the most common and widely dispersed species, for example the tubificids *Limnodrilus hoffmeisteri* and *Tubifex tubifex*. Both these species are associated with eutrophic environments and can tolerate high concentrations of various metal ions (Chapman *et al.*). As the papers in this volume clearly indicate, a tremendous amount of research on these two and on a limited number of other widespread and common species is being done. The result is that the information on oligochaete production biology, ecology, and life histories is based on studies on a fraction of the species. The more "weedy" species are becoming extremely well known, and the biology of species living in polluted environments is much better understood than the biology of species living in areas of minimal human influence. Another consequence of this investigatory pattern has to do with population biology. Giere points to some interesting differences among populations in tolerance to stress in widely dispersed species and indicates that these populational differences may represent genetic differences. This theme is also sounded by Judith Grassle, the only person at the meeting who was not an oligochaete expert, on the basis of her work on the polychaete *Capitella capitata*, and is discussed by Brinkhurst in his postscript. Thus, though synecological patterns of normal environments remain poorly understood, the autecology of a limited number of species has been well enough investigated that populational subgroupings and genetic interactions can be characterized. Such investigations lead in turn to reinterpretations of taxonomic criteria and of the species concept as applied to the group. Since many oligochaetes reproduce mainly, or nearly exclusively, nonsexually, the results are of interest to biologists in general.

The main impetus for increased study of aquatic oligochaetes was of course the finding that a few forms were highly successful in extremely polluted waters (Caspers), but the result of the activity has been an increased understanding of the extremely important role these worms play in the ecology of soft, freshwater benthos in general. The paper by McCall and Fisher on bioturbation in Lake Erie is a case in point, as are the papers by Birtwell and Arthur on worms in the River Thames and Diaz on the transition between the marine and freshwater environments in estuarine situations.

Papers by non-English-speaking contributors were all, I suspect rather extensively, reworked by Brinkhurst. The net effect is a unity of style and format rare in proceedings volumes; it is a bit startling, however, to find a characteristically elegant Brinkhurstian turn of phrase in a paper by, say, a Russian author. With few exceptions, typographic errors are unobtrusive, and the references appear to be reasonably complete. Parts of Brinkhurst's systematic appendix are unnecessary in the context and would have been better presented in a systematic paper in a journal.

The book is important for its summary of ideas and information on aquatic oligochaetes and will be useful as a baseline survey on these worms.

KRISTIAN FAUCHALD
Department of Invertebrate Zoology, National Museum of Natural History, Washington, D.C. 20560

Insects in Neurobiology

Receptors for Neurotransmitters, Hormones and Pheromones in Insects. Proceedings of a workshop, Cambridge, England, Sept. 1979. DAVID B. SATTELLE, LINDA M. HALL, and JOHN G. HILDEBRAND, Eds. Elsevier/North-Holland, New York, 1980. xviii, 310 pp., illus. \$48.75.

Insects may be tolerated in neurobiology, but they are rarely admired. More often they are disdained by students of higher organisms for their lack of relatedness to mammals. Nevertheless, they have always managed to capture a small share of the general interest because of some singular characteristic such as the strangeness of their behavior or the geometrical complexity of their neuroanatomy. Now, as the study of receptors in the nervous system expands to take in the insects, they reveal once again a unique feature or two that should keep them from being relegated to the lowly status of poor relation to the vertebrates.

The collection of papers under consideration here presents a kaleidoscopic picture of research on biochemical, physiological, developmental, and behavioral issues unified by a concern with receptors, or the activators of receptors, in the insect nervous system. The subject matter encompasses much of what is currently of interest in the general realm of transmitter and receptor research: peptide transmitters, transmitter-sensitive adenyl cyclases and the role of cyclic nucleotides in neural responses, receptors for neuromodulators, a spectrum of cholinergic receptors from the central nervous system, and single-channel properties of a glutamate receptor. Also included are studies of the physiology of olfactory cells responsive to pheromones, studies of the ontogeny of receptors during neural development, and one paper on receptors in nonneural tissues for the molting hormone, ecdysone.

