there is now a tremendous opportunity to capture the excitement of emerging phylogeny-based comparative approaches within invertebrate zoology courses.

Despite its emphasis on phylogeny, Brusca and Brusca's new edition harkens back to 1990 not only in its dated phylogenetic hypothesis but also in its omission of many recent landmark studies, especially those from a molecular perspective. I found its updates in this area uneven, often reflecting the authors' skepticism toward newer results. Not surprisingly, given the crustacean expertise of the Bruscas, the arthropod chapters appear to be the most thoroughly revised, and the authors even suggest there is now molecular evidence supporting a clade of hexapods and crustaceans. As in the first edition, major groups such as Mollusca have not received as much attention. Recent alternative proposals of higher-level animal relationships, such as the growing evidence for the monophyly of Lophotrochozoa and Ecdysozoa groupings; sister taxon relationships within Deuterostomia (e.g., Echinodermata and Hemichordata); the proposed basal position of acoelomorph flatworms with Bilateria, apart from other flatworms; and the potential paraphyly of sponges are all examples of widely accepted new views that are almost completely ignored. The chapter on Protista unfortunately has no broad phylogenetic overview of where the covered taxa are found within eukaryotes. The evidence that choanoflagellates are the likely sister taxon of multicellular animals is obscure, at best, and there is no mention that metazoans and choanoflagellates are now considered part of Opisthokonta—a clade that also includes the recently characterized mesomycetozoeans (unicellular parasites of various fish, birds, mammals, and snails, also known as ichthyosporeans) and fungi, neither of which are mentioned.

The eclectic presentation of phylogenetic analysis and classification in the first edition is only slightly updated. The advertisements for this edition claim this text now incorporates "new developments in phylogenetics, developmental biology, and molecular genetics," but the Bruscas' text is more useful as a reference source than as a current overview of animal phylogeny.

This edition at least does have a character matrix (appendix B) in support of the authors' summary cladogram of animal relationships. Unfortunately, the matrix appears to be mostly a compilation of the authors' previously featured node-by-node listings of diagnostic features rather than a less tree-dependent attempt to score morphological variation. There is suspiciously little homoplasy indicated across any of the trees, and the authors still often assert an assumed polarity of character evolution or argue that particular characters are convergent when they conflict with their favored hypothesis. Thus, it is not surprising that Brusca and Brusca's new summary tree is effectively the same in topology as the corresponding one in the first edition, one that is at odds with many aspects of other current phylogenetic estimates of metazoans based on either morphology or molecules or a combination of these data types. Still, as a teaching device, the presence of a matrix and added explanation of the methods used to generate the tree figure is clearly a step in the right direction.

Despite the quirks I have noted, the book has worthwhile views to offer that are lacking in most competing texts.

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LOOKING AT LICHENS

Lichens of North America. Irwin M. Brodo, Sylvia Duran Sharnoff, and Stephen Sharnoff. Foreword by Peter Raven. Yale University Press, New Haven, CT, with the Canadian Museum of Nature. 2001. 828 pp., illus. $75.00 (ISBN 0300082495 cloth).

This gorgeously illustrated tome is a comprehensive guide to the world's genera of the larger and smaller lichens, in spite of the "North America" in its name. The cosmopolitan nature of lichen cover and the transcendent beauty of the plates make the book of profound interest to field naturalists, botanists, symbiosis biologists, and hobbyists far beyond the borders of Canada, Mexico, and the United States. What is missing are not the major common lichen genera of Antarctica, Asia, Europe, and South America but descriptions of the smaller, less conspicuous lichens found in all landscapes.

The lichen body (crustose, foliose, or fruticose), the nature of its reproduction (sexual or not), its propagules (asci, blastidia, isidia, schizidia, or soredia) and their dispersal, and its unique chemistry (over 600 compounds—many limited to lichens—which include depsides, depsidones, anthraquinones, and pulvinic acid derivatives) are explained such that the concepts of these lichenologists are made clear to scientists and teachers who are not specialists in the field. The readers are provided tools and range maps to identify more than 800 species. The glossary and other explanations—for example, of lichen coloration (chapter 4), physiology (chapter 5), and substrates (the rocks, barks, shells, live insect carapaces, and other materials upon which lichens grow; chapter 7)—are splendid. The ecology of lichens, productive pioneers that dominate the photic zone in rocky coastal ecosystems and complement the productivity of forest habitats, is well demonstrated (chapter 8). The ways that lichens relate to people—as food and fodder, as sources of dye, as indicators of pollution, as medicine, or even as poison

(chapter 10)—are all nicely explained. In chapters 12 through 15, the book provides collection and study techniques, advice on names, and other practical information. The keys to the genera present a clear and comprehensive guide for all who desire a better understanding of these beautiful, enigmatic organisms.

