1989 Steele Prizes Awarded at Summer Meeting in Boulder

Three Leroy P. Steele Prizes were awarded at the Society's ninety-second Summer Meeting in Boulder, Colorado.

The Steele Prizes are made possible by a bequest to the Society by Mr. Steele, a graduate of Harvard College, Class of 1923, in memory of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein.

Three Steele Prizes are awarded each Summer: one for expository mathematical writing, one for a research paper of fundamental and lasting importance, and one in recognition of cumulative influence extending over a career, including the education of doctoral students. The current award is $4,000 for each of these categories.

The recipients of the 1989 Steele Prizes are DANIEL GORENSTEIN for the expository award; ALBERTO CALDERÓN for research work of fundamental importance; and IRVING KAPLANSKY for the career award.

The Steele Prizes are awarded by the Council of the Society, acting through a selection committee whose members at the time of these selections were Frederick J. Almgren, Luis A. Caffarelli, Charles L. Fefferman, Jun-ichi Igusa, William S. Massey (Chairman), Frank A. Raymond, Neil J. A. Sloane, Louis Solomon, Richard P. Stanley, and Michael E. Taylor.

The text that follows contains the Committee's citations for each award, the recipients' responses to the award and a brief biographical sketch of each of the recipients. Professors Calderón and Kaplansky were unable to attend the Summer Meeting to receive the prize in person. They did, however, send written responses to the award.

Expository Writing

Daniel Gorenstein

Citation

The 1989 Steele Prize for Expository Writing is awarded to DANIEL GORENSTEIN for his book:

> *Finite Simple Groups, An Introduction to their Classification* (1982);

and his two survey articles:

> *The Classification of Finite Simple Groups*, and *Classifying the Finite Simple Groups*, Bulletin of the American Mathematical Society **1** (1979) pages 43-199, and **14** (1986) pages 1-98, respectively.

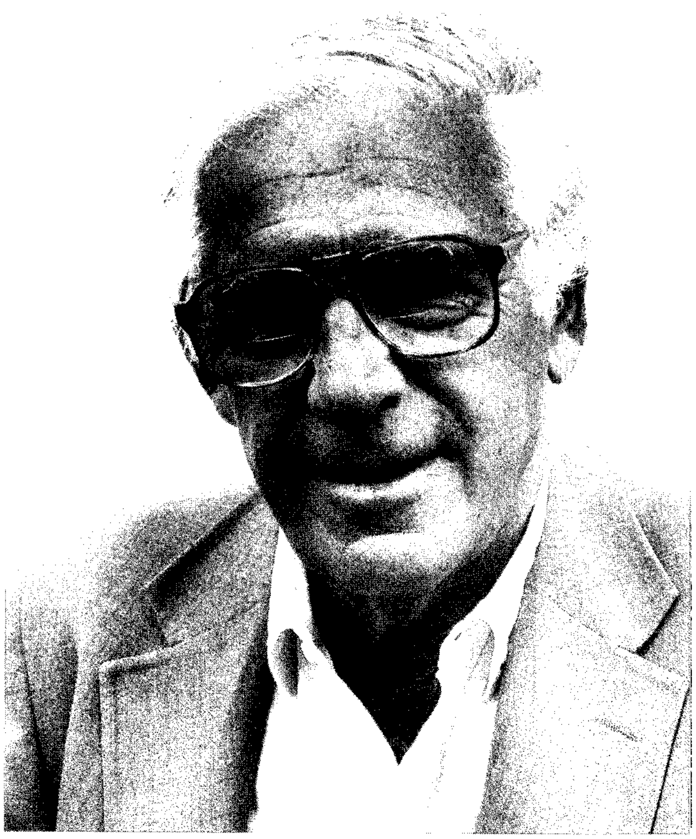
The classification of finite simple groups was the largest joint mathematical effort dedicated to the proof of a single theorem. The first hint that such a classification could be done was given by Brauer at the International Congress in Amsterdam in 1954. Brauer's idea was to study centralizers of involutions. Several deep theorems were proved in the late 50's and early 60's. Early in the 80's the program was finished, except for the formal writing of announced results and the checking of details.

What happened is extremely complicated. Hundreds of mathematicians got involved in the work, a vast enterprise was created, and over 10,000 journal pages appeared. During most of this period it was not at all clear where things were going or even whether success was possible. An uncharted universe full of too many unknown simple groups was an uncomfortable possibility to the classifiers. Twenty-one previously unknown sporadic groups were found in the period 1965-1980.

