pacts on forests and that the chemistry of water leaving the watershed was modified by plants and by exchange processes in the soils. The significant conclusions were drawn from analysis of the whole system. The Hubbard Brook study also showed that ecosystem-level research, focused on a small watershed, could attract independent researchers who could contribute to an understanding of the whole without the need for large budgets.

This review of the events leading to acceptance of ecosystem ecology as a discipline, the shortcomings of the IBP studies, and the emergence of new approaches in the study of ecosystems ends with the middle 1970s. The final chapter of the book examines why ecosystem studies took different directions in Europe, Japan, and the United States and critiques reductionism in ecology.

Golley's historical account is fascinating and effective. It provides perspective on a time when theoretical and experimental studies were increasing, partly because of emerging environmental problems. An emphasis on large field studies by groups of scientists is needed for the study of global environmental problems, which makes Golley's review a timely one. By setting forth the strengths and weaknesses of the IBP and other ecosystem studies, he provides us with a historical perspective and guidelines to make future research more effective. The book is also a timely reminder of Tansley's concept of the ecosystem. Organismal metaphors (environmental "health," for example) are still commonly used in ecology. Their use glosses over concepts that are difficult to define and in the process impedes the building of theories.

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Vignettes: Dire Predictions

The control of the beastlike in human nature is sometimes said to be a matter of species survival. Here is a characteristic sentence from Carl Sagan: "There is today in the West (but not in the East) a resurgent interest in vague, anecdotal and often demonstrably erroneous doctrines that, if true, would betoken at least a more interesting universe, but that, if false, imply an intellectual carelessness, and absence of toughmindedness, and a diversion of energies not very promising for our survival." . . . He goes on to enumerate astrology, flying saucer accounts, modern prophecy, and other efflorescences of popular antirationalist belief. Sagan as scientist shows a bit of siege mentality here: dissent from the rule of scientific reason, even on this small scale, risks apocalypse, the destruction of the species.

—*Alan G. Wasserstein*, in *The Literature of Science: Perspectives on Popular Scientific Writing* (Murdo William McRae, Ed.; University of Georgia Press)

Mathematical studies on the disappearance of rare family names date back to the nineteenth century. Statisticians rigged up a properly simplified model—later called a *branching process*—and derived from it that every family name would inexorably have to vanish sooner or later. This was a heraldic counterpart, so to speak, to the *Würmertod* (heat death) which the contemporary physicists prophesied for our passing world—a disconsolate perspective for a century hooked on progress. Both results turned out to be wrong, by the way. The *Würmertod* is out, like the same physicists' *ether*—today's cosmologists have other fates in store for our world. And the apparently inescapable extinction of family names was based on a simple miscalculation; but it took a long time to discover the error.

—*Karl Sigmund*, in *Games of Life: Explorations in Ecology, Evolution, and Behaviour* (Oxford University Press)

Intergradations

Hybrid Zones and the Evolutionary Process. RICHARD G. HARRISON, Ed. Oxford University Press, New York, 1993. x, 364 pp., illus. $65 or £45. Based on a symposium, College Park, MD, July 1990.

Interest in the causes and consequences of hybridization between genetically differentiated natural populations remains strong in evolutionary biology, both because new molecular and statistical methods make multifaceted studies feasible and because refinements in hybrid-zone theory now provide a richer perspective on thinking about fundamental issues of adaptation and speciation. This compilation provides a timely update on many theoretical issues and includes examples of long-term multidisciplinary studies.

The first four chapters review conceptual issues and practical concerns for field studies. Those unfamiliar with hybrid-zone issues will find chapters 2 through 4 useful. In chapter 2 Barton and Gale describe models used to estimate cline shape and width, linkage disequilibrium between unlinked markers, and the assumptions and limitations of each model and then show how the models are used to estimate the strength of selection maintaining a zone, the number of loci differing between hybridizing populations, dispersal rates, and the facility with which alleles introgress. A fundamental distinction is made between selection maintaining a zone due to extrinsic factors (where fitness varies along an environmental gradient) and the existence of a "tension" zone in which selection acts against hybrids (intrinsic).

