2003 Steele Prizes

The 2003 Leroy P. Steele Prizes were awarded at the 109th Annual Meeting of the AMS in Baltimore in January 2003.

The Steele Prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein. Osgood was president of the AMS during 1905–06, and Birkhoff served in that capacity during 1925–26. The prizes are endowed under the terms of a bequest from Leroy P. Steele. Up to three prizes are awarded each year in the following categories: (1) Mathematical Exposition: for a book or substantial survey or expository-research paper; (2) Seminal Contribution to Research (limited for 2003 to the field of logic): for a paper, whether recent or not, that has proved to be of fundamental or lasting importance in its field or a model of important research; and (3) Lifetime Achievement: for the cumulative influence of the total mathematical work of the recipient, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students. Each Steele Prize carries a cash award of $5,000.

The Steele Prizes are awarded by the AMS Council acting on the recommendation of a selection committee. For the 2003 prizes, the members of the selection committee were: M. S. Baouendi, Andreas R. Blass, Sun-Yung Alice Chang, Michael G. Crandall, Constantine M. Dafermos, Daniel J. Kleitman, Barry Simon, Lou P. van den Dries, and Herbert S. Wilf (chair).

The list of previous recipients of the Steele Prize may be found in the November 2001 issue of the *Notices,* pages 1216–20, or on the World Wide Web, `http://www.ams.org/prizes-awards`.

The 2003 Steele Prizes were awarded to John B. Garnett for Mathematical Exposition, to Ronald Jensen and to Michael D. Morley for a Seminal Contribution to Research, and to Ronald Graham and to Victor Guillemin for Lifetime Achievement. The text that follows presents, for each awardee, the selection committee's citation, a brief biographical sketch, and the awardee's response upon receiving the prize.

Mathematical Exposition: John B. Garnett

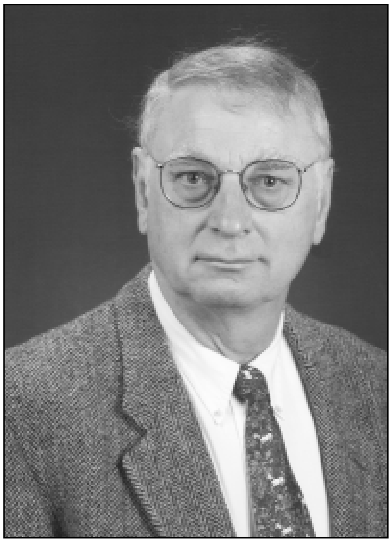
Citation

An important development in harmonic analysis was the discovery, by C. Fefferman and E. Stein, in the early seventies, that the space of functions of bounded mean oscillation (BMO) can be realized as the limit of the Hardy spaces H^p as p tends to infinity. A crucial link in their proof is the use of "Carleson measure"—a quadratic norm condition introduced by Carleson in his famous proof of the "Corona" problem in complex analysis. In his book *Bounded Analytic Functions* (Pure and Applied Mathematics, 96, Academic Press, Inc. [Harcourt Brace Jovanovich, Publishers], New York-London, 1981, xvi + 467 pp.), Garnett brings together these far-reaching ideas by adopting the techniques of singular integrals of the Calderón-Zygmund school and combining them with techniques in complex analysis. The book, which covers a wide range of beautiful topics in analysis, is extremely well organized and well written, with elegant, detailed proofs.

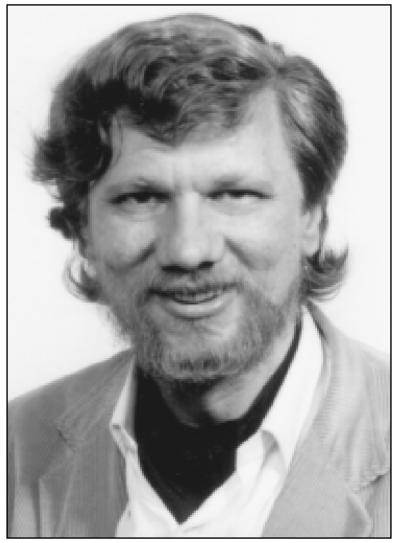
The book has educated a whole generation of mathematicians with backgrounds in complex analysis and function algebras. It has had a great impact on the early careers of many leading analysts and has been widely adopted as a textbook for graduate courses and learning seminars in both the U.S. and abroad.