It would be almost impossible for our mathematical grandchildren to understand the achievements of the present generation on the classification problem without some guide through the tangle. This is what Gorenstein has given them in these three enthusiastic and well written surveys.

Gorenstein was a major figure in setting the direction of the classification program. He coordinated the activities in the program, functioning as the "coach" to a team, with optimism, perseverance, and technical power. His expository articles and books, especially the ones we list here, are beautiful accounts of this fantastic intellectual adventure. His presentation of theorems and definitions, as well as the flow of argument and the evolution of the ideas, is precise and generous and reaches out to the reader. Again and again, he invites the reader to join in yet another episode, to share the excitement of a new idea and the frustration of coping with a deluge of difficulties. Along with the formalities, he tries to give a feeling for the way the ideas work. When appropriate, he is sketchy, yet does not talk down to the reader. These surveys are useful references for specialists and are also narratives for the general mathematical public. Considering the complexity of the subject, this is a great accomplishment.

Gorenstein proved some of the landmark results in the program. His numerous research papers are among the technically most difficult in the field. It is fortunate for mathematics that one who was able to contribute so much to the effort is also able to convey to us the excitement of the discovery and the ultimate coherence of the classification program.



Daniel Gorenstein

Biographical Sketch

Daniel Gorenstein was born on January 1, 1923, in Boston, Massachusetts. He received his Ph.D. from Harvard University in 1950.

Professor Gorenstein's first academic position was at Clark University, where he remained until 1964. He also served as visiting assistant professor at Cornell from 1958 to 1959. In 1964, he moved to Northeastern University. In 1968-1969, he was a member of the Institute for Advanced Study, and in 1969 he became a professor of mathematics at Rutgers University. He was chairman of the department there from 1975-1981, and in 1984, he was named the Jacqueline B. Lewis Professor of Mathematics. Since February, 1989, he has been Director of the new National Science Foundation Science Technology Center in Discrete Mathematics and Theoretical Computer Science, a consortium of Rutgers and Princeton Universities, AT&T Bell Laboratories, and Bell Communications Research. His main research interest is finite simple group theory.

Professor Gorenstein was a Guggenheim Fellow (1972-1973), as well as a Fulbright Research Scholar (1972-1973) and a Sherman Fairchild Distinguished Scholar at the California Institute of Technology (1978). He was elected to the National Academy of Sciences and to the American Academy of Arts and Sciences in 1987. He has been an Associate Editor of *Communications in Algebra* (1975-1983) and of *Annals of Mathematics* (1979-1984).

Professor Gorenstein presented Invited Addresses at the International Congress of Mathematicians in Nice, France (1970) and in Helsinki, Finland (1978), as well as an address at the British Mathematical Colloquium in Bangor, Wales in 1982. A member of the AMS for 45 years, Professor Gorenstein has been active in the mathematical activities of AMS-sponsored meetings. Among these are presentation of an Invited Address in New York in 1971 and organization of a special session on Classification of Finite Simple Groups in San Francisco in 1981. He also delivered the Colloquium Lectures in Anaheim in 1985.

Response

I am delighted and honored to have been awarded the Steele Prize for my writings on the classification of the finite simple groups. From the late 1950s until the early 1980s was a very exciting period in finite group theory. I had switched into the field from algebraic geometry, almost by accident in 1957, learning the basic material from Herstein while collaborating with him over the next few years. My first foray into simple group theory dated from the famous 1960-61 group theory year at the University of Chicago, during which Feit and Thompson settled the solvability of groups of odd order. It was there that I began a long collaboration with John Walter and met many of the then leaders in the field: Brauer, Suzuki, Graham Higman, and Ito. (It was only somewhat later that I met Philip Hall and Wielandt.) Alperin was spending the year in Chicago to write his thesis with Higman, while still a graduate student at Princeton.

Largely under the impetus of the odd order theorem, there was an awakening interest in finite group theory. Throughout the next decade and a half a long list of gifted young mathematicians, who were to play a prominent role in the classification proof, were attracted to the field. In the United States, Thompson had a string of outstanding graduate students: Sims, Goldschmidt, Lyons, Griess. Glauberman was a student of Bruck's at the beginning of the period and Aschbacher near the end. Ronald Solomon wrote his thesis with Feit, Seitz with Curtis, Stephen Smith (an American) with Higman at Oxford, O'Nan with me, and Shult was essentially self-taught.

