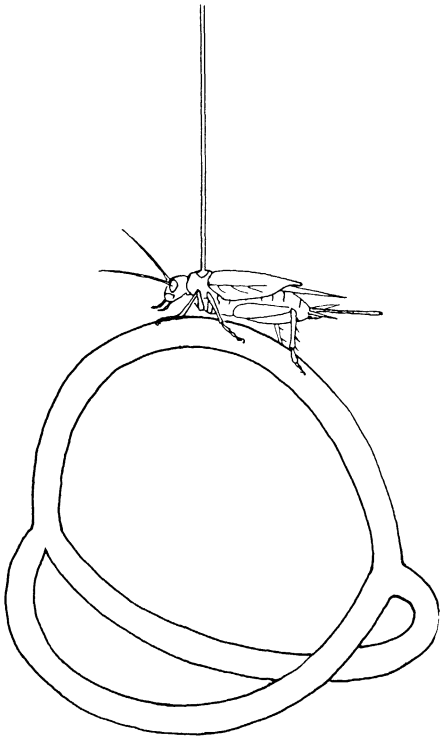
explicitly comparative approach might have been used to great advantage.

The book is particularly strong in its treatment of behavior and evolution. Much of the author's own research has dealt with the mechanics of singing and the evolution of song. His expertise in these areas is clearly apparent in the insightful way he relates issues of behavioral function and evolution to the physical constraints imposed by the devices and media that insects must use for producing, transmitting, and receiving acoustic signals.

It is inevitable that in a survey of this sort there will be some gaps in coverage. Although there are a few citations to quite recent work (1988), most of the material covered dates from 1986 or earlier. It is surprising that a book subtitled "Neurobiology and Behaviour" omits discussion of the relatively recent, but highly germane, work that directly addresses the roles of identified auditory interneurons in whole-animal behavior (see, for example, Nolen and Hoy, *Science* **226**, 992 [1984], and Schildberger and Horner, *J. Comp. Physiol.* **163**, 621 [1988]). Another conspicuous omission occurs in the section on the genetics of *Drosophila* song, where there is no discussion of the possible role of the *per* gene, which was initially identified for its role in determining circadian rhythms, in setting the rhythm of the courtship song (Kyriacou and Hall, *Proc. Natl. Acad. Sci. U.S.A.* 77, 6729 [1980]). The latter work is currently the subject of some controversy and has been challenged by Ewing (*Anim. Behav.* **36**, 1091 [1988]). Nevertheless, rather than ignore the issue, it might have been preferable to present all sides of the story. Even with the limitations mentioned above, the approximately 500 references listed in the bibliography are a valuable resource (although they would have been more useful if more liberal use had been made of citations in the text).

In all, *Arthropod Bioacoustics* is a welcome book. It succeeds in bringing a diverse body of literature together with depth and breadth appropriate for its target readership of advanced undergraduates, graduate students, and biologists seeking a general introduction to this field. It would be excellent as a supplementary text in undergraduate or graduate courses in animal behavior, or as the primary text for a more specialized course in animal communication.

GERALD S. POLLACK
Department of Biology,
McGill University,
Montreal, PQ, H3A 1B1, Canada



Tethered female cricket walking on an expanded polystyrene Y-maze. "Her phonotactic preferences can be assessed by analysing the choices she makes in response to songs played to her two sides." [From *Arthropod Bioacoustics*]

Ecology of Parasitism

Parasite Communities. Patterns and Processes. GERALD W. ESCH, ALBERT O. BUSH, and JOHN M. AHO, Eds. Chapman and Hall (Routledge, Chapman and Hall), New York, 1990. xii, 335 pp., illus. $89.50. From a symposium, Winston-Salem, NC, Aug. 1988.

Based on a symposium on helminth communities, this book is not just a collection of loosely connected essays but a well-integrated introduction to the community ecology of parasites, required reading for anyone working in ecology. Up-to-date and stimulating throughout, it presents an overview of patterns and processes in helminth communities, a discussion of host populations as resources defining parasite community organization, and discussions of communities of larval trematodes in snails and of helminth communities in marine fishes, freshwater fishes, amphibians and reptiles, and birds and mammals, as well as discussions of models for multi-species parasite-host communities and of hypotheses and pattern analysis in free-living communities and alimentary tract helminths.

The first chapter, by Esch, Shostak, Marcogliese, and Goater, is a concise and clear introduction to the terminology and the concepts of parasite community ecology. I know of no better outline of its kind. Nobody has done more to stimulate interest in the community ecology of parasites than Peter Price (*Evolutionary Biology of Parasites*, Princeton University Press, 1980), and in the second chapter, on host populations as resources, he outlines factors, such as host geographic area, density, and body size, that determine community patterns of parasites. He also includes a stimulating discussion of vacant niches. Price stresses that parasite systems must be included in syntheses of ecology, that parasitologists can take a leading role in advancing areas of ecology, and that "parasite community studies will become recognized as essential models for certain kinds of critical analysis" in ecology.

In the chapters on specific parasite communities, general background discussions are given together with detailed presentations of the ecology of those parasite species with which the authors are most familiar. This approach offers the reader up-to-date introductions to the relevant literature as well as discussions of current research, including methods used, and will be welcomed by students and research workers. An example is the chapter on parasites of marine fishes by John Holmes, well known for his experimental contributions to community studies of birds and mammals. After presenting an outline of knowledge of the ecology of marine parasites, he discusses his findings on helminths of *Sebastes nebulosus* in detail and compares them with those on other fish helminths, stressing aspects of community richness, predictability, host specificity, and determinants of helminth community structure in marine teleosts.

