to the notion of a single series of progressively more complex organizations, in animals as well as in plants. Lamarck's is a two-factor theory. First there is a sort of drive of life to produce ever more complex forms, in such a way that all animal and all plant forms should arise in linear succession. Since, as classification testifies, that does not occur, relationships between taxa instead showing repeated branching, some interfering process must have been acting, distorting the serial arrangement without, however, being able to eradicate it completely. That interference is ascribed to the action of circumstances, to the changing environment twisting the organism in a way that makes it an "anomaly" when considered in relation to serial succession. In this context, the problem of adaptation per se never arises; adaptive characters are so to speak explained away by focusing on the primary factor of evolution and the deflection of its effects.

From 1800 to the 1820's the Lamarckian evolutionary explanation showed some modifications, which Burkhardt carefully and usefully documents. Though these did not alter the fundamental principles of the theory, they consistently led to a more and more nuanced appraisal of linearity in the development of the diverse animal classes.

As one progresses through the book one is led by the author to oscillate in one's perception and assessment of Lamarckism. In places Burkhardt makes us feel that Lamarck's ideas should have had a better reception in his time, though elsewhere it is made clear that his solution could not be seen as correct and convincing by his contemporaries, that there was little or no factual evidence supporting it, and that moreover Lamarck's approach to science, as reflected in his writings as well as in his behavior, ran counter to the ethos and standards of the institutionalized French science of the time.

Indeed, it would seem that the author is equivocal in his very perception of Lamarck himself, a most complex character. Burkhardt concludes saying that "one cannot help but feel sympathy" toward Lamarck; this shows consistently throughout the book. But whereas at the beginning of the book Lamarck is described as "a skillful lobbyist on his own behalf," with "a sense of what was politically prudent," he is later characterized as "an inept strategist." In more than one place his paranoia is stressed, though at other times one is made to feel that it is unjustly that his ideas were attacked or brushed away. No doubt this reflects the fact that an equitable assessment of Lamarck's significance in his own environment is a difficult task, the more so because we still lack information on the workings, commitments, and vested interests of the French scientific community in the early decades of the 19th century. All in all Burkhardt has given us an important and reliable study, no doubt the major source now on the topic.

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Phylogenetic Reconstruction

Major Patterns in Vertebrate Evolution. Papers from a NATO Advanced Study Institute, Surrey, England, July 1976. MAX K. HECHT, PETER C. GOODY, and BESSIE M. HECHT, Eds. Plenum, New York, 1977. x, 908 pp., illus. $64.50. NATO Advanced Study Institutes Series A, vol. 14.

The volume under review consists of 22 major papers and seven extended comments arranged in three groups: Approaches to the Analysis of Macroevolutionary Trends (312 pp.), Macroevolutionary Trends among Vertebrate Taxa (426 pp.), and Phylogeny and Classification of Vertebrate Taxa (156 pp.). The type is large and space on the pages is poorly used, presumably as a result of efforts to reduce labor costs. The papers themselves are variable in quality and significance. Some are loosely written summaries, but there are also some important papers that present new data, offer new perspectives, or both.

The overwhelming preoccupation of the contributors is the reconstruction of phylogenetic histories. Most of the papers deal with this issue philosophically or empirically. Major differences in philosophy and practice are apparent among the offerings. There is disagreement on some fundamental issues, such as the contribution, if any, made by the fossil record to phylogenetic interpretation. Even seemingly uncomplicated words produce controversy. Thus Bonde states, "The whole theory of phylogenetic systematics could be looked upon as a semantic analysis of the word 'related' with a precise and unique biological meaning, and the consequences of this analysis for bio-classifications."

There are no defenders of phenetic taxonomies in this book. Farris, who treats the subject, concludes that phylogenetic methods can best be used to attain the goals of pheneticists.

In contrast there are numerous proponents of so-called phylogenetic systematic (à la Hennig) approaches. Some of their attempts to justify their views are emotional, some are restatements of old arguments, and some are simply assertive. Perhaps the most comprehensive paper is Patterson's treatment of teleost phylogeny. Following a concise historical summary, Patterson presents an empirical example of his phylogenetic method as applied to "halecostome" fishes. He argues that cladist approaches give direction and purpose to paleontology. At the same time his phylogenetic taxonomic philosophy leads him to conclude that paleontology must always be subservient to neontology and has no fully independent role in phylogenetic work.

Traditional or evolutionary systematic approaches (in the tradition of Simpson and Mayr) find their strong proponents in Bock (two papers) and Gutmann. Bock argues that clarity of reasoning is more important than methodological detail and that the distinction between opposing approaches often breaks down when it comes to precedural details. Gutmann advocates a rather imprecise adaptational interpretation of phylogenetic transformations. The basis for his analysis is the production of a "Bauplan" for particular systems of groups based on admittedly somewhat simplistic biomechanical, physiological, and ecological relations. Continuous models of change apparently based on optimization ideas are proposed, but I fail to understand how they can be put into practice.

Some workers are skeptical that any single method has been invented that will provide a robust classification. Hecht and Edwards analyze a case history in detail, using their recently formulated cladistic method to examine salamander classification. Despite relatively good data, they are unable to find any scheme that does not require multiple parallelism and reversal. They observe that the mere multiplication of poorly analyzed morphoclines will not lead to correct phylogenies and urge that the desire to find an answer not be allowed to lead to the acceptance of suspect relationships. Their methods at least identify ambiguity.

