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.

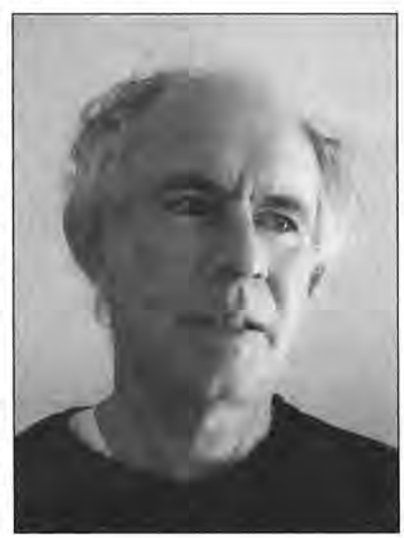
Seminal Contribution to Research: Ronald Jensen

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 co-recipient, 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.

2003 Cole Prize in Algebra

Hiraku Nakajima

The 2003 Frank Nelson Cole Prize in Algebra was awarded at the 109th Annual Meeting of the AMS in Baltimore in January 2003.

The Cole Prize in Algebra is awarded every three years for a notable research memoir in algebra that has appeared during the previous five years (until 2001 the prize was usually awarded every five years). The awarding of this prize alternates with the awarding of the Cole Prize in Number Theory, also given every three years. These prizes were established in 1928 to honor Frank Nelson Cole on the occasion of his retirement as secretary of the AMS after twenty-five years of service. He also served as editor-in-chief of the *Bulletin* for twenty-one years. The Cole Prize carries a cash award of \$5,000.

The Cole Prize in Algebra is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2003 prize the members of the selection committee were: Michael Aschbacher (chair), Armand Borel, and J. T. Stafford.

Previous recipients of the Cole Prize in Algebra are: L. E. Dickson (1928), A. Adrian Albert (1939), Oscar Zariski (1944), Richard Brauer (1949), Harish-Chandra (1954), Serge Lang (1960), Maxwell A. Rosenlicht (1960), Walter Feit and John G. Thompson (1965), John R. Stallings (1970), Richard G. Swan (1970), Hyman Bass (1975), Daniel G. Quillen (1975), Michael Aschbacher (1980), Melvin Hochster (1980), George Lusztig (1985), Shigefumi Mori (1990), Michel Raynaud and David Harbater (1995), Andrei Suslin (2000), and Aise Johan de Jong (2000).

The 2003 Cole Prize in Algebra was awarded to Hiraku Nakajima. The text that follows presents the selection committee's citation, a brief biographical sketch, and the awardee's response upon receiving the prize.

Citation

The Cole Prize in Algebra is awarded to Hiraku Nakajima for his work in representation theory and geometry. In particular the prize is awarded for his papers "Quiver varieties and Kac-Moody algebras" (*Duke Math. J.* **91** (1998), 515–560) and "Quiver varieties and finite dimensional representations of quantum affine algebras" (*J. AMS* **14** (2001), 145–238), where he uses his notion of "quiver varieties" to construct hyper-Kähler varieties, irreducible integrable highest weight modules for Kac-Moody algebras with a symmetric Cartan matrix, and finite dimensional representations of affine quantized enveloping algebras; and for his paper "Heisenberg algebra and Hilbert schemes of points on projective surfaces" (*Ann. of Math.* **145** (1997), 379–388), where he constructs representations of the Heisenberg algebra on the direct sum of homology groups of Hilbert schemes of points on a quasi-projective surface, thus supplying a formula giving the corresponding Poincaré polynomials, found earlier by L. Goetsche.

Biographical Sketch

Hiraku Nakajima was born on November 30, 1962, in Tokyo, Japan. He received his M.A. (under the direction of Takushiro Ochiai) in 1987 and his Ph.D. in 1991 from the University of Tokyo.

Nakajima began his academic career as a research assistant at the University of Tokyo (1987–92). From 1992 to 1995 he was an assistant professor at Tohoku University's Mathematical Institute. In 1995 he returned to the University of Tokyo, where he served as an assistant professor until 1997. At Kyoto University he has advanced from assistant professor (1997–2000) to professor of mathematics (December 2000–).

Nakajima received both the Geometry Prize (1997) and the Spring Prize (2000) from the Mathematical Society of Japan. He was a plenary speaker at the International Congress of Mathematicians (Beijing, 2002). His research interests include geometry and representation theory.

Response

It is a great honor and a great pleasure for me to receive the 2003 Frank Nelson Cole Prize in Algebra. I sincerely thank the AMS and the selection committee for awarding the prize to me.

My field of research is somewhere between geometry and representation theory. I started my mathematical career as a differential geometer. I chose to pursue the study of instanton moduli spaces on ALE spaces and found that it is related to representation theory of affine Lie algebras and quantum groups. This was totally unexpected. But I became a representation theorist in this way. I did not learn representation theory as a student; rather, I gained knowledge from discussions with my colleagues and friends, including G. Lusztig, V. Ginzburg, and others. I would like to express my thanks to all of them.

2003 Birkhoff Prize

The 2003 George David Birkhoff Prize in Applied Mathematics was awarded at the 109th Annual Meeting of the AMS in Baltimore in January 2003.

The Birkhoff Prize recognizes outstanding contributions to applied mathematics in the highest and broadest sense and is awarded every three years (until 2001 it was awarded usually every five years). Established in 1967, the prize was endowed by the family of George David Birkhoff (1884–1944), who served as AMS president during 1925–26. The prize is given jointly by the AMS and the Society for Industrial and Applied Mathematics (SIAM). The recipient must be a member of one of these societies and a resident of the United States, Canada, or Mexico. The prize carries a cash award of $5,000.