Biographical Sketch

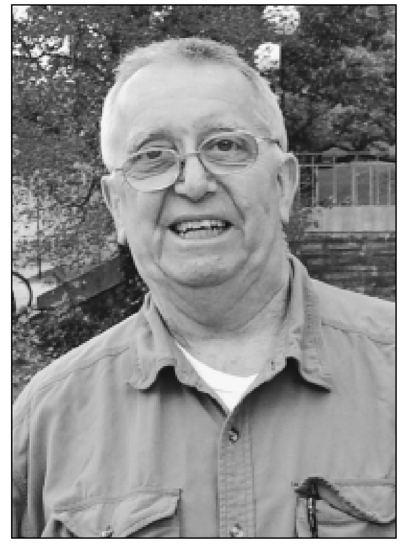
John B. Garnett was born in Seattle in 1940. He received a B.A. degree from the University of Notre Dame in 1962 and a Ph.D. degree in mathematics



John B. Garnett



Ronald Jensen



Michael D. Morley

from the University of Washington in 1966. His thesis advisor at Washington was Irving Glicksberg.

In 1968, following a two-year appointment as C.L.E. Moore Instructor at the Massachusetts Institute of Technology, Garnett became assistant professor at the University of California, Los Angeles, where he has worked ever since. At UCLA, Garnett was promoted to tenure in 1970 and to professor in 1974. In 1989 he received the UCLA Distinguished Teaching Award primarily for his work with Ph.D. students, and from 1995 to 1997 he served as department chairman.

Garnett's research focuses on complex analysis and harmonic analysis. He has held visiting positions at Institut Mittag-Leffler; Université de Paris-Sud; Eidgenössische Technische Hochschule, Zurich; Yale University; Institut des Hautes Études Scientifiques; and Centre de Recerca Matemática, Barcelona. He gave invited lectures to the AMS in 1979 and to the International Congress of Mathematicians in 1986.

Response

I am honored to receive the Steele Prize for the book *Bounded Analytic Functions*. It is especially satisfying because the prize had previously been awarded for some of the classic books in analysis by L. Ahlfors, Y. Katznelson, W. Rudin, and E. M. Stein, from which I first learned much mathematics and to which I still return frequently.

I wrote *Bounded Analytic Functions* around 1980 to explain an intricate subject that was rapidly growing in surprising ways, to teach students techniques in their simplest cases, and to argue that the subject, which had become an offshoot of abstract mathematics, was better understood using the concrete methods of harmonic analysis and geometric function theory. I want to thank several mathematicians: L. Carleson, C. Fefferman, K. Hoffman, and D. Sarason, whose ideas prompted the development of the subject; and S.-Y. A. Chang, P. Jones, D. Marshall, and the late T. Wolff, whose exciting new results at the time were some of the book's highlights.

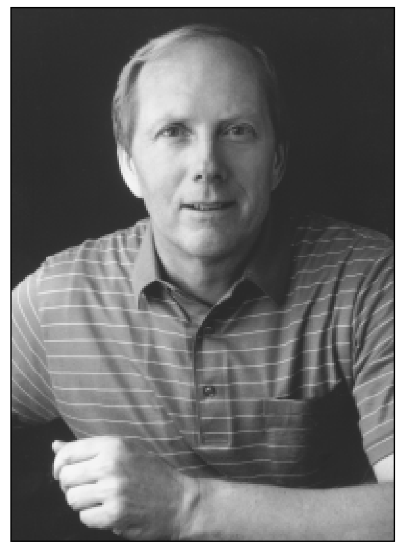
Encouragement is critical to the younger mathematician, and from that time I owe much to my mentors I. Glicksberg, K. Hoffman, and L. Carleson, and to my contemporaries T. W. Gamelin, P. Koosis, and N. Varopoulos. I also want to thank the young mathematicians who over the years have told me that they learned from the book.

