Book Reviews

Processes Underlying Vision

Photoreceptor Optics. Papers from a workshop, Darmstadt, Germany, Oct. 1974. A. W. SNYDER and R. MENZEL, Eds. Springer-Verlag, New York, 1975. x, 526 pp., illus. $14.80.

For most workers concerned with physiological optics the optical properties of the photoreceptive segments of retinal cells are adequately summarized as those of an absorbing rod with a slightly higher refractive index than its surroundings. This book, which is a collection of research papers and reviews presented to a symposium organized by the editors, is devoted to the demonstration that such a description is inadequate, that the details of the size, shape, and membrane organization of photoreceptors have consequences for the way they absorb light that are not predictable from ordinary geometrical optics.

The first third of the book discusses the extent to which waveguide phenomena, well known in radio engineering, also apply to photoreceptors. When a structure approaches in diameter the wavelength of the radiation it conducts a number of interesting effects arise. The radiation—light in this case—no longer follows geometrical ray paths but propagates in the form of modes, transverse interference patterns with characteristic cross sections that are preserved along the length of the guide. The narrower the receptor the smaller the number of modes it will transmit and, more importantly for vision, the greater the proportion of the energy of each mode that is transmitted along the *outside* of the structure. This "leakiness" has several consequences: a narrower receptor is a less effective light absorber per unit length than a wide one, and because this effect is wavelength-dependent the spectral sensitivity of the receptor may be shifted in the direction of shorter wavelengths. Light propagating outside the receptor is also available for capture by other receptors, resulting in optical "cross talk" that will degrade the quality of the neural signal compared with that of the image, and light may also be absorbed by screening pigment acting as a "longitudinal pupil" around the receptor. This effect is beautifully shown in the color photographs of *Drosophila* receptors under different adaptation conditions in the paper by Franceschini. Other phenomena discussed include the relation of waveguide effects to receptor acceptance angles, and the book fittingly begins with a consideration of the Stiles-Crawford effect in humans by Enoch, who was the first person to demonstrate the existence of waveguide modes in photoreceptors. It is perhaps important to point out that most of these effects attain physiological importance only in structures that are really narrow, even by photoreceptor standards, and that for the properties of receptors exceeding about 2 micrometers in diameter classical optics still provides a reasonable approximation. This is no doubt the reason why much of this section of the book is concerned with fly photoreceptors, whose diameters can be less than 1 micrometer.

The second part of the book deals with the mechanisms underlying sensitivity to polarized light, a phenomenon typical of invertebrate receptors but uncommon though not unknown among vertebrates. Fifteen years ago Moody and Parriss postulated that this sensitivity would arise naturally out of the organization of the receptor membrane into parallel microvilli, within which the absorbing molecules are arranged randomly in the plane of the membrane. The principal difficulty here is that this model predicts a sensitivity ratio of 2 : 1 for light polarized parallel and perpendicular to the microvillar array, and in practice it is possible to record much higher ratios electrophysiologically—as high as 12 : 1 in crabs. Equally, some receptors that ought, on the evidence of their ultrastructure, to be polarization-sensitive turn out not to be, and in at least one case the sensitivity is at right angles to the expected direction. The problems are well reviewed by Gribakin and Govardovskii and by Goldsmith. One of the solutions to emerge is that a receptor with maximal sensitivity in one plane may overlie another whose sensitivity is at right angles, and so act as a polarization filter, enhancing the effect in the second cell. Menzel shows that this is probably the situation in the ninth cell of the bee rhabdom. Electrical coupling between cells can have the effect of decreasing polarization sensitivity, waveguide effects may also be involved, and in some instances at least it is necessary to postulate that the pigment molecules are not arranged randomly. On the whole, though, the Moody-Parriss model stands up well.

The remaining papers are something of a miscellany, discussing photomechanial effects and receptor electrophysiology. There is a characteristically provocative paper by Horridge, in which it was a relief to find a section called "the inexplicable mayfly rhabdom," particularly after nearly 500 pages of detailed and often very theoretical reasoning.

The book is very much centered on the ideas of the editors, particularly of Snyder, who is coauthor of no fewer than seven of the 29 papers, and because of the "workshop" nature of the symposium there is considerable overlap between the contributions of different authors. However, Menzel and Snyder provide a useful introduction that helps the reader to tell the wood from the trees. This is a valuable progress report on a subject that serious students of physiological optics can no longer ignore.

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Biology of Transitional Zones

Physiological Ecology of Estuarine Organisms. Papers from a symposium, Apr. 1973. F. JOHN VERNBERG, Ed. Published for the Belle W. Baruch Institute for Marine Biology and Coastal Research by the University of South Carolina Press, Columbia, 1975. xii, 398 pp., illus. $25. Belle W. Baruch Library in Marine Science, No. 3.

Estuaries are of special interest as the meeting ground between freshwater runoff from the upland and salt water from the sea. This zone receives the brunt of human influence on both fresh and marine waters and is characterized by great changes in conditions. As a result adaptations are very pronounced and are more readily understood than they are in more benign ecosystems. *Physiological Ecology of Estuarine Organisms* is a collection of papers on recent developments in the biology of this zone.

