A strong word of caution, however, is necessary for those readers who hope to find something more than an entertaining story here. For whereas the author's mathematical presentation is based on a solid understanding of modern geometry and algebra, his book manifests many of the standard weaknesses found in historical studies undertaken by mathematicians. Indeed, his reflections on the major actors discussed here appear to be based on a combination of folklore, conjecture, and superficial reading of popular (and sometimes notoriously unreliable) secondary work (such as E. T. Bell's *Men of Mathematics*).

Yaglom's second chapter, entitled "Jordan's pupils," describes Klein and Lie as "postgraduate students" of Jordan's during their sojourn in Paris. Most secondary accounts point out how Klein and Lie met Jordan and became familiar with his *Traité des substitutions et des équations algébriques*. The impact Jordan's book actually exerted on them may well be debatable, but this ought not to obscure the nature of their personal relationship. The fact is that neither Lie nor Klein ever referred to himself as a student of Jordan's, even in the loosest sense of the word. Yaglom does mention the influence of Gaston Darboux, with whom they had considerably more contact while in Paris, but he gives no real hint of what it was that they learned from him. Nor is there a single word about any of the principal geometrical results that preoccupied Lie's and Klein's attention at this time: Lie's line-to-sphere transformation, the determination of the asymptotic curves on a Kummer surface, or the generalizations of Dupin's theorem.

The author also has a tendency to exaggerate the accomplishments of famous figures in the history of mathematics. Writing about Riemann's influential *Habilitationsvortrag* of 1854, Yaglom asserts that "he was a direct predecessor of Albert Einstein, whose 'general theory of relativity' is wholly based on Riemann's ideas" (p. 61). On the next page, however, he adds that "Riemann's ideas were truly appreciated only after they were revised by the outstanding twentieth-century mathematician Hermann Weyl and by Albert Einstein." These revisions, of course, took place after 1915 when Einstein presented his general theory. The author seems to imply that when Weyl pointed out the connection between Riemann's ideas and modern tensor analysis in 1919, he was merely affirming that Riemann had anticipated the central mathematical features of Einstein's theory.

Regarding Lie's work, which is notoriously unreadable, Yaglom writes that "his style was leisurely and polished. He carefully set down details and provided many examples." Perhaps Yaglom had in mind the textbooks based on Lie's lectures prepared by his student Georg Scheffers, although he asserts that there are "striking similarities of language, and even style" between Lie's papers and the books published under his name. This leads him to conclude (falsely) that Lie was the chief author of these books. In fact, the contrast between the books written by Scheffers (as well as the three-volume work on transformation groups composed by Lie's leading disciple, Friedrich Engel) and the articles Lie himself wrote could hardly be greater. Yaglom's further claim that all of Lie's work "centered around one subject—the theory of transformation groups" is, at best, misleading. Lie's work was largely motivated by a bold new geometric theory for systems of ordinary and partial differential equations.

In sum, Yaglom has written a readable book that has much to recommend it as a popular introduction to the historical role of symmetry in modern mathematics. It is unfortunate that its merits are spoiled by a superficial approach to history and biography.

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Mathematics vs. Evolution

Mathematical Evolutionary Theory. MARCUS W. FELDMAN. Ed. Princeton University Press, Princeton, NJ, 1989. x, 341 pp. $60; paper, $19.95.

Place the stress on the word "mathematical," for this is a festschrift volume for Samuel Karlin of Stanford University. A mathematician of considerable power, Karlin has been the leading figure in introducing rigorous mathematical arguments into population genetics, already the most mathematical subject in biology. The vision that inspired the members of the Stanford School was of a population genetics reborn as a part of the discipline of applied mathematics. The chief instrument in this revolution was to be the journal *Theoretical Population Biology*, which Karlin founded and which is about to celebrate its 20th year of publication.

There is another, older tradition in theoretical population genetics, which goes back to its founding over 80 years ago. Until the 1960s almost all theoretical work in the field was not rigorous, but was in the cruder tradition of engineering mathematics. The arguments of the three founders, Fisher, Wright, and Haldane, were not mathematically rigorous proofs; they often relied on intuitive and approximate methods.

