stimulus is required for activation. Inactivation processes are so long-lasting that they are not yet characterized. The transmitters released by primary receptors and by many olfactory central neurons are not known, nor is the effect of the endocrine system on sensory responses. Cells of the olfactory cortex send and receive information from more brain regions than any other sensory system, and many of these are not yet physiologically characterized for odor inputs. Connections are diffuse rather than labeled lines. The stimuli and responses that regulate endocrine functions are not characterized psychophysically because this entire major olfactory component is subconscious. The compelling reasons for using the olfactory system as a computational model appear to be offset by the current paucity of experimental facts available to define the functions to be computed and the loops in which the computation occurs. Thus the olfactory system appears to represent a convenient and manageable model for making theoretical models of information processing in the brain. The limitations of our present biological knowledge make this system less useful for modeling and testing hypotheses about the sense of smell.

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Glutamate Panorama

Excitatory Amino Acids and Synaptic Transmission. H. V. WHEAL and A. M. THOMSON, Eds. Academic Press, San Diego, CA, 1991. xxii, 482 pp., illus. $129.

Receptors for glutamate are involved in the passage of signals through nearly every neuronal pathway in the central nervous system of vertebrate animals. This is manifest not only in the broad distribution of excitatory synapses using the AMPA and NMDA subtypes of glutamate receptor but also by a variety of other classes of glutamate receptors, such as those that stimulate transport activity or second messenger systems. Furthermore, the mysterious presence of conventional "synaptic" glutamate receptors on glia and the surprising ability of glia to transmit signals across cells enhance the importance of glutamate receptors in nervous systems. From any angle, it is hard to study neurobiology without confronting some process sensitive to extracellular glutamate. Of necessity, educating new- and old-comers in the field requires tying together diverse experimental and conceptual approaches. For example, receptor action in systems can only be understood in light of molecular details; conversely, the growing number of molecular variants of receptors can only be understood through their ultimate role in systems. In this regard, Howard Wheal and Alex Thomson have generated a valuable panorama of glutamate neurobiology in *Excitatory Amino Acids and Synaptic Transmission*.

Although the styles of the contribution necessarily vary, the writing is generally quite accessible. As a whole, the virtue of this book is its description of neural circuitry, synaptic plasticity, and disease built upon cellular and molecular descriptions of glutamate receptors and the glutamatergic synapse. The chapters are, with few exceptions, written to communicate many of the important issues and include ample technical background to achieve that goal. That this volume is constructed to educate is evidenced by two study aids: a detailed glossary of technical terms in the field, from *alpha function* to *transmembrane domain*, and an exhaustive chart of glutamate receptor agonists, antagonists, and channel blockers, complete with structures, notes on their action, and references to specific chapters.

The book begins with receptor classification and distribution in the brain. Four chapters describe radioligand binding techniques and the way these methods provide insight into receptor structure, diversity, and distribution. Binding studies, although difficult to interpret, formed much of the field's foundation and remain the techniques of choice in the development of the major pharmacological tools used in glutamate research. P. Krogsgaard-Larsen and colleagues describe how the exploration of families of chemically related compounds can provide insight into the structure of glutamate binding sites and suggest new avenues for drug development.

Another exciting theme is the heterogeneity in AMPA or NMDA receptor subtypes. This is emphasized in the chapters by D. Monaghan and K. Anderson and by T. Honore. These authors have used autoradiographic methods, ligand binding to membrane homogenates, and radiation inactivation techniques to discern multiple types of receptors. It will be interesting to see whether their categories are supported by physiological and molecular approaches and whether these lead to an understanding of the functional significance of such subtypes and the development of subtype-specific pharmaceuticals.

The biophysics of glutamate receptors in neurons and glia are ably represented. The topics chosen are generally current enough to provide interesting reading to those in the field but, I believe, are also accessible to nonspecialists. Additional features of these sections include details and history relating to experimental techniques that enhance one's appreciation of the literature. For example, J. Johnson and M. Mayer and colleagues relate some background on the techniques of solution exchange. The added methodology provides more than just details for the aficionada: without methods for very fast and complete application of receptor ligands, many of the biologically important properties of the glutamate receptors would have remained hidden. Additionally, the techniques have enormously facilitated the understanding of drug action at NMDA and AMPA receptors, as the work of Johnson and Mayer has shown. This, plus the occasional description of previously unpublished work, adds spice to the chapters and makes them more pleasurable to read than a monotonic enumeration of published works.

Synapses that use glutamate are involved in more than just excitation: they initiate and mediate those features that we associate with brain function and brain pathology. Many of these phenomena, from memory storage to seizure, are believed to be adequately modeled or represented in the hippocampus, and studies of the hippocampus are emphasized in this collection. Some of the chapters describe older work on epileptiform behavior in vitro. However, others review more recent observations on the microcircuitry within the hippocampus and suggest how this new information can, and must, be incorporated into models of synchronous discharge of neurons by glutamatergic synapses. Indeed, as Thomson and S. Radpour soberly point out, studies of synaptic activity that are designed without recognition of such local circuits are nearly "impossible to interpret" (p. 316). The importance of circuitry is well described in the chapters by R. Miles, R. Sayer, Wheal, Thomson, and their various colleagues. In particular, the chapter by Sayer and colleagues was most pleasurable reading for its succinct overview of local circuits, cable properties of dendrites, the quantal nature of transmitter release, and the conclusion that all of these must be understood to fully appreciate the complex synaptic phenomena of the brain.

R. Malenka and M. Lynch provide background on long-term potentiation of glutamatergic synapses and its possible cellular mechanisms, including the roles of postsynaptic second messengers and transsynaptic messengers. Although somewhat overlapping in content, these chapters provide nice introductory material for the chapter by W. Singer and A. Artola, which elegantly describes the role of long-term potentiation and depression of transmission

in the context of visual-system plasticity. This chapter is, in a sense, the culmination of the book, since it describes the pruning, stabilization, and reorganization of a neural circuit and proposes how this might occur through the action of glutamate receptors.

The field of glutamate receptors is advancing with great momentum. Recent as this book is, the subject material, if drawn together now, might have different content. In the near future, one should expect books like this to have more emphasis on advances in the molecular and protein chemical structure of the receptor, the regulation of receptor function and expression, and the role of nitric oxide in synaptic plasticity. Regarding systems, future collections might describe information transmitted through glutamatergic circuits and the ways in which biophysical properties of receptors shape this communication. Nevertheless, this book is a timely and intelligent overview of neurobiology and should be a valuable resource.

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