book grows out of Weismann's late-19th-century arguments on the significance of germ line segregation during development, but its intellectual viewpoint arises from the last decade's intense controversies on the adequacy (not validity) of the Modern Synthesis as an explanation for evolutionary phenomena, particularly the often heated controversies about units of selection and the possibility that natural selection may act at multiple levels in the biological hierarchy. The high point of this volume is undoubtedly Buss's derivation of a conceptual paradigm for developmental patterns, based on the idea that ontogenetic patterns and specific developmental phenomena such as induction and programmed cell death are best viewed as the consequences of selection on cell lineages within an embryo to limit their replication and to isolate the germ line from potential somatic mutations. This is, in my opinion, the theoretical framework that embryologists have searched for during the last hundred years, rationalizing the common patterns seen early in ontogeny, the great diversity of patterns in later ontogeny, and the commonness of heterochrony as a mechanism of evolutionary change. Buss's exploration of this thesis is the major strength of this book, fitting topics as diverse as developmental patterns, life cycle evolution in parasites, and the dominance of diploidy in both metaphytes and metazoans into a single framework.

Given the importance and potential power of the ideas in this book, it is unfortunate that it has as many flaws as it does. One gets the impression that it was prepared in haste; typographical errors are distressingly frequent, the rows and columns have been interchanged in figure 2.17, making it difficult to follow the argument in the caption, the alga in figure 4.11 is misidentified, and footnote 40 in chapter 2 is totally unrelated to the text and obviously misplaced. The design of the book, with the printed text spanning only two-thirds of the page, leaves the impression that the publisher has attempted to make the book appear longer than it really is. Many of the figures were apparently included more for their esthetic value than for their ability to clarify and illuminate the text, and the figure captions are exceptionally cryptic; if the reader is not already familiar with the information in the figure, the captions will rarely help. Some of the book's central terms are used in ways counter to the common understanding of most biologists. "Heritability," for example, is defined (p. 69) as "the capacity to yield a new multicellular individual," and the word "variant" is apparently used both in the sense of a mutation and to describe the results of cellular differentiation. The citations are in footnote style rather than standard biological format, often making it difficult to determine the specific reference if, for example, it was first cited 20 pages before. The logic underlying some of Buss's arguments is occasionally rather strained, and the reader is continually frustrated by the desire for more examples and more explicit attempts to test the predictions derived from these arguments, but this criticism is perhaps better seen as indicative of the intellectual excitement Buss's ideas engender than as a weakness of the volume in hand. With more documentation and a greater exploration of the implications of these ideas this could easily have been the most important book in biology in this decade, but even with its flaws it should be on the list of required reading for all evolutionary and developmental biologists.

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A Sole Survivor

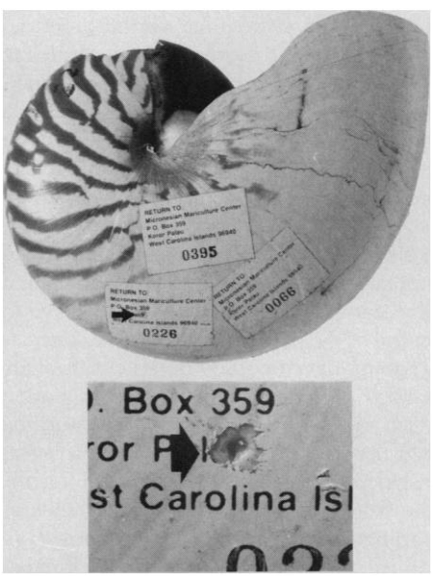
The Natural History of Nautilus. PETER DOUGLAS WARD. Allen and Unwin, Winchester, MA, 1987. xiv, 267 pp., illus. $34.95.

Nautilus. The Biology and Paleobiology of a Living Fossil. W. BRUCE SAUNDERS and NEIL H. LANDMAN, Eds. Plenum, New York, 1988. xxviii, 632 pp., illus., + plates. $95. Topics in Geobiology, vol. 6.

