relatively large capacity for the storage of heat, its temperature can only change significantly by interaction with the atmosphere on a time scale of a decade or longer. However, ocean surface temperatures and near-surface heat storage are thought to be important components of shorter-term climate variability.

The second chapter of the book is concerned with global climate research, and the subjects of the 11 subsequent chapters are climate variability, atmospheric general circulation models, cloud-radiation interactions, land-surface boundary conditions, deserts, the cryosphere, air-sea interaction and the upper ocean, the overall ocean circulation, ocean monitoring, biogeochemical processes, and the role of carbon dioxide and other trace gases in the atmospheric radiation budget.

I found of considerable interest a paper by Yale Mintz that reviews all the general circulation model studies that had previously been carried out to explore the sensitivity of simulated climates to surface soil moisture and surface albedo. Because realistic and surface descriptions have not yet become available, the modeling studies serve to establish the sensitivity of model climates to generally large and unrealistic changes. Thus, they provide no basis for quantitative estimates of the impact of future land-use changes on climate. However, the climate changes revealed by the studies are sufficiently dramatic to promote considerable effort to improve the parameterization of land-surface processes in global models.

The most lengthy paper is one by J. D. Woods entitled "The upper ocean and air-sea interactions in global climate." An especially intriguing subsection on the boundary layer of the upper ocean conveys a sense that we are rapidly developing an understanding of the processes by which heat is exchanged between the atmosphere and ocean through the upper layer of the ocean. Yet the deeper layers of the ocean must also be recognized as important, a perspective defended by Carl Wunsch in the next chapter, which is devoted to "the problem of determining and understanding the climate state of the ocean itself—not its superficial role in forcing the atmosphere." A paper by Peter J. Webster and Graeme L. Stephens on cloud radiation interactions treats especially the autors' own contributions to this topic, which make up about a quarter of the reference list. The conclusion by K. Ya. Kondratyev and N. I. Moskalenko that background tropospheric aerosol warms climate by about 3°C is at odds with a recently published study by Coakley, Cess, and Yurevich which found that background tropospheric aerosol cools climate by about 3°C. The difference in the findings appears to result primarily from differences in the assumed optical properties of background aerosols and may reflect the present level of uncertainty about these properties.

Each chapter contains a comprehensive reference list, which is increased in value by the use of asterisks to indicate which referenced articles in turn have extensive reference lists. The book is recommended reading for anyone concerned about current research on global climate.

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Visual Cortical Function

Neuronal Operations in the Visual Cortex. GUY A. ORBAN. Springer-Verlag, New York, 1984. xvi, 367 pp., illus. $38. Studies of Brain Function, vol. 11.

Neuronal Operations in the Visual Contex is dedicated to P. O. Bishop, and that it is immediately suggests much of its content and flavor. Orban is one of a score or so of scientists, now scattered across the world, who have worked in Bishop's laboratory in Canberra and have come to value his quantitative approach toward investigating the physiological properties of single neurons in the visual system. Studies by these scientists have largely depended on technically sophisticated neurophysiological techniques and computer control of stimuli and data processing and display. Because publications by these scientists have been numerous, often technically complex, and sometimes narrowly focused, those of us who are not directly involved in such research will find the book extremely useful as a review, synthesis, and source of references. The book concentrates on the results of the last 20 years of research on the electrophysiological characteristics of neurons in the three major subdivisions of visual cortex in cats, areas 17, 18, and 19, and it nicely complements recent reviews of visual processing pathways from retina to cortex.

Much is written about the classification of cortical cells into basic types and the distribution of cell types according to cortical field, retinotopic position within a cortical field, and cortical layer. Orban concludes that the pioneering classification scheme for cortical cells of Hubel and Wiesel (1962) requires modification, and he replaces the simple to complex to hypercomplex cell sequence of serial processing with an A, B, C, S scheme that does not imply serial processing. Though Orban considers A and B cells as intermediate between simple (S) and complex (C) cells, A cells appear to be a type of simple cell and B cells appear to be complex. In this scheme the hypercomplex class is eliminated and the class property of a reduced response to elongated stimuli is regarded as a variable feature of all cell classes. A helpful table compares the A, B, C, S scheme with other classification schemes and shows that both A and B types have been considered both as simple and as complex by different investigators.

Given the evident importance of classifying neurons, it is unfortunate that there is no discussion of the goals and purposes of classification. Such a discussion would allow the reader to better understand the strengths and weaknesses of the A, B, C, S scheme and give him or her a feel for the types of modifications that will undoubtedly occur. A discussion of the problems of transposing a classification scheme based on cats to other mammals would also have been valuable. In this regard, Orban avoids the current debate over what cells in the lateral geniculate nucleus of monkeys are homologous to Y cells of the lateral geniculate nucleus of cats and presents one point of view without mentioning the other.

