Book Reviews

The Perfect Societies

Animal Colonies. Development and Function through Time. RICHARD S. BOARDMAN, ALAN H. CHEETHAM, and WILLIAM A. OLIVER, JR., Eds. Dowden, Hutchinson, and Ross, Stroudsburg, Pa., 1973. xiv, 604 pp., illus. $35.

The study of sponges, corals, and other colony-forming invertebrate animals is circumscribed by a paradox. These organisms are for the most part anatomically simple, and in some cases they are phylogenetically very primitive, yet by most intuitive criteria their societies are the most advanced among living organisms. In fact some are just about perfect. In zoology the very word colony implies that the members of the society are physically united, or differentiated into reproductive and sterile castes, or both. When both conditions exist to an advanced degree, as they do in many of these animals, the society can equally well be viewed as a superorganism or even as an organism. The dilemma can therefore be expressed as follows: At what point does a society become so well integrated that it is no longer a society? On what basis do we distinguish the extremely modified members of an invertebrate colony from the organs of a metazoan animal?

These are not trivial questions. They address a theoretical issue seldom made explicit in biology: the conception of all possible ways by which a complex organism can be created in evolution. The coelenterate order Siphonophora, which includes the familiar Portuguese man-of-war, is a case in point. A swimming siphonophore superficially resembles a jellyfish but is actually a complex assemblage of highly reduced individuals variously specialized to provide locomotion, protection, reproduction, and other functions on behalf of the colony as a whole. So complete are the dual processes of differentiation and integration that the colony cannot be regarded as functionally distinct from a scyphozoan jellyfish or some other complex coelenterate individual. As G. O. Mackie has pointed out, the signal achievement of the Siphonophora has been to reach the organ grade of body construction by converting individuals into organs. If other Precambrian invertebrate lines had not invented mesoderm, modern higher animals might well be designed as diploblastic superorganisms in the siphonophore manner.

Animal Colonies is a multiauthored volume based on a symposium of the Paleontological Society held in Washington, D.C., during November 1971. Its purpose is to explain current understanding of the nature of invertebrate colonies, exclusive of those in the social insects. The 26 chapters represent a fair sample of current research efforts and display both the strengths and weaknesses of existing knowledge. The comparative anatomy and reconstruction of colony evolution are revealed to be quite advanced. Since the skeletons of such groups as corals and graptolites make excellent fossils, and living species are both numerous and diversified, the phylogenetic reconstructions are mostly excellent. Examples include the chapters on corals by A. G. Coates and W. A. Oliver, Jr., and by F. M. Bayer, on bryozoans by R. S. Boardman and A. H. Cheetham and by John Utgaard, and on graptolites by Adam Urbanek and by Valdar Jaanusson. In some cases, as in D. L. Kissling's analysis of Silurian corals, even the ecology of the extinct forms can be partially inferred by reference to the correlates existing between colony structure and habitat among living species.

Some progress is being made on the physiological basis of coordination among the colony members. Mackie's study of the siphonophore *Nanomia* has disclosed that the individuals behave to some degree as independent units but are also subject to considerable control from the other members. Each swimming bell, for example, has a separate nervous system that determines the frequency of contraction and the direction in which water is squirted to provide the propelling power. However, it remains quiescent except when aroused by excitation arriving from the rest of the colony. If the rear parts of the colony are touched, the forward bells begin to contract and the others join in. Experiments have shown that the coordination is due to conduction through nerve tracts joining the bells. If the colony float (an individual in its own right) is touched the swimming bells reverse the direction of their jet propulsion and drive the colony backward. However, the conduction that coordinates this movement is not through nerves but through special cells in the epithelium.

Another promising new direction is the analysis of the ecological basis of polymorphism in colonies. Why have the individuals of some species differentiated into highly specialized castes, while those of others retain a generalized body form and nearly complete independence? T. J. M. Schopf develops the theory that specialists are more likely to evolve in stable, predictable environments, while generalists—and the monomorphic colonies they form—succeed best in the most rapidly changing environments. This prediction accords well with the observed facts in the bryozoans. In a complementary paper, K. W. Kaufmann links the pattern of bryozoan colony growth to the kind of substrate on which the species settles and the most profitable rate at which the colonies can grow.

The colonial invertebrates deserve wider attention among biologists than they have received, and I therefore regard it as a serious fault of *Animal Colonies* that most of its chapters are written in excessively technical language. I will go further—this subject has become jargon-ridden. The authors are evidently writing for each other in essentially the same language with which they spoke at the Washington conference. The general introduction, written by the editors, is quite good as far as it goes, but in four pages it is scarcely able to mention some of the basic issues for which the reader is to seek documentation in the later technical chapters. Certain animal groups containing colonial species are omitted entirely; these include the turbellarians, rotifers, entoprocts, polychaete worms, rhizocephalan crustaceans, phoronids, pterobranchs, and tunicates. No comparisons with colonial bacteria, proto-

zoans, and cellular slime molds are attempted, even though the adaptations are in some cases parallel and pregnant with theoretical implications. For a systematic account of animal coloniality it will still be necessary to consult the first volume of W. N. Beklemishev's *Principles of Comparative Anatomy of Invertebrates*. But even this review is overly brief and unnecessarily technical, leaving the need for a modern general synthesis of the subject largely unfilled.