But the attraction was not limited to the United States. Janko in Australia, Conway in England, and Fischer in Germany, each discovering three new sporadic groups, stimulated considerable additional interest, leading to an intensification of the search for further simple groups. Tits (entering the field somewhat earlier) had deepened our understanding of the Chevalley groups and their Steinberg-Suzuki-Ree variations, Bender in Germany was to prove the fundamental strongly embedded subgroup classification theorem, and Harada was beginning his career in Japan. At the end of the period, there were a number of others: Foote from Canada working with Thompson in Cambridge, England, Geoffrey Mason from England, coming to the United States, and writing his thesis with Fong, himself a former student of Brauer, and in Germany, Timmesfeld and Stellmacher, students of Fischer, and Stroth, a student of Huppert, but writing his thesis on a problem suggested by Held, who had himself been a student of Janko.

There were a great many other group theorists as well who made significant contributions to the classification proof. But it was Aschbacher's entry into the field in the early 1970s that irrevocably altered the simple group landscape. Quickly assuming a leadership role in a single-minded pursuit of the full classification theorem, he was to carry the entire "team" along with him over the following decade until the proof was completed.

I was fortunate indeed to have interacted in one way or another during this twenty-year period with most of the mathematicians I have mentioned.

Simultaneously with this burgeoning research effort, finite simple group theory was establishing a well-deserved reputation for inaccessibility because of the inordinate lengths of the papers pouring out. The 255 page proof of the odd order theorem, filling an entire issue of the Pacific Journal, had set the tone, but it was by far not the longest paper. Moreover, the techniques being developed, no matter how seemingly powerful for the problems at hand, appeared to have no applications outside of finite group theory. Although there was admiration within the mathematical community for the achievements, there was also a growing feeling that finite group theorists were off on the wrong track. No mathematical theorem could require the number of pages these fellows were taking! Surely they were missing some geometric interpretation of the simple groups that would lead to a substantially shorter classification proof.

The view from the inside was quite different: all the moves we were making seemed to be forced. It was not perversity on our part, but the intrinsic nature of the problem that seemed to be controlling the directions of our efforts and shaping the techniques being developed.

Thus in writing about the classification for the general mathematical audience, I had a dual motivation: on the one hand, to convey the nature of the solution as it was unfolding, both the methods involved and the striking results themselves, and, on the other, to attempt to convince the larger community that the internal inductive approach we were taking to the classification was, despite its resulting length, the only viable one for establishing the desired theorem. I hope I have achieved this second objective and I am indeed gratified that the summaries I provided of the classification proof have been held in high regard.

Fundamental Paper

Alberto Calderón

Citation

The 1989 Steele Prize for a Fundamental Paper is awarded to ALBERTO P. CALDERÓN for his paper:

> *Uniqueness in the Cauchy Problem for Partial Differential Equations*, American Journal of Mathematics **80** (1958), pages 16-36.

Calderón's paper marks a real watershed in the theory of singular integral operators, taking it beyond its traditional role in the study of elliptic equations. The specific application is to uniqueness in the Cauchy problem, a phenomenon which remains one of the most mysterious in linear PDE. In attacking this problem, Calderón set up an approach to energy estimates which has been of fundamental importance in dozens of subsequent investigations. Its specialization to hyperbolic equations alone has been very significant. It has also provided a model for general investigations, into such matters as local solvability. Truly this paper was a major progenitor of the modern theory of microlocal analysis.

Biographical Sketch

Alberto P. Calderón was born on September 14, 1920, in Mendoza, Argentina. A student of Alberto González Domínguez and Antoni Zygmund, Professor Calderón received his Ph.D. from the University of Chicago in 1950.

Professor Calderón began his academic career as a visiting associate professor at Ohio State University (1950-1953). He was also a member of the Institute for Advanced Study (1955) and served as associate professor at the Massachusetts Institute of Technology (1955-1959). He then moved to the University of Chicago, where he served as professor of mathematics (1959-1968); Louis Block Professor (1968-1972); and chairman of the mathematics department (1970-1972). He returned to MIT, where he was professor of mathematics (1972-1975). From 1975 to 1985, he was University Professor of Mathematics at Chicago and is currently professor emeritus. Since 1975, he has simultaneously held a position as honorary professor at the University of Buenos Aires.

