quently called cladistics, slowly gained ground, but in the late 1970s the suggestion was made that evolution was not necessarily relevant to the process. The subsequent arguments were suprisingly ill-natured. Worse still, philosophers of science started to glide in, pausing only to fold their wings before hopping determinedly toward the increasingly bloodied opponents. Things began to look bad. Fortunately many workers simply stole away from the debate, taking Hennig's basic message, that shared derived characters can be used in principle to reconstruct phylogenies, and went to work. This resulted in a whole series of attempts to chart the past. The present volume is a compendium of such efforts devoted to the lizards. Well produced and illustrated, it is based on a 1982 symposium organized by S. Moody and dedicated to Charles L. Camp, who had produced a seminal phylogenetic classification of lizards in 1923. Like the cladistic method itself, the book seems to have had an eventful and prolonged gestation, taking nearly six years to appear. Of the 12 original speakers only six have contributed to the volume, although another two authors, and two obviously hard-working editors, have been coopted on the way. This strenuous history probably accounts for a coverage rather different from that suggested by the title of the symposium, which has been retained for the book: only two of its chapters deal directly with the interrelationships of the families of lizards. Nevertheless, all the contributions are relevant and their quality is almost uniformly good.

Late Paleozoic and Mesozoic lepidosauromorphs are discussed in relation to lizard ancestry (R. L. Carroll), and the phylogeny of the whole of the Lepidosauromorpha is dealt with on the basis of 171 characters (J. Gauthier, R. Estes, and K. de Queiroz). The same authors (in different order of precedence) also tackle the relationships among the 17 extant families of lizards and their affinities with snakes and amphisbaenians. Based on 148 characters, this key chapter gives a good overview of the problem and sets up a firm framework for future work. On the basis of the evidence presented here, snakes and amphisbaenians seem to be derived from the scincomorph-anguimorph lizards, but their precise relationships are not clear. An independent approach (W. Presch), concentrating on the Scincomorpha but including most other lizard families, produces rather similar results to those of the previous study but also distinct differences. These probably arise because, although large, the data set is less comprehensive in number both of taxa and of characters (91 used).

A study of the Iguanidae (R. Etheridge and K. de Queiroz) shows there are eight main groups, although their relationships are unclear and it is not even certain that they comprise all the descendants of a single ancestor. Relationships within each group are worked out in some detail. This is important not only because iguanids are a large family of nearly 600 species and are the dominant lizard group in North America but also because they have been used so much as ecological models and in evolutionary speculation, which are both areas that benefit from a phylogenetic perspective. By comparison a study of the just 22 species of eublepharid geckoes (L. L. Grismer) might seem like a vignette, but the analysis is very full and the biogeography of the group is also included. This suggests that eublepharids arose in Asia and dispersed in the early Cenozoic into North America and later into Africa, a pattern shared with some other lizard families.

Because of their explicitness, cladistic approaches to relationship have the advantage of making clear what it is we do not know. Areas of doubt, where relationships are undetermined, stimulate a search for new characters that may elucidate these uncertainties. In such searches, aspects of the organisms concerned, usually morphological ones, are surveyed right across the group under study. This may solve the problem, although there is a frustrating tendency for new characters to reinforce the parts of a phylogeny of which we are already reasonably sure without clarifying the sections of which we are not. Even here, however, there are consolations. Classically, comparative anatomy has tended to concentrate on a restricted number of types. In contrast, the analysis necessary for phylogenetic reconstruction involves comparison of numerous forms, sometimes all the species in a group. This gives a radically different perspective. For a start we get a real idea of the range of morphological transformations possible. Again, while the organ system under investigation may throw light on phylogeny, it may itself be illuminated by what we already know about phylogeny from other characters. The organ system can thus be put in a historical perspective so that some conception can be gained of what its original condition was and in what order changes took place. We can also assess its stability and get a minimum estimate of the number of times features have developed in parallel and whether they have been subsequently lost.

In the present volume, this approach has produced detailed and painstaking chapters on the tongue (K. Schwenk) and limb muscles (A. P. Russell). The lizard tongue turns out to reflect pretty faithfully the phylogeny derived from a wide range of other characters. In contrast, limb muscles appear to be riddled with homoplasy (parallelisms and reversals), so that they contribute little to overall analysis. Russell's chapter is a reappraisal of Sukhanov's work published in 1961 and demonstrates how much proper sampling of taxa and attention to polarity determination can alter interpretation of an organ system.

