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.

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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.

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