neighbors without giving away the kind of data that would tell the Soviets the basic characteristics of the U.S. weapons production program. And the slowly growing recognition of the routes Hanford's wastes took through the environment came at the same time as Hanford's radiological safety experts also developed an institutional loyalty that convinced them to put the facility's mission ahead of the public's health.

Here one is frustrated by the lack of identifiable characters in Gerber's account, in which the passive voice predominates. Overwhelmingly, decisions "were made" and actions "are taken" with no one actually responsible. The reader looks in vain for some insight into the operation of the institution or the outlook of its staff. One continuing figure is Herbert M. Parker, Hanford's Health Instruments section supervisor, whose job included monitoring the site's releases and measuring them against the evolving public health standards for radiation. But Hanford had little direct accountability for its actions, in part because of the divided authority of the Atomic Energy Commission and its contractor-operators (successively, Du Pont, General Electric, Rockwell, and Westinghouse), and Parker on occasion deemed the outside standards too rigid and recommended that Hanford not abide by them.

Gerber concludes her account by expressing a faith that Hanford's staff can meet the challenges of repairing the damage of its Cold War operations and of becoming a model for openness appropriate to a federal intrusion into the region's economy and the public's health. She has used the fruits of a small measure of openness to good account in beginning to document the environmental history of the site. But her study remains mainly a list of effects, the causes of which apparently remain hidden in the undisclosed records of a still-secretive institution.

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Vignettes: Forms of Writing

A foreword is a testimony, a warrant to the reader, from the perspective of great renown, that the following book is worth the time. Ideally, it should also convince the reader that there is a larger context within which the book fits, while persuading the reader of the profundity of the insights to follow, displaying, all the while, hints of even greater profundity on the part of the "foreworder."

—*Ryan D. Tweney*, in the foreword to Michael E. Gorman's *Simulating Science: Heuristics, Mental Models, and Technoscientific Thinking* (Indiana University Press)

It is worth recalling why the research grant was invented some thirty years ago. Government contracts had, over the years, accumulated page after page of "boilerplate," that is, fixed requirements that were incorporated into the contracts as a matter of agency routine. These fixed requirements were intended to be incorporated into government contracts written to procure standard products from the lowest bidder. They put too much of a burden on researchers, who were doing something unique. The grant was an attempt to go back to basics.

—*Joseph P. Martino*, in *Science Funding: Politics and Porkbarrel* (Transaction Publishers)

S-Curves Everywhere

Predictions. Society's Telltale Signature Reveals the Past and Forecasts the Future. THEODORE MODIS. Simon and Schuster, New York, 1992. 300 pp., illus. $21.

Whether the arrow of time is thought of as determined by God or by irreversible entropy processes, attempts to foretell the future seem to be a natural outcome. This book describes a number of excursions into what Theodore Modis calls "futuronics"—explorations that commenced when Modis was hired several years ago by a computer manufacturer to forecast the life cycles of computer products. Trained as a physicist, Modis was attracted to the work of another physicist, Cesare Marchetti, who in the 1970s had been given the task of forecasting world energy demands at the International Institute of Advanced Systems Analysis in Laxenburg, Austria. Marchetti's efforts at prediction led him to the proposition that the Volterra-Lotka laws that govern growth and competition among species also describe human activity and led him to the search for *invariants*—universally valid constants manifested through indicators that do not change over time and that represent some kind of equilibrium.

