between individuals. Individual organisms are important only as "temporary executors and propagators of . . . alternative programs" (p. 119); the proper way to understand selection forces is as contingent on strategies. The issues with which Dawkins is concerned in *The Extended Phenotype* will not prove a surprise to readers of his earlier work, though some of his conclusions will be, as when he adopts a rather sympathetic attitude toward the possibility of higher level units of selection (e.g., pp. 108–109). As with his earlier work, the positions he adopts will engage some and enrage many. Whichever camp one is in, Dawkins' newest contribution is unlikely to prove to be boring reading. *Robert C. Richardson, Department of Philosophy, University of Cincinnati.*

T. F. H. ALLEN and THOMAS B. STARR, ***Hierarchy: Perspectives for Ecological Complexity.*** Chicago: University of Chicago Press (1982), xvi + 310 pp. np.

For about fifteen years now, claims have been made that a new technique called hierarchy theory has finally simplified the analysis of complex systems (Pattee 1973). Hierarchy theory, however, is a *theory* only in some very special sense. To this day it does not have anything like a formalism of its own. In its most general form it just captures the intuitive notion of a hierarchy and organizes any collection of objects into ordered levels. The connections between the levels then becomes the subject for analysis. The use of hierarchical ideas in discussing philosophical issues in biology is nothing new. As early as 1961 Popper, for example, had used hierarchies to discuss purposeful behavior (Popper 1961), and, more recently, Gould (1982) has used them in a fascinating discussion of evolution. Yet this past use of hierarchical ideas has always been piecemeal, and the importance of Allen and Starr's work lies in its being the first systematic attempt to apply such reasoning to an entire discipline. The relevance of the work is further enhanced by their choice of discipline—ecology has long been expected to yield significant results from such non-reductive modes of inquiry.

Unfortunately, this program is not quite successfully carried out. In their analysis of ecological models the authors rarely make explicit use of hierarchy theory and, on the whole, fail to show how it could simplify generic problems in ecology. These defects notwithstanding, the book remains very interesting. First, the use of hierarchical ideas in ecology and evolutionary biology is likely to increase, and as a first attempt, this book could provide the necessary background for further discussions of the subject. Secondly, the book proceeds at a leisurely pace and the topics surveyed range from linguistics to sub-atomic physics. This breadth of vision is commendable and the very stimulating secondary discussions include analyses of scales, filters, and the role of the observer in defining the level of observation. For lack of space the rest of this review will ignore these positive aspects of the book and focus on the difficulties with its central program: that of applying hierarchy theory to the discipline of ecology.

Ecology, according to the authors, necessarily needs a description in terms of hierarchy theory because it constitutes a *middle-number* system. *Small-number* systems have few variables and are adequately described by differential equations. *Large-number* systems permit statistical treatment, but in between lie a host of systems that are too large for description by differential equations and too small for statistical averaging. Following Weinberg (1975), Allen and Starr call these systems *middle-number*, and construe ecology as an example. The notion of a *middle-number* system and the domain of its application remain ambiguous and will be dealt with later.

The book is divided into three parts: the first part is supposed to lay down the theoretical foundations for *middle-number* systems; the second explores the origin of life as such a system; and the third applies these ideas to ecology. The first section actually takes up the task of defining a hierarchy with no reference to *middle-number* systems. The authors assume a continuous distribution of hierarchical levels, each level being occupied by entities which, following Koestler (1967), they prefer to call *holons*. Such an "entity has a duality in that it looks inwards at the parts and outwards at an integration of its environment; it is at once a whole and a part" (p. 9). It is emphasized throughout the book that no ontological significance is attached to the *holons*: they are merely epistemological "con-

structs" for model-building. This emphasis smacks of an antirealist bias which perhaps accounts for the authors' preference for quixotic *holons* over mere "entities". The position of each *holon* in the hierarchy is entirely determined by its natural time scale or frequency: the *holons* with the highest frequency are at the bottom, and slower *holons* find their places at higher levels. The definition of a hierarchy purely in terms of time scale is problematic and will be commented on later.

