the observations, it is nevertheless a valuable summary of the state of developmental neurobiology; it demonstrates how little we know, as well as how much. The chapters are well chosen, usually well written, and consistently cautious in their interpretation of data. We enjoyed the book greatly.

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