World country in which exploitation of its own native wildlife is illegal. We provide over 80% of the market for neotropical psittacines—a total of some 1.4 million wild-caught parrots arriving legally and alive to our quarantine stations between 1982 and 1988 alone. An industry that garnered, during this period, more than $1 billion for American entrepreneurs left relatively little economic or other benefit in the countries of origin of these birds.

With its state-of-the-art information on parrot conservation, this book is certainly a must for any biologist or conservationist interested in parrots. In addition, the thematic approach it takes—a deliberate departure from the species-by-species approach taken by its predecessor, *Conservation of New World Parrots*, edited by R. Pasquier (Smithsonian Institution Press, 1981)—makes it a powerful case example of contemporary problems in conservation biology. Reflecting the field of conservation biology, the chapters in the volume represent a blend of basic science, human sociology, economics, management, law, and policy. Highlights include Munn's chapter with intriguing calculations of the value of ecotourism (and the first publication that I know of of some of his wealth of basic data on macaw reproductive biology); Butler's fabulous success story in the Lesser Antilles, the result of a truly innovative approach to saving showcase species (with benefits to many other, less conspicuous species sharing the same habitat); Clubb's surprisingly sharp admonition of private aviculturists, without the soft gloves others have used for this group of people who hold conservationists "over a barrel" with their possession of endangered species and who have yet to act responsibly as a group; Beissinger and Bucher's analysis of whether a harvest of wild psittacines is truly sustainable (including an honest discussion of the contradictions in exploiting a species you are trying to protect); Wiley, Snyder, and Gnam's well-balanced and tightly written chapter on the variable success of reintroductions; and Bucher's discussion of how to manage a species that is considered a pest by some and that is in imminent danger of extirpation. The only possible omission might be a full chapter on legislation (national and international), although various legal aspects are mentioned in several chapters and such information can go out of date quickly.


Techniques for capturing parrots as illustrated in the 16th-century Drake Manuscript. Lures to attract parrots are still widely used in the neotropics. [From J. B. Thomsen and A. Brautigan's paper in *Neotropical Wildlife Use and Conservation* (University of Chicago Press), reviewed 3 July; J. P. Morgan Library]

If the book has a fault, it would be some redundancy among the longer chapters. In particular, the criticisms of captive propagation in several chapters seem not only excessive in length but excessively pessimistic, particularly for a taxon such as parrots that will be kept and bred in captivity whether we conservationists like it or not. No one disputes that habitat preservation should be the highest priority, but I believe that conservationists should exploit the often extensive and healthy captive populations of endangered and threatened species that already exist within countries like the United States. No one says it will be easy, and conservation is not for the faint of heart. This is the ending sentiment and nutshell message of the volume. The problems are bad—very bad—and the word "crisis" does not overstate them. The word "despair" should not be in our vocabulary, however, and the volume offers a variety of solutions for saving one of the world's most appealing animals, with benefits extending to other species, including ourselves.

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## Sensory Studies

**Olfaction. A Model System for Computational Neuroscience. JOEL L. DAVIS and HOWARD EICHENBAUM, Eds. MIT Press, Cambridge, MA, 1991. xii, 319 pp., illus. $50. A Bradford Book. From a conference, Wellesley, MA, May 1990.**

The olfactory system has emerged from decades of obscurity to become a subject of wide interest among neurobiologists, experimentalists and theorists alike. There are multiple reasons for this. Thousands of genes may be involved in coding for odor molecular receptors, the anatomical organization of the receptor epithelium is of utmost simplicity, and projection areas of the olfactory bulb and olfactory cortex are architecturally much less complex than comparable structures for other sensory systems. Olfaction is unrivaled in its capacity for receptor neuron replacement and regeneration and for developmental plasticity in relatively mature animals. A variety of central nervous system cells trace their lineages to cells of the embryonic olfactory placode.

Experimental advantages are equally compelling. Stem cells for olfactory receptors grow and differentiate in culture, and the olfactory placode in organ culture becomes a functional receptor organ and establishes synaptic connection with olfactory bulb neurons in culture. Voltage-sensitive dyes allow simultaneous monitoring of odor-evoked activity in many cells geometrically layered to allow unambiguous interpretation of that activity. A variety of preparations allow membrane properties of receptor cilia and of receptor and higher-order neurons to be investigated.

This symposium volume examines, in a well-organized way, the advantages of the olfactory system for computational modeling of brain activity. About two-thirds of the volume consists of chapters on the anatomy, physiology, and plasticity of the olfactory system, and all are written from a computational perspective. There are models for the formation of molecular images and their transformations as the signals proceed centrally (Shepherd), models describing evoked responses of receptor cells and cells of the olfactory bulb (Kauer *et al.*), oscillatory responses of olfactory cortex (Ketchum and Haberly), subcortical and cortical interactions (Price *et al.*), and discussions of hippocampal connectional plasticity (Leon *et al.*) and its implications for memory processing (Lynch and Granger, Eichenbaum *et al.*).

The second part of the volume considers computational models of the olfactory system, with contributions from Wang *et al.*, Freeman, Granger *et al.*, Bower, and Hammerstrom and Means. The issues raised are provocative and the chapters provide a fair representation of much of current thought in this field.

One major issue, that of an adequate experimental basis for model building and theory construction, receives scant attention. Little is known about odor coding in receptor neurons. It is not known whether these cells respond to a few or many odorous chemicals or what concentration of

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