modifies its feeding behavior in the presence of a predator, with consequences for other species linked to it through the food web.

The food web perspective is nicely illustrated by several chapters on planktonic systems, where top-down predation frequently is a major force. Kerfoot summarizes the extensive field experimentation he and his students have carried out on a small Vermont lake, and Levitan contributes an original and impressively detailed stability analysis of the same lake, which should interest students of food web analysis. Surprisingly for a freshwater planktonic system, top-down predation effects appeared to be small. Levitan's analysis indicated a stable matrix of plant-herbivore interactions, sensitive to small changes in interaction coefficients yet insensitive to greater variation in coefficients adding the major invertebrate and fish predators into a larger web. Mills *et al.* summarize a long-term data set to provide a fine example of predator effects that cascade from the top to the bottom of the Lake Oneida food web. The abundance of young yellow perch is influenced both by climatic conditions during egg incubation and by walleye predation, while fluctuations in perch abundance strongly affect *Daphnia*, which in turn dictates the abundance of other grazers and (less obviously) phytoplankton. This is an excellent case study for an undergraduate ecology lecture. Together with the chapter by Kitchell and Carpenter, it also demonstrates that detailed understanding of food web interactions can provide valuable information for environmental management.

Any predator-induced reduction of a prey species may indirectly benefit other members of the food web linked to it. In one of the most explicitly theoretical papers, Abrams explores the variety of interactions between two prey that have a common predator. Other chapters report experimental evidence for indirect facilitation, including predatory suppression of a competitive dominant (Vanni) and the nutrient-regeneration link between plantivorous fish and the algae that nourish their prey (Threlkeld). Quite intricate linkages may result in indirect mutualisms, such as Dungan describes in an intertidal community.

Anti-predatory defenses are a widespread response to intense predation. Chapters by Sih and Havel provide general discussions, and Sih develops a major theme, namely that such adaptations may compromise life-style, habitat use, or other activities, with far-reaching consequences. Stemberger and Gilbert summarize the now extensive knowledge of rotifer defenses, including the chemically mediated morphological responses for which rotifers are justly famous. The potentially wide use of chemical defenses in freshwater beetles and bugs is perhaps underappreciated, as is indicated by Scrimshaw and Kerfoot's valuable review describing the substances carried, morphology of glands, and delivery mechanisms. Prey also reduce risk by minimizing their temporal or spatial overlap with predators. Some copepods undergo diapause during months when fish predation is intense but conditions are otherwise suitable for continued activity and reproduction, a response that appears to be genetically determined yet evolves rapidly in response to changes in predation intensity (Hairston). In contrast, behavioral flexibility in the use of high-risk habitats appears common in fish vulnerable to larger piscivores. This may have consequences for competitive interactions, described by Mittelbach and Chesson, and for lower trophic levels, discussed by Power. Finally, a paleontological perspective is added by two chapters that consider the habitat restriction over geological time of crinoids (Aronson and Sues) and the larger branchiopods (Kerfoot and Lynch), attributed to mid-Mesozoic changes in predation intensity.

The roots of the current volume lie in influential studies published in the 1960s on predator effects in small lake and rocky intertidal communities. An impressive level of understanding has been achieved in the last two decades of research, and this book provides a current and broad overview of the subject. The standard of quality (both science and presentation) is high, and although the setting is primarily lacustrine, some chapters are quite general and the insights gained into community interactions should be of broad interest.

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Quantum Gravity and Strings

Superstring Theory. MICHAEL B. GREEN, JOHN H. SCHWARZ, and EDWARD WITTEN. Vol. 1, Introduction. x, 469 pp., illus. $39.50. Vol. 2, Loop Amplitudes, Anomalies and Phenomenology. xii, 596 pp., illus. $49.50. Cambridge University Press, New York, 1987. Cambridge Monographs on Mathematical Physics.

In the last few years an ever-growing number of elementary particle theorists have become enamored of a subject called superstring theory. In a string theory the basic objects are tiny strings, 10^{-33} cm long, that propagate in a space-time generated by the theory itself. Each elementary particle is a specific vibrational mode of the string. The prefix "super" denotes the fact that the theory brings together the two broad classes of elementary particles found in nature, the bosons and fermions.