The recipients of the Birkhoff Prize are chosen by a joint AMS-SIAM selection committee. For the 2003 prize the members of the selection committee were: Douglas N. Arnold, Paul H. Rabinowitz, and Donald G. Saari (chair).

Previous recipients of the Birkhoff Prize are Jürgen K. Moser (1968), Fritz John (1973), James B. Serrin (1973), Garrett Birkhoff (1978), Mark Kac (1978), Clifford A. Truesdell (1978), Paul R. Garabedian (1983), Elliott H. Lieb (1988), Ivo Babuška (1994), S. R. S. Varadhan (1994), and Paul H. Rabinowitz (1998).

The 2003 Birkhoff Prize was awarded to John Mather and to Charles S. Peskin. The text that follows presents the selection committee's citation, a brief biographical sketch, and the awardee's response upon receiving the prize.

John Mather

Citation

John Mather is a mathematician of exceptional depth, power, and originality.

His earliest work included contributions to foliation theory in topology and to the theory of singularities for smooth and analytic maps on R^n where he provided the rigorous foundations of this theory. Among his main contributions is a stability result. Here stability of a map means that any nearby map is equivalent to it up to diffeomorphisms of the domain and target manifolds. While this is very difficult to check directly, Mather proved that infinitesimal stability, a condition that can often be verified constructively, implies stability, and he developed an algorithm for describing the local forms of these stable mappings. These astonishing generalizations of the earlier work of Hassler Whitney have provided approaches to understand a variety of applied issues ranging from the structure of the Pareto set of the utility mapping in economics to phase transitions in physics.

Switching to the theory of dynamical systems, Mather has made several major contributions. An early highlight was his result with Richard McGehee proving that binary collisions in the Newtonian 4-body problem could accumulate in a manner that would force the system to expand to infinity in finite time. He was a co-founder of Aubry-Mather theory where, in particular, he proved that twist maps of an annulus possess so-called Aubry-Mather invariant sets for any irrational rotation number. These sets are Cantor sets, and the diffeomorphism on them is equivalent to a rigid rotation of a circle. Since KAM theory, which extends research going back to the work of Birkhoff, provides information about such situations when the rotation number is Diophantine, Mather found the missing circles in KAM theory.

Mather extended this work to multidimensional positive definite Lagrangian systems. He proved the invariant sets he found here—called Mather sets—are Lipschitz graphs over configuration space. He also developed a variational method for constructing shadowing trajectories first for twist maps and then for positive definite Lagrangian systems. In the twist map setting, he established the existence of heteroclinic orbits joining Aubry-Mather sets in the same Birkhoff instability region.

Currently he is doing seminal work on Arnold diffusion. In particular Mather proved the existence of Arnold diffusion for a generic perturbation of an a priori unstable integrable Hamiltonian system, solving the problem left standing from Arnold's famous 1964 paper.

Mather is a member of the U.S. and Brazilian National Academies of Sciences, a Guggenheim and

Sloan Fellow, and the winner of the 1978 John J. Carty Medal from the U.S. Academy.

Biographical Sketch

John N. Mather was born in Los Angeles, California, on June 9, 1942. He received a B.A. from Harvard University in 1964 and a Ph.D. from Princeton University in 1967. From 1967 to 1969 he was *professeur associé* (visiting professor) at the Institut des Hautes Études Scientifiques (IHÉS) in France. In 1969 he joined the faculty of Harvard University as associate professor and was promoted to professor in 1971. He was a visiting professor at Princeton University in 1974–75 and joined the faculty of Princeton University as professor in 1975. He was a visiting professor at IHÉS in 1982–83 and at the Eidgenössische Technische Hochschule in Zurich in 1989–90.

Mather was an editor of the *Annals of Mathematics* from 1990 to 2001 and has been an editor of the *Annals of Math. Studies* from 1990 to the present.

Mather was a Sloan Fellow in 1970–72 and a Guggenheim Fellow in 1989–90. He was elected a member of the National Academy of Sciences in 1988 and a member of the Brazilian Academy of Sciences in 2000. He received the John J. Carty Medal of the National Academy of Sciences in 1978 and the Ordem Nacional do Mérito Científico from the Brazilian Academy of Sciences in 2000.

Mather's current research is in the area of Hamiltonian dynamics. In the past he has worked in the theories of singularities of mappings and foliations.

Response

It is a pleasure to accept the Birkhoff Prize for my work in singularities of mappings, the theory of foliations, and Hamiltonian dynamics. I greatly appreciate the generous citation of my achievements, as well as the honor of the prize. While I have not (yet) worked on applications of mathematics as such, I have always been fascinated by theoretical mathematical questions that originated in applications, for example, the n-body problem in Newtonian mechanics. Poincaré showed long ago that the study of the dynamics of area-preserving mappings of surfaces provides important insights into this problem. G. D. Birkhoff greatly extended Poincaré's work on area-preserving mappings, and his work was one of the inspirations for my contribution to Aubry-Mather theory.

I am grateful to my teachers at Harvard University and Princeton University, as well as colleagues and friends, from whom I have learned so much. I also wish to express my appreciation for the system of higher education, which makes a career of mathematical research possible.

Charles S. Peskin

Citation

Charles Samuel Peskin has devoted much of his career to understanding the dynamics of the human heart. Blurring disciplinary boundaries, he has brought an extraordinarily broad range of expertise to bear on this problem: mathematical modeling, differential equations, numerical analysis, high performance computing, fluid dynamics, physiology, neuroscience, physics, and engineering. His primary tool for understanding the heart is computer simulation. In work spanning more than two decades, much of it with David McQueen, Peskin has developed a computer model that simulates blood circulation through the four chambers of the heart and in and out of the surrounding circulatory system along with the deformation of the cardiac muscle and the valves. This virtual heart enables experimentation in silico that would be impossible in vivo and is of tremendous value to the study of normal heart function and a variety of pathologies, to plan interventions, and to design prosthetic devices.