A pair of papers by Fitch on the phyletic interpretation of macromolecular data and a brief comment by Beintema are the only contributions that deal with problems at the molecular level. The first of Fitch's papers addresses simple meth-

ods and is complete with sample problems and glossary, and the second illustrates the method with sample cases. Fitch's analysis has many biological implications, and several of these are treated directly (for example, the question of whether nucleotide interchanges are equally likely in all codons).

A number of authors deal with specific problems in vertebrate evolution. Keast examines the zoogeography of worldwide bird and mammal faunas and attempts to integrate approaches that are frequently viewed as alternative. Szalay is sharply critical of so-called phylogenetic taxonomic methods, and presents his own higher-category classification of the Eutheria. This is based on his interpretation of cranial as well as postcranial characters and on a fairly traditional evolutionary approach to classification. Luckett uses "sound principles of cladistic analysis" to analyze the phylogeny of amniote fetal membranes. The crux of any such analysis is the determination of character state transformations, and that requires several important assumptions. Marshall argues that the ecological roles of terrestrial carnivores in South America during the Cenozoic were shared by reptiles, birds, and mammals and that a "relay" of various groups occurred. Active competition between groups is postulated, with mammals of North American ancestry finally dominating. Other papers include a discussion of the distribution of the earliest tetrapods (Panchen), treatments of the origin of tetrapods and their appendages (Szarski, Schultze), a lengthy consideration of the effect of insularity on mammalian evolution (Sondaar), a brief paper on the adaptations for terrestrial life of a viviparous frog (Xavier), and a consideration of the phylogenetic implications of chromosomal evolution (Moreschalchi).

A final group of papers involves explorations in functional morphology in relation to phylogeny. Edwards discusses the evolution of terrestrial locomotion on the basis of his analysis of salamander locomotion and concludes that the first terrestrial gait was likely a traveling wave trot, rather than the slow walk that has been postulated by several workers. Pirlot examines wing design and the origin of bats, arguing that, unlike birds, bats took up a flapping flight initially rather than a running, jumping, and gliding pattern, as has been postulated for ancestral birds. Templin, Clark, and Smith add brief notes relating to different aspects of flying, mainly in bats. Dullemeijer and Barel present a stimulating philosophical discussion of the relation of functional morphology and evolution. They are skeptical concerning the way in which evolution is usually used to explain phenomena of functional morphology and argue that evolution is not essential for understanding functional morphology.

The volume contains some weak papers and some that are rambling and repetitive, but the many effective presentations make it required reading for vertebrate biologists interested in phylogenetic analysis.

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Geochronology

Precambrian of the Northern Hemisphere and General Features of Early Geological Evolution. L. J. SALOP. Translated from the Russian edition (Leningrad, 1973). G. M. Young, Transl. Ed. Elsevier, New York, 1977. x, 378 pp., illus., + tables. $59.25. Developments in Palaeontology and Stratigraphy, 3.

In this book the author is aiming at two targets. As the title indicates, he has set out not only to describe the Precambrian of North America and Eurasia but to use this knowledge to tackle the difficult problem of understanding the early development of the earth. Salop in fact has a still broader purpose in mind, for, to quote his own words, "Studies of Precambrian formations . . . are needed to elucidate the general laws of geological evolution." This is a field he has pioneered. In the early 1960's, when Precambrian geochronology was less well documented than it is today, he made some of the first attempts to rationalize Precambrian history. Even at the present time we are, I suspect, far from understanding general laws, though it seems to be increasingly clear that the processes at work in the early Precambrian differ from those at work in more recent times.

I found two features of the book particularly valuable. The first is the extensive account of the Precambrian of eastern Europe and of Siberia. Salop has picked out the highlights and provided an account amply supported by age determinations. The English translation prepared under the aegis of G. M. Young is excellent. Soviet readers of the original edition in Russian no doubt found the accounts of western Europe and North America just as useful. Naturally one can query points of detail and selection, but the result is a working summary of knowledge of the ancient rocks of the Northern Hemisphere.

The second feature I particularly appreciated is Salop's approach to the question of the Precambrian evolution of the earth. He sets out his conclusions as "empirical generalizations." As I understand this expression, these are conclusions based on an understanding of the older stratigraphical successions in three continents—successions summarized in valuable tables that must represent many years' work. These lead to a proposed geochronological scheme for the subdivision of the Precambrian, and bring out many similarities in coeval rocks from various stages in the Precambrian record. Here are two valuable concepts. The book is worth reading for these alone. Salop knows very well that he has not written the last word on these subjects, and quotes with appreciation Sederholm's comparison of Precambrian stratigraphy to Penelope's weaving. What is woven by day is unraveled every night. There is much in this book to ponder, and I would not be surprised if time vindicates many of Salop's conclusions—just as Penelope's patience was in the end rewarded.

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Emanations from the Sun

The Solar Output and Its Variation. Papers from a workshop, Boulder, Colo., Apr. 1976. Colorado Associated University Press, Boulder, 1977. x, 526 pp., illus. $8.95.

One might say that solar astronomy has been caught with its pants down. Suddenly there is widespread concern about changes in the earth's atmosphere and hence climate. The sun is the principal driving source of the global-scale atmospheric winds that carry warmth and cold into our daily lives. Climate is characterized by extreme variability, and it is difficult to separate internal and external influences. But more and more from several quarters comes the question, how constant is the solar output? Climate models suggest that a change of only 1 percent in the solar output, if extended over several decades, could produce significant change in global temperatures. Unfortunately, compared to other physical measurements, radiometry is imprecise, attaining a precision of only about 1 percent even in the laboratory. So deter-