The only obvious deficiency of this book, which prevents it from representing the worldwide diversity in lichens for readers at any level, is its failure to include the smallest and most difficult to identify and analyze "microlichens": for example, *Bactrospora, Biatoridium, Chiodecton, Cresponea, Epigloea, Julella, Leptorhaphis, Mobergia, Mycoporum, Protothelenella, Sclerophyton, Tomasellia,* and *Topelia.* The only North American publication that properly includes the tiny lichens is *Lichen Flora of the Greater Sonoran Desert Region* (2002), the comprehensive work in progress by the team led by Thomas H. Nash III. Only the first volume of the three-volume series has been published; the next two volumes are planned by 2005. Unfortunately, although it is up-to-date, entirely authoritative, and readable, the great work of the Nash group contains few illustrations, none of which are in color. This state of the literature of lichenology makes more precious the unique, truly wonderful book by Brodo and the Sharnoffs.

The old insult of "Schwendenerist" could justifiably be slung at this entire 828-page masterpiece, with more than 1700 beautiful photographs, drawings, and text. What can we possibly mean by "Schwendenerist"? In 1869, Simon Schwendener, the Swiss botanist of Basel, wrote his treatise on lichens and opened himself to ridicule and ignominy. Schwendener's theory that lichens are composite and complex organisms was rejected by the scientific community, and a misunderstanding of lichens as simple plants has persisted in many corners even until today. However, the great Russian plant physiologist A. S. Famintzyn, in his 1870 review, admitted that "Schwendener's discovery that lichens appear to be constructions of fungi and algae constitutes his merit" (Khakhina 1992). By 1937, Russian botanist K. A. Timiryazev defended Schwendener's conclusion, and by now all knowledgeable scientists agree: Lichens are not plants. Rather, they are individualized symbiotic composites of photobionts (oxygenic photoautotrophs, such as cyanobacteria or green algae) that are morphologically and metabolically integrated with mycobionts (heterotrophic fungi, usually ascomycota). Timiryazev wrote, "Some botanists still cannot wake from the impression evoked by this startling discovery and prefer to close their eyes to the obvious. If I am not mistaken, this curious subject has hardly been mentioned in our popular literature; nevertheless, it must be considered one of the most striking and unexpected discoveries of biological science of the last quarter century" (Khakhina 1992, p. 23). Microbiology, fine structure analysis, biochemistry, and molecular biology unambiguously support the unappreciated Schwendener—lichens are not plants at all.

The work of Brodo and the Sharnoffs reminds us throughout that lichens are polyphyletic, that is, they evolved separately: "Every recognizable lichen is derived from a different species of lichenized fungus" (p. 94). This statement of independent evolution applies to all, or nearly all, of the 3600 North American species and perhaps to as many as 15,000 species worldwide; detailed data support this generalization. The thoughtful, elegant coverage of these ubiquitous fungal partnerships is remarkably reliable and complete. Only when the authors claim that lichens "cannot be placed within the hierarchical systems of biological classification [kingdom, phylum, class] because they are dual organisms and each of the components has its own classification" do we disagree. Lichens, of course, can be appropriately classified like any other organism. After all, visible organisms—plants, animals, protoctists, and fungi—are at least dual composites. Indeed, most evolved from triple, quadruple, and higher-order symbiotic associations (Margulis 1993). Individuality, in the

world of the nucleated (eukaryotic, visible) organisms, is composite, complex, and multidimensional at genetic, morphological, developmental, physiological, and molecular biological levels. Lichens, therefore, exemplify the fundamental difference between bacterial (prokaryotic) and all other life and are named, as are almost all eukaryotes, for the most conspicuous member of the symbiotic consortium. In the case of lichens, this means that they are named for the mycobiont, the fungus, rather than the photobiont, the alga, or cyanobacterium.

Students of lichens tramp through deserts and rain forests. They slide on icy mountain slopes and stumble on the tangled shores of mountain lakes. They return to the laboratory with samples that, nearly invariably, require microscopic and other analyses. Is the phycobiont *Trebouxia? Pseudotrebouxia? Nephroselmis?* How are the asci or the pycnidia formed and distributed? Are crystals present? What are the colors and chemistry of the pigments? Although the toehold of lichens on bare exposed rock impresses every hiker, and their capacity for revival from severe desiccation amazes the observant nature lover, the lichenological vocabulary, and especially the microscopic descriptions, baffle any nonspecialist. Brodo and the Sharnoffs' work wonderfully makes amends as it allows us access to the weird world of a great orphaned taxon. That after a quarter of a century of dedicated labor Sylvia Duran Sharnoff failed to live to see the book published in all of its glory is truly tragic.

These valiant authors, flaunting their wealth of detail, illustrate fundamental biological principles worthy of Schwendener's legacy. But, we trust, their beautiful book will not suffer the fate of his. Polyphyly is more apparent in lichens than in other symbiotic associations. Lichens exemplify the details of complex individuality. The relations between syntrophic metabolism and morphogenesis in the emergence of novelty through physical association is made obvious in these colorful creatures, and so too the contribution of symbiogenesis to speciation and taxonomy in them is manifest.

We recommend this book, a gift of world-class scholarship to the scientific community, without reservation. Given its current artificially low price, we suggest that all libraries, private and public, with even a remote interest in natural history obtain it now.

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