MEMORIAL RESOLUTION

GEORGE PÓLYA
(1887 – 1985)

George Pólya, Professor Emeritus of Mathematics, died on September 7, 1985, in Palo Alto after several months of illness. George Pólya held a special place in mathematics, not only for his original and lasting contributions to pure and applied mathematics, but also as a great teacher of mathematics and for his contributions to the teaching of mathematics through his seminal work in heuristics and the methods of problem solving.

He was born in Budapest on December 13, 1887, the son of Jacob and Anne (Deutsch) Pólya. Early in life he was urged by his mother to take up his father's profession, the law, and he dutifully began his work in this subject at the University of Budapest, but this lasted only for one semester. He then studied languages and literature for two years. Fond of philosophy and of literature, particularly the poetry of Heinrich Heine, some of which he translated into Hungarian, he was also attracted to physics. A philosophy professor with unusual insight convinced him that the study of mathematics and physics would help his understanding of philosophy, so he eventually came to the serious study of mathematics. This led to Pó1ya's statement: "I thought "I'm not good enough for physics and I am too good for philosophy. Mathematics is in between."

At the university his physics professor was Lorand Etövös, but the faculty member to influence him most was the mathematician Lipót Fejér. Fejér drew a number of talented students into his circle: Mihály Fekete, Otto Szász, Gabor Szegö, and later Paul Erdös. Pólya spent the academic year 1910-11 at the University of Vienna, and returned to Budapest to receive his doctorate in 1912. He then went to the University of Göttingen in 1912-14 where he encountered Felix Klein, David Hilbert, Carl Runge, Edmund Landau and other eminent Göttingen professors. Even the list of Privatdozents was impressive: Hermann Weyl, Erich Hecke, Richard Courant, and Otto Toeplitz.

In the spring of 1914 Pólya went to the University of Paris, where he met Emile Picard and Jacques Hadamard. In the fall of that year, at the invitation of Adolf Hurwitz, he took his first teaching position at the Eidgenössische Technische Hochschule (ETH) in Zurich, where he was to stay until 1940 and to which he returned for frequent visits later.

He became a Swiss citizen, and in 1918 married Stella Vera Weber, a daughter of a professor of physics at the University of Neuchâtel. Because Mrs. Pólya grew up in French-speaking Switzerland, French was the language spoken in the home, though Pólya was, of course, Hungarian, and they lived in German-speaking Switzerland. He has written mathematical papers in Hungarian, French, German, Italian, English, and Danish.

At the ETH he became Professor in 1928. His colleagues at the ETH included Adolf Hurwitz, and later Hermann Weyl, Michel Plancherel, and Heinz Hopf. Students in his classes included Felix Bloch and Hans Staub, who later became Professors of Physics at Stanford, and the mathematician and physicist John von Neumann.

At the suggestion of G. H. Hardy, Pólya was awarded the first international Rockefeller Fellowship in 1924. This was used to spend the year at Oxford and Cambridge with Hardy and J. E. Littlewood. Thus began his long friendship and collaboration with these mathematicians; one outcome of which was the famous book Hardy, Littlewood and Pólya,, Inequalities. While Pólya was at Cambridge, Hardy was in the midst of is campaign to reform the Mathematics Tripos and asked Pólya to take this examination unofficially. Hardy expected Pólya's poor showing would demonstrate that most questions were irrelevant to "modern continental mathematics." Unfortunately for Hardy's plan, Pólya's was the best performance on the examination, and he would have been named the Senior Wrangler if he had been a student.

Earlier Pólya had developed a close collaboration with Gabor Szegö. Together they wrote their classic work, Aufgaben und Lehrsätze aus der Analysis, published in two volumes by Springer-Verlag in 1925. After 60 years, this work is still cited regularly and is one of the most important sources of problems in analysis. The organization was original; the problems were put together, not according to the topic, but according to the method of solution. This work has been translated into English and is still in print. The collaboration with Szegö continued with joint papers and another book, Isoperimetric Inequalities in Mathematical Physics, in 1951.

In 1933 Pólya was again selected for a Rockefeller grant, this time to visit Princeton. He spent the summer quarter of that year at Stanford. In 1940 the Pólyas left Switzerland. After two years at Brown and Smith, Pólya received an appointment at Stanford, where Gabor Szegö was Department Head. He remained at Stanford for the remainder of his academic career.

Pólya was one of the most popular teachers at Stanford. In 1948 his class on Functions of a Complex Variable was attended by Lincoln Moses and Halsey Royden, then students, and by Hugh Skilling and Fred Terman, then Head of Electrical Engineering and Dean of Engineering, respectively. Pólya became emeritus in 1953, but Fred Terman, who became Provost shortly thereafter, used the excellence of Pólya's teaching as an argument to break the strict rule of the time that emeritus faculty no longer taught. Thus Pólya became the first Professor Emeritus at Stanford recalled to active duty. He taught nearly full-time for a decade, and part-time for many years thereafter. The last course he taught was Combinatorial Analysis for the Computer Science Department in 1977 when Pólya was ninety.