In chapter 3, Howard provides a useful definition of reinforcement (that is, prezygotic barriers to gene exchange improved by natural selection in response to selection against hybridization) and a possible consequence, reproductive character displacement (RCD; a pattern of greater divergence of an isolating trait in areas of sympatry and hybridization between closely related taxa than in areas of allopatry). Several theoretical objections have been raised regarding the importance of these processes, but most empirical studies cited as failing to support RCD were not originally designed to critically test reinforcement hypotheses.

The last chapter of this section (Rieseberg and Wendel) summarizes much of the literature on plant hybridization and suggests that many plant systems are suitable for studies of the transfer of adaptations once molecular markers have been linked to adaptively significant traits.

The remaining chapters summarize data on a variety of different hybrid zones that display a remarkable diversity of characteristics. Moore and Price describe an extremely broad, ecotonal contact on a continental scale between two subspecies of northern flicker (*Colaptes auratus*), whereas extremely narrow zones are described for two complexes of grasshoppers (*Caledia*, Shaw *et al.*; and *Chorthippus*, Hewitt) from Australia and Europe, respectively, several species of *Iris* from the southeastern United States (Arnold and Bennett), Amazonian butterflies of the genus *Heliconius* (Mallet), European toads of the genus *Bombina* (Szymura), European mice and shrews (*Mus* and

Sorex, Searle), and western North American gophers (*Geomys* and *Thomomys*, Patton). Of these narrow zones, *Bombina, Caledia, Chorthippus, Heliconius, Mus*, and *Sorex* form broad contacts several hundred kilometers in length, and many have been studied at multiple transects. Irises and gophers form very limited, patchy hybrid zones, but Arnold and Bennett show the advantages of plant systems for laboratory and transplant experiments. Patton emphasizes that several aspects of gopher demography (exclusive-use territories and polygynous mating systems) make them ideal for studies of how mating systems influence patterns of hybridization and introgression.

Most of these studies concentrate on determining what selective forces are acting to maintain a given zone and, for zones in which there is strong selection against hybrids, whether or not reinforcement might be operating. In many cases, either reinforcement appears not to be operating even with very strong post-mating isolation (*Caledia*) or evidence for it is limited despite seemingly ideal conditions (*Chorthippus*).

Clines for most characters studied are coincident and appear to be maintained by extrinsic factors favoring different genotypes in different habitats (*Colaptes*) or by intrinsic factors coupled with a strong habitat component (most others). The *Heliconius* zones involve a series of Mullerian mimetic morphs of several species, and their structure is unusual in having the dynamics of a tension zone (frequency-dependent selection operates against intermediate phenotypes), but this is due to an ecological agent (avian predators). Some of the *Mus* and *Sorex* chromosomal clines described by Searle are unusual in that they are distinctly noncoincident with each other and form a "staggered" pattern.

The book could have provided a better-integrated exposition of the value of placing process-oriented studies into a phylogenetic context; the matter is mentioned in several chapters, but nowhere is it fully developed. Nevertheless, this book deserves a wide audience; organismal biologists not familiar with hybrid-zone research will be surprised at the number of interrelated topics that require attention. For example, a great deal remains to be learned about the ethological, ecological, and demographic aspects of most hybrid zones, about the genetic basis for ecologically important morphological traits, and about communication signals and mate choice. At the molecular level, the development of new markers will permit more robust estimates of gene flow and facilitate multiple-gene tree comparisons, and causal mechanisms responsible for the generation of new alleles and chromosomal rearrangements in hybrid zones remain only superficially understood. For those with a mathematical or statistical inclination, the extension of cline theory to describe noncoincident "staggered" clines and two-dimensional and small-sample cases, and a refinement of gene-flow estimators under a variety of different mating systems and selection regimes would repay further effort. This book should also stimulate investigators working on groups underrepresented in the hybrid-zone literature to undertake similar studies; only when enough examples are available will generalities emerge. The diversity of phenomena manifested in the examples in this book suggest that we have a long way to go.