Tension between these two approaches to applying mathematics to biology ran high in the 1970s. John Maynard Smith of the University of Sussex, who has wielded intuitive and approximate arguments particularly effectively, expressed it in a talk at the 1973 International Congress of Genetics in Berkeley. Speaking at a time when Karlin was commuting between Stanford and the Weizmann Institute in Israel, he presented an approximate argument and then apologized for its lack of rigor, saying that "someone like Sam Karlin would never approve of it. However I used to design airplanes for a living, and I can assure Professor Karlin that the very airplanes on which he flies back and forth with such confidence were designed by the very methods he deplores."

This tension is by no means unique to population genetics. It is inevitable whenever mathematical theory is asked to come in contact with any part of the real world. Introducing a higher standard of rigor does not always result in universal applause. A news report in *Science* in 1975 (vol. 190, p. 773) reported the mathematician Marc Kac's complaints about applied mathematics itself, which he sees as apt to create "dehydrated elephants"—great achievements no potential user wants or needs.

Has the Stanford school succeeded in their revolution? They have certainly succeeded in establishing a much higher standard of rigor. Theoreticians training today learn more mathematics than they used to and are far more aware of the need to prove their results.

At the same time population genetics theory has not really become integrated into applied mathematics. Real life being messy, many theoretical problems cannot be precisely solved, and experience from such non-rigorous techniques as computer simulation remains relevant. An example is the search for what natural selection might be maximizing. Sewall Wright and R. A. Fisher derived results that seemed to imply that natural selection would act so as to maximize the mean relative fitness of members of a population.

It did not take a new generation of theoreticians long to discover holes in this—systems of linked genes can evolve steadily away from the maximum mean fitness. Even Fisher's and Wright's one-locus equations turn out to be approximations, sometimes bad ones. If we could discover what quantity was being maximized, it might yield some insight into how the details of the genetic system compromise adaptation. After 20 years of effort there has been no great progress on this central problem—the genetic system is not designed for the convenience of mathematical theorists. All theory has done is disprove postulated generalizations. The mathematical tools at hand have not revolutionized our understanding of the evolutionary process.

The papers in this well-produced volume reflect this. They are excellent papers, clarifying how various phenomena are best described mathematically (such as effective population sizes, neutral alleles in population bottlenecks, two-locus linkage disequilibria, kin selection at two loci, and evolutionarily stable sex ratios). Many of the authors passed through Stanford or were associated with the parallel Australian school. Their mathematical powers are put to effective use, and anyone interested in mathematical theory in population genetics will find this book worthwhile to have.

At the same time, many evolutionists will fail to find the clear and simple messages that population genetics theory once seemed to promise. Sabin Lessard's careful examination of genetic models of sex ratio is typical here. After much work, Lessard is unable to conclude in favor of a simple rule put forward by the late Robert MacArthur. But he notes that the exceptions to it are rare and of small effect. Mendelian genetic systems are maddeningly close to allowing simple and general conclusions to be drawn. Similar situations occur in the papers by Marcy Uyenoyama on multilocus kin selection and to a lesser extent by Uri Liberman and Marcus Feldman on evolution of migration rates.

All of which is not to say that the models in this book are divorced from reality. A number of the papers are inspired by the need to draw conclusions about the role of selection in molecular evolution of proteins observed electrophoretically (papers by Warren Ewens, Geoffrey Watterson, and Simon Tavaré) or by sequencing (John Gillespie), of interspersed DNA repeats (Norman Kaplan and Richard Hudson), or of HLA (Walter and Julia Bodmer). Jonathan Roughgarden develops theory relevant to when marine life cycles will have benthic stages, Feldman and Luca Cavalli-Sforza attack models of gene-culture coevolution in the case of human lactose intolerance, and Peter O'Donald and Michael Majerus integrate theory and experiments on ladybird beetle color polymorphisms.

It is clear from those papers that, with enough information, population genetics theory can be extraordinarily powerful. It is when we must generalize over a wide range of possible models that the intractability of the mathematics becomes infuriating. When computer simulations are done on a less general, more realistic range of models the models behave in a less lawless fashion. It would be a great help if we could find some way to express that in the theory. How to do so is one of the main challenges of the future. The papers in this volume are a fair portrait of population genetics theory at a moment when it has cleaned up its act mathematically but has yet to find a way through the resulting complexity to speak powerfully to a future generation of evolutionists.