The second section of the book attempts to apply these ideas to the origin of life. This section is easily the weakest and consists mainly of a confusing discussion of evolutionary processes. Evolution is presented in a dualistic setting: it has a *dynamic* and a *linguistic* mode of description. The former consists of the standard mechanistic model employing natural selection. It is never quite clear what the latter mode consists of, but two arguments are presented to justify its necessity: (i) it is in concurrence with some principle of complementarity that is supposedly central to biological thinking, and (ii) this new mode makes it possible to understand preadaptation through "anticipatory" structures. Both claims are dubious: the existence of such a principle of complementarity is highly controversial, to say the least, and evolutionary biologists seem to experience no difficulty in explaining preadaptation within the Darwinian picture. Finally, what makes this section particularly curious is that, despite its title, it has almost nothing to do with the origin of life. Hierarchical organization is intrinsic to the theories of self-replication proposed by Eigen and others (1977), and it is surprising that they do not enter the book's discussion at all.

The third section deals with ecology. Quite a formidable variety of ecological models is presented and the successful ones are then investigated for implicit hierarchical structure. The authors show, quite convincingly, that simplifying assumptions in models often make them fail to predict the wealth of detail that characterizes ecological phenomena. This happens, the argument goes, because some slowly-varying constraint was assumed as constant in the model. A hierarchical approach, according to the authors, would result in the inclusion of the slow process. It is not clear from the authors' argument why hierarchical thinking is necessary or even well-suited for such an inclusion, which is tantamount to the addition of a variable to the description of the system. Standard model-building heuristics routinely involves refinement of models through the addition of variables, and a better defense of hierarchy theory seems necessary. Such a defense would involve, for instance, a demonstration that hierarchical thinking could prevent the sort of biases that plague reductionist research programs (Wimsatt 1980). After all, it is this last fact that makes hierarchical approaches very popular with many philosophers of biology, and Allen and Starr do not seem to have given it due credit. Also very disturbing about this section is the absence of a single new result that could be attributed to hierarchy theory.

Besides the particular objections already raised, there are two more general objections to the method used in the book: (i) The notion of a *middle-number* system remains ambiguous. While the authors define *large-number* and *small-number* systems in terms of associated mathematical structures, no such structure is presented for *middle-number* systems, and it is by no means certain that such a structure even exists. Moreover, there is an ambiguity in its application: in all the ecological models discussed in the third section, the formalism employed for *middle-number* systems is no different from that of *large-number* systems. As in the last case, crude approximations are made to write down tractable equations involving averages, and the solutions are then explored in detail. Any attempt to make the notion of a *middle-number* system precise must involve, at the very least, some analysis of where the law of large numbers breaks down as, for instance, in situations where fluctuations can cause a qualitative change of behavior (i.e. bifurcation points). Since the authors do not even attempt such a development for *middle-number* systems, and the concept really plays no essential role in the arguments in the book, it would have been less confusing if it had not been introduced at all. (ii) The authors' attempt to define a hierarchy purely in terms of time scale leads to difficulties. Evolutionary processes are normally put at a higher level than ecological processes. Yet, as several biologists have systematically shown, ecological and evolutionary processes often take place on the same time scale. Further, this characterization of hierarchy ruins an otherwise elegant example used by the authors. In discussing the collapse of the Tacoma Bridge the authors mention how the environment, presumably an upper-level *holon*, sets off oscil-

lations in the bridge *holon*. What is crucial to the event is that two interacting *holons* from different levels had the same natural frequency, thus permitting resonance. Contrary to the preference of the authors, it seems more reasonable to define hierarchies in terms of a set of parameters including, at least, spatial organization besides time scale (Wimsatt 1976).

The last two objections could, however, be ignored if the application of hierarchical ideas in this framework had led to some new result. The absence of such results makes it impossible to judge the authors' claim that ecological complexity is best understood in terms of hierarchy theory. Thus, it constitutes a critical problem for the book, and in conclusion, it seems that, though the book remains interesting and very welcome as a first attempt, it does not yet do justice to its subject. *Sahotra Sarkar, University of Chicago.*

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