best, and graduate students feel compelled to use DNA sequencing even when it is not the most appropriate tool. Certainly, a molecular systematist or ecologist needs to know how to sequence DNA (or at least understand the basics of sequence evolution), but I think she also needs to know how to map restriction sites and interpret allozyme patterns. Furthermore, all the technical knowledge in the world is of little value unless she knows how to find, identify, and observe organisms in nature, and ask appropriate questions about what she observes. Avise invites the reader to

> "[i]magine . . . that DNA sequencing methods had been widely employed for the past 30 years and that only recently had protein-electrophoretic approaches been introduced. No doubt a headlong rush into allozymes techniques would ensue, on justifiable rationales that (a) the methods are cost-effective and relatively simple, (b) the variants revealed reflect independent Mendelian polymorphisms at several loci scattered around the genome (rather than as linked polymorphisms in a single stretch of DNA), and (c) the amino acid replacement substitutions uncovered by protein electrophoresis (as opposed to the silent base changes often revealed in DNA assays) might bring molecular evolutionists closer to the real 'stuff' of adaptive evolution. To carry the argument farther, suppose that molecular genetic methods had been employed throughout the last century but that an entrepreneurial scientist finally ventured into the world of nature and discovered organismal phenotypes and behaviors. Finally, the interface of gene products with the environment would have been revealed! Imagine the sense of excitement and the research prospects!"

I think Avise's perspective will help reverse the trend of over-specialization (both taxonomic and technical) that is beginning to dominate the field. Hopefully, this will promote a new generation of naturalists who are willing and able to use whatever tools are most appropriate to unravel the workings of nature.

DAVID M. HILLIS

UNIVERSITY OF TEXAS
Department of Zoology
Austin, Texas 78712

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ECOLOGICAL MICROCOSMS

Beyers, Robert J., and Howard T. Odum. 1993. **Ecological microcosms.** Springer-Verlag, New York. xv + 557 p. $59.00, ISBN: 0-387-97980-8 (acid-free paper).

Beyers and Odum describe ecological microcosms (or the synonym "microecosystems") as "small ecosystems held in containers." Almost any container is considered, from small petri dishes to the giant Biosphere 2. The authors, among the most qualified in the world to discuss these systems, set out both to review the uses of microecosystems in ecological research and to set ecology in the framework of ecosystems as true self-organizing systems, not populations acting in isolation. The authors suggest that this book could be used as "a text for an ecology course organized around students' microcosms." That suggestion is not terribly far off base. There is a lot of ecology in this 20 chapter book.

The book is divided into three parts. Part 1 provides, in eight chapters, basic concepts and a classification and history of microcosm use. After an introductory chapter, Chapter 2 discusses the processes of photosynthetic production, respiration, and nutrient cycling, complete with diurnal cycles of oxygen, carbon dioxide, pH, and a host of other variables, described in a balance of simulation mini-models and field and lab data. Chapter 3 presents the concept of self-organization in the context of ecological succession. Most of the examples are of algal species changes in microcosms and large plastic pools, including early work by Taub, Nixon, Lund, and others. The chapter also introduces some energy calculations by Odum to show the relative importance of different types of energy, e.g., sunlight and physical stirring, on the scale of microcosms. The chapter ends with a discussion of Beyers' standardized successional microcosms, suggested as a "white mouse" from microecosystems. Chapter 4 is similar in approach to Chapter 2 (both appear to be written primarily by Odum) as it discusses the role of material cycling and limiting factors on microcosms by effectively using mini-models (micromodels?) and simulation results to effectively reinforce points. Chapters 5 and 6 are exciting rapid-fires of one idea after another on diversity, information, hierarchy, chaos, control, and many other topics, all related to ecology in general, not just microcosms. Chapter 7 completes the concept chapters with a discussion of stress and ecosystem adaptations to stress. Subchapter topics include "substitution of biomass and diversity," "stress as a diversity generator," and "sensitivity of organisms versus microcosms [to toxic stress]." Stresses discussed include ionizing radiation, mercury, dieldren, zinc, cadmium, and a host of others, with most studies emphasizing the effects on microorganisms in microcosms. Chapter 8 gives a detailed history of microcosms in the past 150 years, going back to the work of Robert Warington, and later contributions of Haeckel, Conger, the Edmondsons, and later Odum himself.

Part 2 includes eight chapters that describe, by examples from the literature, microcosms (and mesocosms) of specific ecosystems including aquaria, streams, terraria, wetlands, ponds, reefs, plankton columns, and thermal and brine systems. Quite a range in size is included in these chapters, from table-top aquaria to 500 m^2 estuarine ponds. These chapters are rich in data-containing graphs and conceptual models (mostly Odum-symbol style as in earlier chapters). Several sketches of actual systems (often from the original publications) make these chapters a good historical treatise.

