out similarities, differences, or relationships between the two classes of cell contacts. For example, N. B. Gilula ("Structure of intercellular junctions") discusses gap junctions as seen in freeze-fracture, but the corresponding chapter by A. Matus ("The chemical synapse: Structure and function") contains no discussion of the freeze-fracture image of chemical synaptic junctions or of the size of membrane particles, types of particle arrays, and the like. Some discussion tying the two parts together would have given the volume more coherence and might have forestalled the question of why these particular classes of intercellular contacts were chosen for it.

On the other hand, the individual chapters are well written and nicely organized. The chapters on the structure and function of gap junctions offer a good summary of current knowledge, from the freeze-fracture appearance of gap junctions of vertebrates and invertebrates and junctional permeability properties to the properties of newly established junctions and evidence for transfer, presumedly via the gap junctions, of endogenous intracellular molecules. In addition, the chapter by M. V. L. Bennett contains a welcome discussion of the evidence that gap junctions mediate the intercellular transfer of ions and molecules.

Interesting topics such as turnover and regulation of gap junctional particles, junctional specificity, and the use made of antibodies against isolated gap junctions are discussed only minimally because of the lack of information about them. Although the ubiquity of low-resistance junctions between nonexcitable cells of both embryonic and adult animals would suggest a fundamental role in cellular processes, the function of these junctions has yet to be demonstrated.

Other chapters deal with selected topics in the broader areas of synaptic physiology and ultrastructure, transmitter biochemistry, and neurospecificity. The final chapter, by C. R. Slater, deals with the formation and experimental modification of chemical synapses. This chapter contains fascinating results obtained in recent years, especially concerning the regulation of acetylcholine receptors of vertebrate skeletal muscle and the regeneration of and competition between nerves at nerve-muscle synapses. In addition, evidence concerning the primary events in the formation of chemical synapses, the transformation of the neuronal growth cone into a secreting nerve terminal, and the development of local transmitter sensitivity in the postsynaptic cell is discussed in some detail.

The book should be useful to cell biologists, developmental biologists, and neurobiologists who are already familiar with the subject and wish to read a summary of some of the more recent findings.

PAUL O'LAGUE
Department of Biology, University of California, Los Angeles 90024

Methods in Ethology

Quantitative Ethology. PATRICK W. COLGAN, Ed. Wiley-Interscience, New York, 1978. xvi, 364 pp., illus. $25.

Ethology has traditionally been a nonquantitative science. This is basically for two reasons. First, the Lorenz-Tinbergen school primarily responsible for the development of the field emphasized observation and inference rather than experiment, and, second, as Peter Slater aptly points out in his chapter in this book, it is by no means obvious just how behavior should be quantified. If one is to study unrestrained animals in their natural habitats, the key principle of classical ethology, then one must take what the animals choose to give rather than relying on the power of factorial experimental design. The resulting data are complex, messy, and often cryptic. What, then, is the ethologist to do?

That is the question this book attempts to answer in a series of chapters by ethologists expert in a variety of quantitative techniques. The range of subject matter is impressive, there being discussions of information theory, temporal patterns, cluster analysis, scaling, modeling, and a number of multivariate methods. All of the 11 chapters are written in the same format, with an introduction to the quantitative analysis in question, some examples of it, and a discussion of its limitations and pitfalls. Colgan has edited carefully, and the resultant relative uniformity of style belies the fact that this is a many-author work. The result is that the book is a useful survey of quantitative methods in ethology for professional ethologists and graduate students looking for ways to handle their data for maximum gain. Mathematical sophistication is not necessary for comprehension, although understanding of matrix algebra, standard statistics, and elementary calculus certainly helps.

Depending on their experience and interest, individual ethologists will have their own biases as to which chapters are most rewarding. Slater's chapter on data collection is valuable and thought-provoking and should probably be required reading for experienced ethologist and novice alike. I found Fagen's chapters (one coauthored by Young) on repertoires and temporal patterns a delight for clarity and style. Losey provides an excellent discussion of information theory, although my own regretful conclusion was that because of its drawbacks and excessive number crunching the approach is probably not worth the effort (except possibly for comparison by the same investigator between similar species). Sustare's chapter is an elegant summary of everything you ever wanted to know about systems diagrams even if you didn't know it was systems diagrams you were constructing. Colgan's chapter on modeling seemed to me less satisfying, perhaps because the subject is really too broad for the brief treatment afforded it.

In spite of its many virtues, however, I think the book gives insufficient attention to what may be the most important and difficult problem in quantitative ethology, one arising from the way behavioral data are usually taken. This is the question of what to regard as the sample and the attendant problem of inflated sample size. Difficulties of this nature are apparent throughout the book. An example is Colgan and Smith's discussion on p. 168 of a contingency table that consists of 939 dyads, but from only four fish. The sample is taken to be the dyads, but one can argue that $N = 4$, namely the individual fish. The authors skirt this problem. Losey in his chapter on information theory deals with possible bias introduced by exceptional individuals and uneven contributions from different individuals but does not deal explicitly with the sample size problem. The assumptions involved in statistically treating acts rather than animals need to be emphasized and dealt with explicitly; in this book they are not.

My other caveats are best summarized by Fagen and Young at the close of their chapter on temporal patterning:

> We are frankly skeptical about the value of many quantitative methods currently in use in ethology, and especially of the more complex formalisms. Quantification of perfectly adequate verbal descriptions of behavior is not what we mean by "quantitative ethology." Is any insight really gained by reducing a data set of 10,000 behavioral acts of 10 types to a first-order transition matrix of 100 numbers of unknown accuracy? . . . By contrast we strongly support the modeling approach, and we feel that judicious quantification is an essential aspect of the ethological approach to behavior.

HUGH DINGLE
Department of Zoology, University of Iowa, Iowa City 52242