Taken over all, this book is a worthy tribute to Camp. As with his own publication on lizard relationships, working copies will undoubtably get that final accolade of utility, a battered and well-thumbed appearance.

E. N. Arnold
British Museum (Natural History), London SW7 5BD, United Kingdom

Fossils Demystified

The Conodonta. Morphology, Paleoecology, and Evolutionary History of a Long-Extinct Animal Phylum. Walter C. Sweet. Clarendon (Oxford University Press), New York, 1988. x, 212 pp., illus. $65. Oxford Monographs on Geology and Geophysics, vol. 10.

When impressions of conodont body fossils were discovered in 340-million-year-old Scottish rocks several years ago, much of the mystery that had surrounded these fossils for almost 150 years was resolved. Before 1982, what was known concerning conodonts was based entirely on their microscopic toothlike elements, of enormous importance in solving geologic problems but of less help in identifying the nature of the animal that bore them. What were widely acknowledged to be the most enigmatic of fossils (assigned alternately to chordates, plants, and most of the invertebrate phyla) were finally identified from body impressions and determined to be "conodonts." With short wormlike bodies, bilobed heads, and a posterior fin, conodonts represented a phylum extinct for 200 million years.

Now, some seven years after the discovery, Walter Sweet removes more of the mystery in a splendid volume that forever elevates conodonts and their taxonomy from the "nuts and bolts" categorization of G. G. Simpson to respectable science. This synthesis of earlier work with the latest research substantiates that conodonts were among the most interesting of nature's great experiments. The heart of the volume is a refined classification of the major conodont groups. This includes recognition of two classes, possibly polyphyletic, the Cavidonti (new), a mostly coniform group with one to five elements per apparatus but no element in the "P" position, and the Conodonti (revised), distinguished by six- or seven-element apparatuses with a variety of pectiniform elements in the "P" position. Some seven orders and 42 families are included. This section is not intended for the unanointed or even the casual conodont student. This is stuff for the conodontophile, the best of feasting at the High Table.

Although details of generic apparatuses are the book's strength, both theoretical and applied interpretations of conodonts are discussed. An appendix of stratigraphic range charts for 562 of the most important of more than 5000 species defines 156 biozones and substantiates an earlier claim that conodonts have the longest range of stratigraphic utility of any group of organisms.

What were the evolutionary dynamics of a 300-million-year period during which conodonts were among the most widespread and prominent of marine animals? Why are conodonts extinct while other less vigorous or interesting phyla survive? *The Conodonta* doesn't provide all of the answers because so much is still unknown, but what is known confirms that, as Stephen Jay Gould wrote in *Natural History* in July 1983.

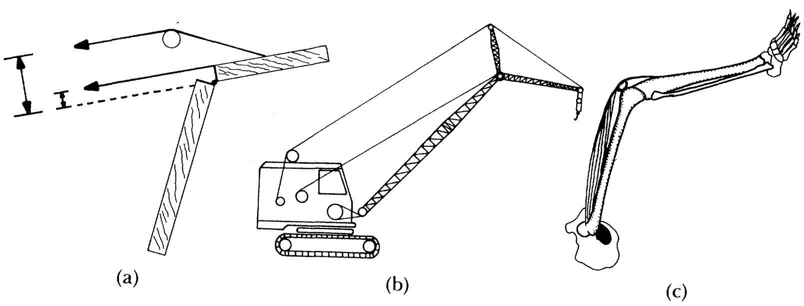
> We should . . . care about conodonts, even if we have never correlated a rock or tend to look askance at inch-long worms with faint tail fins and bilobed heads. For their age, their taxonomic uniqueness, and demise record the nature of history.

DAVID L. CLARK
Department of Geology and Geophysics, University of Wisconsin, Madison, WI 53706

A Broader Biophysics

Life's Devices. The Physical World of Animals and Plants. STEVEN VOGEL. Princeton University Press, Princeton, NJ, 1989. xii, 367 pp., illus. $49.50; paper, $17.95.

