Biophysics of Ecology

Energy Flow in Biology. Biological Organization as a Problem in Thermal Physics. HAROLD J. MOROWITZ. Academic Press, New York, 1968. xii + 179 pp., illus. $9.50.

This book is a biophysicist's view of the complex levels of organization of biology, ecology, and the biosphere. It is an effort to resolve the deep contradiction felt by many physicists in the biological tendency toward order in systems whose molecular components have tendencies toward disorder. The book starts with two chapters on physical theorems concerning the behavior of energized populations of molecules, including aspects of steady-state thermodynamics, and a chapter that recapitulates biology into 13 generalizations as seen from the molecular stance. Chapters 4 and 5 are lucid statements of the thermochemistry of protoplasm, including calculations of the entropy contents of formation that will allow more biologists to change their calorimetry data on heats of reaction to potential energies instead of incorrectly using one to approximate the other. Included is the quantitative statement of the effect of temperature on the maintenance requirement of biological structure. The book's central concept is then introduced in the final chapter with an order function, $L = \Delta A/(kT/h)$, the ratio of Helmholtz free energy (ΔA) of the biological structure to the temperature-dependent disordering flux that must continually be overcome if that structure is to be held at steady state. Morowitz's order function is similar (reciprocal) to a quantity which I have called the Schrödinger ratio (*Pollution and Marine Ecology*, T. A. Olson and F. J. Burgess, Eds., p. 135) and which is identical with the very old empirical variable in ecological measurement, respiration-to-biomass (turnover) ratio. Morowitz uses Helmholtz free energy, whereas most biologists use Gibbs free energy and thus sweep pressure-volume changes under the rug. At the end he does some elegant manipulations showing, for example, that as temperature rises the difference in behavior of numerator and denominator causes the order function to pass through a maximum. Following Margalef he believes that nature maximizes the ratio of structure to maintenance metabolism. In this he is probably wrong, because he ignores the role of natural selection by which energy flow is maximized instead, so that sometimes high biomass is produced and sometimes low, depending on programs for adaptation to temporary irregularities in input energies.

This book's elaboration of the Schrödinger theme and related functions will irritate many biologists because old concepts are generated *de novo*, as if new, whereas what is new is putting them in the language of the molecular physicist. This Yale professor was trained in a setting in which the ideas of A. J. Lotka were influential. Without citation of Lotka's writings or of others in the literature he now writes the same story of the self-correcting homeostasis of the closed mineral cycle, general reaction kinetics of light on a cycling receptor system, and other well-established principles of systems ecology.

As the diversity of scientific schools of thinking and scientific languages increases, it may be increasingly frequent that synthesizers will use the notation of one field to generate theory concerning the material of another without mastering the literature of the latter and without realizing that the theorems are as clearly established in other forms. If it is quicker for a keen mind to generate knowledge anew than to be responsible for the huge literature of other fields, what is his obligation? A real difficulty may be the Ptolemaic arrogance with which those working at one level of integration tend to regard a theory as unproven until it is stated in the notation of their own discipline. This is a pitfall for students of the small who undertake to deal with the large, mainly because education for the small often omits the large as if it didn't exist.

In any case, ecologists and biologists will be fascinated to find their familiar concepts restated in the (to them) more cumbersome molecular formulations which they must now master. The book will help their colleagues in physics to discover complex open systems and will show biologists who among the molecular contributors to unfamiliar journals have written papers pertinent to the old problem of order.

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