Alberto Calderón

Professor Calderón received the Bôcher Prize of the AMS in 1978 for a paper on the Cauchy integral on Lipschitz curves. In 1989, he was awarded the Wolf Prize in mathematics for his groundbreaking work on singular integral operators and their application to important problems in partial differential equations. He is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, and the French Academy of Sciences.

Professor Calderón gave an Invited Address at the International Congress of Mathematicians in Moscow (1966). In addition, he presented an AMS Invited Address in University Park in 1957 and delivered the AMS Colloquium Lectures on Singular Integrals in Ithaca in 1965. He serves as associate editor of the *Journal of Functional Analysis*, the *Journal of Differential Equations*, and *Advances in Mathematics.*

Professor Calderón has been a member of the AMS for 40 years. He was a Member-at-Large of the Council (1965-1967) and has served on numerous committees. These include the *Transactions* and *Memoirs* Editorial Committee (1959-1964); the Nominating Committee (1968-1969); the *Colloquium* Editorial Committee (1971-1976); and the Publications and Communications Committee (1971-1976).

Response

The Steele Prize bestows great honor on its recipients. I am most grateful for having been deemed worthy of joining their ranks.

I would like to make a few remarks—some of them perhaps of still current interest—on the paper "Uniqueness of the Cauchy Problem ..." for which I was awarded the Prize.

In trying to obtain the result in the paper, and after several fruitless attempts, I was finally led to the realization that every linear differential operator with sufficiently smooth coefficients can be represented as a composition of a singular integral operator and a fractional power of the Laplacian. These singular integral operators, which were slightly more general than the ones considered up to that time, form a nice algebra and can be manipulated with relative ease. This permitted me to obtain the necessary energy estimates and to prove the desired result.

It was immediately realized that the representation described above had a much wider scope of applications than just to the uniqueness of the Cauchy Problem, and other applications soon followed. Also the theory was greatly refined and extended in a certain direction through the introduction of the algebra of pseudo-differential operators by Kohn and Nirenberg. Linear differential operators with infinitely differentiable coefficients are included in this algebra, but more general ones are not, as can be seen immediately by observing that differential operators with non-infinitely differentiable coefficients cannot be composed freely. To deal with such operators it is necessary to return to the representation described above. It is possible to construct a scale of algebras of singular integral operators of various degrees of refinement well suited to the treatment of differential operators with coefficients of various degrees of smoothness. The description of these algebras will appear in print in a not too distant future.

Finally I would like to mention two problems of interest that await solution.

The first one is to decide whether it is possible to further refine the theory of singular integral operators so as to bring within its scope the results of De Giorgi and Nash on the regularity of weak solutions of elliptic equations with merely bounded measurable coefficients. It has been known for a long time that this is possible in the case of two variables.

The second problem is to study the algebra generated by singular integral operators on Lipschitzian submanifolds of Euclidean space and find out whether this algebra posesses a structure similar to that of the algebra of singular integral operators in Euclidean space. If this were the case it would permit a systematic treatment of boundary value problems for elliptic equations in domains with Lipschitzian boundaries.

Career Award

Irving Kaplansky

Citation

The 1989 Steele Prize for cumulative influence is awarded to IRVING KAPLANSKY for his lasting impact on mathematics, particularly mathematics in America.

By his energetic example, his enthusiastic exposition and his overall generosity, he has made striking changes in mathematics and has inspired generations of younger mathematicians. His early works range over number theory, statistics, combinatorics, game theory, as well as his principal interest of commutative algebra. He completed the solution of Kurosch's problem on algebraic algebras of bounded degree, where Jacobson had made a decisive reduction, and considered numerous questions in the area of Banach algebras, always with the algebraic viewpoint. In particular, he brought the algebraist's instincts to bear on the problem of abstract characterization of von Neumann algebras.

Kaplansky has always been ready to lecture on something new, and the new lectures have usually turned into monographs or papers giving us his special insights. (His students will testify to less obvious enrichments.) The monographs on infinite abelian groups and on differential algebra are examples of such texts that have attracted many students to try their hands at these fields. In the early days of Lie algebras of prime characteristic he showed what ingenuity and patience could achieve regarding the structure of these troublesome systems.