John Mather

Charles S. Peskin

Peskin's computer simulations are based on the immersed boundary method, a unique numerical method he developed for the solution of dynamic fluid-structure interactions. This method, which is built on a novel approach to couple a fluid description in Eulerian coordinates to a solid description in Lagrangian coordinates, was originally designed to describe the flow of blood around cardiac valve surfaces. But it has found much wider use, allowing simulation of a variety of complex systems, such as the inner ear, swimming fish, locomoting microbes, flowing suspensions, and filaments flapping in soap films. The development and analysis of the immersed boundary method is an ongoing and active field of study.

While the heart is a large biological motor, much of Peskin's recent research concerns biological motors at the smallest scales. Here too he brings innovative mathematical modeling and computational simulation to bear, exploring and explaining the microscopic machinery inside cells which harness Brownian motion for transport and motility.

A former MacArthur fellow, Charles Peskin is a member of the American Academy of Arts and Sciences, the National Academy of Sciences, and the Institute of Medicine.

Biographical Sketch

Charles S. Peskin was born in New York City in 1946. His mathematical education began at the Ethical Culture School, where arithmetic was done with sticks tied together, when possible, in bundles of ten to explain the decimal system. His father, an electrical engineer, was another early mathematical influence, teaching him the elements of algebra from the simple yet mysterious example $x + y = 10, x - y = 2$. At Morristown (New Jersey) High School, Peskin had an inspiring mathematics teacher named Betty Wagner, who emphasized sketching graphs of functions and who was kind about undone homework. There is a picture of Peskin in his high school yearbook standing in front of these words written in chalk on the blackboard: "Resolved: That Homework Be Abolished".

Peskin studied engineering and applied physics at Harvard (A.B., 1968). "Engineering at Harvard? Isn't that MIT?" was a common comment he heard at the time. He then entered the M.D.-Ph.D. program at the Albert Einstein College of Medicine, Bronx, NY, but dropped out of the M.D. part of the program after completing a Ph.D. (1972) in physiology with a thesis entitled "Flow patterns around heart valves: A digital computer method for solving the equations of motion". This thesis was the beginning of the work that has now led to the Birkhoff Prize. Once he had decided not to go on to the M.D., Peskin nevertheless remained at the Albert Einstein College of Medicine for a year, studying pediatric cardiology and pulmonary medicine. During this time he developed an interest in fetal circulation and congenital heart disease, and he has since done mathematical modeling in these areas.

In 1973 Peskin joined the faculty of the Courant Institute of Mathematical Sciences, New York University, where he has been ever since. He became a professor of mathematics in 1981 and received the additional title professor of neural science in 1995. At NYU, Peskin teaches courses like Mathematical Aspects of Heart Physiology, Mathematical Aspects of Neurophysiology, Partial Differential Equations in Biology, Biomolecular Motors, and a freshman seminar on Computer Simulation. He is the coauthor (with Frank Hoppensteadt) of *Modeling and Simulation in Medicine and Biology*, Second Edition (Springer-Verlag, 2002). At New York University, Peskin has received the Sokol Faculty Award in the Sciences (1992) and the Great Teacher Award of the NYU Alumni Association (1999).

Peskin's other honors are the MacArthur Fellowship (1983–88), SIAM Prize in Numerical Analysis and Scientific Computing (1986), Gibbs Lecturer (1993), Cray Research Information Technology Leadership Award (joint with David M. McQueen, 1994), Sidney Fernbach Award (1994), Mayor's Award for Excellence in Science and Technology (1994), and von Neumann Lecturer (1999). He is a fellow of the American Institute for Medical and Biological Engineering (since 1992), fellow of the American Academy of Arts and Sciences (since 1994), member of the National Academy of Sciences (since 1995), fellow of the New York Academy of Sciences (since 1998), and member of the Institute of Medicine (since 2000).

Response

It is a pleasure to accept the George David Birkhoff Prize of the Society for Industrial and Applied Mathematics and the American Mathematical Society. I am awed to be placed in the company of former winners such as Jürgen Moser, Fritz John, Marc Kac, Paul Garabedian, and S. R. S. Varadhan, whom I also count as colleagues and friends. Although some of them are no longer with us, their influence, both mathematical and personal, surely lives on. Some of that influence is encapsulated in particularly memorable remarks. I especially remember when Mark Kac greeted me in his booming voice: "Ah, Peskin, the man with the two-dimensional heart!" I think he would be pleased to see that I have now won this great honor in large part for a three-dimensional heart model. Then there is the famous remark of Fritz John (that he claims never to have said) that the rewards of mathematics are the grudging admiration of a few friends. As the recipient of a reward of mathematics today, I would like to thank the mathematics community for welcoming me without proper credentials (my Ph.D. is in physiology) and (with no hint of grudging that I have ever detected) for honoring my research.

I would like to thank my father, Edward Peskin, and my thesis advisors, Edward Yellin and Alexandre Chorin, for starting me off on the road that has now led to the Birkhoff Prize. It was my father, an electrical engineer, who first suggested to me that it might be a good idea to apply mathematical methods to biological problems. It was Yellin, a mechanical engineer turned physiologist, who first introduced me to the fascinating dynamics of the heart and its valves. Around this time I had the incredible good luck to meet Alexandre Chorin, who invited me to his course on fluid mechanics at the Courant Institute. Chorin taught me his new projection method for incompressible flow; set me up with an office and an account on the CDC6600 (which we programmed with punch cards—I still recall the satisfying sounds of the keypunch and the relaxed mode of submitting a deck of cards to the computer and then going for a walk around Washington Square while awaiting the result); and introduced me to such inspiring characters as Peter Lax, Cathleen Morawetz, and Olof Widlund, each of whom has had a profound influence on my life and work.

