ence, in which he includes astrology, parapsychology, dream predictions, UFOs, drug testing, and numerology. He also gives some very practical applications of mathematics, showing that an item whose price has been increased 50% and then reduced 50% has had a net price reduction of 25% (something some investors don't seem to realize). He explains the law of large numbers that, in the long run (that is, as the number of cases increases), the difference between the probability of some event and the relative frequency of its occurrence approaches zero; and notes that despite statements in advertisements the incidence of maladies such as cavities cannot be reduced 200%. However, his penchant for startling, counterintuitive statements, many of which he admits are "psychological tricks," causes him to neglect more commonplace examples of innumeracy, such as the tendency of some journalists to decry as shameful the fact that more than half the students in some class or school are below the average of some academic standard or the use of "megawatt" in a recent issue of a national newsweekly to mean 100,000 watts, rather than a million. Overall, this is an interesting book, but the author's exhibitionism makes it not nearly as good as it could or should have been; and it is highly dubious that it will achieve its purpose of appealing to innumerates. A much more practical and appealing approach to the truly innumerate has been made by the ecologist Garrett Hardin in *Filters Against Folly* (1986), among various recent guides to mathematical reading for nonmathematicians.

In contrast, Peterson's tour of modern mathematics assumes the reader to be numerate to the extent of knowing scientific notation and elementary algebraic notation, but explains all concepts and calculations beyond this level. His story of developments in the last two decades begins with a brief verbal description of the fields of mathematics and proceeds to a detailed explanation of the significance of prime numbers and their practical importance to modern cryptosystems. Nearly all the developments discussed involve computers and graphic printouts, many of which are scattered throughout the text, further aiding comprehension by nonmathematicians. This leads Peterson to assert that experiment plays an important part in mathematical research, that number theorists cannot rely simply on deduction but, like other scientists, often must collect piles of data before they can extract the principles that account for their observations.

Topology, a 20th-century development in the mathematics of space and shapes, has used such simple techniques as dipping model configurations into soapy solutions to study the contours of soap films and thus determine minimal surfaces for structures. Today, computer graphics can play the role of soap films, and computers can be used in situations where physical experiments aren't possible, such as determining infinite minimal surfaces. Thus, computer graphics has proved to be an indispensable tool for exploring hitherto unseen, and unimagined, geometric forms. Examples appear in the book in both black-and-white drawings and color illustrations. A limitation of this technique is that an explicit equation defining a surface or group of surfaces is needed to produce a computer picture; but visual exploration may furnish clues that suggest mathematical proofs and equations.

Discussing higher dimensions, Peterson shows that any set of four numbers, variables or parameters, can be considered either as a four-dimensional entity or as a string of numbers that can be manipulated. Einstein's fourth dimension represents only one of many different types of four-dimensional space; and going beyond four dimensions (as in modern string theory) is simply a matter of adding more variables. This presents a challenge to modern mathematicians in solving the ancient problem of classifying all geometric shapes. With topology inventing new shapes and geometry spreading into higher dimensions, mathematicians face "an unruly zoo of geometric forms," and classification now lags behind discovery of new forms.

A class of new forms, named by Benoit Mandelbrot in 1975, is fractals. These are irregular and fragmented self-similar shapes that contain structures nested within one another, each a miniature, though not necessarily identical, version of the larger form. Nature is full of such shapes, such as trees, mountains, or a coastline. Finer and finer scales reveal more and more detail and lead to longer and longer coastlines, until length can finally be considered infinite. Similarly, fractals can be created by taking away successively smaller parts of a line, plane, or cube, ending in a shower of dimensionless fragments that constitute a Cantor set. Astrophysicists confirm that this model accurately predicts the distribution of mass within the universe, of stars in a galaxy, and of galaxies in the universe, with large regions left empty. Fractals describe an astonishing array of other natural structures. However, mathematical fractals have properties not found in natural objects, as no real structure can be magnified an infinite number of times and still look the same, both because of the finite size of molecules and atoms and because at some magnification real objects abruptly shift from one type of structural pattern to another. So scientists taught to think of integers as the way to represent physical processes are beginning to see that noninteger exponents are just as likely to turn up in nature.

