that the acraeine, heliconiine, and danaine butterflies "may be pre-adapted to feed on toxic plants, rather than the larval hosts contributing significantly toward overall unpalatability." Indeed, dependence on host-derived cardenolides for defense may be a derived state in the monarch and its close relatives, with the autochthonous defenses posited by Rothschild *et al.* being the remnants of an ancestral system, latterly made redundant. But the whole concept of preadaptation is notoriously prickly, and Ackery does not press on to its full implications for mimicry theory.

Do monarchs at least migrate properly? Adrian Wenner (with Ann Harris) tries to convince us in his best iconoclastic style that they don't, at least in California. His local natural historicizing is immediately answered by Nagano *et al.*, who, using both pre- and post-Moncon data on recaptured tagged butterflies, effectively refute his claims. Cockrell, Malcolm, and Brower settle another controversy by demonstrating in several ways that eastern monarchs spread northward in generational waves, not all in one long reach. Lynch and Martin complement this by showing that the milkweeds used by the first arrivals on the Gulf Coast in spring are highly toxic and emetic and thus help to condition predators farther north to avoid monarchs. This is important, because most monarch reproduction in the north occurs on innocuous plant species and the butterflies are largely palatable.

So far so good for conventional wisdom. But now Ackery's systematist colleague Richard Vane-Wright raises the biggest controversy of all with what he calls—rather ostentatiously—the "Columbus hypothesis." In a nutshell, this claims that the monarch's seasonal mass migration is a recent phenomenon, an artifact of colonial and modern land-use patterns and concomitant vegetation changes in temperate North America. He notes provocatively that nearly all the aggressive colonization by the monarch beyond American shores (in the South Pacific and various Atlantic islands) occurred in a short time in the 19th century and there has been almost none since—a pattern not readily explained by the evolution of commerce. Moreover, the first reports of wintering clusters appear about the same time. Are both, then, epiphenomena of a huge population explosion triggered by deforestation?

Remarkably, historical data examined so far are of little help in testing Vane-Wright's idea. The Mexican wintering sites were only discovered by Fred Urquhart's group in the 1970s and seem to have little associated local tradition. The oldest (implied) notice of the Californian roosts is from the 1860s. None of the authors in this volume cites Boisduval's important *Lépidoptères de Californie* (1869), which incorporates notes from Lorquin's extensive lepidopterological journeys—but it doesn't mention the phenomenon anyway. Entomological resources have probably been exhausted, but there exists a wealth of narratives, published and unpublished, of Monterey, Santa Barbara, and other modern monarch wintering grounds as they were in Mission and early Californian times. There is at least some hope that such archival research may yield older descriptions of monarch roosting. Is anyone sufficiently motivated—and skilled—to look seriously?

Much of the conservation interest in the monarch revolves around migration as an allegedly "endangered phenomenon." Is it? If Vane-Wright is correct, it evolved very recently and indeed may not be biologically "necessary." Property owners and municipalities on the California coast have very tangible interests in this question. In fact, the antiquity, stability, plasticity, and necessity of monarch migration and roosting are far from purely academic questions. Several contributors to this volume discuss the life cycle of the monarch in Australia, where it arrived in the past century and where it has developed a degree of seasonal migration as well. The apparent plasticity of its biology in its range beyond the seas cautions us not to interpret its current behavior at home as necessarily eternal. At any rate, Pleistocene geography and climatology force us to assume that monarch migration has not been static for any very long time.

The South American monarch, which is questionably distinct at the species level from ours, appears to migrate as well—but once again the phenomenon is poorly understood. It breeds on milkweeds in northern and central Argentina and flies up above their altitudinal range in the altiplano of northwestern Argentina and nearby Bolivia. But what is it doing there, and where is it during the austral winter? My suspicion is that it will be found roosting somewhere in the Bolivian yungas, giving our ignorance an interhemispheric symmetry.