My long-term colleagues in the research that is described in the citation for the Birkhoff Prize are David McQueen (in the case of the heart) and George Oster (in the case of biological motors). Both deserve a large share of the credit. McQueen handles all of the details of heart model construction, conducts our computer experiments, and visualizes the results with custom software of his own design. My role is to think about the methodology and suggest changes as needed. In the case of biomolecular motors, I am particularly grateful to George Oster for introducing me to this exciting field. Most of the concepts in our joint work have been his. I have been happy to help him reduce some of these concepts to specific mathematical models and computer simulation programs, which we can then use to see whether the concepts are capable of explaining the observed behavior of the biomolecular motor.

I would like to conclude with a few words of explanation about the immersed boundary method. This is a numerical method for fluid-structure interaction that I originally introduced to study the flow patterns around heart valves. Heart valve leaflets are thin membranes that move passively in the flow of blood and yet have a profound influence on the fluid dynamics. Examples of this influence are that they stop the flow when the valve is closed, and when the valve is open, the leaflets shear the flowing blood to create vortices that then participate in efficient valve closure, as was first described by Leonardo da Vinci.

The standard way to model this situation would be to treat the valve leaflet as an elastic membrane obeying Newton's laws of motion with forces calculated in part from the elasticity of the membrane and in part by evaluating the fluid stress tensor on both sides of the membrane. Then the fluid equations would have to be supplemented by the constraint that the velocity of the fluid on either side of the membrane must agree with the instantaneously known velocity of the elastic membrane itself. There are two difficulties with this standard approach to the problem. First, the valve leaflet is incredibly thin and light, with hardly any mass per unit area. (Indeed, if the mass per unit area were zero, the dynamics of the valve would not be noticeably different.) Because of its small mass, the valve leaflet is supersensitive to any imbalance in the forces acting upon it. The second challenge is the practical one of evaluating the fluid stress tensor on either side of the boundary. This seems difficult (or at least messy) to do numerically, unless the computational grid is aligned with the boundary. On the other hand, in a moving boundary problem, it is both expensive and complicated to recompute the grid at every time step in order to achieve alignment.

In the immersed boundary method, the mass of the heart valve leaflet is idealized as zero. (Recent work shows how to handle immersed boundaries of nonzero mass, but I won't discuss that here.) This means that the sum of the elastic force and the fluid force on any part of the immersed boundary has to be zero. Once we know this, it becomes unnecessary to evaluate the fluid stress tensor at the boundary at all! We can find the force of any part of the boundary on the fluid by evaluating the elastic force on that part of the boundary. (Note the use of Newton's third law: the force of boundary on fluid is minus the force of fluid on boundary.) All we need is a method for transferring the elastic force from the immersed boundary to the fluid. On a Cartesian grid, this may be done by spreading each element of the boundary force out over nearby grid points. The particular way that this is done in the immersed boundary method involves a carefully constructed approximation to the Dirac delta function. This force-spreading operation defines a field of force on the Cartesian lattice that is used for the fluid computation. Then the fluid velocity is updated under the influence of that force field. The Navier-Stokes solver that updates the fluid velocity does not know about the geometry of the heart valve leaflet; it just works with a force field that happens to be zero everywhere except in the immediate neighborhood of the leaflet. Note that there is no constraint on the fluid velocity coming from the state of motion of the leaflet. On the contrary, since the mass of the leaflet is zero, the leaflet velocity is not a state variable of the problem. Indeed, the no-slip condition has been turned on its head: it is now the equation of motion of the leaflet instead of a constraint on the fluid. The local fluid velocity at a point of the leaflet is evaluated by interpolation from the Cartesian grid. The same approximate delta function that was used to spread force can also be used to get an interpolation operator that is the adjoint (or transpose) of the force-spreading operator.

In summary, the immersed boundary method avoids many of the difficulties and pitfalls of the standard approach to fluid-structure interaction. By representing an immersed elastic boundary in terms of the forces applied by the immersed elastic boundary to the fluid, the immersed boundary method avoids any consideration of boundary geometry in the fluid computation; makes it unnecessary to evaluate the fluid stress tensor at the immersed elastic boundary; and makes it possible to simulate immersed elastic boundaries that are essentially massless, like the valve leaflets of the human heart.

2003 Satter Prize

Abigail Thompson

The 2003 Ruth Lyttle Satter Prize in Mathematics was awarded at the 109th Annual Meeting of the AMS in Baltimore in January 2003.

The Satter Prize is awarded every two years to recognize an outstanding contribution to mathematics research by a woman in the previous five years. Established in 1990 with funds donated by Joan S. Birman, the prize honors the memory of Birman's sister, Ruth Lyttle Satter. Satter earned a bachelor's degree in mathematics and then joined the research staff at AT&T Bell Laboratories during World War II. After raising a family, she received a Ph.D. in botany at the age of forty-three from the University of Connecticut at Storrs, where she later became a faculty member. Her research on the biological clocks in plants earned her recognition in the U.S. and abroad. Birman requested that the prize be established to honor her sister's commitment to research and to encouraging women in science. The prize carries a cash award of $5,000.

The Satter Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2003 prize, the members of the selection committee were: Alexandra Bellow, Bhama Srinavasan (chair), and Jean E. Taylor.

Previous recipients of the Satter Prize are: Dusa McDuff (1991), Lai-Sang Young (1993), Sun-Yung Alice Chang (1995), Ingrid Daubechies (1997), Bernadette Perrin-Riou (1999), Karen E. Smith (2001), and Sijue Wu (2001).