Seminal Contribution to Research: Ronald Jensen

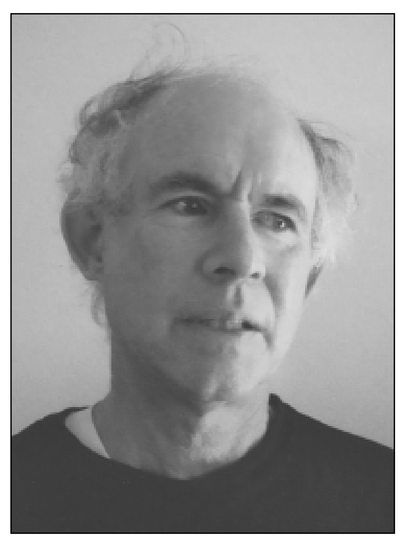
Citation

Ronald Jensen's paper "The fine structure of the constructible hierarchy" (*Annals of Mathematical Logic* **4** (1972) 229–308) has been of seminal importance for two different directions of research in contemporary set theory: the inner model program and the use of combinatorial principles of the sort that Jensen established for the constructible universe.

The inner model program, one of the most active parts of set theory nowadays, has as its goals the understanding of very large cardinals and their use to measure the consistency strength of assertions about



Ronald Graham



Victor Guillemin

much smaller sets. A central ingredient of this program is to build, for a given large cardinal axiom, a model of set theory that either is just barely large enough to contain that type of cardinal or is just barely too small to contain it. The fine structure techniques introduced in Jensen's paper are the foundation of the more recent work of Mitchell, Steel, Jensen himself, and others constructing such models. The paradigm, initiated by Jensen, for relating large cardinals to combinatorial properties of smaller sets is first to show that the desired properties hold in these inner models and then to show that, if they failed to hold in the universe of all sets, then that universe and the inner model would differ so strongly that a large cardinal that is barely missing from the inner model would be present in the universe. The paper cited here contains the first steps in this direction, establishing for the first time combinatorial properties of an inner model, in this case Gödel's constructible sets, that go far beyond Gödel's proof of the generalized continuum hypothesis in this model.

The second direction initiated by Jensen's paper involves applying these combinatorial principles to problems arising in other parts of mathematics. The principle $\diamond$, which Jensen proved to hold in the constructible universe, has been particularly useful in such applications. A good example is Shelah's solution of the Whitehead problem in abelian group theory; half of the solution was to show that a positive answer to the problem follows from $\diamond$. By now, $\diamond$ has become part of the standard tool kit of several branches of mathematics, ranging from general topology to module theory.

Biographical Sketch

Ronald Jensen received his Ph.D. in 1964 from the University of Bonn. He continued his research at Bonn as a scientific assistant (1964–69).

From 1969 until 1973 Jensen was a professor of mathematics at the University of Oslo. During this period he held concurrent positions at Rockefeller University (1969–71) and the University of California, Berkeley (1971–73). At the University of Bonn he was awarded the Humboldt Prize (1974–75) and served as a professor of mathematics (1976–78). He was a visiting fellow at Oxford University's Wolfson College (1978–79), a professor of mathematics at the University of Freiburg (1979–81), and a senior research fellow at Oxford University's All Souls College (1981–94). He moved to Humboldt University of Berlin, where he was a professor of mathematics (1994–2001).

His areas of research interest include set theory.

Response

I feel deeply honored that on the basis of my paper "The fine structure of the constructible hierarchy", I was chosen to share the Steele Prize for seminal research with Michael Morley. I came to set theory in the wake of Cohen's discovery of the forcing method, together with a group of other young mathematicians such as Bob Solovay, Tony Martin, and Jack Silver, all of whom influenced my work. It was an exciting time. Much of the work centered on independence proofs using Cohen's method, but the research on the consequences of strong existence axioms, such as large cardinals and determinacy, was also beginning. The theory of inner models—in particular Gödel's model L—was comparatively underdeveloped. After discovering that the axiom $V = L$ settles Souslin's problem, I began developing a body of methods, now known as "fine structure theory", for investigating the structure L. Much of this work was done in 1969–71 at Rockefeller University and the University of Oslo. The above-mentioned paper was subsequently written at Berkeley. In the ensuing years it became apparent that these methods were also applicable to larger inner models in which strong existence axioms are realized. The most important breakthrough in this direction was made by John Steel. He and Hugh Woodin have applied the methods widely. This work is being extended by a very capable group of younger mathematicians, such as Itay Neeman, Ernest Schimmerling, and Martin Zeman. I feel privileged to have worked in such gifted company.