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Macrocyclic Chemistry

The Chemistry of Macrocyclic Ligand Complexes. LEONARD F. LINDOY. Cambridge University Press, New York, 1989. viii, 269 pp., illus. $69.50.

The Pimentel Report, *Opportunities in Chemistry* (National Academy Press, Washington, D.C., 1985), predicted that chemistry was on the verge of a renaissance because of the emerging ability to fold experiment and theory together to design chemical structures with properties of choice. This ability is amply demonstrated in the field of macrocyclic chemistry, where scientists with organic, biochemical, and inorganic backgrounds have produced novel compounds that show remarkably selective chemical behavior. This work has attracted attention in many fields where selectivity is of primary concern, including chemical catalysis, enzyme action, selective transport of ions and molecules in membrane systems, and chemical separations. The significant progress in macrocyclic chemistry is reflected by the selection of three of its pioneers—C. J. Pedersen, D. J. Cram, and J.-M. Lehn—for the 1987 Nobel Prize in chemistry.

The creation of new molecules with predetermined properties is not a trivial process. It requires a combination of factors including recognition of a problem, a creative approach to its solution, the ability to visualize the molecular properties needed, and the ability to synthesize the required compound. Central to this process are the thought processes that precede the actual synthetic work.

Using many examples, Lindoy has provided a well-organized overview of the main developments in the chemistry of macrocycles. He emphasizes the description of the many types of macrocycles that have been prepared and studied. The examples given offer convincing evidence that macrocycles have excellent selectivity for particular ions and molecules and that their presence can result in significant modifications of the chemical properties of the complexed species.

The book discusses the structures and properties of macrocyclic compounds; the synthesis of macrocycles; the complexation chemistry of polyether crowns, cryptands, aza crowns, cyclophanes, cyclodextrins, and naturally occurring macrocycles; molecular recognition aspects; and kinetic, thermodynamic and electrochemical aspects of a variety of macrocyclic systems.

The chapter on natural macrocycles provides a good summary of the variety of these compounds found in nature. Their uses in biological systems are many and varied. One of their most interesting characteristics is the way in which they change the properties of metal ions. This ability is illustrated by iron (II), which will bind O_2 in its myoglobin complex, and vitamin B12, where bound cobalt plays an important role. Lindoy gives numerous examples of the active effort to design synthetic macrocycles to mimic the cation binding behavior of natural systems.

The book is organized and written appropriately for a senior undergraduate or graduate course on macrocyclic chemistry. It will also be of interest to the non-specialist who desires a general introduction to macrocyclic chemistry. References are supplied throughout, and the excellent illustrations make it easy to follow the text.

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Reprints of Books Previously Reviewed

Natural Obsessions. Natalie Angier. Warner, New York, 1989. Paper, $14.95. *Reviewed* **242**, 602 (1988).
Racial Hygiene. Medicine Under the Nazis. Robert Proctor. Harvard University Press, Cambridge, MA, 1989. Paper, $12.50. *Reviewed* **242**, 785 (1988).

Books Received

Central Limit Theorems for Generalized Multilinear Forms. P. de Jong. Centrum voor Wiskunde en Informatica, Amsterdam, 1989. viii, 84 pp. Paper, Dfl. 14.10. CWI Tract 61.
The Challenge of d and f Electrons. Theory and Computations. Denis R. Salahub and Michael C. Zerner, Eds. American Chemical Society, Washington, DC, 1989. x, 405 pp., illus. $89.95. ACS Symposium Series, vol. 394. From a symposium, Toronto, Ontario, June 1988.
Characterizations of Banach Spaces Not Containing l^1. D. van Dulst. Centrum voor Wiskunde en Informatica, Amsterdam, 1989. vi, 163 pp. Paper, Dfl. 25.30. CWI Tract 59.
Chemical Hazards of the Workplace. Nick H. Proctor, James P. Hughes, and Michael L. Fischman. 2nd ed. Lippincott, Philadelphia, 1989 (distributor, Van Nostrand Reinhold, New York). xviii, 573 pp. $56.95.
The Chemistry of Macrocyclic Ligand Complexes. Leonard F. Lindoy. Cambridge University Press, New York, 1989. viii, 269 pp., illus. $69.50.