The 2003 Satter Prize was awarded to Abigail Thompson. The text that follows presents the selection committee's citation, a brief biographical sketch, and the awardee's response upon receiving the prize.

Citation

The Ruth Lyttle Satter Prize is awarded to Abigail Thompson for her outstanding work in 3-dimensional topology. As a consequence of her work, the concept of thin position, first introduced by Gabai for the study of knots in the 3-sphere, has emerged as a major tool for attacking some of the fundamental problems in the study of 3-manifolds. Her paper "Thin position and the recognition problem for S^3", *Math. Res. Lett.* **1** (1994), 613-630, used the idea of thin position to reinterpret Rubenstein's solution to the recognition problem of the 3-sphere in a startling way. Her papers with Martin Scharlemann, "Thin position for 3-manifolds", *Geometric Topology* (Haifa, 1992), 231–238, Contemp. Math. **164**, Amer. Math. Soc., Providence, RI, 1994; and "Thin position and Heegaard splittings of the 3-sphere", *J. Differential Geom.* **39** (1994), 343–357, provide remarkable applications of thin position to Heegaard splittings of 3-manifolds. Her 1997 paper "Thin position and bridge number for knots in the 3-sphere", *Topology* **36** (1997), 505–507, gives a completely unexpected connection in the case of knots in 3-spheres between thin position and the much more classical notion of bridge position.

Biographical Sketch

Abigail Thompson was born on June 30, 1958, in Norwalk, Connecticut. She received her B.A. from Wellesley College in 1979 and her Ph.D. from Rutgers University in 1986. She held a Lady Davis Fellowship at Hebrew University (1986–87), a University of California President's Postdoctoral Fellowship at UC Berkeley (1987–88), a National Science Foundation Postdoctoral Fellowship

(1988-91), and a Sloan Foundation Fellowship (1991-93). In 1990-91 and 2000-01 she was a member of the Institute for Advanced Study. Since 1988 she has been on the faculty at the University of California at Davis. She is the director of the California State Summer School in Mathematics and Science at UC Davis, a month-long residential program for talented high school students. Her current research concerns structures of 3-dimensional manifolds. She is married and has three children.

Response

I am very grateful to the AMS and the Satter Prize Committee for awarding me this prize. I have been supported and encouraged throughout my career by many mathematicians, especially Ann Stehney, Bill Menasco, and Rob Kirby. I am also deeply indebted to my long-time collaborator, Marty Scharlemann. The Satter Prize is particularly meaningful to me, because Joan Birman, whose generosity funded the prize, has been a great inspiration to me in my field.

2002 Morgan Prize

Joshua Greene

The 2002 AMS-MAA-SIAM Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student was awarded at the Joint Mathematics Meetings in Baltimore in January 2003.

The Morgan Prize is awarded annually for outstanding research in mathematics by an undergraduate student (or students having submitted joint work). Students in Canada, Mexico, or the United States or its possessions are eligible for consideration for the prize. Established in 1995, the prize was endowed by Mrs. Frank Morgan and carries the name of her late husband. The prize is given jointly by the AMS, the Mathematical Association of America (MAA), and the Society for Industrial and Applied Mathematics (SIAM) and carries a cash award of $1,000.

Recipients of the Morgan Prize are chosen by a joint AMS-MAA-SIAM selection committee. For the 2002 prize, the members of the selection committee were: Kelly J. Black, Fan C. Graham, Thomas C. Hales, Svetlana R. Katok, Robert O. Robson, Kris Stewart, and Robert S. Strichartz.

Previous recipients of the Morgan Prize are: Kannan Soundararajan (1995), Manjul Bhargava (1996), Jade Vinson (1997), Daniel Biss (1998), Sean McLaughlin (1999), Jacob Lurie (2000), and Ciprian Manolescu (2001).

The 2002 Morgan Prize was awarded to JOSHUA GREENE. The text that follows presents the selection committee's citation, a brief biographical sketch, and the awardee's response upon receiving the prize.

Citation

The winner of the 2002 Morgan Prize for Outstanding Research by an Undergraduate is Joshua Greene for his work in combinatorics. His prize is based on his paper "A new short proof of Kneser's conjecture", which is to appear in the *American Mathematical Monthly*, and his undergraduate senior thesis "Kneser's conjecture and its generalizations".

Discrete mathematics has often been enriched by the interplay of topology and combinatorics. One such example is Lovász's classic 1978 proof of Kneser's conjecture which states that if the k-element subsets of an n-element set are partitioned into $n-2k+1$ classes, then one of the classes must contain a pair of disjoint subsets. Greene gave a beautiful new short proof without using Gale's theorem on the distribution of points on a sphere. His proof is a gem that is widely admired and has already been included in a forthcoming book by Matousek. In his senior thesis, Greene addresses further associated combinatorial questions and has already provided two new simplified proofs of Schrijver's theorem on chromatic-critical subgraphs of Kneser graphs. His insight in topological combinatorics bypasses traditional technical difficulties in this area, and experts predict that his method will become the standard approach in this rapidly developing area of mathematics.

The committee was impressed by the depth and quality of Greene's research, and by his command of a large body of topology, geometry, and combinatorics required for his work. The quality of his research papers, the enthusiastic letters from his mentors, and the response to his work from many researchers all confirm the outstanding nature of his research.

The committee is proud to award the 2002 Frank and Brennie Morgan Prize to Joshua Greene.