The physical world of mass, linear dimensions, time, and temperature—and combinations thereof—was here first. Plants and animals had to live with laws of physics that preceded them. Evolutionary fitness involved selection of the proper materials and structures and "the tuning of design to the details of the mechanical characteristics of the environment." An appreciation of physics, though fundamental to the understanding of life, is missing from the perspectives of many biologists and most nonscientists. It is time for some biologically relevant physics, but how does one find it? Fashions in science funnel the majority of practitioners into the study of a small subset of the



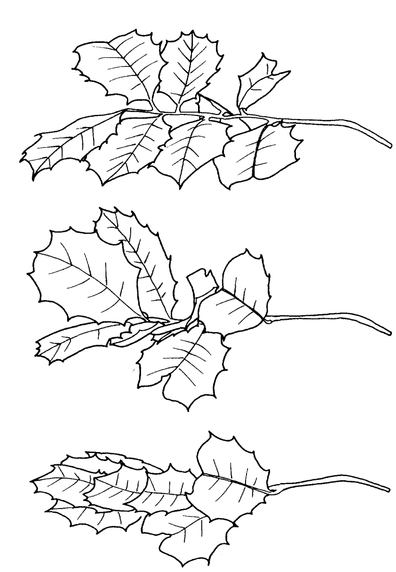
"The uses of a jib. In (a) the moment arm (two-ended arrows) of a force is increased by running a cable over a pulley instead of pulling directly on the hinged member. The force is exerted in the same direction but is much more effective when its line of action is further from the hinge. (b) An articulated crane runs the support cable for its outer, hinged member over a jib for just this reason. (c) In a human leg the tendon of the muscle that extends (straightens) the lower leg runs over an extra bone, the kneecap." [From *Life's Devices*]

appropriate phenomena. Biophysics is literally the application of the concepts of physics to the study of life, but use of "biophysics" as a key word leads to disappointment if one has something other than electron microscopes, ionizing radiation, ultracentrifugation, or nucleic acids in mind. In *Life's Devices*, Steven Vogel addresses this need and restores a broader biophysics—or "comparative biomechanics" (as distinguished from plain "biomechanics," which Vogel observes "has been preempted by an incorrigibly anthropocentric branch of medical or athletic science").

"Man can learn nothing unless he proceeds from the known to the unknown," wrote Claude Bernard. This principle seems to have guided Vogel, who made effective use of everyday experience in writing this book for adult nonscientists in a graduate program in liberal studies at Duke, trying, in his words, "to exclude as few people as possible from the intuitive satisfactions of the . . . topic." It is obvious that he enjoys the subject and sharing it. Each chapter is a feast, seasoned with humor that underscores the enjoyment. Though tempted to quote a pun or two, I leave them for you to read, for they are best in context.

A core of four chapters on the physics of gases and liquids and four on solid materials and structures is preceded by clear treatments of necessary conceptual tools and semantics of physics: quantities, dimensions, and units, conservation laws, the consequences of size and shape, gradients and summations. Vogel finishes with chapters on motility, "staying put and getting away," and energy and philosophical afterthoughts. There are two appendixes (notes on numbers, problems, and demonstrations).

I became hopelessly confused in only one section, that on non-saggy beams and chains (pp. 227–229). Physics is fun, but I, for one, would "get the picture" more easily if it appeared with the discussion. I counted 11 figures one page-flip past the discussion I



"A branch and leaves of holly in a wind tunnel at three different speeds," 0, 10, and 20 meters per second. "The wind here blows from the right. Notice how the leaves bend over and, at the highest speed, reduce their exposed surface area by pressing against each other and against the branch." [From *Life's Devices*]

was trying to visualize. Why not have dispersed the blank space from the last page of the chapter to enhance figure alignment? This criticism would apply to many books, but it is especially troublesome when reading physics.

This broader biophysics belongs in the biology curriculum. Whether it is offered by a physics or biology department, *Life's Devices* is an excellent textbook. For the tenured biologist, it is a fine refresher, a warm-up for specialized reading, and a pedagogical model for teaching science to nonmajors. There is more to life than *our* narrow subset of appropriate phenomena.

WILLIAM A. CALDER
Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ 85721