which they farm bottom lands and artificial terraces. Although nonurban, they duplicate in each valley an elaborate political structure directed by a genealogy-conscious caste. As with the islands of Polynesia, the limited setting of meager resources belies the intricate ranking system. The nobility seems incongruous—a diluted version of something more grandiose. The Mixtecs could have developed their taste for royalty as builders of the classic urban centers of Teotihuacán, Cholula, and Xochicalco, but this is merely conjecture.

Spores eschews conjecture. His history is documented and, therefore, firm. And in avoiding theoretical polemics about the hydraulic factor and the geo-managerial role of the nobility, Spores sagaciously places historical explanation as prerequisite to theoretical understanding.

With the Spanish colonial regime, the hereditary Mixtec rulers are not liquidated. Instead, a new political and economic structure forms gradually as the Spaniards chip away at the land holdings and privileges of the nobility. The emergence of the new plural society is a complex process, its study a complex task. Spores has made an auspicious beginning. The importance of his book lies not only in this, but in pointing the way to further elucidation of problems beclouding the study of the Mixtec.

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Neurobiology

Nervous and Hormonal Mechanisms of Integration. A symposium, St. Andrews, Scotland, September 1965. G. M. HUGHES, Ed. Published for the Company of Biologists on behalf of the Society for Experimental Biology. Academic Press, New York, 1966. 573 pp., illus. $16.50.

This volume contains the proceedings of the 20th Symposium of the Society for Experimental Biology. It presents a diversity of selected topics in the field of neurobiology and related areas and is concerned with integration in the broadest sense. The book is remarkable for several reasons: it is symptomatic of the curious schism that still exists between the medical school physiologists and the physiological zoologists or zoological physiologists. Physiologists of the latter kind are usually labeled "comparative" physiologists, even though it has long been recognized that the comparative approach is the fundamental approach of all physiology.

With very few exceptions the participants in the symposium were chosen from among zoologists. There is not a single representative of a physiology department associated with a medical school. The representation is the more noteworthy because, simultaneously and in competition with the St. Andrews symposium, there was a Symposium of Comparative Neurophysiology in Tokyo, Japan, which was attended by an even larger number of mainly zoologically oriented physiologists. The fact that two somewhat similar symposia have been held on opposite sides of the globe at the same time is a strong indication for the vitality and enterprise of the physiologists interested in the general problems of excitability and the specific problems of the integration of nervous function. It is obvious, however, that we still need a synthesis that will permit an overview of the entire field concerned with the integrative action of the nervous system and that encompasses both the mammalian work and the work conducted on selected but highly successful invertebrate preparations.

The papers presented at the symposium are veritable gems sparkling with information. Each displays many facets of the topic it covers. All participants made it their goal to present their own experimental work in wider contexts, and the individual papers provide excellent introductions to their subjects.

A prologue by the sage of comparative neurophysiology, T. H. Bullock, points out some of the latest developments and hints at future ones. In the first paper, M. A. Sleigh discusses the coordination and control of cilia, concentrating on protozoans and molluscs. The name of v. Brücke is misspelled twice in the article, but this is a minor detraction from the usefulness of a review that covers the older as well as the more recent literature concerning the relation between ciliary beating and membrane permeability, ion effects, membrane potentials, and the action of local hormones. An excellent paper by R. K. Josephson on the mechanisms of pacemaker and effector integration in Coelenterates again summarizes the older literature and points out some of the newer developments. A most welcome paper by T. Sibaoka treats action potentials and electrical aspects of integration in plant organs. The coverage of the literature ranges from 1922 to 1962. Donald Kennedy, W. H. Evoy, and H. L. Fields report on the unit basis of some Crustacean reflexes. These authors analyze the roles of proprioceptive control elements and of intraganglionic "command" neurons, "driver" neurons, and inhibitory connections in the activation pattern of individual motoneurons. Their analysis is based on the pioneering work of C. A. G. Wiersma, who first established that in any nervous system the central nervous system contains interneurons individually equipped to respond to specific sets of inputs. D. M. Maynard presents, in addition to a review of earlier literature, a tremendous amount of new information. He describes several types of integrative units in the lobster brain (among them units that exhibit intracellular delays and "alarm clock" properties) and reports on new experiments on cardiac ganglia and extensive investigations on the stomatogastric ganglion. Wiersma summarizes the ingenious work he and his co-workers have conducted over several years on integration in the visual pathways of several crustaceans. Considering that the analysis includes the interaction of optically controlled events with those dictated by mechanoreceptors and statoreceptors, these investigations offer a deeper insight into the fundamental neurophysiological aspects of vision than any work carried out on vertebrate organisms. In his analysis of optokinetic responses in crabs, G. A. Horridge integrates his recently published studies on the ultrastructure of the optic ganglia. The roles of pacemaker- and oscillator-coupling in the control of rhythmic movements (flight, walking) of insects are the subject of papers by D. M. Wilson and G. Wendler. K. D. Roeder and R. S. Payne have carried the investigations of acoustic orientation of moths further by observing and analyzing the integration of the inputs from the two sense cells in the central nervous system and the modification of the sensory input by the moth's own wingbeat. Chemical sense communication in insects and other animals is reviewed and systematized in a fine paper by D. Schneider. H. M. Gerschenfeld presents an eclectic but very stimulating discussion of current studies on chemical synaptic transmitters in invertebrates. The production and release of hormones from neurosecretory cells is briefly but criti-