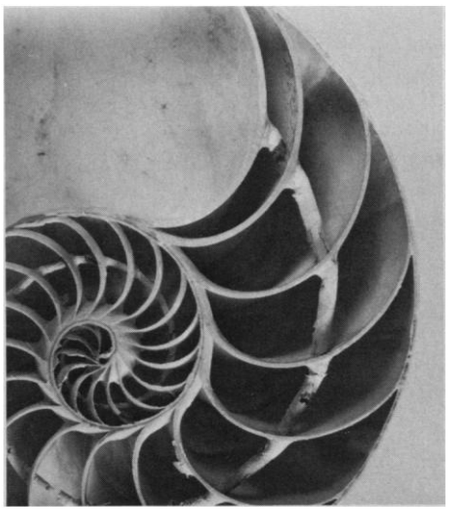
Nautilus is a small, ecologically unimportant genus of deep-water tropical invertebrates. If it were like most other such genera, one would be lucky to find even a single obscure paper devoted to it during any given year. Why, then, should *Nautilus* merit the publication of two full-length books in a single year? The answer is simple. As the single surviving genus of cephalopods with a chambered external shell, *Nautilus* is the only key we possess for unlocking the biology of the hundreds of fossil nautiloids and ammonoids that were so prominent in the seas of the Paleozoic and Mesozoic eras. Moreover, *Nautilus* offers a fascinating contrast in its physiology and mode of life to the other living cephalopods—squids, octopuses, and cuttlefishes—in which the shell is either internal or lost entirely.

The two books under review—one a single-authored synthesis by P. D. Ward, the other a multi-authored collection of papers edited by W. B. Saunders and N. H. Landman—cover much the same ground and reveal remarkably few points of disagreement. Both provide much new information as well as incisive reviews of previously published work. Ward emphasizes buoyancy control and shell growth, together with extensive observations on the ecology of the living species on forereef slopes in the tropical western Pacific. Several physiological aspects only briefly touched upon by Ward receive more extensive treatment in the Saunders-Landman volume, which also contains chapters on many other topics including ecology, reproduction, shell microstructure, and taxonomy.

The picture of *Nautilus* that emerges from these two books is of a low-energy animal that, compared to other cephalopods, swims and grows slowly and hatches as an unusually large (25-millimeter-diameter) juvenile. Whereas most other cephalopods have an extraordinarily sophisticated visual system, the comparatively simple camera-obscura eyes of *Nautilus* appear to play a subordinate sensory role to the highly developed olfactory and tentacular sense organs. Vertical movement in the water column is made possible by a complex buoyancy-control mechanism, in which liquid is pumped into and out of the shell chambers by the siphuncle. The rate of liquid removal from the chambers, which varies according to depth and temperature as well as with the thickness and permeability of the siphuncular wall, controls diverse aspects of the life of *Nautilus*, including growth rate and the ability of the animal to respond rapidly to sudden changes in its density. The maximum depth at which *Nautilus* can live is



Mature *Nautilus belauensis* "trapped three times in 1977 off Mutremdiu Point, Palau (shell diameter 216 mm." The arrow on tag 0226 points to *Octopus* boring. [From W. B. Saunders *et al.*, "Predation on *Nautilus*," in *Nautilus: The Biology and Paleobiology of a Living Fossil*]



Dorsoventral view of a *Nautilus pompilius* from the Philippines, "showing the final two septa thickened and strongly approximated." [From D. Collins and P. D. Ward, "Adolescent growth and maturity in *Nautilus*," in *Nautilus: The Biology and Paleobiology of a Living Fossil*]

dictated not only by the efficacy of buoyancy control, but also by the mechanical strength of the shell and siphuncle. Contrary to what might have been expected for a living fossil like *Nautilus*, the half a dozen or so species of this genus display considerable genetic variation both within and between populations, as is particularly well documented in the chapter by D. Woodruff *et al.* in the Saunders-Landman volume.

