Evolution: The Pattern or the Process

Speciation and Its Consequences. DANIEL OTTE and JOHN A. ENDLER, Eds. Sinauer, Sunderland, MA, 1989. xiv, 679 pp., illus. $50; paper, $29.95. From a symposium, Philadelphia.

Over the years, "speciation" has acquired two very different meanings. Used descriptively, it refers to the fact that many coexisting species may be observed to have evolved within an evolutionary grouping. For example, some lineages (genera or families) are rich in species, whereas others are species-poor. Data are used to infer how the broader patterns of past evolutionary change have affected the group. Practitioners of this approach are often referred to as "cladists"; they study the pattern rather than the process of evolution.

"Speciation" can also refer to the processes or mechanisms whereby new species originate from pre-existing life forms. In this case, research scrutiny centers on genetics and ecology of selected contemporary populations. Conditions that existed in the past have to be inferred from conditions observed at present. What may happen in the future must be estimated from studies that embrace the rather few generations that an experimenter can observe during his or her lifetime. Thus this field is somewhat resistant to direct observation; it is replete with models and theories, most of which are difficult to test directly. These "populationists," therefore, emphasize process rather than pattern.

These two lines of work traditionally have not meshed well. The pattern people define a species one way and the process people define it another. This inhibits communication, resulting in confusion and controversy. The assemblage of about 40 evolutionists who have produced this book was supposed to help bridge these differences by bringing the diversity of thought in evolutionary biology together. But rather than asking sharp questions that are potentially answerable with available methods, the book is an incautious attempt to deal directly with the hardest problems and generalizations about life. Why does life come in so many forms? Why do these forms come in related clusters, some sharing special characteristics? What is a species and how do new ones arise? Most life is changing continually and permanently from generation to generation and has been doing so for several billion years. If we take a "snapshot" view (in Endler's graphic term) of this moving process, many things will have changed before the shutter can be set for another picture. How do we deal scientifically with such a kaleidoscope?

Darwin and those following him amassed overwhelming evidence establishing that evolution, that is, descent with genetic change, is the central integrating fact of life science. Such great generalizations are hammered out bit by bit, by answering simple, relevant questions. The potentially revolutionizing effect of the extraordinary new genetic techniques has yet to be widely felt, and little attention has been given to reordering the questions asked relative to them. Advances do not come from the confusing "brainstorming" that goes on at big symposia like the one reported here. Needed are crafted books in the tradition of Darwin, Simpson, Mayr, and Dobzhansky.

The evolutionary biologist's most knotty problem is the definition of "species." If any meeting of pattern and process is ever to occur, we must try to get the basic unit straight. In the introductory chapter, Templeton (a populationist) struggles to recast and integrate several leading populationist definitions, in order to make them at least partially palatable to all. Judging from the chapters of Cracraft and Nelson (the latter writes: "I confess a disbelief in species"), the old split is intact.

Most of the participants at this conference, however, were populationists, and Templeton succeeds in clarifying some of the debates among them over how to define the species. He develops the notion of the species as a genetically and demographically cohesive populational unit. He stresses not what intrinsically isolates a species from others but rather what the many positive selective forces are that build it into an increasingly efficient reproducing unit. This idea is the outgrowth of Paterson's recent sharp criticisms of the biological (or isolation) concept of the species. Indeed, Paterson is widely quoted by many authors in this book; apparently his ideas are being taken seriously. There appears to be a revolution brewing here.

Under the neo-Darwinian populationists Mayr and Dobzhansky, the species as a population unit isolated from other similar units by intrinsic, ad hoc "isolating mechanisms" gained prominence. This kind of definition, however, has been on the hate list not only of the cladists but also of many plant biologists, whose species are prone to form hybrids. Despite this, the isolation concept is an appealing one and continues to dominate in textbooks. Coyne and Orr put it neatly by saying that it narrows "the problem of the origin of species to the origin of reproductive isolating mechanisms." In this confusing field, any such reductionist idea is bound to be appealing. Although the recognition (Paterson) and cohesion (Templeton) ideas are stirring up a lot of thinking, most of the populationist authors still consider the origin of "isolating mechanisms" to be crucial to speciation process. But who said science must advance by majority vote?