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Neural Bases of Rhythmicity

Neurobiology of Invertebrates. Mechanisms of Rhythm Regulation. Proceedings of a symposium, Tihany, Hungary, 1971. J. SALÁNKI, Ed. Akadémiai Kiadó, Budapest, 1973. 494 pp., illus. $24.

In his introductory remarks to this satellite symposium of the 25th International Congress of Physiological Sciences Salánki notes that "rhythmicity and cyclic character is one of the rules of the living processes." The proceedings volume presents 33 papers examining aspects of rhythmicity at various levels of biological organization.

In line with the current emphasis on physiological analysis of arthropod and molluscan nervous systems, little attention is given to rhythmic phenomena in invertebrates other than crustaceans, gastropods, insects, and pelecypods.

Most of the papers may be cataloged under three topic categories: the cellular basis of pacemaker rhythmicity, the regulation of cardiac rhythms, and the generation of rhythmic behavior patterns.

Three papers examine the contributions of K^+ conductance changes and Na^+ pump activity to the generation of neuronal pacemaker activity. The reports of Carpenter and of Wachtel and Wilson respectively support the primary pacemaking role in *Aplysia* of K^+ conductance changes and of Na^+ pump activity. A synthesis of these contradictory results is suggested by Livengood and Kusano, who demonstrate in the crustacean cardiac ganglion that rhythmic pacemaker activity is most likely generated by a decrease in K^+ conductance and modulated by an electrogenic Na^+ pump.

Several papers deal with the role of neurotransmitters, neurohormones, and pharmacological agents in the regulation of cardiac rhythmicity. Among the most interesting are the three by Greenberg *et al.*, Miller, and Richter, who examine the cardioregulatory effects of extracts from neural tissues. A lively discussion erupts when Miller demonstrates the myogenic nature of cockroach heart rhythmicity.

Complete analysis of the neural generation of complex rhythmic behavior patterns requires quantitative study at two levels: detailed analysis of motor neuron activities that generate the behavior, and intracellular recording from the neuronal elements that participate in the generation of the motor neuron output. Elegant examples of the first type of study are provided in this book by Elsner's paper on grasshopper courtship and Wyman's statistical analysis of dipteran flight motor neurons. Reports of intracellular examination of neuronal interactions in the locust, presented by Hoyle, and in *Tritonia*, presented by Willows, provide new insight into the structure of the neuronal circuits which generate rhythmic motor outputs.

As Prosser notes in his concluding remarks, this symposium was characterized by the diversity of topics considered. Unfortunately it was also afflicted by a great disparity in the interest and quality of the work presented. Some papers are excellent, providing concise reviews of recent work with supporting experimental data. These are counterbalanced by several papers of poor quality which in terms of ideas, experimental design, and results presented should have been excluded from this volume.

A general characteristic of most papers in this symposium is insufficient breadth for the general reader in physiology or zoology and insufficient depth for the interested comparative neurophysiologist. While I cannot recommend the book to the general reader, about two-thirds of the papers do present work of sufficient interest to merit the attention of the neurobiologist. For the neurophysiologist interested in rhythmic phenomena the book contains a sufficient number of provocative discussions supported—in part—by experimental data to merit inclusion in his or her personal library.

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Instruments and Their Use

The Encyclopedia of Microscopy and Microtechnique. PETER GRAY, Ed. Van Nostrand, Reinhold, New York, 1973. xii, 638 pp., illus. $32.50.

Microscopy is covered by five pages of contributors from Acanthocephala to zoom microscopes, in alphabetical order, and an index facilitates access to the material. The statement that this is not a second edition of Clark's *Encyclopedia of Microscopy* (1961) precludes comparison with that work. Gray has included useful information on stains and preparation methods from his earlier out-of-print books. This book is new and different.

Many of the biological entries give preparation technics and information useful to microscopists. Most entries have up-to-date reference lists. Some (automatic histology, fluorescence, Quantimet, reconstruction, stereo, zoom, and others) fail to indicate that more is known than is given in the entry itself. The illustrations vary from excellent to poor. Most of the entries should be usable for high school seniors and college freshmen; a few (holography, resolution) use simple mathematics.

Industrial microscopy is included: atmospheric, bakery products, clay, metals, sand, and so on. Microscopes receive less full treatment than preparation methods. For example, the account of polarized light microscopy is limited to crystallography and fails to indicate its usefulness in particle identification or biological applications. Resolution is discussed in several entries and one ten-page entry that fails to mention modern work of Charman, Osterberg, van Duijn, and others. It does compare optical and poor electron microscope pictures of diatom shells. Diatoms are not listed. Only the entry on photomicrography mentions accommodation of the eye with reference to depth of field and focus.

Of recent active methods, stereology and, in a limited way, microspectrophotometric methods are recognized. I am amazed that interference microscopy (except for a listing under another topic) and the considerable developments and trends toward automated microscopy are not included. The item on blood fails to mention instruments developed for automatic blood counts, nor does the item on chromosomes mention computer methods for typing and analysis. The only entry along these lines is Quantimet, which lacks refer-