Inspired by interactions with Marchetti, Modis describes his subsequent conceptualization, development, and multifarious application of a tool kit for the quantitative prediction of human activities that consists of four elements: S-curves, evolution through natural selection, invariants, and an overall historical cycle that governs people's adventures with a period of about 56 years. The simplest mathematical function that produces an S-curve is the logistic, originally described in 1845 by P. F. Verhulst, which is derived by specifying that the rate of growth in some phenomenon is proportional to both the amount of growth already accomplished and the amount of growth remaining to be accomplished. Modis notes interpretations of S-curves in terms of the diffusion of innovations and learning processes, but most generally refers to them as representing "the law of natural growth." His invocation of evolution emphasizes the mutation of innovations (due to "the law which says that when something can happen, it will happen"), selection (governed by competition, which plays a supreme role and should be called the "father of everything"), and diffusion (which proceeds along natural-growth lines, smoothly filling a niche to capacity). When growth is completed, its signature is an invariant that, despite erratic fluctuations, indicates the existence of thresholds and social balance (for example, car users seem to be satisfied with an average speed of about 30 miles per hour, hardly changed since Henry Ford's time). Finally, Modis documents that a 56-year cycle either of occurrences per decade or of percentage deviations from S-curves fitted to trends is encountered over a broad spectrum of human activities—including energy consumption, use of horsepower, appearance of basic innovations, discovery of stable chemical elements, bank failures, energy prices, life expectancy, cirrhosis of the liver, speed of the one-mile run, and women Nobel laureates.

The undeniable fascination of this book, intended by Modis to reach a literate general public, is the large and diverse array of topics to which this conceptual scheme is applied—the cumulative number of words learned by children from birth through 70 months, the cumulative number of European explorations of the Western Hemisphere following and including Columbus's voyage, the cumulative sales in Europe for Digital's VAX 11/750 minicomputer, cumulative oil discovery and production in the United States, the cumulative number of Roman Catholic saints canonized ("Did Christianity begin before Christ?"), the rise and fall of creativity in the life course of artists and scientists and the prediction of their times of death ("Did Einstein publish too much?"), the cumulative number of American Nobel Prize winners, the substitution of cars for horses in personal transportation, the cumulative number of films produced by Alfred Hitchcock. Studiously obeying the "law of the hammer," Modis seemingly cannot resist putting any set of historical time-series data on his personal computer workbench and pounding away. In the process, he subjects virtually every technological growth curve from the first (canals and tunnels), second (railways, steamships, cars, subways, and oil pipelines), and third (paved roads, motorized ships, natural gas pipelines, car populations, jet engine performance, passenger aircraft performance, passenger air traffic, and personal computer manufacturers and models) waves of industrial growth to analysis, puts forth some intriguing forecasts for energy, environmental waste-management, and transportation technologies in the forthcoming decades, and even gives a chaos-theoretic interpretation to the erratic fluctuations often observed after a growth or diffusion process has closed in on its ceiling. I strongly recommend the book to readers who may be interested in such analyses and conjectures.

On the other hand, I am compelled to note that Modis misses many opportunities to relate his work to a large and growing body of social-scientific literature on the same or similar topics. Modis is the latest of a long line of physicists to poach on social science territory in relative ignorance of extant relevant theories, methods, concepts, and findings. As he remarks (p. 22), "Squeezed by diminishing returns, physicists have started to scatter outside the musty dungeons of particle accelerators in recent years." My point is not the pedantic one that Modis should have cited more extant social science literature. Rather, it is that much of his work could have been made stronger and more general, and precisely what his unique contributions are made more apparent, by being brought into contact with this literature. Some examples: Modis seems blissfully unaware of the decades-long tradition of modeling the diffusion of innovations, technologies, information, and cultures by S-curves (with contributions by, among others, S. Dodd, W. F. Ogburn, J. S. Coleman, and R. L. Hamblin); he similarly seems not to be aware of much of the work by futurologists (such as R. U. Ayres) on the use of S-curves and envelope-curve analysis for predictions; extant applications of evolution through natural selection and Volterra-Lotka systems to the interactions of human populations (for example, by N. Keyfitz), organizations (for example, by M. Hannan and J. Freeman), and consumer goods (for example, by V. Mahajan and R. A. Peterson) similarly seem to have escaped his attention; and his advice to management that there is a time to be conservative (when the S-curve is in steep growth) and a time to innovate and explore new directions (when the growth curve starts flattening out) is not related to various theories of organizational behavior and management (such as the hierarchical garbage-can theory of J. Padgett) from which similar normative guidelines previously have been deduced.