cally examined by H. A. Bern. R. B. Clark presents a rather comprehensive survey of studies on integration in the brain of polychaete worms, including aspects of neurosecretion, hormone action, habituation, learning, and memory. W. Loher and F. Huber describe old as well as new experiments on nervous and endocrine control of sexual behavior in a grasshopper, and R. A. Hinde and E. Steel describe the integration of external and internal (hormonal) stimuli in the control of reproductive behavior in female canaries; B. Baggerman takes a similar approach in a study of reproductive behavior of the three-spined stickleback. J. Bruner and L. Tauc attempt to explain learning processes and "plastic changes" in the central nervous system on the basis of modifications of transmitter production at synapses and "episynapses." Intensive research on learning in the octopus is beautifully reviewed by M. J. Wells. Short-term and long-term plastic changes in the mammalian nervous system are discussed by W. Kozak and R. Westerman.

This carefully edited and beautifully produced volume has an assured place on the bookshelves of comparative physiologists and neurophysiologists. Like the 16-year-older proceedings of the fourth Symposium of the Society for Experimental Biology, *Physiological Mechanisms in Animal Behavior*, it can be regarded as a landmark and will be of value for many years to come.

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Research Tools

Glass Electrodes for Hydrogen and Other Cations. Principles and Practice. GEORGE EISENMAN, Ed. Dekker, New York, 1967. 594 pp., illus. $24.75.

With the commercial introduction in recent years of many highly specific electrodes for both cations and anions, and with the improvement of electrometers for measurement of electromotive force, there has been much increase in the use of electrodes in various analytical situations. Electrodes have the advantages of being relatively inexpensive, nondestructive, and, in the case of highly specific ones, relatively easy to apply. This is a kind of research that is developing rapidly, and unfortunately the time involved in assembling and publishing a book like this one seems to mean that the book is two or three years old when published. That is not to say that this book is obsolete; on the contrary, it is a valuable addition to the library of anyone interested in the theory of electrode response or in the problems of practical use of electrodes in inorganic or biological research. It deals, however, almost entirely with silicate-glass electrodes, and as readers of *Science* know, there are now available specification electrodes whose sensitive membrane is an organic liquid, or, as in the case of the fluoride electrode, a crystal.

The glass-electrode potential and, by inference, an organic-liquid potential, or a crystal-electrode potential, is now generally accepted as being the sum of two potentials: the boundary potential, which arises from exchange equilibrium between the electrode and the solution, and a diffusion potential, arising from interdiffusion of ions in the membrane. Empirical electrode equations and equations stemming from solid solution theory have been derived to aid in understanding the potential changes of an electrode sensitive to more than one ion, and these equations may be applied to any ion-sensitive electrodes. No doubt the increased understanding of the sources of glass-electrode potentials has aided in the development of the newer nonglass electrodes. In practical applications, however, it is best not to assume that any electrode will respond ideally for very long; one should recalibrate frequently, with standard solutions as much as possible like the unknowns.

George Eisenman has compiled, edited, and contributed to a book that contains chapters by many different authors, who represent many if not most of those involved in current research on glass-electrode theory and applications. The first seven chapters deal with theory; there follow 12 chapters of a practical nature, describing techniques of construction and of measurement in inorganic solutions, in soil studies, and in biological applications, both in vitro and in vivo. Glass electrodes are especially useful in biological research because the glass can be formed into microelectrodes for intracellular ion analyses. The practical section will be welcomed by those who struggle with the mundane problems of experimental arrangements and interpretations of measurements. Because each chapter has many references, the book amounts to a review of the literature of glass-electrode technology up to early 1965 and constitutes a convenient source of recent experience with glass electrodes.

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Mammalian Anatomy

Traité de Zoologie: Anatomie, Systématique, Biologie. Vol. 16, Mammifères, fascicule 1, Téguments et Squelette. Pierre-P. Grassé, Ed. Masson, Paris, 1967. 1170 pp., illus. F. 255.

The comprehensiveness of the treatment of the mammalian integument and skeleton in the first installment of volume 16 of the *Traité de Zoologie* will be no surprise to those who have read or consulted previous volumes in this series. The mammals as a class take up two volumes (16 and 17), which are divided into seven installments. Installments 2 through 4 of volume 16, covering other aspects of mammalian anatomy and reproduction, are in press, and installment 5, which will contain notes on embryology, postembryonic growth, and taxonomy, is in preparation. Volume 17, in two installments dealing with taxonomy and ethology of mammals, has already been published.

The first 233 pages of the present book are devoted to the skin and its accessory structures. This section, which is written by Manfred Gabe, director of research at the National Center of Scientific Research in Paris, includes a large amount of factual material gleaned from the literature on morphology, histology, histochemistry, histophysiology, cytology, general physiology, vascularization, innervation, lymphatics, and embryology. Most of the information about the structure and function of skin comes from studies of man and the common laboratory animals. For this reason, a truly comparative treatment of the subject was not possible, and discussions of morphology and physiology relative to environmental adaptation are limited.

The author adds interest to his presentation of facts by including a history of ideas and a list of unsolved problems. For example, the covering of hair is one of the important distinctive characteristics of mammals, and many theories have been advanced to explain its evolution. Certain mammalogists