Book Reviews

Neural Integration

Dynamic Biological Networks. The Stomatogastric Nervous System. RONALD M. HARRIS-WARRICK, EVE MARDER, ALLEN I. SELVERSTON, and MAURICE MOULINS, Eds. MIT Press, Cambridge, MA, 1992. xx, 328 pp., illus. $65. Computational Neuroscience. A Bradford Book.

Donald Kennedy's 1967 *Scientific American* article "Small systems of nerve cells" enunciated a new view of the relationship between neural activity and behavior: that principles of neural integration underlying complete behavioral function can be traced in small systems of nerve cells characteristic of invertebrate nervous systems. This book presents another defining moment in this enterprise. *Dynamic Biological Networks* reports the fruition of years of painstaking study of central pattern generation in the crustacean stomatogastric nervous system. New and important principles of nervous integration have emerged. The once static view of neural circuit functioning has been replaced by a dynamic one in which neuromodulation plays a central role. These concepts are certain to be of ever greater significance as more complex systems and their behaviors are investigated. This book is essential reading for anyone interested in the dynamic operation of the nervous system.

The treatment begins with an overview of the anatomy and function of the four neural networks that make up the stomatogastric system (Johnson and Hooper). Thirty interconnected identified neurons form the pyloric, gastric-mill, cardiac-sac, and esophageal networks, which produce the rhythmic output necessary to mediate the feeding behaviors of Crustacea. The intrinsic electrophysiological properties of the component neurons, their synaptic connections, and the generation of rhythmic motor patterns are clearly presented. The analysis is then extended (Hartline and Graubard) to the nuts and bolts of the system with a consideration of the cellular properties of its individual neurons, including structure and function, voltage-gated currents, and several properties that play an important role in shaping the network output.

The pivotal role of neuromodulators in coaxing flexibility from this restricted system is reviewed by Harris-Warrick, Nagy, and Nusbaum. Modulation of firing properties and synaptic efficacy between neurons is emerging as an important theme in network function generally, and this chapter makes clear the significant contribution made by studies of the stomatogastric system to the development of this idea.

The magic of the system and the break with the older, "hard-wired" view is revealed in an account by Dickinson and Moulins of the ability of the system to use neuromodulation to produce a different functional output. Functional reconfiguration, in which a neuron's allegiance can switch from one circuit to another or in which circuits can merge or be disbanded and configured anew, underlies the dynamic behavioral output of this system.

The wealth of detailed cellular data already collected on this system begs for a theoretical modeling approach to tease apart the contributions of single neurons to the final output. Marder and Selverston summarize the daunting but very promising task at hand. Several different approaches to the modeling of the rhythmical neural networks of the stomatogastric nervous system are presented. The current work is summarized along with advantages and drawbacks of each approach.

Turrigiano and Heinzel close the circle with a chapter connecting behavior and neural activity. Exciting recent findings are beginning to bridge the gap between the cellular and network observations obtained with the isolated nervous system and the behavior observed in the more intact preparations.

A view of the stomatogastric system from a comparative and evolutionary perspective is presented by Katz and Tazaki. Though important details of decapod phylogeny are still uncertain, the evidence marshaled here supports a strong conservation of stomatogastric circuitry; the basic ensemble of neurons, their neurochemistry, and their principal connections are common to all decapods studied. The peripheral motor apparatus is more varied, serving the diverse gustatory life-styles of the decapods. An important insight emerging from this chapter is that neuromodulators may be a principal substrate for evolution, calling forth a repertoire of behaviors from a relatively fixed circuit.

Points of contact between central pattern generation and rhythmical motor output in other systems are considered by Pearson and Ramirez. Shared principles of operation among these systems are emerging, and the role of neuromodulation and network reconfiguration promises to be a unifying principle in motor systems, vertebrate and invertebrate alike.

Dynamic Biological Networks is a good read. The selection of topics and the pairing of authors from different professional lineages produce unbiased, thoughtful discussion of the topics at hand. The chapters can profitably be read individually, but the editors have exercised great care in integrating them, and the sum is much greater than the parts. Well-annotated, uncluttered illustrations and a discussion of how to use the book make it well suited for use in a graduate course.

The challenge now is to apply the approach represented by *Dynamic Biological Networks*, the analysis of circuits operating in their natural, modulatory environment, to other problems, including learning and development. The only downside is the nostalgia one feels for a simpler time of simpler systems.

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Land-Based Evolution

Terrestrial Ecosystems Through Time. Evolutionary Paleoecology of Terrestrial Plants and Animals. ANNA K. BEHRENSMEYER, JOHN D. DAMUTH, WILLIAM A. DIMICHELE, RICHARD POTTS, HANS-DIETER SUES, and SCOTT L. WING, Eds. University of Chicago Press, Chicago, 1992. xx, 568 pp., illus. $75; paper, $29.95. Based on a conference, Washington, DC, 1987.

Paleoecological and macroevolutionary patterns in the fossil record of the marine realm have received more attention in recent decades than have such patterns in the terrestrial realm. The marine record is significantly more complete and is richer in species and specimens through a longer time period than is the terrestrial record, permitting a head start in the evaluation of ecosystem evolution in marine communities, particularly of invertebrates. Although there have been some remarkable studies of terrestrial systems, the spottiness of their records has made the study of their trends through long reaches of time seem daunting. Now, it seems, that situation is about to change.