Biographical Sketch

Joshua Greene was born and raised in the sprawling suburbs of Columbia, Maryland. After early unsuccessful attempts to become an artist and pro hockey player, Greene took up an interest in science and mathematics during high school. Beginning in his junior year, he studied astrophysics under the guidance of Dr. Jay Norris at NASA/Goddard Space Flight Center and was named a finalist in the 1998 Westinghouse Science Talent Search for his work there. In the summer of 1998 Greene was a student at the Hampshire College Summer Studies in Mathematics, which sparked his interest in combinatorics, and he returned to teach at the program in 1999 and 2002. He matriculated at Harvey Mudd College in 1998, where he enjoyed a broad education, learning from a dedicated, enthusiastic faculty and graduating with distinction in mathematics in 2002. During college Greene also participated in the Budapest Semesters in Mathematics; Joseph Gallian's Research Experiences for Undergraduates (REU) in Duluth, Minnesota; and the Director's Summer Program. Each program uniquely shaped his research experience and current interests, which include discrete mathematics, number theory, and topology. Greene is currently building houses with Habitat for Humanity in Appalachia through the AmeriCorps service program, and he plans to enter the University of Chicago next fall to pursue a doctorate in mathematics. When he is not studying or communicating mathematics, Greene enjoys hockey, Frisbee, nature, and trying to determine the meaning of life.

Response

I am deeply honored by this distinction. My sincerest thanks extend to Mrs. Frank Morgan for endowing this prize and to the AMS, MAA, and SIAM for sponsoring it and awarding it to me this year. I owe this honor to everyone who has contributed to my research experience in college. Amongst these many people, I specifically thank Joseph Gallian for supervising my work at the Duluth REU; to Liz Pyle for overseeing my work at the Director's Summer Program; to András Gyárfás, whose combinatorics course inspired a substantial portion of my research; to Art Benjamin, Weiqing Gu, and Mike Moody for their ongoing support; and, moreover, to my advisor, Francis Su, for his tireless encouragement and guidance in all matters mathematical and otherwise. Finally, I thank my friends, Kate, and my family for all of their tremendous support.

2003 Conant Prize

Nicholas Katz

Peter Sarnak

Sarnak (left) and Katz

The 2003 Levi L. Conant Prize was awarded at the 109th Annual Meeting of the AMS in Baltimore in January 2003.

The Conant Prize is awarded annually to recognize an outstanding expository paper published in either the *Notices of the AMS* or the *Bulletin of the AMS* in the preceding five years. Established in 2000, the prize honors the memory of Levi L. Conant (1857–1916), who was a mathematician at Worcester Polytechnic University. The prize carries a cash award of $1,000.

The Conant Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2003 prize the members of the selection committee were: Brian J. Parshall, Anthony V. Phillips, and Joseph H. Silverman.

Previous recipients of the Conant Prize are: Carl Pomerance (2001), and Elliott Lieb and Jakob Yngvason (2002).

The 2003 Conant Prize was awarded to Nicholas Katz and Peter Sarnak. The text that follows presents the committee's citation, brief biographical sketches, and the awardees' response upon receiving the prize.

Citation

The Levi L. Conant Award in 2003 is granted to Nicholas Katz and Peter Sarnak for their expository paper "Zeroes of zeta functions and symmetry", *Bulletin of the AMS* **36** 1–26 (1999). "Zeroes of zeta functions and symmetry" is a model of high-level exposition. Katz and Sarnak do justice to their beautiful topic, a rich mix of intensive numerical exploration, conjectures, and theorems. The theorems take us deep into Weil-Deligne territory, but the authors manage, with well-chosen, concrete examples, to keep the general mathematical reader on the trail. In this paper, obviously a labor of love, the authors' enthusiasm and wonderment are inescapable and contagious.

Biographical Sketch: Nicholas Katz

Nicholas M. Katz was born in Baltimore, Maryland, in 1943. He received his B.A. from Johns Hopkins University in 1964 and his Ph.D. from Princeton University in 1966 under the direction of Bernard Dwork, who had a profound influence on his entire mathematical life. He has been at Princeton University ever since. In 1968–69, he was awarded a NATO Postdoctoral Fellowship, which allowed him to spend his first year at the Institut des Hautes Études Scientifiques (IHÉS). There he came under the enduring spell of Pierre Deligne and Alexander Grothendieck. He returned to IHÉS incessantly over the years to come. On later visits he was able to learn from Ofer Gabber, the fourth of his mathematical heroes. He has held Sloan and Guggenheim Fellowships, been a Japan Society for the Promotion of Science Fellow, and several times has had the privilege of being a visiting professor at Orsay and an Ordway Visiting Professor at the University of Minnesota.

Biographical Sketch: Peter Sarnak

Peter Sarnak was born on December 18, 1953, in Johannesburg, South Africa. He received his Ph.D. from Stanford University (1980).

Sarnak began his academic career at the Courant Institute of Mathematical Sciences, advancing from assistant professor (1980–83) to associate professor (1983). He moved to Stanford University as a professor of mathematics (1987–91). Since 1991 he has been a professor of mathematics at Princeton University. At Princeton he has also served as the H. Fine Professor (1995–96) and as department chair (1996–99). He was a professor at the Courant Institute (2001–02).

Sarnak was a Sloan Fellow (1983–85) and a Presidential Young Investigator (1985–90). He was a fellow at Hebrew University's Institute of Advanced Studies (1987–88), the Sherman Fairchild Distinguished Scholar at the California Institute of Technology (1989), and a member at the Institute for Advanced Study (1999–2002).

He has published extensively in his areas of research interest, which include number theory and cusp forms.

Response

It is both a great honor and a great pleasure for us to receive the Levi L. Conant Award in 2003 for our article "Zeroes of zeta functions and symmetry". We are very pleased to be complimented on our exposition. We are also particularly gratified that our article and the ideas put forth in it have stimulated some very interesting work by others. Some of this work provides partial evidence for our conjectures, which we find reassuring. Even more exciting to us is that much of this work, both analytical and numerical, goes way beyond what we had envisioned and establishes the use of random matrix models as a powerful predictor of what should be true in some very classical questions concerning Dirichlet L-functions and the Riemann zeta function.

