although certain aspects have of necessity been considered only superficially, most of the major subjects have been given sufficient consideration to permit the reader to obtain more detailed information with the use of the ample bibliography. Proceeding from a definition and consideration of the structure and chemistry of estuaries, Green moves on to encompass most aspects of the life history of estuarine animals and plants. Although a different organization might have been preferable, his treatment of plankton, macrobenthos, microbenthos, the freshwater component, the terrestrial component, estuarine fish, estuarine birds, and estuarine parasites does follow an orderly progression. The examples are taken from studies of estuaries throughout the world and usually from relatively recent research, although in some cases an earlier, classic work is used as the reference. The diagrams and figures, many of which are original, are well done and carefully selected to convey the points under discussion. There is a reasonable balance between field observations and experimental studies, although in certain cases one would have hoped for a greater emphasis on certain physiological aspects. The only part of the book which might have been improved by greater attention is the index. Although the indexing of authors' names and scientific names is more than adequate, many subject headings have been omitted. For example, in spite of the treatment which the text gives to the general subject of ionic regulation and osmoregulation, these headings are not included in the index. The book can be highly recommended to undergraduate students who are seeking a general introduction to estuaries, their fauna, and the unique aspects of these highly productive portions of the sea.

JOHN D. COSTLOW, JR.
Duke University Marine Laboratory, Beaufort, North Carolina

Connections in the Nervous System

Interneurons. Their Origin, Action, Specificity, Growth, and Plasticity. G. ADRIAN HORRIDGE. Freeman, San Francisco, 1968. xxiii + 436 pp., illus. $12.50. A Series of Books in Biology.

Adrian Horridge, who previously coauthored *Structure and Function in the Nervous Systems of Invertebrates* with T. H. Bullock, wrote this book with three stated purposes in mind: to update the first nine chapters of *Structure and Function;* to describe the evolution of behavior through the evolution of neuronal connectivity patterns; and to develop a general description of the properties of interneurons by using a variety of examples from the nervous systems of different animals. Each of these tasks is large, and the attempt to deal with all three in one format has resulted in a broad but uneven book. This fault is regrettable, because some sections of this book are good and would stand better alone.

For example, the early chapters on the evolution of connectivity patterns in lower forms, although not sufficiently detailed to update the scholarly *Structure and Function*, are nonetheless delightfully informative. Exercising both a fine grasp of detail and perspective, Horridge traces the development of cellular communication from intracellular controls in protozoa to the intercellular conduction in non-nervous (ciliary) cells and in nervous nets in simple metazoa. Particularly interesting is the suggestion that one of the early functions of the nerve net is to inhibit the endogenous pacemaker activity of the non-nervous ciliary cells. Horridge next considers the rules of neuronal connectivity that are essential for development of higher central nervous systems and suggests that they can first be recognized in jellyfish and certain swimming anemones in which two independent nerve nets coexist. One nerve net is concerned with the coordination of symmetrical swimming movements, the other with coexisting behaviors such as feeding. The basic rule is: specificity. Each neuron must connect only with neurons of its own net; it cannot indiscriminately synapse with any neuron it encounters.

Horridge next takes up synaptic transmission and the cellular properties of more highly differentiated nervous systems. Here Horridge seems on less familiar ground, and he begins this section on a biased note ("a thorough knowledge of the ionic nature of the membrane currents or of the biophysical features that make neuron membranes excitable is of little help in explaining how neurons coordinate behavior") and runs speedily on.

Horridge goes on to describe well-differentiated ganglia and central nervous systems. Using the cardiac ganglion of crustacea as a transitional example, he considers in turn the ganglia of the annelid CNS (discussing variations in the giant fiber systems), the ladderlike cords of arthropods, and the vertebrate sensory systems. There are additional chapters on the development of neuronal connections and on learning. The section on learning, an area to which Horridge has himself contributed importantly, is particularly valuable.

The last two chapters are on features common to interneurons and on limitations inherent in interneuron studies. These chapters are essentially collections of aphorisms and they highlight the weaknesses of the book. One weakness is the repeated attempt to describe the properties of interneurons as if they were a specific class of cells whose properties were so well understood and distinctive that they could be clearly distinguished from other neurons. Actually, the biophysical properties of all neurons are remarkably alike, not only in different regions of the same brain but even in different brains. What distinguishes interneurons from each other and from motor and sensory cells is the way they are interconnected, and this will of course vary greatly from region to region and from brain to brain. It is therefore possible and even profitable to speak of interneurons in a restricted and specific sense and to examine the functional differences between a monosynaptic reflex, where sensory neurons synapse directly on motoneurons, and a polysynaptic reflex, in which a number of interneurons are interposed between the input and output neurons. Here one compares two anatomically distinct connectivity patterns to see what interneurons add to the dispersion and transformation of neural activity and to the generation of reflex behavior. By contrast, it is difficult to describe the properties of interneurons in a general sense, because the term thus used refers to all neurons in the brain which are neither primary sensory nor primary motor, and the interconnections of most neurons in most brains cannot as yet be specified.

