RNA's of the cell which lead to protein specificity and the differentiation of cells. The volume brings together provocative examples of control mechanisms acting during development. Clearly, this subject will be the center of attention for many more symposia during the next quarter century.

JOHN G. TORREY
Biological Laboratories, Harvard University, Cambridge, Massachusetts

Between Neuron and Neuron

Physiological and Biochemical Aspects of Nervous Integration. A symposium, Woods Hole, Mass., 1967. FRANCIS D. CARLSON, Ed. Prentice-Hall, Englewood Cliffs, N.J., 1968. viii + 392 pp., illus. $7.

The nervous system is an accumulation of cells which are organized in highly specific functional relationships. The long axonal and dendritic processes of many neurons permit direct contact with a large number of other cells. These intercellular contacts are what the nervous system is all about. Excitatory and inhibitory impulses converge on and diverge from neurons and result in the highly integrated process which is behavior.

Because each neuron may interact directly with so many others, studies of interneuronal relationships are extremely difficult. Many of the researchers confronting this problem participated in the symposium recorded in this volume. Their presentations, which are often summaries of published experiments, show that much of the work attempts to answer several crucial questions: What are the details of neuronal circuitry which combine the activation of a number of neurons into an integrated response? What are the mechanisms for establishing specific interneuronal relationships, and how specific are they really? What are the biochemical correlates of the establishment of interneuronal relationships both in embryonic differentiation and in the finer differentiation which occurs during learning?

Although the answers to all these questions are extremely incomplete, the answer to the first of them is at a comparatively advanced stage. Not only have there been important analyses of integration in the vertebrate visual pathway, as described here (rather briefly) by Hubel and Wiesel, but there have also been a considerable number of important studies in invertebrates. Because the number of neurons present in invertebrate ganglia is relatively small, it is relatively simple to identify, in the living state, individual neurons, some of their axonal branches, and other neurons with which they make functional connections. Many of the components of "simple" pathways can thus be identified and activated experimentally. Here then are systems in which the interaction of neurons can be studied in a fairly detailed way. In this volume, there are a number of reports of the usefulness of this approach.

Kandel and Wachtel present the most highly developed example in their study of the neuronal interactions in the abdominal ganglion of *Aplysia*. The influence of periodic endogenous activity in individual neurons on the properties of a network in *Aplysia* is demonstrated by Strumwasser. The ability of single "command neurons" to release complex coordinated patterns of behavior involving hundreds of neurons is analyzed by Kennedy in studies of the arthropod nervous system. The great functional complexity which is possible with even a relatively small number of interacting neurons controlled by relatively few basic mechanisms is strikingly demonstrated. From studies such as these the principles by which neuronal interactions produce complex internal and behavioral responses are becoming known.

Far less advanced is our understanding of the development of such specific neuronal connections during embryogenesis. From interesting studies of the development of retinotectal relationships in Amphibia, Jacobson reports evidence for the establishment of highly specific interneuronal recognition at a specific stage in development. At an early stage of development, individual retinal ganglion cells have the potentiality to make synapses with any cell in the optic tectum. At a later, well-defined stage, they are directed to specifically choose and make connection with specific partners in the tectum. It appears that each ganglion cell in the retina and each tectal cell is instructed to make contact with a particular partner, and that these instructions are given before the cells involved have met. Although this degree of specificity may not be characteristic of all interneuronal relationships, this study shows how specific these relationships can be in certain systems. This poses the enormous question of explaining how such precise intercellular recognition is brought about.

The biochemical approach to a related problem, the nature of the processes which mediate the development of new functional interneuronal relationships after learning, is also considered in this symposium. Because of its common participation in other biological regulatory processes, protein synthesis receives primary attention. Evidence for the participation of cerebral protein synthesis in memory is presented by Agranoff and Davis, studies of cerebral protein synthesis during learning are discussed by McEwen, and a unique class of cerebral proteins of unknown function is described by Moore and Perez. Horridge and M. Cohen, among others, consider behavioral responses in invertebrates which might prove appropriate for studies of learning in relatively small ("simple") nervous systems.

The remaining reports describe still other significant discoveries which may all contribute to the solution of the core problems which I have identified. As one reads this collection of papers, one gets a feeling for the concepts and techniques with which one must struggle in order to come to grips with the complex functioning of the nervous system. Because it may be difficult for many readers to integrate these diverse studies, the book would have benefited from a critical summary. However, the participants speak well for themselves and will educate all readers who have a fundamental background in neurophysiology and biochemistry.

SAMUEL H. BARONDES
Departments of Psychiatry and Molecular Biology, Albert Einstein College of Medicine, Bronx, New York

Pacific Archeology

Prehistoric Culture in Oceania. A symposium of the 11th Pacific Science Congress, Tokyo, 1966. I. YAWATA and Y. H. SINOTO, Eds. Bishop Museum Press, Honolulu, 1968. 179 pp., illus. Paper, $7.

Four of the papers in this symposium volume are devoted to Melanesia, three to Micronesia, eight to Polynesia, and one to the status of archeological research in Oceania as a whole. The publication is directed to specialists in the subject, and the reader with a more casual interest may profitably limit his reading to the five interpretative papers by Emory, Heyerdahl, Golson, Green, and Spoehr.

