2000 Steele Prizes

The 2000 Leroy P. Steele Prizes were awarded at the 106th Annual Meeting of the AMS in January 2000 in Washington, DC.

The Steele Prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein and are endowed under the terms of a bequest from Leroy P. Steele. The prizes are awarded in three categories: for expository writing, for a research paper of fundamental and lasting importance, and for cumulative influence extending over a career. The current award is $4,000 in each category.

The recipients of the 2000 Steele Prizes are John H. Conway for Mathematical Exposition, Barry Mazur for a Seminal Contribution to Research (limited this year to algebra), and I. M. Singer for Lifetime Achievement.

The Steele Prizes are awarded by the AMS Council acting through a selection committee whose members at the time of these selections were: Ciprian I. Foias, Bertram Kostant, Hugh L. Montgomery, Louis Nirenberg, Marc A. Rieffel, Jonathan M. Rosenberg (chair), John T. Tate, François Trèves, and S. R. S. Varadhan.

The text that follows contains, for each prize recipient, the committee's citation, a brief biographical sketch, and a response from the recipient upon receiving the prize.

Steele Prize for Mathematical Exposition: John H. Conway

Citation

The Leroy P. Steele Prize for Mathematical Exposition is awarded to John H. Conway of Princeton University in recognition of his many expository contributions in automata, the theory of games, lattices, coding theory, group theory, and quadratic forms. He has a rare gift for naming mathematical objects and for inventing useful mathematical notations. His joy in mathematics is clearly evident in all that he writes. Conway's book *On Numbers and Games*, London Math. Soc. Monographs, vol. 6, Academic Press, London, 1976, ISBN 0-12186-350-6, is a classic in its field and even inspired a novel (*Surreal Numbers* by D. Knuth). In the words of John Dawson's review in *Mathematical Reviews*, "Overall, this book is a momentous addition to the mathematical literature: a new, exciting, and highly original theory is expounded by its creator in a style that is at once concise, literate, and delightfully whimsical." An anonymous reviewer at `amazon.com` of Conway's book *The Book of Numbers*, co-authored with Richard Guy, Copernicus, 1996, ISBN 0-387-97993-X, writes that "the book is so fascinating that it can be a real time sink." Carl Riehm, reviewing Conway's *The Sensual (Quadratic) Form* ("with the assistance of Francis Y. C. Fung"), based on Conway's Hedrick Lectures in 1991, Carus Mathematical Monographs, vol. 26, Math. Assoc. of America, Washington, DC, 1997, ISBN 0-88385-030-3, in *Mathematical Reviews*, states:

> This is a book rich in ideas. They seem to burst forth from almost every page, and it is perhaps not surprising that it seems a little disorganized at times. I suspect that the author's hope that "even the experts in quadratic forms will find some new enlightenment here" will be realized. The parts of the book

> dealing with topographs, and with Voronoi cells, vonorms and conorms are especially interesting. One can only hope that this book will help to bring them into the argot of quadratic forms.

Conway is the author or co-author of at least eight different books and of many expository articles. They have had substantial impact not just on research mathematicians but even on mathematical amateurs.

Biographical Sketch

John H. Conway is one of the preeminent theorists in the study of finite groups and one of the world's foremost knot theorists. He is the author of more than 10 books and more than 135 journal articles on a wide variety of mathematical subjects. He has also done path-breaking work in number theory, game theory, coding theory, tiling, and the creation of new number systems.

John H. Conway

Beyond the academic world Conway is widely known as the inventor of the "Game of Life", a computer simulation of simple cellular "life", governed by remarkably simple rules which give rise to amazingly complex behavior. It was popularized by Martin Gardner's columns in *Scientific American* in the early 1970s and has had a large group of devotees ever since. Conway may well have the distinction of having more books, articles, and Web pages devoted to his creations than any other living mathematician.

Conway was educated at Cambridge University and served as a professor of mathematics there prior to joining Princeton University in 1986 as the John von Neumann Professor of Mathematics. A fellow of the Royal Society of London, he received the Pólya Prize of the London Mathematical Society and recently the Nemmers Prize in Mathematics from Northwestern University.

Response from Professor Conway

What a delicious surprise! But if ideas tumble out in such profusion, then why aren't they here now when I need them to write this little acceptance? The thing that makes this so surprising is that I associate writing more with pain than with the pleasure I get from actually doing the mathematics.