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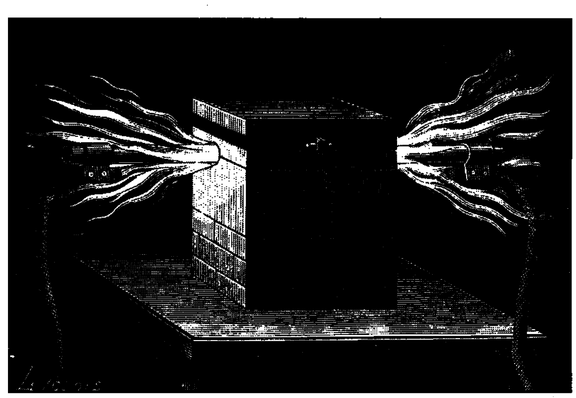
Diamond-Making

The New Alchemists. Breaking Through the Barriers of High Pressure. ROBERT M. HAZEN. Times Books, New York, 1993. xvi, 286 pp., illus. $25.

Synthesis of diamond from carbon is certainly the most spectacular achievement of high-pressure research. I believe no other material can challenge synthetic diamond's honored place, not even metallic hydrogen, if it is ever made. During my three decades at Bell Laboratories I was often asked by visitors, "What is the use of high-pressure research?" My ready reply was that high pressure has enabled us to accomplish feats that previously could be performed only by nature in the Earth's deepest interior. Then I would say, "Give me peanuts and I will turn them into diamonds with this apparatus in front of you," a massive, green-hued press that we had christened "the green elephant." The astonished visitor would retreat a few steps, look at me and the press and exclaim, "Is it really that simple?" It is indeed that simple now, but it was not prior to 1955.

The successful synthesis of diamond has a long history behind it of failures, frustrations, rivalries, faked claims, and missed opportunities. Celebrated chemist and Nobel laureate Henri Moissan failed. The father of high-pressure research and Nobel Prize–winning physicist Percy Bridgman did not succeed either, despite many attempts. As a result of studies of natural diamonds by geologists it has long been known that diamond production requires both high pressures and high temperatures. What exactly these pressures and temperatures must be eluded the early diamond makers, and their hit-and-miss methods yielded no good results. Finally, thermodynamic calculations revealed diamond's pressure–temperature stability field. But the generation of sustained pressures and temperatures under which graphite would transform to diamond rapidly would have to await the advances of high-pressure technology of the 1950s. The expensive venture also needed the support of corporate players, for no individual scientist could afford the cost.

The feat was finally accomplished on 16 December 1954 by a team of scientists at the General Electric Research Laboratory with the so-called "Belt Apparatus," invented by one of its members. From 1950 to the day of success, the team plodded and sweated to build the right kind of apparatus, find the right recipe to cook, and prove the repeatability of the experiment so that the discovery could be patented. It was a great scientific achievement of immense practical value. (Diamond mines in Africa, Australia, and Russia together yield something like 20 tons annually, but the world annual production of synthetic diamond is estimated to be over 100 tons, almost all of which is marketed as abrasives and used in the machine-tool industry and in rock drilling. Synthetic gem-quality diamonds of a few carats in size have been produced, but the cost is at present prohibitive.)



"At full power, Henri Moissan's electric air furnace, pictured in this illustration from his 1904 monograph The Electric Furnace, produced a spectacular display of sparks and flame as it reached temperatures of 3,000°C. Moissan believed that he had synthesized diamonds in his apparatus." [From *The New Alchemists*]

The New Alchemists tells the exciting human story behind this important achievement, describing the players, the game they played and how they played, and consequent events. It is a brilliant exposition, very absorbing and gripping. I could not put the book down; the first part, called The Diamond Makers, reads like