If it is unclear whether the North American, tropical, and South American monarchs are conspecific, is it clear who their closest relatives are or how long ago they differentiated? Of course not. Attempts to date divergence in this lineage by way of genetic differentiation are based on such generalized molecular-clock assumptions as to be essentially worthless, and despite some striking advances in danaid systematics by the use of cladistics and the incorporation of early-stage characters in the analysis, the phylogeny of the monarch is still a muddle. And given that the danaids are overwhelmingly an Old World tropical group, how did the monarch get here? Kitching, Ackery, and Vane-Wright are quite right when they detect an ideological element in the 19th-century tendency to derive *Danaus* (and a great deal else) from the Old World via the Bering land bridge, but that does not mean that interpretation must be wrong. It is true, as claimed elsewhere in this volume, that there are few danaid mimics in the Americas as compared with the Old World, but how does one test the "statistical significance" of that? The authors in this volume nearly miss noting the unambiguous monarch mimicry of the odd pierid *Neophasia terlootii* (which, contrary to what one might think from the discussion here, occurs not only in Arizona but rather widely in northwestern Mexico, where it is not uncommon) and do miss altogether the monarch-mimicking female form *eusemna* of the ancient Mexican relict *Baronia brevicornis*, which is involved in multiple mimicry associations.

There are more and more surprises—more Mexican overwintering sites, possible overwintering sites in interior California, all sorts of chemical and morphological delights—and I am struck by how useful this book will be to some historian of science several decades hence, who will undertake to use the study of the monarch as an exemplar of how science works. The book has no epigraph; may I suggest one? The 19th-century American humorist "Artemus Ward" (Charles Farrar Browne) wrote: "It ain't so much the things we don't know that get us in trouble. It's the things we know that ain't so."

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The Neuroglia Mystery

Astrocytes. Pharmacology and Function. SEAN MURPHY, Ed. Academic Press, San Diego, CA, 1993. xx, 457 pp., illus. $99.

Traditionally, introductory neurobiology textbooks begin with the statement that central nervous tissue contains two main types of cells: glial cells and neurons (nerve cells). After definitions are given and morphology is covered, glial cells are rarely mentioned again, with attention focusing on nerve cells. The reason is obvious: neurons produce electrical signals about which much is known, whereas glial cells are electrically silent. Yet, as is made clear in *Astrocytes*, this silence does not equal passivity. In the vivid, if mixed, metaphor of

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Australian surfing authority, Thor Svenson, once said that "choosing a (surf) board is a very individual thing, like choosing a wife or girl-friend, almost." I never fail telling my students that choosing the first technical book to be read from cover to cover on a long vacation is as important as choosing a surfboard.

—G. Korvin, in *Fractal Models in the Earth Sciences* (Elsevier)

Dutton (p. 185), "the stodgy, merely supportive, and unresponsive 'ugly sister' of neurons . . . is emerging from its cocoon to exhibit colorful wings of its own." In spite of the neglect by textbooks, there has always been a dedicated core of research workers who have believed in the importance of glia. More general interest in these cells has ebbed and flowed, with each wave lasting a decade or two. Currently glia research is riding the crest of such a wave, propelled by the invention of a number of methods enabling closer scrutiny of these formerly inaccessible cells.

The word *neuroglia* (*Nervenkitt* in German), meaning "nerve-glue" or "nerve-putty," was coined by Virchow around the middle of the last century. As the term implies, Virchow believed that glia was the equivalent of connective tissue, holding nerve cells together and giving shape to the brain. A few decades later, scientists began to question the assumption that these cells were inactive and played merely a structural supportive role. Ideas about their true functions remained, however, purely speculative for a long time. In the absence of experimental data, tenuous inferences were made on the basis of morphology alone. That some of these guesses were right on target attests to the astuteness of some of the early thinkers.