What superstring theory seems to provide is a mathematically consistent quantum theory of the gravitational force together with many new ideas for unifying gravity with the other forces. Direct effects of quantum gravity are probably negligible at energies less than 10^{19} GeV. This level is so far beyond current accelerator energies (10^4 GeV are planned for the new Superconducting Super Collider) that the theory will forever remain beyond experimental test. Conventional theories based on point-like elementary particles cannot predict quantum gravity effects even in principle, so gravity seems to be the arena of confrontation for the fundamental ideas of quantum physics. Further, many suspect that the correct theory of quantum gravity may answer questions about particle properties at lower energies that are left open by the current "standard model." Thus the enthusiasm of string theorists for the first consistent theory of quantum gravity is easy to understand. But it is worrisome that their ideas are so hard to test experimentally and that the highly mathematical nature of their research ignores the historical paradigm that progress in particle physics occurs through a partnership of theory and experiment in the exploration of a steadily increasing range of energy.

String theory was first developed in the late 1960s, but it was put aside by all but a few proponents about five years later, after other, more promising ideas emerged that led to the standard model. The second coming of the subject occurred in 1984 when it was shown that the symmetry group of particle forces could be almost uniquely predicted by superstring theory. It is clear that string theory is rich enough, whether right or wrong experimentally, to be a part of the graduate curriculum in particle physics. There is a genuine need for books that explain the early development and integrate it with the more modern mathematical view that has been developed largely in the last three years. This brings us to the two-volume work under review here.

The credentials of the authors are superb. It was Green and Schwarz who wrote the 1984 paper that led to the rebirth of the theory, and Witten immediately recognized the importance of that paper as indicating the potential solution to the problem of chiral fermions (in simple terms, why the weak interaction in nature is left-handed), a problem on which he had focused for years and developed many rich ideas. It is admira-

ble that active research physicists of their stature have taken the time to prepare a book that will allow others to learn the subject systematically. Indeed, theirs is the only comprehensive textbook on string theory currently available, and it is excellent in many ways. Because of this and the general fervor in the field, physicists in one research group have affectionately dubbed the book "the greatest story ever told," or "the greatest story ever written."

The book is intended for advanced physics graduate students and other scientists with some technical understanding of quantum field theory and particle physics. For such readers the first chapter provides a quick tour of the history of string theory, its relation to gravity, and the important role of conformal invariance. The chapter clearly describes one of the most startling facts about string theory, namely that a path-integral formula for a correlation function in a two-dimensional free-field theory can be interpreted and evaluated as a scattering amplitude for particles in a higher-dimensional space-time. In subsequent chapters string quantization is treated in the light-cone and modern covariant methods, the various superstring theories are discussed, and operator and functional methods for the calculation of tree and one-loop amplitudes are presented. Chapters 12 through 15 are very useful as an introduction to many of the modern mathematical methods that enter into string theory and its phenomenological interpretation.

Certainly the book's greatest strength is the way in which it brings modern methods into the treatment. For example, there is a nice discussion of the relation between the GSO projection and spin structures on Riemann surfaces. However, conformal field theory, which many regard as the simplest approach to string theory, is not adequately treated. There are other places where the treatment seems confusing and even wrong, some of which were brought to my attention by puzzled students. For example, the discussion in chapter 3 of the beta function and conformal invariance of the nonlinear sigma model is at best misleading, partly because it is based on a different form of the background field expansion from that used in the research literature. The functional methods that are the subject of chapter 11 are very important. The original literature is difficult to read, and the book does attempt to explain several points in more detail. However, I did not find these explanations as illuminating as I would have hoped. One elementary error occurs in the treatment of the Neumann function (vol. 2, p. 200) where the flux conservation constraint is neglected, so that there is, under most conditions, no solution to the equations given.

The shortcomings of this book lie in the treatment of specific topics, not in the overall scope or structure. They can be corrected in a later edition. Serious readers may get stuck at some points and are advised to consult an experienced string theorist. They should realize that the second wave of string theory developed so quickly that there was no time for the usual process of pretesting the material in graduate courses. It is rare that a book on an active subject of research appears early enough to be as useful as this one.

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Reprints of Books Previously Reviewed

Biology of Spiders. Rainer F. Foelix. Harvard University Press, Cambridge, MA, 1987. Paper, $14.95. *Reviewed* **218**, 46 (1982).

An Introduction to Science Studies. The Philosophical and Social Aspects of Science and Technology. John Ziman. Cambridge University Press, New York, 1987. Paper, $14.95. *Reviewed* **229**, 458 (1985).

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Russian Drinking. Use and Abuse of Alcohol in Pre-Revolutionary Russia. Boris M. Segal. Rutgers Center of Alcohol Studies, New Brunswick, NJ, 1987. xxii, 383 pp. $29.95; paper, $19.95. Monographs of the Rutgers Center of Alcohol Studies, no. 15.

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