Seminal Contribution to Research: Michael D. Morley

Citation

Michael Morley's paper "Categoricity in power" (*Transactions of the AMS* **114** (1965) 514–538) set in motion an extensive development of pure model theory by proving the first deep theorem in this subject and introducing in the process completely new tools to analyze theories (sets of first-order axioms) and their models.

When does a theory have (up to isomorphism) a unique model? An early result in mathematical logic is that, for basic cardinality reasons, a theory never has a unique infinite model. The next question is: when does a theory have exactly one model of some specified infinite cardinality? An important example is the theory of algebraically closed fields of any given characteristic, which has a unique model in *every* uncountable cardinality. Answering a question of Łoś, Morley proved that a countable theory which is categorical (has a unique model) in one uncountable cardinality is categorical in every uncountable cardinality.

Morley used most of the then-existing model theory, but what makes his paper seminal are its new techniques, which involve a systematic study of Stone spaces of Boolean algebras of definable sets, called type spaces. For the theories under consideration, these type spaces admit a Cantor-Bendixson analysis, yielding the key notions of Morley rank and ω-stability. This property of ω-stability of a theory was the first of many to follow that are of an intrinsic nature, that is, invariant under biinterpretability.

Morley's work set the stage for studying the difficult problem of the possible isomorphism types of models of a given theory. This was pursued with great success by Shelah, who vastly generalized Morley's methods. Also, the recognition grew that categoricity properties and notions like Morley rank and ω-stability are intimately tied to underlying combinatorial geometries (Baldwin-Lachlan, Zil'ber). In combination with the fact that an infinite field with uncountably categorical theory has to be algebraically closed (Macintyre), this led to the geometric orientation of current model theory. In the last ten years, the development started by Morley enabled remarkable applications by Hrushovski and others to questions of diophantine character, with impact on areas such as differential and difference algebra.

Biographical Sketch

Michael Morley was born in Youngstown, Ohio, in 1930. In 1951 he received a B.S. degree in mathematics from Case Institute of Technology and began graduate work at the University of Chicago. There was a five-and-one-half year hiatus (1955–61) in his graduate education, during which he worked as a mathematician at the Laboratories for Applied Sciences of the University of Chicago. After returning to graduate school, he received his Ph.D. from the University of Chicago in 1962, though the last year of his graduate work was done at the University of California, Berkeley.

He was an instructor for one year at Berkeley, an assistant professor for three years at the University of Wisconsin, and joined the Cornell faculty in 1966. He was associate chairman and director of undergraduate studies for the mathematics department at Cornell from 1984–95. He achieved emeritus status at the end of 2002.

He served as president of the Association for Symbolic Logic in 1986–89.

Response

I am grateful for this award. By definition, a paper is judged seminal because of work that follows it. Therefore, I am aware that I am being honored in large part for the work of other people.

This paper was written just over forty years ago. At that time most mathematicians considered mathematical logic as philosophically very interesting but mathematically not very deep. (After all, some of the work was done by professors of philosophy.) There was some justification for this attitude. However, in the early 1960s several papers appeared that obtained spectacular results by applying nontrivial mathematics to logic. This attracted many of the best young mathematicians to mathematical logic. Today there is a large body of mathematically deep and lovely work in logic. One worries that we may have lost some of the philosophical significance.

The paper was my doctoral dissertation written under the supervision of Professor Robert Vaught. Bob Vaught died last spring. I must express the gratitude that I, and indeed many of his students, felt towards Robert Vaught, not just for his mathematical direction, but for his great personal kindness and generosity of spirit. He was a fine mathematician and a truly good man.

Lifetime Achievement: Ronald Graham

Citation

Ron Graham has been one of the principal architects of the rapid development worldwide of discrete mathematics in recent years. He has made many important research contributions to this subject, including the development, with Fan Chung, of the theory of quasirandom combinatorial and graphical families, Ramsey theory, the theory of packing and covering, etc., as well as to the theory of numbers, and seminal contributions to approximation algorithms and computational geometry (the "Graham scan"). Furthermore, his talks and his writings have done much to shape the positive public image of mathematical research in the USA, as well as to inspire young people to enter the subject. He was chief scientist at Bell Labs for many years and built it into a world-class center for research in discrete mathematics and theoretical computer science. He served as president of the AMS in 1993–94.