This book is by no means entirely devoted to hassles over definitions. A lot of fascinating evolutionary patterns are summarized here, making the book essential for anyone interested in contemporary trends in evolutionary biology. One of its great virtues is that many of the participants who present new scenarios come from the ranks of the younger biologists; there has indeed been a refreshing changing of the guard. For example, there are six superb chapters on hybridization and nine more that emphasize biogeography and ecology as guiding forces in the diversification of species. There are considerations of sympatric speciation modes by Tauber and Tauber, Grant and Grant, and Diehl and Bush, although there appears to be little new in this field. There are a splendid chapter on orchids by Gill and voluminous accounts of Hawaiian crickets by Otte and of pocket gophers by Patton and Smith.

Endler's provocative concluding chapter is an uninhibited attempt to pull things together. He likes labels: he stings population geneticists, accusing them of treating organisms as "machines" that "act independently of the environment." He faults Mayr for lack of interest in ecology with the statement that he "worked on museum specimens." Dobzhansky "worked on flies with unknowable ecology and largely with laboratory populations." Where such queer notions came from I can't imagine. Mayr's monumental grasp of evolutionary biology testifies to the opposite of the implied narrow outlook; Dobzhansky wrote 53 papers in the series Genetics of Natural Populations and strongly promoted work on the ecology of *Drosophila*, which is neither unknowable nor unknown. There is also similar unwarranted ridicule for Simpson, Wright, and Haldane.

Endler's purple prose, however, has a purpose with which I agree. Speciation process must be studied in selected organisms that are workable both genetically and ecologically. That pervasive ecological agent natural selection hovers over every population geneticist's "machine." In both nature and laboratory, it guides the genetic system at every turn. Will a population geneticist who denies this please identify himself?

HAMPTON L. CARSON
Department of Genetics, University of Hawaii at Manoa, Honolulu, HI 96822

The Hard Science of Fractals

Fractal Growth Phenomena. TAMÁS VICSEK. World Scientific, Teaneck, NJ, 1989. xii, 355 pp., illus. $67; paper, $28.

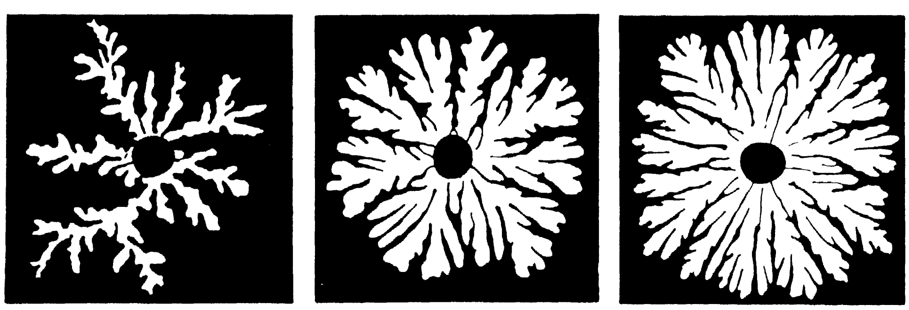
It has been said many times in recent years, perhaps because it continues to be true, that fractals enjoy widespread attention not only in science, but increasingly even in popular culture. Or maybe it's the other way around. Fractals are showing up in everything from computer graphics and science fiction films to strange attractors living in the phase space of a dynamical system and the characterization of the properties of porous media or of the processes of dielectric breakdown. The outside observer, especially a scientist, may want to know more precisely what the fuss is really about. A rich variety of applications of fractal ideas has been set forth persuasively, sometimes eloquently, in Benoit Mandelbrot's books and lectures. Now Tamás Vicsek has provided a much-needed new resource, a nice vehicle for gaining entry into the gradually developing hard science of fractals.