Horridge unfortunately assumes as his task the description of interneurons in the general sense. He manages well in systems where the available anatomical and physiological knowledge is sufficiently detailed to encourage reasonable guesses as to how neural informa-

tion is sequentially transformed. However, where anatomical information is lacking he is reduced to making vague generalizations. For example, in the section on instincts and interneuron growth he writes: "The only explanation of innate behavior is that interneurons grow and mature their connections in particular patterns which are derived from hereditary material" (p. 315). In another context he writes: "Basically, the properties of interneurons are an inescapable a priori of behavior. Perhaps the whole mind-body relation depends upon them . . . What any man or animal perceives or does, and all human conceptions, are restricted by the limitation of interneurons" (p. 372). In this context the properties of interneurons are equated with the properties of brain, and Horridge adds little but his justifiable admiration to our understanding of the complexities of central nervous system functioning.

The other problem with this book is its scope. In order to cover so many topics in a short monograph Horridge is forced to summarize rapidly large bodies of research. The reader is often not told how certain data were obtained, and most factual statements are not documented by references to the literature. As a result this book provides a rather personal account of Horridge's interesting and provocative view of the nervous system and will be of most value to those who enjoy following his train of thought. Other readers may benefit less, for the book is likely to prove difficult for the beginning student and impressionistic for the specialist.

ERIC K. KANDEL
Departments of Physiology and Psychiatry, New York University School of Medicine, New York

Mathematics

A History of Mathematics. CARL B. BOYER. Wiley, New York, 1968. xviii + 717 pp., illus. $10.95.

At last there is a history of mathematics that can be recommended without reservation. Making full and critical use of recent scholarship, Boyer has avoided major errors of fact or interpretation. And unlike several currently popular handbooks, the work is neither too concise nor too elementary.

The guiding principle of Boyer's book is that continuity in the development of mathematical ideas is the rule rather than the exception. Important ideas of modern mathematics, such as infinity, coordinate geometry, and the striving toward generality and rigor, are discussed in their ancient and medieval settings. The author makes judicious assessments of the influence and importance of individuals and schools, and illustrates his generalizations with well-chosen examples. Especially praiseworthy are the chapters on medieval European mathematics and early-17th-century mathematics, areas which Boyer's own research has illuminated.

Mathematicians will be most interested in the last quarter of the book, which gives a fine account of mathematics since 1789. Of particular excellence are the chapters on "The rise of abstract algebra" and "The arithmetization of analysis." Also worthy of notice are the discussion of the nature of modern mathematics that begins the last chapter, "Aspects of the twentieth century," and the treatment of Hilbert's Problems which helps organize that chapter. A high level of mathematical sophistication is reached, and the author has chosen to treat selected topics in depth rather than to try to cover everything superficially.

Teachers of the history of mathematics could not want a better textbook. Most of the book can be read by anyone who knows elementary calculus. Expositions of more advanced mathematical results are done with clarity and skill, often enabling one who has not studied a particular result to appreciate its place in the development of mathematics. Each chapter is followed by a number of instructive problems in the style of the time under study, as well as by a set of questions on the contents of the chapter.

Historians will find the work a splendid place to begin research; the bibliographical footnotes and the chapter bibliographies include most of the important secondary sources. Boyer pays attention to the role of translations and national styles in mathematics, and to social and economic conditions. The relations between mathematics and philosophy and between mathematics and physics are touched on at times, but the work does not claim to treat them with any degree of completeness.

The weaknesses of the work are really the weaknesses of the existing secondary literature, especially apparent for the 19th and 20th centuries. In particular, a full-length history of algebra is needed, as are overall evaluations, based on a careful study of original works, of a number of important men and topics in the modern period. The treatment of 20th-century mathematics is extremely brief, though the author does give many bibliographical suggestions. Finally, it would have been helpful had the chapter bibliographies been annotated, and had the annotations in the general bibliography been longer and more critical. But these are minor flaws. Boyer has produced a work which should be welcome to mathematicians, teachers, and historians alike.

JUDITH VICTOR GRABINER
Department of History of Science, Harvard University, Cambridge, Massachusetts

Rural Pollution

Agriculture and the Quality of Our Environment. A symposium presented at the 1966 meeting of the American Association for the Advancement of Science, Washington, D.C. NYLE C. BRADY, Ed. AAAS, Washington, D.C., 1967. xvi + 460 pp., illus. $13.50; members' cash orders, $11.50. AAAS Publication 85.

Improvement of environmental quality is of great concern today, as is evidenced by the prominence of the subject in the local, state, and national political arenas and by the trend for many college courses to be organized around the "environment." One undeniably important factor in that environment, though often taken for granted, is agriculture. The present book brings together for the first time in one volume a summary of our knowledge of the effects of a polluted environment on agriculture and, conversely, of the contribution of agriculture to environmental quality.

The 30 symposium papers are presented in three sections dealing with the three portions of the environment, air, water, and soil, and a fourth section devoted to disposal of wastes in rural areas.

The first section discusses the effects of various gaseous and particulate air pollutants, including radionuclides, on plants and animals. The effects of air pollution on agriculture are aggravated by the increasing invasion of rural areas by industry and urban communities. One interesting aspect of the problem relates to forests: whereas we readily recognize the threat to agronomic crops, recognition of the threat to trees,