BOOK REVIEW

Michael Conrad, *ADAPTABILITY: The Significance of Variability from Molecule to Ecosystem*, Plenum Press, 1983, 383 pp., $42.50

The author acknowledges in the preface that the writing of this book spanned 19 years, in more than 17 institutions, located in at least seven countries. The potential reader, in thumbing through the volume, might wonder whether a proportional commitment of time and energy is required to digest the work. Such fears are hardly exaggerated—this book is not for the casual reader. The crucial question, however, is whether perseverance on the part of the reader will be rewarded.

The central thesis is rather simple, but nonetheless profound. Biological dynamics are usually described using mathematical tools developed in the physical sciences, where variations on an underlying principle are considered noise to be discarded. Many biologists are convinced that it is wrong to neglect such variability, and theoreticians such as Ashby, Atlan, and Prigogine have highlighted the importance of variability in developing systems. Conrad goes further to contend that variability is *the fundamental object* from which dynamics (or more primitively, state transitions) are inferred.

If Conrad is correct in his assertion, then society needs to reconsider the ways in which it plans for the future. The designs of man are predominantly concerned with predictability and efficiency at the necessary expense of variability. But designs that are successful in achieving high efficiency are ultimately doomed to fail because they lack the requisite variability to deal with inevitable stochastic events.

If this seems rather self-evident to anyone with a tolerant frame of mind, one need not look far to find evidence of those who are blissfully unaware of such a paradox. For example, one reads accounts of efforts to simulate intelligence algorithmically on machines of high reliability and precision. Conrad points out the crucial role that stochasticity, unreliability, and imprecision play in the workings of the brain and in the development of true intelligence. He shows how the "gradual transformability" necessary for intelligence is impossible with the "nondecomposable" systems in use today, thus implying that the present attempts are akin to earlier efforts to realize perpetual motion. Of course, the number of persons concerned with artificial intelligence pales in comparison to the legion of political and economic ideologues who would impress their precise visions of an efficient society upon the world!

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Familiar tools, such as probabilities, entropies, and conditional entropies are used to give concrete mathematical expression to the different forms of variability. The algebra expressing the relationships among these forms is not tedious.

If the book bears upon such weighty and exciting matters using only intermediate level mathematics, what, then, makes it so excruciatingly difficult to digest? In my opinion the author tries to cover too much in one volume. He is understandably enamored of the generality of his thesis and is anxious to demonstrate its applicability to a wide range of systems extending "from molecule to ecosystem." To do this, he finds it necessary to create a seemingly endless array of verbal concepts and mathematical symbols.

To further complicate matters, there is simply no room to present enough background material on thermodynamics, information theory, genetics, evolution, physiology, ecology, molecular biology, and cybernetics, so the author presupposes that the reader is fluent in these fields. Therefore, anyone lacking depth in *all* these disciplines (and that includes virtually everyone) is apt to lose patience with the author at some point along the way.

"Needless to say, any formalism which is capable of coping with the full complexity of adaptability processes in nature must itself be complex," the author warns in the preface. But I strongly suspect that the significance of adaptability could be more effectively impressed upon the reader without having to consider "the full complexity." One can only wish that the author had rounded out a score of years and taken the time to ruthlessly prune the manuscript into a more efficient text. (But in all fairness the present form is at least self-consistent with the author's caution against overemphasis on design.)

Lest anyone get the wrong impression, I regard Michael Conrad as a strong contributor to the inchoate domain of theoretical biology. Anyone in the field who is unwilling to tease out the author's insights from among the welter of definitions is likely to be at a disadvantage in the exciting debates that loom in the near future. If only someone could convince Professor Conrad to be a little less self-consistent!

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