Inferences about fossils depend on the judicious application of the principle that the observed relationships among form, function, and ecology in living representatives also held in fossil forms. In the final section of his book, Ward demonstrates the power of this approach by applying his data on buoyancy control in *Nautilus* to the interpretation of fossil chambered cephalopod shells. From their thinner shells, more complex and thinner chamber partitions, smaller larval shells, smaller muscle-attachment areas, and marginal position of the siphuncle, he convincingly argues that, compared to *Nautilus*, ammonoids grew faster, hatched at much smaller sizes, lived in shallower waters, and were for the most part sluggish swimmers. Mesozoic nautiloids grew more slowly and lived in deeper water than did most contemporaneous ammonoids. The decline and ultimate demise of the ammonoids in the Cretaceous, in Ward's view, is explained in part by the fundamental incompatibilities among the demands for rapid density compensation, rapid locomotion, and adequate passive protection by the external gas-filled chambered shell. Such a body plan is still adequate in the deep-water habitats of *Nautilus*, but in shallow waters it has been eclipsed by the endoskeletal plans of fishes and the other living cephalopods, in which more active forms of defense and higher locomotor performance have evolved. Given that the deep-water habitat of *Nautilus* may not have been typical for many other fossil cephalopods, we must be wary of speculations by several authors in the Saunders-Landman volume that the poorly developed eyes and other characteristics of *Nautilus* represent the primitive condition in the Paleozoic ancestors of the other living cephalopods.

These books should be required reading for anyone working with living or fossil cephalopods. At a time when some paleobiologists are dismissing functional morphology as irrelevant to the interpretation of life's history, it is heartening to see in these two books how illuminating the study of form and function can be for an understanding of large-scale evolutionary patterns. The general reader will probably find Ward's the more concise and unified account, as well as the source for the more interesting speculations, but both books provide a wealth of valuable information that will serve as the springboard for all future work.

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Unusual Fishes

Frogfishes of the World. Systematics, Zoogeography, and Behavioral Ecology. THEODORE W. PIETSCH and DAVID B. GROBECKER. Stanford University Press, Stanford, CA, 1987. xxiv, 420 pp., illus., + plates.

This monograph focuses on a remarkable assemblage of marine shorefishes, the Antennariidae, that qualify as one of nature's most novel evolutionary products. A wide interest in frogfishes beginning with 18th-century naturalists resulted in a descriptive proliferation of 165 nominal species (41 are currently recognized) and a confusing taxonomic history involving over 350 different scientific name combinations. This monograph consists mainly of descriptive accounts (including many drawings and 16 pages of color plates), identification keys, comprehensive synonymies, nomenclatural and distributional comments, and other such material. Many original observations are presented, and with this reference antennariids can be readily identified. Several chapters make interesting reading, especially the "historical perspective," which includes brief biographies of selected workers and fascinating accounts of folklore and erroneous observations of frogfish biology. The chapter on "behavioral ecology" will be of interest to the widest audience and covers such diverse topics as feeding dynamics, defensive behavior, locomotion, and reproductive biology. Frogfishes are cryptic mimics that attract prey with a fleshy lure; all that is known concerning a wide range of morphological, functional, and behavioral adaptations associated with this mode of existence is discussed in eloquent detail.

The frogfish *Histrio histrio* (Linnaeus) as represented by Albertus Seba in the *Locupletissimus Rerum Naturalium Thesaurus* of 1734 (plate 74, figure 3). [From *Frogfishes of the World*; courtesy of Ben Williams and the Field Museum of Natural History, Chicago]

The infraordinal classification and specific taxonomy of frogfishes appear to be well established, but other aspects of their systematics are not resolved. No derived characters have been identified that unite the 24 species assigned to *Antennarius*, and none of the 11 other genera contain more than 3 species. Despite considerable effort, no synapomorphies have been discovered that convincingly establish the intrafamilial relationship of any of these genera. A reader attempting to re-evaluate antennariid character-state polarities and phylogenetic relationships is at a disadvantage because only partial data are given for the three other families included in the suborder Antennarioidei: Tetrabrachiidae and Lophichthyidae (both monotypic) and Brachionichthyidae (with about four species). This omission is the only fault I have to find with this otherwise comprehensive monograph. Biogeographic patterns are discussed and spot distribution maps are given for each species, but incomplete knowledge of antennariid phylogeny precluded a detailed analysis.

Easily maintained in aquaria and fascinating to observe, frogfishes are recommended as ideal laboratory animals for scientific investigations of all kinds. Perhaps the most important contribution of this book is that it identifies a challenging array of unanswered questions about a remarkable group of animals and serves as a basic foundation for further inquiry.

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