Terrestrial Ecosystems Through Time is an up-to-date treatment of the nonmarine fossil record; the subtitle, "Evolutionary Pa-

Vignettes: Nonuniversality

It is commonly said, especially by boosters of science, that its language is international and is mutually comprehensible around the world. But, of course, the facts are otherwise.... Take the names for certain of the standard chemical elements. In German these were built up from vernacular roots, in English from classical roots—thus, *Wasserstoff*, "hydrogen"; *Sauerstoff*, "oxygen." As it happens oxygen was given its name by Lavoisier (*oxygène*, roughly "acid maker") on the mistaken notion that it was an essential ingredient of acids. In English, the *oxy-* root has for all practical purposes lost any connection with acidity; it is used only to indicate the presence of oxygen. But in German the word for acid is *Säure*, and the spurious connection of oxygen, Sauerstoff, with acids is constantly maintained; it is as though in English one always said "acidogen" for "oxygen." German chemists, of course, are not fooled by its name into thinking that oxygen behaves differently than it does .... But surely, the associations, the connotations, the idea of the kind of thing one is dealing with, is different in the two cases.

—*David Locke*, in *Science as Writing* (Yale University Press)

In some ways modern science can be seen as the push to erase individual, craft skill from the scientific workplace, to ensure that no idiosyncratic local, tacit, or personal knowledge leaks into the produce. Anyone should be able to reproduce scientific results if they can afford the equipment and follow the recipe. Research findings that are purely personal or irreplicable are just not science. Yet recent work in the sociology of science and engineering keeps discovering traces of craft in the modern scientific commodity. Some lab technicians have "golden hands"...; some engineers are "wizards"...; some physicists have "physical intuition."

—*Susan Leigh Star*, in *The Right Tools for the Job: At Work in Twentieth-Century Life Sciences* (Adele E. Clarke and Joan H. Fujimura, Eds.; Princeton University Press)

leoecology of Terrestrial Plants and Animals," conveys the approach well. The book was written by a consortium of workers (35 in all, designating themselves The Evolution of Terrestrial Ecosystems Consortium) interested in the history of the terrestrial realm; each chapter has a different mix of authors. The heart of the book, accounting for about three-fifths of its length, begins with the records of the earliest terrestrial fossils known, nonvascular plants from the Ordovician, and proceeds to describe successive states of terrestrial ecosystems up to the present. The discussion of each time slice is accompanied by paleotopographic and paleotectonic maps. This is a wonderful read; the breadth of expertise represented by the authorship serves to bridge the various disciplines involved and to provide an integrated account of the evolving systems.

A number of fascinating puzzles are presented. For example, the earliest terrestrial animal assemblages known, which are arthropods of late Silurian and early Devonian ages, contain predators and detritivores but few if any herbivores, which only came to prominence in the late Carboniferous. Thus these animals were linked to plants chiefly through detritus, or perhaps through decomposer microorganisms, for perhaps 80 million years. Meanwhile, in the late Devonian, tetrapods appear, and they seem to be chiefly predators, including insectivores, so that arthropod detritivores form the most likely link between the tetrapods and plants. Tetrapod herbivores finally become common late in the early Permian. What, one wonders, took herbivory so long to become well established?

Other striking problems in plant-animal relations are provided by Mesozoic plant associations and tetrapods. For example, the early (to mid-Triassic) herbivorous tetrapods were generalized browsers on plants largely within a meter or so of the ground, but the large sauropods of later Mesozoic times presumably browsed many meters high and may have lived in herds. Yet the trees of that time did not produce abundant foliage and were probably slow-growing. Even though dinosaur metabolism may have been low, it is difficult to account for the energetic base required to support bands of such giant herbivores.

These examples are chosen from among many because they involve one of the book's more interesting features, the display of the relations between successive waves of producers and consumers. The inclusion of the invertebrate record as an integral part of terrestrial biotic history is certainly laudable. The marine record, for all its relative completeness, lacks a fossil record of the evolution of primary producers that can be interpreted with any confidence to yield information about its effects on the evolution of the consumers. Although the terrestrial and marine systems may exhibit rather different patterns of energy transfer, data from at least one environmental realm are most welcome to all concerned.

The early chapters of the book are less successful. These consist of an outline of the basic aims and principles of paleoecology and a review of the nature of the record—processes of taphonomy in particular—and of the methodology deemed best suited for evaluating it. This account is if anything weighted toward plant fossils, which have received less study than animal fossils, and thus it fills an important need. But these chapters, especially the first, seem to suffer rather than gain from the multiple authorship, although the treatments are thorough. Perhaps what is missing is a certain purity of viewpoint that is often found when an individual author is forced into the disciplines of scholarship. Theoretical topics seem not to fare well when expounded by committees.

At any rate I learned a great deal from this book and recommend it highly. Certainly it will be a landmark in terrestrial paleontology. Because it brings together and integrates our knowledge of the broad history of a major ecological realm, it will interest all those who care about the history of life.

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A Backwater Reconsidered

Wealth and Hierarchy in the Intermediate Area. FREDERICK W. LANGE, Ed. Dumbarton Oaks Research Library and Collection, Washington, DC, 1992. xii, 463 pp., illus. $36. From a symposium, Washington, DC, Oct. 1987.

This book brings under discussion the long-debated but still intriguing question of whether the evolution of societies is unilineal or multilineal. Using archeological data from Central America and northern South America, the authors discuss whether societies always change from simpler to more complex forms and how such changes are reflected in archeological remains. This brings out some fundamental questions