Ecological models and mechanisms

Richard G. Wiegert

Systems Ecology: An Introduction.
By Howard T. Odum.
Wiley: 1983. Pp.644. $54.95, £56.25.

IN *Systems Ecology*, Howard T. Odum attempts to wrap virtually all living systems in the explanatory mantle of systems science and energetics. The mantle is frayed in some places, stretched too thin in others and is certainly far from large enough to cover everything, yet credit must go to the author for simply making the attempt. Odum's arguments touch, in one manner or another, on just about every aspect of ecology. They are often controversial, occasionally wrong, rarely naive but never dull.

The book consists of 27 chapters, divided into four sections, the first of which is a general overview of systems ecology and modelling. The remaining three deal with the main elements and interactions found in ecological models, the organization of systems in terms of energy and other physical factors, and the system attributes of various levels of biological organization. This last section concludes with a chapter on the unity of systems.

In the first part Odum makes a laudable attempt to describe and compare the various possible ways (that is, the languages) that can be used to explain the workings of a system and translate them into forms understandable by a computer. Unfortunately, the set of defined "languages" he discusses (given in Table 1-1) is, in the sense of comparing apples and oranges, a veritable fruit-basket. The language of mathematical notation, for example, has been subdivided into a number of "different" languages before being compared to English or the energy-circuit language long-used effectively by Odum. Many workers choose to use the latter in its entirety. Others, myself included, use mathematical notation, perhaps supplemented by some of the more general state-variable symbols of Forrester or Odum. A much more careful and rigorous definition of "language" would have immensely increased the usefulness of the comparison.

In Part II Odum systematically lists the functional descriptions of ecological interactions that have been used in the past. These cover control of autocatalytic modules, influence loops, serial predator-prey interactions, parallel competition interactions and food webs. This is a most helpful entrée to the literature. But the effort to find and convert all such functions to the language of energy circuits has unfortunately left no room for assessment of the various functions and their relevance in light of theory. For example, the important topic of *r* versus *K* strategy is disposed of in a single paragraph of eight lines!

Part III deals with the importance of energy in system organization and pattern. In Odum's concept of "embodied energy", the value of the energy content of matter is augmented in proportion to its position or distance (in terms of trophic transformations) from the Sun. This is an important distinction. But I believe it is overdone by drawing an analogy with temperature, as the latter is used to measure the "availability" of heat energy. Temperature is an exact reference because it always has an absolute (zero degrees Kelvin) or a relative reference (the temperature of the surroundings). But energy transformations in living systems involve many unknown pathways and are variable; organisms often feed from several trophic levels while accumulating their stored energy. Furthermore, the human value-system may often make the concept of embodied ecological energy meaningless. For example, the pearl has the same embodied ecological energy as an equal weight of oyster shell, yet, because of its value, it can affect ecosystems to a much larger degree.

In general this part of the book suffers from too great an emphasis on physical examples. The chapter on temperature would have profited from mention of the temperature functions in models necessitated by the great wealth of behavioural and physiological adaptations of organisms to ameliorate the effects of varying temperature. More importantly, Odum is wrong when he says (p.318) that "The energy flow of maintenance respiration divided by the Kelvin temperature gives the entropy change". This old analogy presumes the living entity in question to be closed to exchanges of matter and in reversible thermodynamic equilibrium. Neither is true and the entropies of exchanging matter and the irreversible heat loss completely swamp the rather small entropy changes associated with internal chemical transformations. This is why we use First Law energy balance equations in ecological energetics.

In Part IV Odum discusses system modelling of successively larger ecological hierarchies, culminating in a presentation of world patterns. This, the freshest and most interesting part of the book, contains more detailed and free-ranging discussion and critical evaluation. In particular the modelling of monetary flows as well as of energy flows is explained clearly and there are some excellent examples of embodied energy expressed in monetary terms.

Alongside the stress on a holistic view of ecosystems, throughout the book Odum implicitly makes a strong case for modelling ecosystems with components for which mechanistic explanations have been supplied. This in turn implies an awareness of and reliance upon population genetic selection and fitness as the basic units of evolution in ecosystems. The incorporation of these concepts into ecosystem models is a prime objective of most ecological modellers today. Explicit treatment of this subject in the next edition of the book would be a valuable addition. □

Richard G. Wiegert is Professor of Zoology at the University of Georgia.

Star appeal

R. J. Tayler

Superstars: How Stellar Explosions Shape the Destiny of Our Universe.
By David H. Clark.
McGraw-Hill: 1984. Pp.216. $17.95.

WHEN a star explodes as a supernova, there is a short period in which it is as luminous as a whole galaxy of ordinary stars. The sudden appearance of such a "new star" has in the past been regarded as a portent, and two supernovae observed in 1572 and 1604 played a part in the acceptance of the new astronomy in which all objects beyond the Moon were no longer regarded as perfect and unchanging. Supernovae are important sources of heavy chemical elements and of cosmic rays; their explosions are crucial to the energy balance of the interstellar medium; they may stimulate the formation of new stars; and, in some cases, their explosions leave behind highly compact and exotic remnants, pulsars. It has also been suggested that biological extinctions might have been caused by the occurrence of supernovae relatively close to the Earth.

David Clark gives an account of all these aspects of supernovae for a general audience. He is at his best when discussing the historical significance of supernovae and describing how, for example, the Chinese and Korean astronomical records have provided evidence for the explosions of supernovae whose remnants can be studied today. Although the book also contains a good assessment of the astronomical importance of supernovae without the introduction of any mathematics, it inevitably contains many complicated physical ideas, some but not all of which are conveniently discussed in appendices. Because of this the book will be most readily appreciated by readers with a basic training in physics.

Anyone who does read the book will realize why astronomers are hoping that there will soon be another bright supernova in our Galaxy. Every possible instrument would be used to study the supernova and the early development of its remnant, and the increase in astronomical knowledge would potentially be very great indeed. □

R.J. Tayler is Director of the Astronomy Centre of the University of Sussex.