The book covers five principal re-

search areas: resistance adaptations, respiration and energetics, water and ions, reproduction and development, and perception of the environment. The longest paper in the book is the first one, a review of adaptations of phytoplankton to estuarine conditions. The paper discusses individual factors as well as their interactions and summarizes the consequences of pollution to these organisms. The following paper deals specifically with the effects of mercury as a pollutant, stressing the care needed to experiment with a substance that is lost from experimental vessels by volatilization. Another paper deals with salinity resistance of a copepod. The paper I find most interesting is by B. L. Umminger on the resistance to low temperatures of the killifish, *Fundulus heteroclitus*. These marsh minnows are subject to potentially damaging low temperatures in winter, usually only for relatively short intervals in very cold weather. They bury themselves in the mud at the bottom of marsh creeks and are thus protected from the danger of contact with ice but not from supercooling, since their blood osmolarity protects them only to −0.8°C even when the mud reaches −1.5°C. Killifish protect themselves (as do many other temperate fishes) by increasing only the concentration of glucose in their blood serum. Serum glucose increases not at all between 20°C and 4°C, slightly at 2°C, but sixfold when temperatures drop below zero. The sugar is mobilized from liver glycogen through a mechanism that starts with hypertrophy of glucagon-containing alpha cells in pancreatic islets. The elevation of glycagon in the blood inhibits glycogen synthetase and increases the activity of hepatic glycogen phosphorylase, leading to increased serum glucose. Though it is unable to prevent freezing if the fish's blood is seeded with ice crystals, the mechanism provides rapidly adjustable protection against freezing caused by the spontaneous formation of ice, and the protection can be rapidly removed when it is no longer needed. It is an efficient mini-antifreeze system that provides protection for short periods against temperatures slightly below freezing.

The volume contains 20 papers and a summary and ranges over subjects from adaptations in halophytes to color discrimination by fiddler crabs. I found the three papers on fish most interesting. Others will favor other aspects of this very diverse collection.

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Symbiotic Associations

Symbiosis. Papers from a symposium. Published for the Society for Experimental Biology by Cambridge University Press, New York, 1975. viii, 634 pp., illus. + plates. $47.50. Symposia of the Society for Experimental Biology, No. 29.

Understanding a single organism that is grown in the laboratory is difficult enough; when a symbiotic association is being studied, the complexity increases tremendously. There is great need to appreciate various symbioses because they play an important role in ecology, nutrition, disease, and agriculture. This book points out what is known about many important symbiotic systems, and a general appreciation of techniques used and work that must yet be done is gained from reading it.

There are 24 contributions from experts in bacteriology, zoology, biochemistry, and botany. Most of the chapters are well written, but quite a few undefined technical terms are used that probably are not going to be understood by most readers. The arrangement of chapters helps inexperienced readers to appreciate the simpler systems before wading into the more complex symbioses.

The book begins with an attempt to define "symbiosis," and then a scheme for classifying different symbioses is discussed. Three chapters present a stimulating discussion of the strong and weak points of several theories of the evolution of eukaryotic organelles.

Two symbionts of *Paramecium*—the kappa factor and *Chlorella*—are discussed in detail. There are several other chapters that deal with the "borrowing" of a photosynthetic apparatus by an organism that normally is not photosynthetic. Examples include the hydra and certain mollusks. The marine flatworm has an association with certain algae that permits the flatworm to obtain most of its carbon from carbon dioxide in the presence of light. Fungal diseases of plants are covered and there is also discussion of the nematode-plant association. It seems that in certain situations the nematode can actually help the plant. There is a fine chapter on lichens.

Other topics include the Protozoa–red-blood-cell association (as in malaria), the way certain parasites evade the immune response, the way the tapeworm interacts with the host, and the crucial role of bacteria in the ruminant animal. There is an interesting chapter on nitrogen-fixing and methane-forming bacteria in the termite gut. The last chapter is quite different from the rest, since it deals solely with behavioral relationships among different marine animals.

There are many excellent light and electron micrographs in the book. A general biologist as well as an expert in just about any biological field should be able to gain a lot from it. The book points out the need for a great deal of work and imagination on the many important problems involving intimate interactions between organisms. I hope it will stimulate some readers to undertake this kind of research.

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Quantized Fields

Introduction to Axiomatic Quantum Field Theory. N. N. BOGOLUBOV, A. A. LOGUNOV, and I. T. TODOROV. Translated from the Russian edition (Moscow, 1969) by Stephen A. Fulling and Ludmila G. Popova. Stephen A. Fulling, Ed. Benjamin, Reading, Mass., 1975. xxviii, 708 pp. $32.50. Mathematical Physics Monograph Series, vol. 18.

As the title suggests, this book provides the reader with an overview of those aspects of quantum field theory that have been placed on a rigorous mathematical basis. This is an area in which two excellent books already exist: R. F. Streater and A. S. Wightman's *PCT, Spin and Statistics, and All That* (Benjamin, 1964) and R. Jost's *The General Theory of Quantized Fields* (American Mathematical Society, 1965). These books present stiff competition. The first is a model of clarity of exposition in mathematical physics, and the second, though terse, is full of interesting material. The book under review nicely complements these two classics. The simplest description of it is as encyclopedic—it is about twice as long as the Jost's and Streater and Wightman's books put together. I would recommend it strongly to the student or particle physicist who wants a second book after reading one of the classics.

The book is quite well written, and it is nice to see various subjects—for example, the Haag-Ruelle scattering theory—treated exhaustively. But the book is occasionally too exhaustive. For example, there is an appendix that attempts to give the reader a quick course on topological groups, Lie groups, and Lie algebras in 25 pages. This kind of blitzkrieg can be sloppy. For example, on p. 210 "simple Lie group" is defined so as