As commutative algebra took on new life with the infusion of homological methods, he turned his interest once more in this direction, always trying to see past the formalism into "what was really going on." His remarkable success in doing so is witnessed by his publications from the late fifties onward and the influence they have had on other writers. Meanwhile he was continuing his diversified lecturing schedule, branching into infinite-dimensional Lie algebras and Lie superalgebras, among other topics.

Colleagues and students from the Chicago days report that one could always rely on his availability and on a challenging idea or question as a result of each conversation. His service to the University of Chicago and to the AMS has been characterized by the same unselfish spirit. The most recent evidence is offered by his superb leadership at MSRI.

His texts, at a range of levels, are numerous, even if one does not count second or later editions, or Chicago Lecture Notes. Though numerous, they are certainly not ponderous. He is a man of few words, writing with polished economy to get the important ideas across.

Biographical Sketch

Irving Kaplansky was born on March 22, 1917 in Toronto, Ontario. He received his Ph.D. from Harvard University in 1941. His main area of research interest is algebra but there was a substantial component in functional analysis (especially C*-algebras) during the 1950's. Work on Lie superalgebras that began in 1975 was inspired by mathematical physics.

Professor Kaplansky began his academic career as a Benjamin Peirce Instructor at Harvard University (1941-1944). He was a research mathematician in the Applied Mathematics Group of the National Defense Research Council at Columbia University (1944-1945). At the University of Chicago, he progressed from instructor to professor (1945-1969) and served as chairman of the mathematics department (1962-1967). From 1969 to 1984, he was the George Herbert Mead Distinguished Service Professor at Chicago. Since 1984, he has been the director of the Mathematical Sciences Research Institute in Berkeley.

Professor Kaplansky served as President of the AMS during 1985-1986. A member of the AMS for 48 years, he was also elected Member-at-large of the Council (1951-1953) and Vice President (1975). He has also served on numerous committees, including the *Bulletin* Editorial Committee (1945-1947; 1979-1985); the *Transactions* Editorial Committee (1947-1952); the Committee on Translations from Russian and other Slavic Languages (1949-1958); the *Proceedings* Editorial Committee (1957-1959); and the Nominating Committee (1977-1978). He presented AMS Invited Addresses at Ann Arbor in 1948 and at Stanford in 1955.

A member of the National Academy of Sciences, Professor Kaplansky also served on the executive committee for the mathematics division of the National Research Council from 1959 to 1962. In 1989 he was elected to a four year term on the Council of the American Academy of Arts and Sciences.

He was on the Toronto team that won the first William Lowell Putnam competition and received the first Putnam scholarship at Harvard. In 1948-1949 he held a Guggenheim fellowship. He received two honorary degrees: Doctor of Mathematics (University of Waterloo, 1968) and Doctor of Science (Queen's University, 1968).

Irving Kaplansky

Response

The citation is flattering and I am very grateful. Indeed, it is too flattering.

If, during the nineteenth century, there had been a world wide Steele Prize for cumulative influence, most of the giants who come to mind would undoubtedly have been honored. Probably some others would have been honored who are only dimly remembered today. Time has a way of sorting these things out.

The citation kindly refers to my interest in a variety of subjects over the years. I hope I have helped to set a good example in that respect. There have, after all, been so many instances where the key idea needed to crack a problem in a certain field came from a totally different field. To give just one example: it is fortunate that the mathematicians working on Lie algebras of characteristic p and those working in Lie superalgebras were aware of Cartan's infinite pseudo-groups. I am going to take this opportunity to put in print some advice that I regularly give to students: spend some time every day learning something new that is disjoint from the problem on which you are currently working (remember that the disjointness may be temporary), and read the masters.

Another thing I wish to do is express my indebtedness to others. In the well worn phrase, mathematics is where it is today because we have all been standing on the shoulders of giants. I look back on the inspiration I derived from Richard Brauer at Toronto, from Saunders Mac Lane at Harvard, from colleagues and students at the University of Chicago, and during my visits to the Institute for Advanced Study.

The concluding reference in the citation to my directorship of MSRI is also much appreciated. Not counting conferences, more than a thousand mathematicians have been welcomed to MSRI in its first seven years. I hope that most of them enjoyed it and got a nontrivial shot of mathematical adrenalin. I am going to keep trying to make this happen.