It should be noted that Modis is not completely remiss with respect to previous social science research. For instance, he does cite the relationship of his "overall" 56-year cycles and evidence on the associated clustering of technological innovations to prior work by Kondratieff and Schumpeter (in my opinion, Modis's evidence on these topics is more extensive and compelling than that of either of these scholars). It also must be acknowledged that there are finite limits to the capacity of any scientist to engage the theories, concepts, and findings of many disciplines. Nonetheless, to avoid perpetual reinvention of the wheel, multidisciplinary collaboration and cooperation with respect to modeling complex social and natural systems and forecasting or foretelling the future (which this reviewer previously has attempted to foster) appear to be called for.

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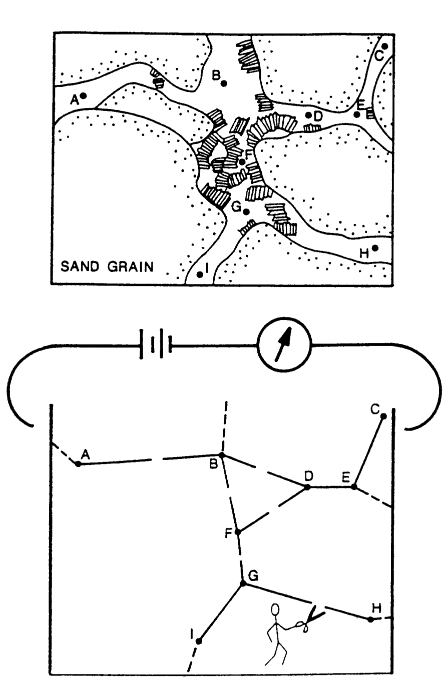
Geofractology

Fractal Models in the Earth Sciences. G. KORVIN. Elsevier, New York, 1992. xxviii, 396 pp., illus. $125.50.

More than any other single book, Mandelbrot's *The Fractal Geometry of Nature*, first published in 1977, introduced the scientific community to the concepts of self-similarity and its ubiquitous occurrence in nature. Since many of the examples in that book were drawn from the earth sciences (the length of coastlines, the morphology of rivers, lakes, and islands, and the shapes of clouds), it has inspired scientists from a wide range of earth science disciplines to look for self-similarity in their data. In some instances they have gone on to ask deeper questions regarding the physics that is responsible for the observed fractal geometry or observable physical consequences of the fractal structure.

In *Fractal Models in the Earth Sciences*, Korvin reviews the progress of fractal re-



"Fluid transfer through a kaolinite-bearing sandstone [top] and the corresponding percolation model [bottom]. The symbolic 'current' can be an arbitrary transfer process." [From *Fractal Models in the Earth Sciences*]

search in the earth sciences since Mandelbrot's original book. Korvin states in the preface that this book is not intended as a textbook in fractals, and I must agree that it is not a good first book for someone not familiar with fractal analysis. Rather, it is a loosely organized collection of case studies, interspersed with bits of mathematical background and sprinkled with literary references and artistic plates presumably intended to give it a certain intellectual patina. To his credit, the author does touch on most of the important applications of fractal analysis that have been developed in the earth sciences, and the book is a valuable source of references otherwise widely scattered across the scientific literature. On the negative side, the coverage is so broad that it is sketchy in many areas. Not surprisingly, the strongest coverage is in the author's field—the fractal geometry of pore space in sedimentary rock and its implications for permeability. The discussion of fractal research in geomorphology as applied to coastlines, lakes, and islands is also strong, as is an interesting and unique discussion of the implications of fractal geometry for exploration geophysics. The weakest discussion is that of fragmentation and earthquake statistics, which does not include recent ideas on the role of self-organized criticality and dynamical systems in establishing temporal and spatial self-similarity in these systems.

What I found most disappointing about this book is that the discussion does not go very far beyond the individual studies.