The book's final section includes four chapters on microcosms and society, in essence discussing the application of microcosms in what we now call "ecological engineering." The chapters cover food-producing systems such as aquaculture, shrimp mariculture, and fish hatchery ponds, waste processing systems (starting with the trickling filter and activated sludge systems themselves as microcosms!), microcosms and mesocosms designed for space travel (including a lengthy introduction to Biosphere 2). Chapter 20 ends the formal part of the book with a series of narratives (only four figures in this chapter) on self-organization, scaling, ecological education, global policy, sustainable ecosystems, Gaia theory, and other topics, all in the context of microcosms.

Three appendices follow the book chapters. Two give directions for classroom microcosms and monitoring of microcosms. The last appendix is the only part of the book written by others—a contribution on the Biosphere 2 system by several former biospherians and researchers on that project. The bibliography, 64 pages long, is a veritable treasure chest of citations on microcosms and related topics.

This is a book for *real* ecologists, but not for the faint of heart. It covers a dazzling amount of ecosystem theory and spans at least 70 years of combined research experience by the two authors. The book is centered on the concept that ecosystems, including little ones in containers, self-organize in their metabolism, mineral cycling, diversity and spatial and temporal hierarchy, toward systems that maximize power and contribute effectively to survival of both lower (e.g., species) and higher levels (e.g., landscape) levels of hierarchy. Beyers and Odum argue that the study of multi-species microcosms is a good compromise between experimenting with whole lakes, wetlands, forests, and streams (a proposition that is rarely possible because of expense in replication), and more traditional science of studying specific mechanisms isolated from the system in which they are found. I found two parts of the book particularly enjoyable. Chapters 2 through 7 present energy flow, succession, biogeochemical cycling, limiting factors, hierarchy, control, stress, and adaptations as any good ecosystem book should, but do so with a nice use of both provocative subtitles and useful artwork. While some of the models appear to be out of Odum's previous works, especially *Systems ecology* (Odum, Howard T. 1983. Wiley, New York), there is also a great deal of new work. Chapter 20 on "Microcosm Perspectives" is my other favorite part of the book. It is both a summary and a plea for a systems approach to be used in ecology from two scientists who know it best. It is one of the best chapters in the book, with quotes such as the following:

> "Because science and engineering have emphasized taking apart and studying component mechanisms, many future advances are possible with the expansion of the neglected science of putting together. Microcosms are a means for synthesis. . . . The standard format for scientific experimentation in 'take-apart,' analytical science has been to isolate a process from all other variables in order to study its principles. For synthetic science (putting back together), experiments use the whole system, retaining everything except some one variable which is changed or omitted."

With 444 pages devoted to the main body of the book (and another 100 plus for the appendices, bibliography, and index), there is a substantial amount of ecology in this book. While it would be difficult to think of this book as a text for a standard ecology course, it would be exciting to see if it could be used for a course on experimental ecosystems, complete with laboratory exercises on class mesocosms. The text is clear, the figures reproduced well, and the organization of the book is generally correct in going from principles to ecosystems to societal applications. I would have liked to have seen the historical Chapter 8 as a part of the introductory chapter but that is a minor quibble.

I recommend this book to almost every ecologist. If you study microcosms or mesocosms, this book is a must. If you teach ecology, have this book by your side. By effectively using the table of contents and the index as your guide, you will get what will probably be an alternative (or possibly a clearer) view of the subject you are teaching. If you are a traditional population ecologist or reductionistic scientist, you will want at least to hear the other side. If you are a systems ecologist, you will benefit from the frequent illustrations of the close connection between laboratory results of these model ecosystems and the simulations of the computer minimodels. As with computer models, microecosystems, as simplifications of ecosystems, are indeed one of the best approaches we have to understand nature.

WILLIAM J. MITSCH

THE OHIO STATE UNIVERSITY
School of Natural Resources
2021 Coffey Road
Columbus, Ohio 43210

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AN OVERVIEW OF SYMBIOSIS

Douglas, Angela E. 1994. **Symbiotic interactions.** Oxford University Press, New York. vi + 148 p. $45.00 (cloth), ISBN: 0-19-854286-0; $21.95 (paper), ISBN: 0-19-854294-1.

Symbioses are intimate relationships between species that often last for the entire lifetime of both partners. Despite the undeniable importance of symbiotic interactions in natural systems, most ecologists have paid little attention to all but the best-known of them (for example, rhizobial and mycorrhizal symbioses). Perhaps the most interesting feature of symbioses from the perspective of ecologists is that they often give one or both participants in the interaction access to novel metabolic capabilities. This exchange can permit organisms to flourish in nutrient-deficient habitats, as well as lend them a competitive edge over individuals unable to form symbioses. The vast majority of research on symbiosis to date, however, has been highly mechanistic and laboratory-based, rather than ecological in either intent or approach. Attempts to penetrate the symbiosis literature are easily stalled by a level of technicality that makes it nearly impossible to recognize ecological or evolutionary phenomena that cut across mechanistically different interactions.

Reading *Symbiotic interactions* should help. Angela Doug-