sufficient attention is given to the role of the flight period in the life cycle or to the features of free flight by individuals. No readily discernible logic underlies the sequence of topics. Considering the range of the book, some articles have too much jargon and too little perspective. And inevitably, some are already seriously dated (from summer 1974).

On the whole, though, the synthetic, as opposed to reductionist, approach of this volume is very attractive and should have widespread appeal to those interested in insects, behavior, and biology.

DAVID BENTLEY
Department of Zoology, University of California, Berkeley

Invertebrate Structure

A Functional Anatomy of Invertebrates. V. FRETTER and A. GRAHAM. Academic Press, New York, 1976. viii, 590 pp., illus. $31.

The vast domain of invertebrate zoology, rich in tradition and largely untainted by economic necessity, stands today as a testament to the power of the comparative method in phylogenetic reconstruction championed a century ago by T. H. Huxley. Those groups that menace man, notably the parasitic worms and the insects, have largely seceded from the invertebrates as we know them in undergraduate classes, leaving us with a long parade of diverse animals, many of them obscure, most of them very beautiful, the delight of connoisseurs. They are the stuff of courses that range from the worst of pickled assemblages to the highest delights of marine stations.

Textbooks for such diverse material can be thick catalogs, packed with anatomical details that define systematic position, enlivened with some bits of biology, and held together with phylogenetic speculation. An alternative approach takes function as the primary theme, but it is difficult to fit texts of that type, excellent though they may be, into courses that follow a systematic sequence.

A compromise solution is now offered by Fretter and Graham in *A Functional Anatomy of Invertebrates*. Groups are presented in systematic order, with recourse where appropriate to Huxley's method of describing a representative type in detail. Structure is presented with emphasis on what it does and how it does it. Successive phyla are treated in 14 closely written, informative essays that cover broad classification, organization of a type, and such topics as feeding and digestion, locomotion, excretion, osmoregulation, and reproduction. All are beautifully illustrated with sensitive, lively line-and-stipple diagrams that are models of clarity even when they are printed smaller than they deserve. They shine in comparison with those of comparable textbooks and will be the most attractive feature of the book to many readers. It is a delight to see the illustrative style adopted by these eminent authorities on the Mollusca extended to other groups, especially the annelids, which are superbly treated.

No single volume of reasonable size can be expected to give adequate coverage to all invertebrate phyla. Emphasis necessarily reflects personal taste, but it is a disappointment, at least to one with admittedly arthropocentric attitudes, to find that whereas annelids receive 100 pages and mollusks 80 the land arthropods are disposed of in 18, of which barely 30 lines concern the arachnids. A break with tradition is the unexplained exclusion of the lower chordates. This may be justifiable on the grounds of phylogenetic relationships, but the functional anatomy of these animals is best considered in an invertebrate context.

Manton's views on arthropod evolution are admirably epitomized; the emphasis on polyphyletic pathways and grades is reflected in the absence throughout of evolutionary trees. A serious error is perpetuated in opening the section on arthropods with the statement that the cuticular exoskeleton is composed of chitin. The cuticle is in fact composed of sclerotized protein, variably strengthened with chitin fibrils as in fiber glass. Variations in the composition of the cuticle provide some of the marvels of functional anatomy, and the book is the poorer for ignoring them. It is the lipid component of the cuticle, not the degree of tanning as stated, that serves the function of waterproofing.

As might be expected, Mollusca provide the high points of the volume, though the cephalopods get scant attention.

A pervasive shortcoming in a book that in its preface celebrates the bioengineering approach is the virtual absence of any such analyses beyond the level of bioplumbing. Quantitative treatments are rare. Ciliary action is touched on in the account of protozoan locomotion, but the emphasis is on microstructure rather than mechanics. The discussion of the arthropod cuticle includes no significant account of its profoundly important mechanical properties, especially in relation to flight; resilin, the remarkable animal rubber, is not mentioned. An account of the hydrodynamics of cephalopod locomotion could well have displaced some material of lesser functional significance in the mollusk chapter.

The functional approach of the book is used to justify a somewhat flaccid approach to systematics that will cause confusion to students. The authors properly emphasize the arbitrariness of units in the hierarchical classification but thus justify bald listings of taxonomic groupings at the end of each chapter without any indication of hierarchical level other than degree of indentation. Fortunately, these pages provide ample white paper for annotation.

In summary, this is a book notable for the general quality of its discursive essays on invertebrate structure and its admirable illustrations, but one that falls short of its proclaimed goal of bioengineering functional anatomy.

JOHN S. EDWARDS
Department of Zoology, University of Washington, Seattle

Insect Behavior

Evolution of Instinct. Comparative Ethology of Hymenoptera. KUNIO IWATA. Translated from the Japanese edition (Kanagawa Prefecture, 1971). Amerind, New Delhi, 1976 (available as PB257052 from National Technical Information Service, Springfield, Va.). xii, 536 pp., illus. Cloth, $13; microfiche, $3.

Kunio Iwata has been studying the behavior of wasps and bees for half a century, beginning, he notes, shortly after the appearance of the Japanese translation of Fabre's *Souvenirs Entomologiques*. His *Comparative Studies on the Habits of Solitary Wasps*, published in 1942, provided a needed synthesis of studies up to that date and stimulated many young investigators (including this one) to enter this field of research. Two of Iwata's trademarks were already evident in this earlier work: his practice of including a great many data in tabular form, permitting quick comparison; and his use of behavioral formulas, in which individual behavioral elements are indicated by a single letter, so that the sequence of behavioral acts can be quickly compared in different genera.

The present book is in a sense an expansion and updating of the 1942 monograph, though the organization is much different and the coverage broader. *Evolution of Instinct* was published in Japa-

nese in 1971, and coverage of the literature is complete through 1969. Through the efforts of Karl V. Krombein (who provides a foreword), the book is now available in a translation by Alamelu Gopal. Despite sometimes awkward phraseology and use of words, perhaps inevitable because of the great differences in the languages, Iwata's meaning is always clear. Once again students of insect ethology are deeply in debt to Iwata for his untiring efforts at synthesis and interpretation of a mass of data in several languages. Especially appreciated is the first coverage in English of numerous papers originally published in Japanese, for example those of Okada and Shida.

The title of Iwata's book is somewhat misleading. Although the approach is strongly comparative, the major concern is with the phylogeny of behavioral traits rather than with selection pressures or modes of behavioral evolution. Iwata believes that "it is contradictory for a group to be both advanced and primitive." But does a group exist that is not an amalgam of generalized and specialized features?

With respect to the subtitle, it should be explained that no complete coverage of the Hymenoptera has been attempted. The ants are omitted entirely, and short shrift is given to the sawflies. Coverage of the parasitoids and bees is less thorough than that of the wasps, and such topics as the origin of social behavior and the phenomenon of cleptoparasitism are covered only incompletely. As Iwata states in his preface, he is concerned mainly with "maternal" behavior, that is, the ways in which the female provides for her offspring. Such topics as mating, grooming, and male territoriality are not discussed. A full exposition of the behavior of Hymenoptera would, after all, require several volumes. Within its sphere this book is replete with data gathered from a great many sources and organized in such a way as to suggest innumerable avenues for further research.

A few years ago John B. Free commented (in reviewing another book on wasps), "The contribution that wasp studies have made to the field of animal behavior is quite remarkable." With Iwata's book as a stimulus and source of background information, persons intrigued by the behavior of Hymenoptera are likely to bite deeply into the many problems still to be solved.

HOWARD E. EVANS
Department of Zoology and Entomology, Colorado State University, Fort Collins

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