

organisms for students of competition. Starting with V. S. Summerhayes's classical experiments with voles during the 1930's, a significant literature has grown up that involves mammals as competitors or as agents that promote or relieve competition in other taxa. Since knowledge of competitive processes appears to be a key to understanding species diversity and extinction, the absence of a discussion of competition is a serious gap in terms of the book's and IBP's goals.

Several of the contributions at the end of the volume are addressed to applications of knowledge to rodent control for agricultural and health purposes. Other chapters refer to these problems either as worthy of attention or as motivating forces in their research. Unfortunately, at this stage, the best these authors can do is point out some of the opportunities for application and suggest untried philosophies and methodologies.

Remarks about applications throughout the volume are biased against rodents. Granted, rodents can be pests. Granted also that they can carry diseases. However, they also consume vast quantities of insects, and insects are also pests and vectors. In only one place in the book did I find any mention of the possibility that most rodents at most times are more helpful than harmful. And no one seems to have taken this possibility at all seriously. It is my belief that offending rodent species are more than equaled by inoffensive and beautiful forms in whose absence we would be esthetically poorer, at least.

The book accurately reflects the immaturity of the science of ecology as a whole. It reports observations made and data collected, but rarely indicates the hypotheses that were being tested. That is because hypotheses are usually not involved. It is not inaccurate to characterize most current ecology as Baconian—rooted in the faith that pure induction is the only (or the best) way to do science.

History, however, teaches a different lesson. As sciences mature, they develop a hypothetico-deductive philosophy. They progress by generating hypotheses and disproving them in controlled experiments. It is my opinion that such a maturation is now under way in ecology, and that after it is completed we shall be in a much better position to offer aid and advice to those involved in public health and agriculture and to those who would save our wild lands and their denizens from extinction. Inasmuch as this book hints at the ongoing change, it is like a beautiful larva caught spinning a cocoon;

we can see the glory that was and anticipate that which is coming, all at the same instant. From this reviewer's point of view, three cheers for the metamorphosis!

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Pattern in Evolution

Complex Adaptations in Evolving Populations.
T. H. FRAZZETTA. Sinauer, Sunderland, Mass., 1975. xiv, 270 pp., illus. Cloth, \$11; paper, \$4.95.

Why are there so many kinds of organisms, and how have so many complex structural patterns evolved? Frazzetta assumes that the evolution of complex adaptations occurs in a manner compatible with what is known concerning the evolution of simple characters, but seeks to determine if such knowledge is sufficient to explain the diversity of nature. This monograph deals with complex structures, and strives for answers to the questions set forth above. The examples are exclusively animal, and deal mainly with vertebrate hard parts, but the approach is general. In Frazzetta's view history, developmental canalization, and physical laws constrain lineages during phylogenesis. Ledyard Stebbins has proposed that these and other factors lead to a kind of evolutionary canalization, with groups being set on trajectories early in their history and from that point following paths of least resistance. Evolution runs in grooves, so to speak. If this is so, how do complex novel features appear, and how do they become incorporated into the genome?

This work is an attempt to integrate genetics, population ecology, morphogenesis, and biomechanics with some notions and hypotheses from a variety of fields to achieve a synthesis. It is a tall order. Frazzetta has articulated the problem clearly, and must be credited with courage for his struggle in this conceptually difficult area. His attempt at synthesis is only modestly successful, however. Gene duplication, the Britten-Davidson model, the Ludwig hypothesis, the Baldwin effect, and problems of relative growth all enter into his synthesis. Yet one is left with the numbing feeling that biologists remain unable to present convincing arguments to explain the evolution of callouses in mammals, divided maxillary bones in an obscure group of snakes (both discussed here), and many

other structures. The author repeats his earlier arguments that bones broken during feeding in ancestral snakes gradually evolve into two separate bones in descendants living on an island lacking major competitors. The contrived explanation is an example of a pattern in this work, with stress on the possible more than the probable. Evolutionary biologists are indeed clever, but has the production of pattern in evolution really been explained, or has it been explained away?

The narrative flows well for the informed reader, but to one not already conversant with population ecology, genetics, and developmental biology the arguments may be obscure. The connections between seemingly disparate fields are not made smoothly, and the habit of using extensive, often esoteric, notes in every chapter is distracting. The author frequently generalizes broadly and speculates from a very few, narrowly defined experiments. Yet, he freely states again and again that evidence is "merely circumstantial," or that his arguments depend heavily on the validity of a fine, often controversial, point. Nearly every argument is heavily qualified, but there are some striking insights and some useful models. For example, arguing by analogy from the history of technological development, Frazzetta suggests that truly new complex adaptations can be effective even though very imperfect. What is important is novelty and progress, not precision. Population ecology is stressed out of proportion to the use made of the formulations later in the book. However, a model Frazzetta presents integrating parameters of population dynamics with aspects of natural selection (unified as a general factor—an intuitively defined "selective diversity") may have heuristic value.

Frazzetta concludes that there are but a few fundamental patterns underlying animal diversity. The differences we perceive are real, but their biological causes might be simpler than we think.

There is a vagueness in some instances approaching mysticism in this treatment, and it is difficult to know exactly how to use the book. It is, in effect, a long essay, appropriate for supplemental reading lists in advanced courses. Surely many would benefit from pondering anew some of the fundamental questions in evolutionary biology as perceived by this thoughtful and imaginative biologist.

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