Biographical Sketch

Ronald Graham's undergraduate training included three years at the University of Chicago (in Robert Maynard Hutchins' Great Books program); a year at Berkeley as an electrical engineering major; and four years in the U.S. Air Force, three of which were spent in Fairbanks, Alaska, where he concurrently received a B.S. in physics in 1959. He subsequently was awarded a Ph.D. in mathematics from the University of California, Berkeley, in 1962.

He spent the next thirty-seven years at Bell Labs as a researcher, leaving from what is now AT&T Labs in 1999 as chief scientist. During that time he also held visiting positions at Princeton University, Stanford University, the California Institute of Technology, and the University of California, Los Angeles, and was a (part-time) University Professor at Rutgers for ten years. He currently holds the Irwin and Joan Jacobs Chair of Computer and Information Science at the University of California at San Diego.

Graham has received the Pólya Prize in Combinatorics from the Society for Industrial and Applied Mathematics, the Euler Medal from the Institute of Combinatorics and Its Applications, the Lester R. Ford Award from the Mathematical Association of America (MAA), and the Carl Allendoerfer Award from the MAA. He is currently treasurer of the National Academy of Sciences, a foreign member of the Hungarian Academy of Sciences, a fellow of the American Academy of Arts and Sciences, a fellow of the American Association for the Advancement of Science, and past president of the International Jugglers Association. He was an invited speaker at the International Congress of Mathematicians in Warsaw in 1983 and was the AMS Gibbs Lecturer in 2000.

Response from Professor Graham

I must say that it is a great honor and pleasure for me to receive this award in recognition of a life in mathematics, and I would like to express my deep appreciation to the American Mathematical Society and to the Steele Prize Committee for their selection. When I was first notified, my initial reaction was to recall the famous quote of Mark Twain, who, upon seeing his obituary printed in a local newspaper, wrote that "the reports of my death are greatly exaggerated."

I can't remember a time when I didn't love doing mathematics, and that desire has not dimmed over the years (yet!). But I also get great pleasure sharing mathematical discoveries and insights with others, even though this can present a special challenge for mathematicians talking to nonmathematicians. However, I really believe that this type of communication will become increasingly important in the future.

As an undergraduate at Berkeley, a one-year course in number theory taught by D. H. Lehmer fired my imagination for the subject and formed the basis for my Ph.D. dissertation under him (after a slight detour of four years in the military and Alaska). Although I never took another course from Dick Lehmer, he taught me the value of independence of thought and an appreciation for the algorithmic issues in mathematics. I feel that I have been very lucky to have been at the right place and time in history for participating in the rapid and exciting current developments in combinatorics. No doubt, all mathematicians in every generation feel this way! In particular, I have had the good fortune to work with, and be inspired by, such giants as Paul Erdős and Gian-Carlo Rota, who, though different in many ways, were both driven by grand visions which have helped guide the paths of many combinatorial researchers today.

Number theory and combinatorics are especially rife with simple-looking problems which, like Socratic gadflies, constantly remind us how little we really know. (For example, are there infinitely many pairs of primes which differ by 2? The answer, of course, is yes! However, at present we don't have a clue how to prove this.) I recall the story of a civilization so advanced that a prize was awarded to the first mathematician who realized that the Riemann Hypothesis actually needed a proof. Perhaps more imminent (and more likely?) is the related version in which the Great Computer a hundred years from now, when asked whether the Riemann Hypothesis is true, pauses for a moment and then says, "Yes, it is true. But you wouldn't be able to understand the proof!" Still, I am a firm believer in Hilbert's famous dictum "Wir müssen wissen, wir werden wissen" ("We must know, we shall know"). And with this thought in mind, I will happily continue to keep hammering pitons into the sides of the infinite mountain of mathematical truth, as we all slowly inch our way up its irresistible slopes.

Lifetime Achievement: Victor Guillemin

Citation

Victor Guillemin has played a critical role in the development of a number of important areas in analysis and geometry. In particular, he has made fundamental contributions to microlocal analysis, symplectic group actions, and spectral theory of elliptic operators on manifolds. His work on generalizations of the Poisson and Selberg trace formulae has been particularly influential. Moreover, Guillemin has greatly advanced these areas, and mathematics in general, by mentoring many graduate students and postdoctoral fellows, some of whom have become leading mathematicians in their own right.

