of research on the pineal-parapineal problem in lower vertebrates. The summary emphasizes the work of Eakin and his associates, as is appropriate since they have done most of the basic work in this area; experimental work by classical as well as other recent students of the topic is also reviewed, however.

The book deals in sequence with morphological, developmental, and functional aspects. Eakin confirms again the view that the parietal eye is a remnant of the left or parapineal organ seen in agnathans. Not surprisingly he concludes that the eye functions as a dosimeter of solar energy exposure in many Recent reptiles; this view was, after all, developed by his school. The monograph gives evidence that the Recent amphibians are quite aberrant, rather than represent an "intermediate" condition between the patterns observed in lower fishes and those observed in reptiles. It also documents that our knowledge of this system still depends on a phylogenetically most limited sample from among the many groups of lower vertebrates.

The book is written in a style that allows it to be read profitably by undergraduates or by any vertebrate biologist wishing a summary of an interesting subject. Eakin's treatment is historical, and he communicates the ideas that one owes a debt to one's predecessors and that science is an ongoing process that proceeds by successive approximations. He goes out of his way to define terms and to emphasize related matters, but without wasting much space on asides. It is refreshing to read a monograph that starts by thanking the taxpayer who funded the work and ends by thanking the reader.

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Visual Psychophysics

Eye-Movements and Visual Perception. R. W. DITCHBURN. Clarendon (Oxford University Press), New York, 1973. xvi, 422 pp., illus. $30.50.

Helmholtz would have liked this book. As the foremost practitioner of the art of analyzing the physical basis of perception, he would have recognized in the author a kindred spirit. Ditchburn, a physicist trained at the Cavendish laboratory, helped a generation of physics students to a better appreciation of optics through his textbook on light. During the last 25 years, however, his main interest has been the visual effects of stabilizing the retinal image, which he was one of the first to achieve. Now Ditchburn has kept a promise made by so many other scientists, namely to write a book after retirement. What is more, he has written a good book.

It opens with an excellent introduction to the optical and optomotor factors in the formation of the retinal image. There is also a great amount of information on the physiology of visual sensory processes as well as of the eye movement apparatus in man. Most of it, however, is concerned with the effect on visual thresholds of various programs of eye movements, and, in particular, the nulling out of normal micronystagmus. An appendix covers some of the techniques of making tight-fitting contact lenses to help stabilize retinal images. The book is up to date and well documented, though there are occasional mismatches between citations and references.

It is only fair to issue a warning to those who would look for coverage of what has traditionally been understood as perception. To be sure, a few sections of this book deal with changes in pattern perception when retinal images are stabilized, but the vast bulk of the material covers the psychophysicist's preconditions of visual perception—optical images, retinal excitation, thresholds. Ditchburn is at home here because his own contributions, characterized by innovation in technique and precision of attack, are in this area. What about the more global questions of perception? They are hardly touched on in this book, or for that matter in most other books with "perception" in the title. One continues to wonder what the Gestalt psychologists of a generation ago did wrong to leave such an arid heritage. Yet it is a good bet that even the most global formulations of perception will be the more securely based the more consonant they are found to be with the psychophysicists' strictures. In laying these out, both in a general way and through examples of research in the author's field, Ditchburn's monograph will have a lasting place.

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Ecological Simulations

The Structure of Marine Ecosystems. JOHN H. STEELE. Harvard University Press, Cambridge, Mass., 1974. xii, 128 pp., illus. $7.95.

Theoretical ecology got off to a good start in the 1920's with Vito Volterra's seminal, and still central, contributions springing from his interest in fish catches in the Adriatic. There are many subsequent instances of fruitful interplay between ecological theory and marine biology, and John Steele's monograph lies in the mainstream of this tradition. His general aim, which I think is fulfilled admirably, is "to show how theory, observation, and experiment may be combined, and how closely each depends on the other."

Specifically, Steele sets out to build a model describing the dynamical behavior of the populations of phytoplankton, zooplankton, and other beasties in the North Sea in spring and summer. Any such enterprise requires a skilled helmsman to steer between the Scylla of a multiparameter, computerized Goon Show and the Charybdis of total abstraction. As an applied mathematician of note, and deputy director of the Marine Laboratory maintained in Aberdeen by the Department of Agriculture and Fisheries for Scotland, Steele is well qualified for the task.

The study begins (chapter 2) with a descriptive account of the properties of marine food webs in general, and those in the North Sea in particular.

In order to gain some understanding of the dynamical structure of these food webs, the author next (chapter 3) turns to broad questions of stability, diversity, and efficiency. There is a perceptive and original discussion of the intuitive idea that "extra links in the

web somehow contribute to the stability of the system"; Steele's conclusion, which parallels much recent work elsewhere, is that such added complexity does not in itself enhance community stability. He next discusses the stabilizing effects of spatial heterogeneity, deeming them insufficient to explain the long-term survival of populations in the open sea. Steele finally turns to the functional form of the interactions between the grazing zooplankton and their prey, the phytoplankton, and argues that it will in general be of the "Holling Type III" (or "vertebrate") character: there is a threshold at low food densities, below which feeding is negligible and above which feeding increases rapidly, eventually leveling off to some saturation value. It is widely appreciated that such functional responses between plant and herbivore, or prey and predator, can be stabilizing over a wide range of prey densities. Looking ahead to the simulation results, Steele argues that these features of the plant-herbivore interaction are the crucial stabilizing elements in marine ecosystems.

