## Aspects of Ulam

**From Cardinals to Chaos**. Reflections on the Life and Legacy of Stanislaw Ulam. NECIA GRANT COOPER *et al.*, Eds. Cambridge University Press, New York, 1989. 319 pp., illus. $75; paper, $24.95. First published as a special issue of *Los Alamos Science*.

In an introductory "Esquisse," Françoise Ulam claims that her husband defied description: no one person "ever viewed the whole of him." This volume instead aims at a composite picture, made up of excerpts from his own reminiscences, reflections of colleagues and friends, appreciations of his scientific accomplishments, and accounts of recent research influenced by his work.

The title of the book suggests the breadth of Stanislaw Ulam's scientific work. During Ulam's first year in the Lwów Polytechnic Institute, Kuratowski introduced him to a problem in set theory involving the transformation of sets and infinite cardinals; Ulam later described it as "the first problem on which I really spent arduous hours of thinking" (p. 10). "Chaos" refers to studies of the complex behavior of nonlinear systems, as guided by Ulam's pioneering work in experimental mathematics.

The book's contributors number more than two dozen and include specialists in mathematics, physics, and biology. Some come from the long list of Ulam's collaborators; others work in fields where his influence and example have proven decisive.

The volume begins with excerpts from Ulam's *Adventures of a Mathematician* (first published in 1976). These reminiscences provide a tantalizingly brief biographical sketch, in which Ulam describes how it was "that mathematics had taken possession of me" (p. 11) and how he flourished in the intellectual atmosphere of the Scottish Café in Lwów. The launching of Ulam's career in the United States was conditioned by good fortune and timing: von Neumann's offer of a temporary stipend at the Institute for Advanced Study, Ulam's meeting with Birkhoff and subsequent appointment to the Harvard Society of Fellows, his successful application for an immigration visa shortly before Hitler's advance closed that option for most Poles.

After 1941 von Neumann helped engineer an invitation for Ulam, then at the University of Wisconsin, to participate in the Manhattan Project. Before his departure for Los Alamos, Ulam checked out the WPA guide for New Mexico from the local library, discovering that other colleagues from Madison, who had already disappeared "to hush-hush war jobs" (p. 15) at unknown destinations, had done likewise. Ulam's experiences in wartime and postwar Los Alamos were crucial in his own work and that of the institution. There, as at the other institutions he served, Ulam's intuition and ingenuity spurred colleagues in various fields. They recall: "Like a master of reflecting boundaries, he would bounce ideas back to us from an endless variety of angles" (p. 52); "Stan habitually turned things to view from a variety of directions. . . . and often supplied the connection that dispelled a gathering fog" (p. 288); "Stan did his best work in fields where no one dared to tread" (p. 30). His was a combination of "deep intuition and impatience with detail, playful inventiveness and dislike of prolonged work" (p. 24).

Most contributions to this volume, however, are not meant for the lazy reader. The book, which appeared originally as a special issue of *Los Alamos Science* (1987), was aimed at an audience with ready-made interest in the research programs at Los Alamos National Laboratory. Its republication in this form anticipates a larger audience, with interests in contemporary mathematical research and its applications in physics and biology.

In the opinion of his colleague and friend Gian-Carlo Rota, Ulam's two problem books will secure him a lasting reputation among mathematicians. Contributions to this volume also focus on his leading role in developing computer-aided experimental mathematics. Themes first sounded in the section on mathematics echo elsewhere in the volume, as in Ulam's work itself: witness, for example, the utility of measures of similarity in analysis of DNA sequences, recognition of speech, and graph theory.

The section on physics likewise combines a review of developments and accounts of current research, as inspired by Ulam and aided by computer experiments. Much here is made of Ulam's contributions to research in nonlinear science, customarily defined as the study of systems and phenomena that are not linear. This definition once prompted Ulam to draw an analogy to zoology as the study of "non-elephant animals" (p. 218). The section contains excerpts from "FPU," Fermi, Pasta, and Ulam's influential work on nonlinear systems; a thoughtful overview of nonlinear science by David K. Campbell, which identifies three major paradigms and tracks them through physical and mathematical examples; and more detailed treatment of turbulence and many-particle systems, problems that challenge powerful computer technologies.

Another section explores Ulam's "genius" for casting basic biological problems in the form of mathematical models, including the notion of genealogical distance, encoding in genes of "rules for the change of rules," and "cellular automaton models of growth patterns" (p. 281). The section concludes with Ulam's Gamow Memorial Lecture (1982), "Reflections on the brain's attempts to understand itself," published for the first time in this compilation.

The book has been carefully designed and produced. Variety in format and use of sidebars accommodate much mathematical notation and technical discourse; generous margins and lavish color in illustrations enhance the presentation. The book contains a useful bibliography of Ulam's publications, and most of the contributions also offer suggestions for further reading. The utility of the index is diminished by its brevity.

A final section, The Ulam Touch, includes two pieces closely linked to Los Alamos. One is "a memorable memo" dated 1947, in which Ulam and Carson Mark alphabetized, for the "convenience and ready reference" of the Administration and Services division at Los Alamos, the numbers from 0 to 100. An AEC Commissioner once called it the "best thing to come out of Los Alamos yet!" (p. 294). A second, entitled "Sub rosa," is a playlet dictated by Ulam (1965) in which three characters (Bethe, Teller, and Ulam) debate issues of nuclear testing. Its tone is light, the editor's recommendation "Enjoy!" Both of these pieces remind us, however, of the unique scientific environment and political context in which Ulam operated.

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## Cold Episode

**The Little Ice Age**. JEAN M. GROVE. Methuen, New York, 1988. xxii, 498 pp., illus. $144.

Does the recent warming observed in time series of global temperatures indicate "greenhouse warming," or is it simply a component of natural climatic variability? Is the 20th-century earth, as some suggest, merely escaping the clutches of the 15th- to 19th-century "Little Ice Age"? Could another natural cold episode help compensate human-induced warming? Are warm events such as the 12th- to 13th-century "Medieval Warm Period" real, and could they occur in the future? These questions are currently the subject of hot scientific debate and illustrate how little is known about the patterns and causes of natural decade- to century-scale climatic variability. The scientific community has already unraveled many mysteries of the "big" Quaternary ice ages, but we have yet to even define when and what "the Little Ice Age" was.