Biographical Sketch

Victor Guillemin was born in Cambridge, Massachusetts, on October 15, 1937. He received his B.A. from Harvard in 1959, his M.A. from the University of Chicago in 1960, and his Ph.D. from Harvard in 1962. He was an instructor at Columbia from 1963 to 1966 and an assistant professor at the Massachusetts Institute of Technology from 1966 to 1969. He was promoted to associate professor in 1969 and to full professor in 1973. He has held a Sloan fellowship (1969–70), a Guggenheim grant (1988–89), and an Alexander Humboldt fellowship (1998). He was elected to the American Academy of Arts and Sciences in 1984 and to the National Academy of Sciences in 1985.

Response

I want to thank the AMS Steele Prize Committee for the wonderful honor of being selected as corecipient, with Ron Graham, of this year's Steele Lifetime Achievement award. For me personally, my main "lifetime achievement" has been to have had, over the course of my career, some remarkable mentors, collaborators, and students. In particular, as a graduate student I had the good fortune to have Raoul Bott and Shlomo Sternberg as teachers at a time when Morse theory, index theory, and K-theory were revolutionizing differential topology. It was also a time when Raoul Bott was, for Shlomo and me, not only a teacher and mentor but a greater-than-life role model. I can't speak for Shlomo, but "greater-than-life" remains my view of Raoul to this day.

In the collaborations I've been involved in, I feel I have been extraordinarily lucky. I was Shlomo Sternberg's Ph.D. student when we wrote our first paper together in 1962, neither of us imagining that this was going to be the first of thirty papers and six books that we would produce together or that we would still be actively working together four decades later. These four decades have tempered somewhat the awe I felt in his presence when I first started working with him, but not my awe for the range and depth of his understanding of mathematics.

When I met Richard Melrose at a conference in Nice in 1973, he seemed, with his scruffy beard and ponytail, the embodiment of the 1970s counterculture Zeitgeist. He had, however, just settled an important special case of one of the main open problems in physical optics, the glancing ray problem; and two years later, together with Mike Taylor, he solved this problem in complete generality (a result for which he won the Bôcher Prize in 1979). Thirty years later the ponytail is gone and the beard marginally less scruffy, and when the occasion requires, he can pass himself off as a respectable middle-aged academic. However, he is still, with his many students and collaborators (of whom I am fortunate to be one), exploring the consequences of this result and the beautiful ideas to which it has led in microlocal analysis on manifolds-with-corners and singular spaces.

One of the most rewarding collaborations of my life was working with Hans Duistermaat on the Poisson formula for elliptic operators; however, at the time it was also one of the most exasperating. I enjoy writing mathematical papers but find it hard to edit and revise and am often content with efforts that give one a glimpse of, without entirely embodying, the good, the true, and the beautiful. Hans is the opposite: With the fiercely competitive instincts of the accomplished chess player that he is, he is content with nothing short of perfection, and our paper went through many rewrites before he was completely happy with it. With each rewrite my exasperation mounted, and when we finally sent it off, I recalled his once warning me that Duistermaat is Dutch for "dark mate".

The early 1990s saw a curious blip in the demographics of the population of Generation-X mathematicians of that era. Jobs in theoretical physics became hard to come by, and as a consequence many would-be graduate students in physics gravitated to adjoining areas of mathematics. My own field of symplectic geometry was one of the beneficiaries of this development, and in the early and mid-1990s there were a large number of exceptionally talented postdocs in our department at MIT, some of whom became my collaborators and many of whom became cherished friends. Among them were Jiang-Hua Lu, Reyer Sjamaar, Sue Tolman, Yael Karshon, Jaap Kalkman, and Eckhard Meinrenken. I like to believe that they learned a little symplectic geometry from me, but I suspect I learned much, much more from them. (In particular, I learned from Eckhard Meinrenken that, as Shlomo and I had conjectured fifteen years before, "quantization and reduction commute".)

My first student, in 1968, was Marty Golubitsky, and my last student, in 2002, Tara Holm. To them and to the students in between I owe everything that has made my life in mathematics worthwhile.