Many insights are tossed off in passing. One concerns predator "switching," a phenomenon often appealed to as a sort of Universal Stabilizing Mechanism. Steele remarks that if a predator switches between two prey species, with each of which individually its interaction is unstable, the outcome remains unstable: the discussion crisply encompasses qualitative reasoning, analytic results, and computer simulation, within the space of two pages.

Chapters 4, 5, and 6 set out and discuss the simulations, which include the hydrodynamics of the North Sea, plant (phytoplankton) production, copepod (zooplankton) grazing and growth, and predation upon these herbivores. The model eventually contains 14 adjustable parameters, and four initial conditions. The system has a strong propensity to exhibit stable limit cycles, with (as mentioned above) the key element in the dynamics being the zooplankton grazing behavior. Among other things, the model leads to predictions about copepod respiration rates, which have been successfully tested in laboratory experiments. It is clear that fluctuations in the recruitment of common fish (whiting, haddock, plaice) are tied to variations in copepod populations; one interesting, if unhelpful, practical conclusion is that although the factors underlying these variations are undoubtedly physical, there is unlikely to be a significant correlation between fish stock size and any one or two physical parameters.

A theme which is emphasized in the introduction (chapter 1) and in the conclusion (chapter 7) is the dichotomy between marine ecosystems, where the stabilizing "control" resides at the plant-herbivore level (and where man largely harvests higher predators, usually with little effect on lower trophic levels), and terrestrial ecosystems, where control is alleged to be provided by predators (and man mainly harvests plants and herbivores). These are provocative ideas, but they rest on too uncritical an acceptance of the fact that herbivores rarely consume more than 10 percent of terrestrial vegetation as a proof that such populations must be controlled by carnivores. The argument that "herbivores would decimate their food unless controlled in a density-dependent manner by the carnivores" (p. 6) overlooks the biological warfare waged between most land plants and herbivores. (Pedantically, it may be noted that in this sentence the misuse of "decimate" to mean something in excess of the literal decimation that prevails testifies to the slack copy editing.) The strategic decisions as to investment in biochemical defenses against being eaten are likely to differ in many ways between trees and phytoplankton, and the possibility remains that the plant-herbivore interface dominates the dynamics both on land and in the sea.

A blemish in the book is its lack of contact with the recent ecological literature. In the extensive bibliography, only eight citations refer to 1971, two to 1972, and one to 1973; chapter 3, in particular, could have benefited from connection with recent work. The explanation, I believe, is that the printers were slow. It remains a pity.

Science recently ran a Research News article entitled "Theoretical ecology: beginnings of a predictive science" (**183**, 400 [1974]). This took a rather generous view of the successes to be expected in this field in the near future. For those who wish to form a closer view of such questions, Steele's excellent monograph is a readable and thoroughly professional account of efforts to marry theory and empiricism in an area of great practical importance.

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Bottom-Dwelling Faunas

Abyssal Environment and Ecology of the World Oceans. ROBERT J. MENZIES, ROBERT Y. GEORGE, and GILBERT T. ROWE. Wiley-Interscience, New York, 1973. xxiv, 488 pp., illus. $24.95.

The biology of deep-sea benthic animals has not been dealt with before in a single monographic work. There is a voluminous literature on the faunistics, physical surroundings, and history of the deep-ocean biota, some of it in scarce 19th-century treatises and a significant fraction of that from the 20th century in Russian, both difficult to approach for those without easy access to the major libraries. Menzies, George, and Rowe review much of this field and present some important hypotheses about the distribution of deep-sea animals, adaptations for feeding and breeding, and the age, origin, and changes of deep-water faunas in relation to continental drift and climatic shifts since the Precambrian.

One chapter, as an introduction, deals with some aspects of the history of deep-sea biology from Edward Forbes to modern research vessels. It is followed by a description of the methods and difficulties of sampling. Next, a system of vertical faunal regions in the deep sea, based mainly on isopod Crustacea, is set up. The five chapters following are devoted to this concept: that four major faunal provinces, the intertidal, the shelf, the archibenthal zone of transition, and the abyss (with several zones), varying geographically in extent and bathymetric limits, may be distinguished by objective means, namely, an "index of distinctiveness" which expresses the percentage of genera or species not held in common by any two sampling points along a depth gradient. A chapter is devoted to trench faunas, to which some other investigators have attributed distinctive faunal composition, high endemism, and peculiar morphological features.

In three chapters the authors discuss the distribution of biomass in the oceans, the dispersion of animals and species diversity, morphological adaptations to life in the deep ocean, hypotheses about the distribution of feeding methods, evidence for reproductive periodicity, and the incidence of eyes in deep-water benthic isopods. Two concluding chapters deal with biogeography, first in terms of tolerance to temperature, salinity, and depth, then in terms of the geographical distribution