The studies that have made the best use of the chosen class of organism are those concerned with the biology of the receptors and their effectors, that is, with the functions the receptors mediate in the various parts of the animal where they are to be found. A paper by James Truman on eclosion hormone in the moth is a particularly good example. It explores the actions of a peptide secreted by the brain at the end of metamorphosis that sets off in the abdominal ganglia the sequence of neural events necessary for the pupa to emerge from the cocoon. Not only does this peptide (with its implicit receptors) act as a behavioral trigger, it subserves developmental functions in such a way that a ganglion, once exposed to eclosion hormone and activated, cannot respond to subsequent exposures. Moreover, in one species, many of the neurons actually degenerate in response to the peptide after they have served their behavioral function. Here the emphasis is on the role of the receptor rather than on the less accessible mode of its action, but the paper establishes a context in which the preliminary work that has been done on mode of action can be furthered.

At a level intermediate between an eclosion hormone, with its global effects, and an acetylcholine or glutamate receptor, with its more classical action, lie octopamine and its receptors, which are discussed in a paper by Peter Evans. This transmitter, found quite generally in insect nervous systems and studied most effectively in the locust muscle, has been shown to exert a modulatory effect on neuromuscular transmission, increasing both the muscle tension generated for each motor neuron impulse and the rate of the muscle's subsequent relaxation. Investigations into the mode of action of the transmitter were initiated with the demonstration of octopamine-sensitive adenyl cyclase activities in the cockroach thoracic ganglion and in the firefly light organ, another putative site of the transmitter's action. If octopamine participates in a general arousal system, as Evans suggests, then these insects may provide an excellent opportunity for studying the organization and strategies of such a system at the level of the whole nervous system as well as at the level of the macromolecules involved in the response.

Of the many studies dealing with the pharmacology, biochemistry, and physiology of more classical transmitter receptors, the work on acetylcholine receptors in *Drosophila* tends most strongly in the direction of assignment of biological roles to the multiple classes of these receptors that are found in the insect central nervous system. Work from the laboratories of Linda Hall, Yadin Dudai, and Eberhard Rudloff documents biochemically and cytologically the presence of a nicotinic-like cholinergic receptor in the fruit fly brain. Dudai has further demonstrated a muscarinic-like receptor and has found suggestions, based on behavioral effects of various drugs, of additional cholinergic receptors. The important point here is that the first steps in the use of genetic techniques to study such receptors have been taken by Hall with the discovery and preliminary mapping of a genetic variant of the nicotinic receptor in *Drosophila*. The variant has an altered isoelectric point, which has permitted the location of the gene responsible for the alteration to be narrowed down to one chromosome and will eventually yield a more exact map position. An ability to manipulate this (or any other) receptor genetically will distinguish these studies, for it will allow investigators to ask what role a particular class of receptor, defined by its genetic constituents as well as its pharmacological characteristics, plays in the central nervous system.

The prospects for the study of structure and function relations do not appear to be any better for insect receptors than they are for many other organisms. Even the most preliminary obstacles, the difficulty of obtaining pure material or the lack of physiological correlates, are at least as stubborn in insects as they are in other organisms. Similarly, the appearance of receptors during development in insects is not very accessible to perturbation except as one of many parameters of differentiation. An exception to these reservations can be clearly provided by the trump card of genetics in *Drosophila*, with its potential for dealing with questions on many different levels. What is required, however, is less rhetoric and more concerted effort on the part of the interested *Drosophila* laboratories to develop this potential by laying genetic groundwork for identifying the important genes. Then perhaps we can look forward to a day when the insect will reach as exalted a position in neurobiology as *Escherichia coli* has occupied in molecular biology.

RALPH J. GREENSPAN
Department of Physiology, University of California, San Francisco 94143

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