The various chapters cast light on the differences between helminth communities in different vertebrate classes. A. P. Dobson, in his chapter on models, emphasizes these differences and the necessity of further experimental work for a fuller understanding of coevolution and host-parasite relationships. Daniel Simberloff's critical approach to ecological questions shows itself in his comparison of free-living communities and intestinal helminths. He emphasizes the inadequacy of many statistical tests used to demonstrate species interactions in view of the difficulties in establishing valid null hypotheses: "Without experiment, even improbably low overlaps cannot strongly implicate the present action of competition" (compare *Evolutionary Theory* **8**, 305–350 [1989] on this point and others in Simberloff's discussion). Simberloff discusses competitive and reproductive character displacement as possible explanations for genetically determined non-overlapping niches and a third possible ultimate explanation of non-overlap, that the "genetic integrity of a species would make it difficult to be sufficiently flexible to occupy a large range of

niches." Bush and Aho stress the many advantages helminths offer for community studies, among which is the existence of many replicas.

The book concentrates almost exclusively on endoparasitic helminths, and protozoans, microorganisms, and ectoparasites are not considered in any detail (except in the chapter by Price). Little is known of the community ecology of protozoans and microorganisms in contrast to the ectoparasites, many taxa of which are known to be much more host- and site-specific than most endoparasites. Hence community patterns different from those of endoparasites must be expected for them, and probably a greater importance of coevolution. Also, most studies discussed in the book are from northern cold-temperate environments, and latitudinal effects are little considered (again except in the chapter by Price). It is hoped that a volume (or volumes) dealing with ectoparasites and zoogeographical patterns will follow this one.

KLAUS ROHDE
Department of Zoology, University of New England, Armidale, N.S.W. 2351, Australia

The Problem of Time

The Physical Basis of the Direction of Time. H.-DIETER ZEH. Springer-Verlag, New York, 1989. viii, 166 pp., illus. Paper, $35.

The arrow of time: what is the problem and how do you know if you've solved it? The problem most amenable to physical inquiry is the study of whether the various physical arrows imply one another. The physical arrows include the second law of thermodynamics, the expansion of the universe, CP violation, radiation reaction, and perhaps a quantum measurement arrow. For most of physics, knowing that you've solved a problem involves experiments and observations. This problem is seldom blessed with such criteria.

The most effort has been devoted to deriving the thermodynamic arrow from something else. Since the beginnings of statistical mechanics, the second law has been recognized as peculiar. For what other "law" of nature, after all, is there an entire discipline—fluctuation theory—devoted to its violation?

What then should imply the thermodynamic arrow? CP violation is so small an effect that one is hard put to see how it could dominate macroscopic physics. (Conceivably it could tip the balance in an unstable situation, just as P violation has been proposed to explain L-enantiomers.) The radiation arrow is unlikely to have fundamental status, a viewpoint that seems reasonable in the light of time-symmetric radiation theories that acquire directionality through the (thermodynamically based) Wheeler-Feynman absorber theory.

This leaves " 'cosmological arrow' implies 'thermodynamical arrow' " as the most plausible possibility. The trouble is that arguments for this thesis can be slippery. The most common mistake is the dogma of initial conditions, and the list of its errant adherents is a distinguished one. This dogma is the implicit and circular (when one is trying to derive the second law) assumption that initial conditions should be "arbitrary." Although this dogma was criticized two decades ago, you can still find it in works of some of our best thinkers. To his credit, Zeh is innocent of this sin, although he does miss the opportunity of exploring, in classical language, the interesting scenarios for a loosely time-symmetric universe, an opportunity that presents itself once the shackles of the initial condition dogma are removed.

What then is an argument for "cosmo implies thermo"? Dropping all fine points, I think what's happening is that the universe expands too fast for matter and radiation to relax. Matter has gotten caught in metastable states, like stars, whose entropy is far lower than that of a fully equilibrated state at, say, the current radius of the universe. Of the fine points I've dropped, the one I worry about is my implicit use of ensemble or coarse graining concepts in talking of our one-sample-point universe.

A strong point of Zeh's book is its treatment of many (but not all) of the significant topics needed for an informed, physical discussion of the arrow of time. A second strength is the presentation of a point of view founded on recent ideas of quantum gravity and the inclusion within this framework of globally time-symmetric scenarios.

There are several deficiencies. First there is a disregard of relevant physical data. For example, a well-known criticism of the absorber theory is that when one estimates the amount of matter needed to absorb—even if one accepts the theory of Wheeler and Feynman—there does not seem to be enough around. A similar shortage of matter also goes unmentioned in the treatment of Olber's paradox. Moreover, Zeh provides no discussion of whether the ideas he presents are experimentally testable. Wheeler has made a beautiful, if slightly overoptimistic, suggestion for measuring (by means of long-lived nuclides) the time left before the big crunch—if cosmo implies thermo. A physicist's book on the arrow of time should not ignore the potential for input from nature. Also lacking is serious old-fashioned discussion of "cosmo implies thermo." This may be okay if you are a believer in Zeh's version of quantum gravity, but in a book purporting to do more than propound the author's own ideas I would have welcomed—in fact the reason for my undertaking to review this book was mainly the hope for—a critique of the simple-minded "cosmo implies thermo" argument that I gave above. I also found the style of the book offputting. I can't blame the author for sounding like Immanuel Kant, and at times being just as hard to follow; it's the source language, I suppose. But I do take exception to an often dogmatic presentation of what are after all rather speculative ideas and to his glib dismissal of some of the ideas of others.

Let me say, however, that the deficiencies do not outweigh the strong points, and I recommend this book to those willing to devote serious effort to learning part of the subject.

LAWRENCE SCHULMAN
Department of Physics, Clarkson University, Potsdam, NY 13676

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