# 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-