Book Reviews

A Special Invertebrate

The Anatomy of the Nervous System of Octopus vulgaris. J. Z. YOUNG. Oxford University Press, New York, 1972. xxxii, 690 pp., illus. $35.25.

Cephalopods are unique among invertebrates in having brains and sense organs comparable in size, complexity, and general design to those of vertebrates. The resemblances are entirely due to convergence, but they are no less striking for this reason, and it is possible to feel a sense of kinship with an octopus that one can never feel with an insect or a crab. An octopus has a personality. He behaves differently from other octopuses. His behavior is largely the product of individual experience. In the octopus, man can recognize a stranger and a brother, a sapient being from another world.

The brain of an octopus has between 1 and 2×10^8 nerve cells, compared with 1 to 2×10^{10} in the human brain. There are 30 distinct lobes, differing in numbers and types of cells, amounts of neuropil, fiber distribution pattern, and types of synaptic connections. There are higher and lower motor centers, receptor analyzers, memory stores, and centers concerned with motivation and the pursuit of goals.

Octopuses can accurately distinguish textural differences with their suckers, although they appear to be insensitive to differences in the shape and weight of objects handled. They cannot hear, but they have acute vision and color sensitivity. Suitably rewarded or punished, they learn to modify their behavior. Learning is rapid and memories are retained for lengthy periods. They can learn both by sight and by touch, using different parts of the brain.

These facts have been made widely known to the general zoological public through the writings of J. Z. Young, M. J. Wells, and others, particularly over the last decade. Now, in the present volume, Young provides what he calls "a progress report on the functional anatomical organization of the octopus brain mainly at the level of light microscopy." As a progress report it is remarkable in being 690 pages long and having taken oven ten years to produce. Far from being a mere summing of the main themes, it is a compendious and very largely original work of scholarship, beyond question the *opus major* in its field. It is also, as B. B. Boycott states in his interesting historical introduction, a monument to Young's creative industry as an anatomist.

All the main components of the nervous system are dealt with: the brain, the eyes and statocysts, the stellate ganglion, the nervous system of the arms, where much reflex activity is locally organized, the blood supply to the nervous system, the glia, and the neurosecretory tissues. There are appendices on surgical and histological procedures.

Contributions by P. Graziadei, J. B. Messenger, R. D. Lund, and P. R. Stephens are included, but in such a way that there is no break in continuity, and only minor stylistic differences can be found from one part to the next. Indeed, a striking thing about this book is the craftsmanship with which it has been put together. The print is unusually large. Line drawings and optical and electron micrographs are grouped together in logical and esthetically pleasing formations.

One glance at this volume and its page upon page of superb illustrations of Golgi and Cajal stained nerves leaves no doubt that we are dealing with an anatomical treatise, but the approach is strongly functional throughout. Without consulting Young's other writings one can get a clear picture from this account of the general way in which the brain works and how it has evolved. On this latter point, a comparison with the primitive *Nautilus* is included in chapter 1. All this will tend to increase the interest of the volume for the large group of people who are not specialists in the field but who try to keep up with the cephalopod work because of its general significance for evolutionary and comparative neurology.

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Living Machines

How Animals Work. KNUT SCHMIDT-NIELSEN. Cambridge University Press, New York, 1972. vi, 114 pp., illus. Cloth, $5.95; paper, $1.95.

This book is a little gem; it treats in an authoritative and charming manner a number of physiological and morphological adaptations which animals evolved in coping with certain environmental exigencies. The title is broad; after all, the verb "to work" occupies nearly one finely printed three-column page in the Oxford Universal Dictionary. Flying, swimming, and breathing are discussed, and they all involve work, but what really ties the chapters together is the attention to evolutionary finesse which often leads to energy saving in the performance of gross metabolic activities. Since the author's lifework has been done with vertebrates, mostly birds and mammals, and since more is known about their energetics, locomotion, excretion, and so on than of like aspects of invertebrates, it is not surprising that the latter, and even fish, get rather short shrift. That is not to say that fish are not mentioned where appropriate, as in the excellent chapter on countercurrent mechanisms where the difference between exchangers and multipliers is properly stressed and lucidly explained.

The book is short, and even though it treats a few general topics only, it covers a lot of ground. Through the selective marshaling of facts, it strives, successfully, and effortlessly at that, toward the exposition of principles. It so conveys Schmidt-Nielsen's excitement with his own research that I read it in one sitting, as did Torkel Weis-Fogh, the head of the department of zoology at the University of Cambridge, who wrote a short foreword. Specific chapters deal with respiration and evaporation, panting and heat loss—this one with a subsection headed "on cooling hot dogs"—with the special anatomy that makes for highly efficient gas exchange in the bird lung, with energy costs of activity, with countercurrent devices in various organs, and with body size and the problem of scaling.

The first chapter, for instance, ends with an account of the Stirling heat engine, which, to quote from the book, "utilizes the same principle as that which is the single most important factor in the water balance of small rodents in some of the hottest deserts of the world." Amusingly enough, when I read *How Animals Work* I happened