The Newer Elements

The Elements Beyond Uranium. GLENN T. SEABORG and WALTER D. LOVELAND. Wiley, New York, 1990. xiv, 359 pp., illus. $49.95. A Wiley-Interscience Publication.

Today the distinctions between the fields of nuclear physics and nuclear chemistry are so blurred as to be nonexistent, but that was not so in the 1940s when a small band of nuclear chemists participated in one of the great adventures of scientific research—the creation of new elements. Those must have been heady days, which became years and then decades. In a period of a little over 40 years, beginning with the production of element 93—neptunium—in 1940 and ending, at least for the nonce, with element 109 in 1982, 17 new elements were fashioned where none had been before—10 of them by the end of the 1950s. One of these, plutonium-244, was later found in nature but in negligible amounts. Plutonium-239, one of the explosive ingredients of fission weapons, has now been produced artificially in quantities that must amount to many metric tons.

The story of this modern-day alchemy is recounted in this 12th volume of a series on transuranium elements with which coauthor Glenn Seaborg, who has played a key progenitorial role in the forging of most of the new elements, has had a close association.

The techniques for the production of the elements are varied, as are the methods used in their identification and the exquisitely refined microchemical techniques required to deal with samples sometimes involving only a few atoms. All these are described in the book. Production methods include slow neutron irradiation in reactors, bombardment with light projectiles (hydrogen and helium isotopes) from cyclotrons and other accelerators, thermonuclear explosions, and bombardment by a whole arsenal of heavier stable projectiles from boron to xenon, again from a variety of accelerators. Concerning the means both of physical and chemical extraction and of detection, the investigators had to contend not only with vanishingly small samples but with samples that actually vanished, sometimes in a matter of minutes, owing to their nuclear instability.

To this reviewer the two most interesting chapters in the book are the one on details of the synthesis of the new elements and the one on superheavy elements (in the region of atomic number 114). The former includes black-and-white photographs of the proud progenitors and is liberally laced with their reminiscences as well as the criteria for the discovery of a new chemical element. In the chapter on the superheavies the authors lament that these elements still elude detection even though their creation should be possible and some, at least, should survive long enough to make their presence known. Another chapter on practical applications of uranium and the transuranium elements is also to be commended. Much of the book, involving as it does chemical and nuclear properties of elements in the periodic table in general and of the transuranics in particular, is too detailed for nonexperts in the field and not detailed enough for the experts. The latter deficiency is mitigated by extensive bibliographies.

The book, in general, is a quite readable account of an exciting chapter in scientific endeavor. Some of us in atomic and nuclear science have spent a large part of our lives attempting to elucidate the properties of atoms and nuclei. The nuclear chemists featured in this book did more than that; they first manufactured those elements whose properties they proceeded to study.

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Codiscoverers of Element 106, Lawrence Berkeley Laboratory, 1974. Left to right: Matti Nurmia, Jose R. Alonso, Albert Ghiorso, E. Kenneth Hulet, Carol T. Alonso, Ronald W. Lougheed, Glenn Seaborg, Joachim M. Nitschke. [From *The Elements Beyond Uranium*]

Patterns of Change

Evolutionary Trends. KENNETH J. MCNAMARA, Ed. University of Arizona Press, Tucson, AZ, 1990. xviii, 368 pp., illus. $45; paper, $24.95.

To the layperson, evolution is nearly synonymous with directional change. The history of life is thought of as a more or less steady progression toward "higher" forms culminating in *Homo sapiens*. Although such a simplistic view is now discredited, debates still rage among evolutionists about whether long-term evolutionary trends exist and, if so, what they mean and how they are brought about.

Evolutionary Trends is a potpourri of opinion pieces, essays, and overviews dealing with patterns of evolution. The first part of the book and the epilogue comprise general chapters on the nature, measurement, and causes of evolutionary trends. The remainder contains reviews of trends and other evolutionary patterns in some groups of invertebrates (part 2) and vertebrates (part 3). Many important groups in which trends have been well documented, including protists and plants, are left out.

Debates about evolutionary trends cannot be resolved satisfactorily until three things happen. First, methods must be developed for distinguishing long-term trends from other evolutionary patterns. Second, these methods must be applied to the fossil record systematically, to provide more than just a large catalogue of examples. Third, we must

make sure we are not arguing about the wrong things.

There are all kinds of trends—trends in variance, trends in the mean of a characteristic, anagenetic trends (those taking place in an unbranching evolutionary lineage), and cladogenetic trends (those describing the pattern and fates of branches in an evolutionary tree)—and each type requires different forms of measurement and analysis. McKinney provides an introduction to the measurement and classification of trends in his chapter. He discusses serial correlation among other techniques, but it is clear from his discussion that existing methods require assumptions that most empirical studies probably cannot satisfy. The reader will need to consult the cited literature in order to gain a full understanding of the statistics and their limitations.