The ubiquity of the fractal seems to have deep origins. There may be many settings in nature for which a framework for a geometry of the irregular is more badly needed than is recognized. For example, the geometry of cloud morphology is surely tied up very deeply with physical processes. It is possible that new basic insights into cloud dynamics may emerge through imaginative use of fractal ideas. Perhaps there will be significant overlap with turbulence theories. Another example may be the hydrodynamics of the ocean surface shape or of the surface of a lake on a windy day.

Of those fields that are amenable to fractal applications, the study of kinetic growth phenomena is perhaps the most developed. Vicsek's book covers a good sample of it, including percolation, diffusion-limited aggregation, the Eden model, and cluster-cluster aggregation, as well as random walks of many stripes (self-intersecting, self-avoiding, and others). There's actually much more in the book. The position space renormalization group application is discussed for percolation; there's a nice section on multifractals; and Laplacian growth processes, such as viscous fingering, crystallization, and dielectric breakdown, get a section to themselves.

Vicsek's style, though in no way pedantic, is logical and precise. His general discussions mesh nicely with numerous examples and accounts of numerical and experimental results. The book contains a very good accumulation of references, although a notable omission is the early paper of Broadbent and Hammersley (*Proc. Cambridge Philos. Soc.* **53**, 629–41 [1957]), the intellectual ancestor of the modern study of kinetic growth phenomena or at least percolation theory. And, despite a good section on fractals themselves and fractal dimensions, we shall still have to wait for a definition of Hausdorff dimension, a matter that ought not to be avoided as religiously as it is by physicists and other writers on fractals. The book has numerous typographical errors and, it appears, at least one error of substance, in equation 5.27, which seems to allow for probabilities larger than 1. Finally, I thought the discussion of fractional Brownian motion was too casual and would have been better omitted. These are mostly small complaints, and I have another one or two, with which virtually no one in the fractal physics community would agree. In spite of these really very minor matters, I think the book is excellent and likely to be interesting and informative to a wide class of readers.

ROBERT CAWLEY
Naval Surface Warfare Center, Silver Spring, MD 20903-5000



Patterns made by injecting gas into a layer of smectic A liquid crystal. For low pressures (left; p = 30mmHg) the interface has a fractal structure analogous to that of DLA clusters, whereas the patterns become homogeneous (non-fractal) for large pressures (right; p = 70mmHg). [From *Fractal Growth Phenomena*; Horváth *et al.*, 1987]

Hot Halos

Cooling Flows in Clusters and Galaxies. A. C. FABIAN, Ed. Kluwer, Norwell, MA, 1988. xiv, 391 pp., illus. $99. NATO Advanced Science Institutes Series C, vol. 229. From a workshop, Cambridge, U.K., June 1987.

The last ten years have seen the steady growth of interest in the existence and long-term evolution of the hot gas surrounding some galaxy cluster cores and some field galaxies. This gas is detected through its x-ray emission, and interest in it has been, for the most part, confined to the x-ray astronomy community. This collection of papers can be read simply as a summary of our current understanding of the topic, but it has a more important mission. A number of the contributors are convinced that their work is providing important clues to the processes of galaxy formation and evolution, clues that need to be taken more seriously by the astrophysical community at large.

What is a cooling flow? From the observational point of view it is the detection of an extended region of x-ray–emitting gas whose temperature decreases toward the center so that its cooling time drops below the age of the universe. The most straightforward interpretation of the observations is that gas is cooling and condensing in the central regions and is being replaced by a steady flow of gas from larger radii. The observations may be used to estimate the rate at which mass is disappearing from the flow. The resulting estimates are surprisingly large, sometimes hundreds of solar masses a year, although more usually the derived accretion rates are a few solar masses a year. In any case, the obvious conclusion is that the mass of the central galaxy is often dominated by material that has condensed out of the cooling flow.

How firm is the evidence? A number of the papers include attempts to rule out alternative hypotheses and provide quantitative estimates of cooling flow parameters. Most of the papers are directly concerned with x-ray observations, which provide fairly accurate density profiles but somewhat more uncertain temperature estimates. Still, a fair number of the contributions address