Mathematics People

Baouendi and Rothschild Receive 2003 Bergman Prize

M. Salah Baouendi and Linda Preiss Rothschild have been awarded the 2003 Stefan Bergman Prize. Established in 1988, the prize recognizes mathematical accomplishments in the areas of research in which Stefan Bergman worked. For one year each awardee will receive half of the income from the prize fund. Currently this income is about $22,000 per year.

The previous Bergman Prize winners are: David W. Catlin (1989), Steven R. Bell and Ewa Ligocka (1991), Charles Fefferman (1992), Yum Tong Siu (1993), John Erik Fornæss (1994), Harold P. Boas and Emil J. Straube (1995), David E. Barrett and Michael Christ (1997), John P. D'Angelo (1999), Masatake Kuranishi (2000), and László Lempert and Sidney Webster (2001). On the selection committee for the 2003 prize were John Erik Fornæss, J. J. Kohn (chair), and Yum Tong Siu.

Citation

The Bergman Prize was awarded to Professors Salah Baouendi and Linda Rothschild for their joint and individual work in complex analysis. In addition to many important contributions to complex analysis they have also done first rate work in the theory of partial differential equations. Their recent work is centered on the study of CR manifolds to which they and their collaborators have made fundamental contributions.

The Cauchy-Riemann equations on a complex manifold define holomorphic functions. A real submanifold in a complex manifold inherits the Cauchy-Riemann equations along its complex tangential directions. A CR manifold (abbreviation for Cauchy-Riemann manifold) is a manifold which is endowed with tangential Cauchy-Riemann equations modeled on a real submanifold in a complex manifold. A function on a CR manifold which satisfies the tangential Cauchy-Riemann equations is a CR function. A map between CR manifolds which satisfies the tangential Cauchy-Riemann equations is a CR map.

The work of Baouendi and Rothschild on CR manifolds focuses on two aspects. One aspect concerns CR maps. When can a locally defined CR map be extended to a global CR map between two CR manifolds? When is a global CR map already determined locally or even by the infinite jet at one point? Another aspect concerns CR functions. When is a CR function on a real submanifold of a complex manifold the restriction of a holomorphic function, or the limit of holomorphic functions, defined on some open subset of the complex manifold?

In a series of seminal papers (some jointly with X. Huang, P. Ebenfelt, and D. Zaitsev) they showed, under some natural nondegeneracy conditions, that germs of smooth CR maps between two real analytic hypersurfaces always extend to global CR maps which, moreover, in the case of algebraic hypersurfaces (and even for the higher codimensional case), must be algebraic maps. Furthermore, formal equivalence of real submanifolds implies biholomorphic equivalence. Many of the methods which they developed for the results, such as those of Segre sets and mappings, have since become major tools in the field.

For the basic problem of when CR functions are boundary values of holomorphic functions Baouendi and Rothschild made a number of fundamental contributions. In addition, Baouendi, jointly with F. Treves, showed that any CR function on a smooth CR submanifold of $\mathbf{C}^n$ is a limit of holomorphic functions and that any CR function on a smooth hypersurface of finite type extends holomorphically to at least one side.

The operators which are sums of squares of vector fields play an important role in the study of CR manifolds. Baouendi, mostly in joint work with C. Goulaouic, gave necessary conditions for analytic hypoellipticity of such operators with analytic coefficients, and also discovered some remarkable counterexamples to analytic hypoellipticity.

Rothschild, in a joint paper with E. Stein, introduced Lie group methods to prove L^p and Hölder estimates for the sum of squares operators as well as the boundary Kohn

Laplacian for real hypersurfaces. In later joint work with L. Corwin and B. Helfer, she proved analytic hypoellipticity for a class of first order systems. She also proved the existence of a family of weakly pseudoconvex hypersurfaces for which the boundary Kohn Laplacian is hypoelliptic but does not satisfy maximal L^2 estimates.

The work of Baouendi and Rothschild has had and continues to have tremendous impact on the theory of several complex variables.

Biographical Sketch: M. Salah Baouendi

M. Salah Baouendi, born in 1937, received his B.S. from the Université de Paris in 1961 and his Ph.D. from the Université de Paris, Orsay, in 1967. He held positions in Paris and at the University of Tunis, the Université de Nice, Purdue University, the University of Chicago, and Rutgers University before assuming his present position as professor at the University of California, San Diego. He received the Prix d'Aumale from the French Academy of Sciences (1969) and was an invited speaker at the International Congress of Mathematicians in Vancouver (1974). He has served on several AMS committees and was a member of the AMS Council.

Biographical Sketch: Linda Preiss Rothschild

Linda Preiss Rothschild, born in 1945, received her B.A. from the University of Pennsylvania in 1966 and her Ph.D. from the Massachusetts Institute of Technology in 1970. She held positions at MIT, Tufts University, Columbia University, Princeton University, and the University of Wisconsin before assuming her present position as professor at the University of California, San Diego. She has been a member of the Institute for Advanced Study (1974–75, 1978, 1981–82) and was a fellow of the Alfred P. Sloan Foundation (1976–80). She has served on various committees of the AMS and was an AMS vice president from 1985 to 1987. She served as president of the Association for Women in Mathematics from 1983 to 1985.

About the Prize

The Bergman Prize honors the memory of Stefan Bergman, best known for his research in several complex variables, as well as the Bergman projection and the Bergman kernel function that bear his name. A native of Poland, he taught at Stanford University for many years and died in 1977 at the age of eighty-two. He was an AMS member for thirty-five years. When his wife died, the terms of her will stipulated that funds should go toward a special prize in her husband's honor.