How common are the various kinds of trends? This is a question about relative frequencies. It can be answered only if we have available a systematically compiled set of evolutionary patterns that can then be classified according to type, cause, direction, and so on. Among the empirical chapters in the book, those by Fortey on trilobites and Janis and Damuth on mammals stand out as thorough, carefully crafted contributions in which attempts are made to synthesize the available information rather than to document a few selected examples. I believe there are other groups in which the information required for a systematic survey—an abundant fossil record, good stratigraphical control, well-documented ancestor-descendant relationships, and a sufficiently long time interval for the detection of patterns—exists or is at least obtainable. Cretaceous and younger foraminifers, Mesozoic ammonoids, and Paleozoic graptolites and conodonts come to mind as examples.

One of the editor's requests to the contributors was that they consider the role of intrinsic as compared to extrinsic factors in effecting trends. Extrinsic factors include ecological agencies of selection—predation, competition, the weather, and so on—whereas intrinsic factors include those aspects of an organism's body-plan or pattern of development that channel change in particular directions. I believe that there is a false dichotomy here. Phenotypic change in response to selective agencies is accomplished within the established genetic and developmental system of the organism. To me, heterochrony (the change in relative timing of developmental events) and the incorporation of new traits within the established developmental framework are mechanisms by which change is achieved, not causes of it. Seen in this light, extrinsic and intrinsic factors are complementary rather than mutually exclusive. In order to understand how phenotypic change is channeled along particular pathways by heterochrony, it is instructive to consider the conditions that permit the established order to be violated. Sadly, no chapter in the book takes this tack. Lots of interesting examples of trends explicable by heterochrony are presented, and few observers could doubt that shifts in the timing of developmental events have been frequent in the history of life; but we have little to go on besides examples, and the dichotomy between extrinsic and intrinsic factors draws attention away from distinctions among different mechanisms by which trends could be brought about.

The study of trends and their relationship to heterochrony has traditionally been beset with complex terminology. This situation is exacerbated in the book by some pretty woolly writing. Consider, for example, the following sentence, which appears on p. 72: "Cladogenetic heterochronoclines, where ancestral species persist following the evolution of the descendant, may be considered to be *autocatakinetic* (Hutchinson, 1959)—in other words, self-generating in a particular direction." Given statements like this, how is one to appreciate the forest through the evolutionary trees?

In short, there is plenty of interesting work to be done on evolutionary trends. Readers will find good reviews in some of the chapters of this collection, but we are some way from a definitive treatment of the subject.

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LMCFs

Large Marine Ecosystems. Patterns, Processes, and Yields. KENNETH SHERMAN, LEWIS M. ALEXANDER, and BARRY D. GOLD, Eds. American Association for the Advancement of Science, Washington, DC, 1990. xiv, 242 pp., illus. Paper, $39.95. AAAS Publication no. 90-30S. From symposia, Boston, 1988.

This volume is the third of a series on its topic following on symposia at AAAS annual meetings. Subsequent symposia on the topic were held at the 1990 and 1991 AAAS meetings, and an internationally sponsored meeting on the same theme was convened in Monaco in October 1990. Hence more volumes may be expected.

The common thread connecting all these meetings is their primary organizer, Kenneth Sherman, who has popularized the term "LME" (large marine ecosystem). There are many other common threads, since several of the authors are to be found in two or more of the symposia.

LMEs are defined in this volume as "relatively large regions of the global EEZs [exclusive economic zones], generally on the order of 200,000 km^2, characterized by unique bathymetry, hydrography, and productivity, within which marine populations have adapted reproductive, growth, and feeding strategies." Many people (including myself) have considerable reservations about this rather pragmatic and mundane definition of what one might have hoped to be an enlightening new concept in theoretical marine ecology.

A glance through the accumulated contributions in the three existing volumes, however (as well as the definition quoted above), makes it clear that the topic is LMCFs—large marine coastal fisheries. The emphasis is on the description of coastal fisheries and any considerations that might be helpful in understanding how to manage them. These include legal, economic, and geographic considerations, but particularly important is the approach in which the fishery is set in the context of the whole ecosystem. One senses that this is the major point being made, and it is being made to the fisheries management community.

The list of LMEs reviewed during the course of the meetings to date now approaches 30. The first section of this volume contributes to this list, with descriptions of LMEs such as the Weddell, Caribbean, Banda, and Norwegian seas. A second section has chapters on topics in marine ecology (such as larval fish ecology, predator-prey relationships, and growth and feeding) as well as technological aspects (application of molecular and image-analysis techniques to zooplankton enumeration). The third section includes contributions concerned with ecological and management concepts such as scale interactions, modeling of ecological systems and other approaches to understanding fish biomass yields, and geographical and legal perspectives on LMEs. The second and third sections are mostly not specific to any particular LME.

Sherman himself, summing up, organizes LMEs on the basis of "predominant variables." This gives rise to hypotheses regarding major controlling factors, such as excessive fishing mortality, changes in upwelling systems, or pollution (such as in nutrient enrichment to the Baltic ecosystem from the surrounding land). Several of the chapters are well-prepared reviews of their subjects.

Inherent in the "LME concept" is the recognition of the importance of long-term data series collected for management purposes. These are necessary to measure trends and the changing health of the system. They