Orban goes on to discuss cortical cells as filters for different parameters of visual stimuli, including orientation, length, width, spatial frequency, velocity, and direction of movement. Cortical neurons characteristically respond over a limited range of values of a parameter, and the usual assumption is that by differing individually in selectivity groups of neurons code various stimulus parameters. Orban uses the different properties of cells and the different distributions of types of cells across the three cortical areas to speculate on the functions of classes of cells and cortical areas in vision. Though he argues that areas 17, 18, and 19 operate essentially in parallel, the anatomical connections of these fields indicate that cortical processing across these areas has both serial and parallel components.

Other parts of the book are designed to put the studies of visual cortex in the cat into a broader perspective. Thus, the basic visual systems of cats and monkeys are described and compared, the many cortical visual areas of cats are described, and the complicated connec-

tions of visual cortex in cats are outlined. These descriptions are useful, but they are not closely tied to the main theme. Except for a brief description of the response properties of neurons in area 17 of macaque monkeys, such research on mammals other than cats is largely ignored. Comparative statements about other mammals are few and sometimes seem naïve or motivated by a need to justify research on cats. Yet what the book does well it does quite well, and there is no comparable review of visual cortical processing and coding in the three main visual areas of cats.

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Molecular Neurobiology

Molecular Neurobiology. Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y., 1983. xxii, 921 pp., illus. Cloth (in two volumes), $125; paper, $68. Cold Spring Harbor Symposia on Quantitative Biology, vol. 48. From a symposium, Cold Spring Harbor, N.Y., June 1983.

This large volume combines the market appeal of molecular biology and that of neurobiology, the two fields of biology that, along with immunology, have grown the most rapidly during the past two or three decades. As Kandel in his thoughtful epilogue points out, one should not suppose that the publication of the book marks the sudden discovery of neurobiology by molecular biologists, for many turned their attention to the brain more than 20 years ago. It is only in the last few years, however, that rapid progress has begun to be made.

With respect to detailed molecular analysis of a membrane protein of critical importance to the function of the nervous system, studies of the acetylcholine receptor protein must rank as the supreme example so far. The receptor, which controls the fast opening of membrane channels for sodium and other cations in cells receptive to acetylcholine, has been purified to homogeneity, and understanding of the complex molecular architecture is well advanced. This has been achieved both by the classical techniques of biochemistry, the isolation and characterization of the receptor protein, and by the modern techniques of molecular genetics, by which means the entire primary sequences of all four different subunits of the receptor protein can be deduced from the DNA sequences of the cloned receptor genes. At the same time, electrophysiological techniques have advanced to the point at which recording of the opening and closing of a single receptor-controlled membrane channel has become a practical possibility. The studies of the acetylcholine receptor thus combine the most powerful new tools of electrophysiology with those of molecular biology in a most impressive manner, to give considerable new insight into the working of the system.

Also well advanced, along similar lines, are studies of the voltage-sensitive sodium channels present in all nerve cell membranes, which are responsible for the ability of these cells to propagate electrical signals.

Modern nucleic acid technology allows a new range of possibilities in analyzing the macromolecules synthesized in brain. By the use of screening techniques it is possible to focus attention on those mRNA species that are present only in brain and to try to obtain more information about the nature of the gene products that they represent. This is a formidable undertaking, for the number of different brain-specific mRNA species in mammals is high (estimates range from tens of thousands to hundreds of thousands). By focusing on narrower categories (such as brain-specific phosphoproteins), however, progress may be made quite rapidly.

Another approach is to study mRNA species specific for particular key enzymes in neurotransmitter metabolism, such as those coding for tyrosine and dopamine hydroxylases in catecholamine synthesis. Analysis of mRNA species or DNA sequencing of gene families may well be the most powerful tools for identifying novel brain peptides. It is already known that some three dozen small peptides exist in neurons and are probably released as a novel class of chemical messengers in brain. More neuropeptides are being discovered as the approaches of molecular genetics reveal the multiple gene families that specify most brain peptides and the molecular heterogeneity in each peptide family. Thus, the two morphine-like peptides [Met]enkephalin and [Leu]enkephalin are now known to be members of a family of opioid peptides numbering more than one dozen members and specified by three different genes.

Among the most intriguing problems facing neurobiology is to understand the complex mechanisms that regulate the development of the nervous system and the formation of appropriate connections between its individual cellular components. Here the study of nerve growth factors will be of crucial importance, as will the understanding of the neuronal cell-surface markers and adhesion molecules that determine recognition and cell adhesion during development.

The present volume reviews all of this and much more in more than 80 short papers. Overall it is an exciting book. It portrays a field of great scientific promise and intellectual vigor, with just an occasional note of arrogance. The volume is strongly recommended to all who wish to become acquainted with or to be brought up to date in this field.

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