While Peterson discusses far more subtle and complex concepts than Paulos, he takes the reader through explanations and derivations of the concepts. Those with only a smattering of mathematics will have to read Peterson more slowly and carefully than the mathematically sophisticated, but they will be rewarded by learning more, and quite painlessly. This is not a complete handbook to modern mathematics, but it is a lucid and fascinating exposition of fields of recent development that should be instructive to all but the most advanced professional mathematicians.

Perhaps the most significant message of both books is that numbers and other mathematical symbols represent ideas; and that mathematical concepts can almost always be stated in words. Numbers are the language of science because they are more precise than words; but they are also more ambiguous, as each number may represent an infinite variety of phenomena. So descriptive mathematical equations cannot be fully formulated without words to specify the ideas which the numbers and other symbols represent. Peterson does this well for several fields of mathematics.

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Neoconservative Paleobiology

Arguments on Evolution. A Paleontologist's Perspective. ANTONI HOFFMAN. Oxford University Press, New York, 1989. xiv, 274 pp. $29.95.

This provocative book is a response to the last decade's excitement in evolutionary paleobiology. Like a number of recent works, it is concerned with the present health and primacy of neo-Darwinism: do short-term processes at the individual level ("microevolution") explain all evolutionary phenomena, including those observed in the fossil record? So baldly stated, this question is a bit outmoded. Even at the peak of the controversy the answer was very much in the eye of the beholder; for example, Will Provine has been careful to distinguish between the views of Sewall Wright and those of his strict neo-Darwinian contemporaries, whereas many staunch neo-Darwinists today view Wright as one of the giants in their field. Far more important, now that the rhetorical furor has abated, is that evolutionists, whether studying living fruit flies or fossil brachiopods, are addressing a broader array of questions and recognizing a greater diversity of phenomena as worthy of concerted study than in the previous few decades. Hoffman is skeptical of many of these new concepts and approaches. He is not ungenerous in acknowledging the salutary effect that the controversial ideas he ultimately rejects have had on the development of evolutionary paleobiology. But in the end he argues that most of the recent work has been erroneous or trivial, analytical or paleontological artifact, or simply reducible to the organismic level.

Hoffman offers a series of critiques, taking in turn punctuated equilibria, species selection, the periodicity and evolutionary role of mass extinctions, and global diversity patterns (he says little on evolutionary morphology or evolution and development, both active arenas of macroevolutionary research). I found much to disagree with here, but the discussion is stimulating and gracefully written and draws on a wide reading of the paleontological literature. A number of useful points are raised, for example in the attempts to define and classify the different workers' views of some of the most hotly debated concepts, such as macroevolution or punctuated equilibria. Hoffman is straightforward about his biases: in place of multiple working hypotheses posed at a variety of levels within the biological hierarchy, Hoffman presents "pragmatic reductionism" as an alternative to "falsificationism." In effect, a strictly microevolutionary approach, rejecting all hierarchical effects, is taken as the null hypothesis for any evolutionary phenomenon; this is a dangerous approach, given that few if any macroevolutionists would argue that microevolutionary processes are not operating simultaneously with macroevolutionary ones. Rigorously distinguishing among processes operating at different hierarchical levels can be fiendishly difficult and laborious, and Hoffman's advocacy of such a simple default procedure seems overly conservative (and not so different from the errors-by-default that he contends paleobiologists fall into when they use evolutionary stasis as a null hypothesis for patterns of morphological change in the fossil record). This is very much in contrast to the more pluralistic approach of such neo-Darwinians as John Maynard Smith, who draws a distinction between the role of higher-level processes in shaping complex adaptations such as the eye (trivial, Maynard Smith believes, relative to microevolutionary processes) and in determining the distribution of those adaptations in time and space (perhaps "of decisive importance"; see *Nature* **336**, 107 [1988]).