The AMS was asked by Wells Fargo Bank of California, the managers of the Bergman Trust, to assemble a committee to select recipients of the prize. In addition, the Society assisted Wells Fargo in interpreting the terms of the will to assure sufficient breadth in the mathematical areas in which the prize may be given. Awards are made every one or two years in the following areas: (1) the theory of the kernel function and its applications in real and complex analysis, and (2) function-theoretic methods in the theory of partial differential equations of elliptic type with attention to Bergman's operator method.

—Allyn Jackson

McKay and Perkins Awarded CRM-Fields Prize

John McKay, Concordia University, and Edwin Perkins, University of British Columbia, have been named joint winners of the CRM-Fields Prize for mathematics for 2002–2003. The prize, presented annually by the Centre de Recherches Mathématiques (CRM) in Montreal and The Fields Institute in Toronto, recognizes exceptional contributions by a mathematician working in Canada. It carries an award of $5,000, and recipients are asked to present lectures at both the CRM and The Fields Institute.

McKay's work revolves around the properties of finite groups, their representations, and their symmetries. He has launched two areas of mathematics by his observations and conjectures, one known as the McKay correspondence and the other called "monstrous moonshine", underlying the role of the largest sporadic simple group, which is known as the "monster". He is a pioneer in the use of computers as a tool in algebra, either in the study of sporadic groups (he is the codiscoverer of two such groups) or in the explicit computation of Galois groups. He also took part in one of the feats of computational algebra of our time, the proof of the nonexistence of a projective plane of order 10.

Perkins has made outstanding contributions to several areas of probability theory and is one of the world's leading probabilists. Much of his early work concerned the delicate analysis of the sample paths of stochastic processes. His most spectacular achievements are his contributions to the analysis of measure-valued diffusions, or "superprocesses", in which he has been a pioneer. His accomplishments include deep and surprising results about the support of super-Brownian motion, including identification of its Hausdorff dimension; the identification of the historical process as the correct way to understand genealogy in superprocesses; and the construction of a class of interacting superprocesses.

—From CRM and Fields Institute announcements

Petters Receives Blackwell-Tapia Prize

Arlie O. Petters of Duke University has been selected as the first recipient of the David Blackwell and Richard A.

Tapia Prize. Petters's chief research interests are in the field of mathematical physics. His current research includes the development of a rigorous mathematical theory of light deflection in gravitational fields and the investigation of the observational consequences of the theorems in such a theory.

The Blackwell-Tapia Prize has been established by the Mathematical Sciences Research Institute (MSRI) and Cornell University in honor of David Blackwell and Richard A. Tapia, distinguished mathematical scientists who have been inspirations to more than a generation of African American and Hispanic American students and professionals in the mathematical sciences. The prize will be presented every other year to a mathematical scientist who has contributed significantly to his or her field of expertise and who has served as a role model for mathematical scientists and students from underrepresented minority groups or who has contributed in other significant ways to the addressing of the problem of the underrepresentation of minorities in mathematics.

—From an MSRI announcement

Mathematical Society of Japan Prizes Awarded

The Mathematical Society of Japan (MSJ) has announced the awarding of several prizes.

The Autumn Prize of the Mathematical Society of Japan for 2002 was awarded to Yasumasa Nishiura of Hokkaido University for his distinguished contributions to pattern dynamics for reaction-diffusion systems. The Autumn Prize is given to an individual who has made outstanding contributions within the past five years to mathematics in the highest and broadest sense.

The 2002 Geometry Prize was awarded to Kazuyoshi Kiyohara, Hokkaido University, for his study of Riemannian manifolds whose geodesic flows are integrable and C_l metrics, and to Hajime Tsuji, Tokyo Institute of Technology, for his work on existence and applications of singular Hermitian metrics in algebraic geometry. Both Kiyohara's and Tsuji's work contributed major and fundamental advances in geometry.

The Analysis Prize, inaugurated in 2001, has been awarded to the following three mathematicians: Junjiro Noguchi, Tokyo University, for contributions to Nevanlinna theory in several complex variables and geometric complex analysis; Tadahisa Funaki, Tokyo University, for outstanding contributions in statistical mechanics on interface models and stochastic analysis; and Eiji Yanagida, Chiba University, for insightful research on nonlinear diffusion equations.

The Takebe Prize for outstanding research was established to encourage young mathematicians in their research. The Takebe Senior Prize is awarded to recipients chosen from nominations by members of the Mathematical Society of Japan. The Takebe Junior Prize is awarded to self-nominated applicants. The Takebe Prizes for 2002 were awarded to the following mathematicians:

Takebe Senior Prize: Narutaka Ozawa, University of Tokyo, for the study of applications of operator spaces to C^* algebras; Hideo Kubo, Shizuoka University, for the study of the asymptotic behavior of solutions of nonlinear wave equations in higher dimensional spaces; and Atsushi Shiho, Tohoku University, for the study of the crystalline fundamental group.

Takebe Junior Prize: Kazuhiro Ichihara, Tokyo Institute of Technology, for the study of Dehn surgery on 3-manifolds and essential surfaces; Yusuke Okuyama, Shizuoka University, for the study of irrationally indifferent periodic points in complex dynamics; Shinich Kobayashi, Tokyo University, for the study of Iwasawa theory of elliptic curves with supersingular reduction; Shin Sato, Chiba University, for the study of projections of surface knots; Hitoshi Tanaka, Gakushuin University, for the study of weighted norm inequalities for the Kakeya maximal function; and Takako Fukaya, Tokyo University, for the study of K_2 Coleman power series and their applications.

—From a Mathematical Society of Japan announcement