Histologists divide glial cells into three classes: astrocytes, oligodendrocytes (sometimes known as oligocytes), and microcytes (also called microglia). Of oligodendrocytes we know that they lay down and maintain the fatty insulating layer (myelin) that surrounds nerve fibers (axons). Microcytes are normally few in number, but they proliferate in response to infection or injury. They are involved in defense and immune reactions of central nervous tissue. The astrocytes, however, remain mysterious. Although *Astrocytes* focuses on these enigmatic cells, the volume also gives some attention to the other glial subtypes, with chapters devoted to the interactions of astrocytes with oligodendrocytes and microcytes, as well as with neurons and even vascular endothelial cells.

The recent surge of glia research has been made possible by technical advances in cell culture, biochemistry, immunochemistry, molecular biology, and molecular genetics. The advances made in cell culture are most significant, having enabled the harvesting of glial cells without contamination by neurons and connective tissue cells. Studying cultured glial cells does, however, have its pitfalls, as described by Wilkin and Marriott (pp. 67–68): "Liberating cells from the central nervous system into a culture dish might produce a situation in which the cells switch from normal to reactive phenotype." In fact nearly every chapter in *Astrocytes* contains a disclaimer to the effect that results obtained with cultured cells may not be relevant to "real life" in the brain.

Yet at least some of these results have been confirmed by observations of cells in their normal habitat, in intact brain tissue. Even if examined with appropriate caution, the evidence is impressive that astrocytes do more than help neurons stick together. At the very least they are crucial for "fine tuning the local environment [of neurons] in the brain" (Kimelberg *et al.*, p. 194). There are also good indications, for example, that astrocytes play an essential role in both the synthesis and the recycling of the neurotransmitter glutamic acid. Astrocytes also possess membrane receptors for a wide variety of other neurotransmitters and similar neuroactive substances. Activation of these glial receptors can trigger a number of cellular processes, indicating that astrocytes interact with neurons in numerous, as-yet-to-be-defined ways. Most remarkably, these electrically silent cells are equipped with membrane ion channels of both the voltage-gated and the ligand-gated variety. The significance of this finding remains unclear.

Readers who want to orient themselves in this rapidly advancing field will find what they need in this compact, well-written volume, although it is not an exhaustive review of neuroglia research. As is to be expected in a multiauthored compilation, not all of the contributions are equally up to date (some of the reference lists include papers from 1992, whereas others stop with 1991), and there is some overlap and redundancy among chapters. These are, however, minor flaws. The main ideas, the techniques, and the most important results of current glia research are all there, in easily digestible form.

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Crystallography Explained

Fundamentals of Crystallography. C. GIACOVAZZO, Ed. Oxford University Press, New York, 1992. xvi, 654 pp., illus. $125 or £65; paper, $65 or £27.50. International Union of Crystallography Texts on Crystallography, 2. Revision of *Introduzione alla Cristallografia Moderna.*

Crystallography is not only a pursuit in its own right, claiming the time and efforts of many experts; it is also basic to the pursuit of many other subjects. The ever-expanding capabilities of computers are opening new doors for those who make use of crystallography in their work. Intense and highly collimated forms of radiation from synchrotron sources make possible experiments that were out of the question only a decade ago. A wide range of scientists, from geologists to biologists, need access to information about the basics of crystallography as well as the exciting new methods that are now becoming available. Yet tracking down this information in diverse publications can be frustrating. Thus *Fundamentals of Crystallography* is a welcome contribution, bringing diverse information about crystallography under one cover where it can be easily found.

If you are looking for homey examples of symmetry or simplified explanations of diffraction, this is not the book for you. On the other hand, if you are seeking a book with a wide range of topics along with a high level of detail, you will not be disappointed. The reader with some background in crystallography will find that the book, although dense, is carefully organized, with a well-ordered structure and a high packing efficiency. Moreover, it has been completely revised and updated since its original publication in Italian in 1985. I think it makes a better reference book than textbook, although it could be useful in advanced courses.

A number of features make this volume particularly useful. First, it contains many attractive illustrations that do a good job in