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.

JOHN TEAL

*Woods Hole Oceanographic Institution, Woods Hole, Massachusetts*

## 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.

WINSTON J. BRILL

*Department of Bacteriology* and *Center for Studies of Nitrogen Fixation, University of Wisconsin, Madison*

## 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