Finally, because this is a work of strong advocacy (or unabashed criticism, as Hoffman says in the introduction), it is not a substitute for the primary literature. New ideas are sharply criticized, but defenders of the faith suffer no such scrutiny. This unbalanced treatment hampers the usefulness of the book as an entry into the controversies and even yields internal contradictions. For example, Hoffman blithely accepts Smith and Patterson's critique of the paleontological data underlying Raup and Sepkoski's claim for periodic mass extinctions, but elsewhere advances arguments—including some from his own work—that incorporate the same alleged flaws (for example, use of paraphyletic taxa, which do not include all the descendants of a given ancestor and are thus arbitrary and illegitimate to a strict cladist). He also tends to omit rebuttals to the criticism he cites; for example, a number of the arguments cited against periodic extinction have been refuted (for a recent review and update, see Sepkoski, *J. Geol. Soc. London* **146**, no. 1, 7 [1989], which cites earlier papers). Similarly, Hoffman's claim that a neutral model can explain the history of global diversity is flawed by its failure to account for one of the most remarkable patterns in the fossil record: the 250-million-year plateau in the number of marine invertebrate families from the Late Ordovician to the Late Permian, maintained in the face of the waxing and waning of many groups and a series of mass extinctions. (It is also not clear whether a neutral model that has to be tuned by the addition of a Cambrian explosion and an end-Permian extinction is still simple or neutral.)

Overall this is a thought-provoking, if sometimes infuriating, volume. With its admittedly biased viewpoint, the book inevitably provides fuel and focus for debate (and, of course, for university seminars, if care is taken to offset its imbalances), but no resolution.

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Some Other Books of Interest

Star Catalogues. A Centennial Tribute to A. N. Vyssotsky. A. G. DAVIS PHILIP and ARTHUR R. UPGREN, Eds. Davis, Schenectady, NY, 1989. vi, 100 pp., illus. $20. Contributions of the Van Vleck Observatory, no. 8. From a meeting, Baltimore, MD, Aug. 1988.

In 1963 the Russian-born astronomer Alexander N. Vyssotsky, working at the University of Virginia, produced a catalog of stars, *Dwarf M Stars Found Spectrophotometrically*, comprising five lists that, in the words of Upgren, "together still form probably the purest and most complete magnitude-limited sample of unevolved stars of all possible ages within the Milky Way galaxy." The 1988 meeting of the International Astronomical Union Commission on photographic astrometry, of which this book is the proceedings, commemorated the centennial of Vyssotsky's birth. The book consists of a dozen papers reporting on current efforts in stellar cataloging. The first enterprise reported on is the *Third Catalogue of Nearby Stars* ("nearby" being defined as within 25 parsecs of the sun) being prepared at the Astronomisches Rechen-Institut in Heidelberg. Upgren and E. W. Weis then discuss uses of data on Vyssotsky stars, a complete catalog of which, with added data, is being prepared for publication. Other projects represented include the *Catalogue of Positions and Proper Motions* (a compilation of catalogs currently including over a million positions) of the Astronomisches Rechen-Institut, several efforts related to the European Space Agency's Hipparcos satellite, the *Second Cape Photographic Catalog* (with 5280 plates) of the Royal Greenwich Observatory, the *Astrographic Catalog* of the U.S. Naval Observatory, the *Catalog of the Components of Double and Multiple Stars* of the Observatoire Royal de Belgique, the new edition of the Yale *General Catalogue of Trigonometric Stellar Parallaxes*, and the *Guide Star Catalogue* to be used for pointing the Hubble Space Telescope.—**K.L.**

The Chemistry of α-Haloketones, α-Haloaldehydes and α-Haloimines. NORBERT DE KIMPE and ROLAND VERHÉ. Saul Patai and Zvi Rappoport, Eds. Wiley, New York, 1988. x, 496 pp., illus. $196. Updates from The Chemistry of Functional Groups.

The series The Chemistry of Functional Groups now contains over 30 volumes in many more parts, to which have been added some half-dozen "Supplements." The volume at hand introduces a new "offshoot of the main trunk." The aim of the "Updates" series is to "present selected chapters on a single topic or on closely related topics from the main series . . . in the form of more modestly sized and priced volumes," with appendixes to update the chapters and in some cases with treatments of new subjects. This volume draws on Supplement D (1983), *The Chemistry of Halides, Pseudo-Halides, and Azides* (priced at $917 but now out of print), reprinting chapters on the synthesis and reactivity of α-halogenated ketones and imines, with appendixes covering the literature up to the first half of 1986, and including a new chapter on α-haloge-