Pólya's doctoral dissertation was on probability. Since there was no one at Budapest in this subject, he wrote without an advisor. He continued his study of probability, and early papers explored aspects of geometrical probabilities. He may have been the first person to use in print the term "Central Limit Theorem" to describe the normal limit law in probability. Pólya also worked on characteristic functions in probability theory, for which there is a "Pólya criterion." One example of his work is the Pólya urn scheme, which is often used as a model to describe contagion. An offshoot of this model is the "Pólya distribution."

He was the first person to investigate "random walk," a phrase he originated. In 1921 he showed that a random walk in a plane almost surely returns to its starting point, but in three dimensions it almost never returns.

Pólya's most profound and difficult work is in the theory of functions of a complex variable. He was one of the pioneers, along with Picard, Hadamard, and Julia, of the modern theory of entire functions. It is an indication of the level of Pólya's contribution that the language

of the subject contains such phrases as "Pólya peaks," "the Pólya representation," "the Pólya gap theorem," "the Pólya-Carlsen theorem," "Pólya's 2z theorem," etc. Some of Pólya's most interesting work in this area concerns the zeros of entire functions. Work in this area is often close to the subject of the famous "Riemann hypothesis," an unproved conjecture made by Riemann in 1859 which would have important consequences in the theory of numbers. One paper of Pólya's in 1926 came close to proving the Riemann hypothesis. Although it failed to do so, it led to further developments, including some in statistical mechanics.

Pólya was much interested in geometry and geometrical methods, especially those involving symmetry. In 1924 he described the 17 types of symmetry in the plane. The Dutch artist M. C. Escher studied this paper, and soon after, some of the additional symmetries found by Pólya began to appear in Escher's etchings and prints. Pólya and Escher corresponded with each other prior to the second world war.

Pólya's interest in symmetry emerged again in 1935 in a series of papers on isomers in chemistry, culminating in his monumental paper in 1937 on groups, graphs and molecular structures. One of the high points in the history of combinatorics, this paper showed how to count essentially different patterns, patterns that could not be changed into each other by geometrical transformation such as rotation in space. Pólya's work was accessible and comprehensive, and the principal theorem is now called the "Pólya Enumeration Theorem." Found in any combinatorics text, it provides a powerful and subtle technique for counting graphs, geometrical patterns, and, not surprisingly, chemical compounds.

In his later years Pólya became very much concerned with problems of the teaching of mathematics. Even before coming to America he had started a manuscript for his book How to Solve It, originally published by the Princeton University Press in 1945. It proved to be very popular and has now sold more than a million copies and been translated into fifteen languages. After this came the two-volume set, Mathematics and Plausible Reasoning, (1954) again illustrating some of the heuristic principles set out earlier in How to Solve It, and in some of his articles. That was followed by a more elementary set, Mathematical Discovery, in 1962 and 1965. These works established him as the foremost advocate of problem solving and heuristics in his generation. Though he had distinguished antecedents from Descartes to Hadamard, who had also written about heuristics and the psychology of problem solving, Pólya nevertheless is the father of the current trend toward the emphasis on problem solving in mathematics teaching.

In addition to the books already cited he wrote a text, Complex Variables, with Gordon Latta in 1974, and several books and monographs: The Stanford Mathematics Problem Book (with Jeremy Kilpatrick), 1974; Mathematical Methods in Science (edited by Leon Bowden), 1963, 1977; and Notes on Introductory Combinatorics (lectures by Pólya and R. Tarjan, notes by D. Woods), 1984. His bibliography also contains 250 published articles.

George Pólya has been the recipient of many honors and awards. In addition to various honorary degrees, he was a corresponding member of the Académie des Sciences, Paris, and a member of the Hungarian Academy, the U.S. National Academy of Sciences, and the Académie Internationale de Philosophie des Sciences, Bruxelles. In 1963 he was given the Award for Distinguished Service in Mathematics by the Mathematical Association of America, and in 1968 the Blue Ribbon by the Educational Film Library Association for his film "Let us Teach Guessing." The Society for Industrial and Applied Mathematics established the Pólya Prize in

Combinatorial Theory and Its Applications, and the Mathematical Association of America gives the Pólya Prize for Expository Writing in the College Mathematical Journal.

His friends will always remember George Pólya's enthusiasm, his warmth and humor, and his ready wit. George and Stella Pólya welcomed visitors to their home in College Terrace with pleasure, and George loved to recount anecdotes from his many contacts with the great mathematicians of the world.

In Professor Pólya's death, Stanford loses one of its most distinguished scholars and teachers. Those of us who were privileged to know and learn from George Pólya have lost a great teacher, colleague and friend.

Gerald Alexanderson
(University of Santa Clara)
Harold Bacon
Solomon Feferman
John G. Herriot
Halsey Royden, Chairman