The earliest evidence for human occupation occurs on New Guinea in Melanesia. This large island was probably a stepping-stone in the migration to Australia, where radiocarbon dating indicates an occupation at least 20,000 years ago. Still, on New Guinea, archeological work has not succeeded in confirming the presence of man before 10,000 to 15,000 years ago. The domesticated pig appears by about 4500 B.C., cultivated plants by about 3000 B.C., and pottery by about 500 B.C. Man seems to have penetrated into Micronesia at a later date, but was making pottery there as early as the 16th century B.C. The occupation of Polynesia came still later, probably beginning about the 5th century B.C. in Samoa and Tonga.

As in other areas of the world, ceramic studies offer promise as aids in the unraveling of some of the more perplexing problems of migration and diffusion. Pottery is common in Melanesia and Micronesia, but in Polynesia it forms an important part of the material culture only on island groups immediately adjacent to Melanesia and Micronesia, especially Samoa and Tonga. Important new contributions to ceramic studies are embodied in papers by Poulsen, Dickinson, R. Shutler, and M. E. Shutler.

Throughout Oceania stone adzes and shell, or bone, fishhooks offer important criteria for the study of the distribution of culture traits in time and space. The characteristics of the stone architecture are equally important. Artifacts often occur in such small numbers in a particular site or level within a site that statistically valid studies must often be limited to broad island-to-island comparisons.

On the basis of pottery found in the earliest period, Sinoto sees the Marquesas Islands as the first in Eastern Polynesia to be settled from Samoa. He then postulates that the Marquesas formed the center for dispersal to Hawaii, Easter, the Society Islands, and New Zealand. He has already revised the recent interpretations for Marquesan archeology as set forth by Suggs on the basis of new excavations on Uahuka and Nukuhiva. Such revisions are a normal state of affairs in the early stages of archeological work in any area. Suggs's earliest occupation date is revised upward from about 124 B.C. to about A.D. 850. I think the true date may be found to lie somewhere between these two extremes when more work has been done in the area.

The symposium papers reveal that tremendous strides have been made in Oceanic archeology since the Tenth Pacific Science Congress in 1961, but because many of the reports are of a preliminary nature much remains to be done in the laboratory as well as in the field in the next decade before a really coherent picture of Oceanic prehistory emerges.

CARLYLE S. SMITH
Department of Anthropology, University of Kansas, Lawrence

Statistical Questions in Optics

Fundamentals of Quantum Optics. JOHN R. KLAUDER and E. C. G. SUDARSHAN. Benjamin, New York, 1968. xii + 279 pp., illus. $13.50. Mathematical Physics Monograph Series.

Since optics consists of the generation, propagation, and detection of light, one would expect *quantum* optics to be the study of the quantum mechanical aspects of optical sources or wave fields or detectors, or perhaps all three at once. But all three have been capable of quantum mechanical description for nearly 40 years. So what is new in quantum optics? And why have we had to wait until 1968 to find a book to teach us the Fundamentals?

The answer to the first question is simply statistics. The newest aspects of optics are those in which statistical fluctuations and correlations, both classical and quantum, play an important role. Those aspects have been systematically investigated only within the past decade—which answers the second question.

Statistical studies are farthest advanced in what might be called propagation optics, the part of optics that deals with the free wave field, and it is now well understood how the coherence properties of an optical field propagate in space and time. The rest of modern optics, having to do with coherence in detectors and sources, has been studied very little, although it has been nearly 15 years since Dicke first pointed out the possibility of highly correlated "super-radiant" atomic states. The study of cooperative optical processes such as photon echoes and self-induced transparency in the past three years indicates a growing interest in this area.

In their book Klauder and Sudarshan have then necessarily confined their attention to the statistical description of free electromagnetic fields. All of the very recent developments springing from Glauber's use of "coherent" quantum states of the field and the discovery by both Sudarshan and Glauber of the diagonal representation of density operators are given full exposure. The statistical questions arising in intensity interferometry and photoelectric detection are treated extensively, principally from the point of view of quantum electrodynamics. The approach taken to these questions is very much in the spirit of mathematical, rather than theoretical, physics.

The book begins with a sketchy introduction to classical statistical optics, stochastic processes, and photoelectric counting. With specific situations and physical examples thus disposed of, the authors then plunge into four chapters of very general discussion of the statistical states of the quantized electromagnetic field. Optics as such does not intrude into the discussion until more than a hundred pages later, when the photodetection problem is treated again. In the final two chapters the quantum electrodynamic coherent state formalism is applied to a number of different model radiation fields and to intensity interferometry. There is a good bibliography with emphasis on the last five years, with comments appended to nearly every reference.

The imbalance that might be inferred from the foregoing summary is actually the principal strength of the book. The degree of care with which mathematical questions are considered throughout the book is unusually high. Especially in the fifth and seventh chapters this is the case, and there one may find any number of interesting results derived or summarized. However, this strength is a serious flaw as well. So much attention is devoted to the almost purely mathematical aspects of the subject that the physics behind it is easy to lose sight of.

For this reason the title of the book is far from appropriate. It's even a bit unfair to the prospective purchaser who is approaching the subject for the first time. What is treated here isn't really the fundamentals of quantum optics at all, but rather mathematical questions suggested by problems in quantum optics.

Most of the usual faults with books written on the run about currently fashionable fields of study may be found here. The treatise itself might better be called a "benjamin" than a book, since it sits securely in the limbo between lecture notes and monograph. As far as style goes it is even lumpier than might be expected for a two-author project. One can frequently find common slips of the spoken language, such as *classi-*