I think the pain comes from the fact that in mathematical writing one has to be so terribly careful to distinguish between phrases that would be equivalent in ordinary English, where a "happy crowd of people" obviously means the same as "a crowd of happy people". A large set of numbers, on the other hand, is very different from a set of large numbers.

So mathematical writing is definitely hard—steel hard. This Steele Prize—what a steal!—I don't deserve it, but suppose I must steel myself to accept it. Thank you very much indeed.

Steele Prize for a Seminal Contribution to Research: Barry Mazur

Citation

The Leroy P. Steele Prize for a Seminal Contribution to Research, which this year was limited to algebra (broadly interpreted), is awarded to Barry Mazur of Harvard University for his paper "Modular curves and the Eisenstein ideal" in *Publications Mathématiques de l'Institut des Hautes Études Scientifiques*, no. 47 (1978), 33–186. This paper determined the possible torsion of the rational points of elliptic curves defined over $\mathbb{Q}$ and also laid the foundation for many of the most important results in arithmetic algebraic geometry over the last 20 years, including (but not limited to):

1. The proof of the Main Conjecture of Iwasawa theory by Mazur and Andrew Wiles, in "Class fields of abelian extensions of $\mathbb{Q}$", *Invent. Math.* **76** (1984), no. 2, 179–330.

2. Ken Ribet's proof that the Taniyama-Shimura conjecture implies a proof of Fermat's Last Theorem, in "On modular representations of $\mathrm{Gal}(\overline{\mathbb{Q}}/\mathbb{Q})$ arising from modular forms", *Invent. Math.* **100** (1990), no. 2, 431–476.

3. Wiles's proof of the Taniyama-Shimura conjecture and of Fermat's Last Theorem, in "Modular elliptic curves and Fermat's last theorem", *Ann. of Math.* (2) **141** (1995), no. 3, 443–551, using results with R. Taylor ("Ring-theoretic properties of certain Hecke algebras", ibid., 553–572).

4. Loïc Merel's proof of the uniform boundedness conjecture for the torsion of elliptic curves defined over number fields, in "Bornes pour la torsion des courbes elliptiques sur les corps de nombres", *Invent. Math.* **124** (1996), no. 1–3, 437–449.

Rarely has a single paper given rise to such a wealth of important mathematics as has Mazur's paper on "Modular curves and the Eisenstein ideal".

Biographical Sketch

Barry Mazur spent two years as an undergraduate at the Massachusetts Institute of Technology and then went to graduate school at Princeton University, where he received a Ph.D. in mathematics (1959). He was a research fellow at the Institute for Advanced Study (1958–59).

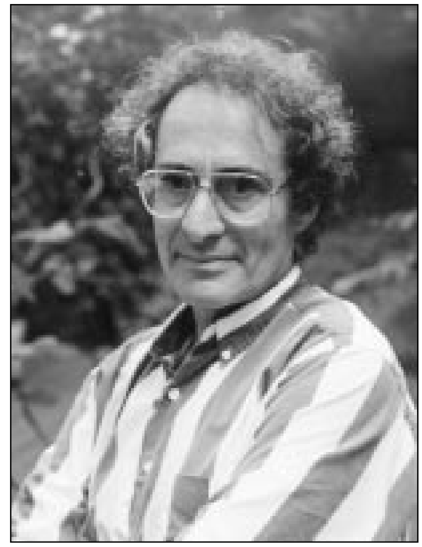
In 1959 he moved to Harvard University and has remained there ever since. At Harvard he was a junior fellow (1959–62) before joining the mathematics department in 1962. In 1966 Mazur shared the AMS Oswald Veblen Prize in Geometry with Morton Brown, and in 1982 received the AMS Cole Prize in Number Theory. Mazur is a member of the National Academy of Sciences.

Response

What an honor to receive the Leroy P. Steele Prize for a Seminal Contribution to Research! I thank the committee for its generous citation regarding the article for which they awarded me the prize. It is a joy to do mathematics at a time when there are so many enormously talented people at work and so many exciting new ideas being developed. That the committee cited the works of such mathematicians as Wiles, Ribet, and Merel in connection with the prize they awarded to me is a further source of joy.

Sometimes a line of mathematical research extending through decades can be thought of as one long conversation in which many mathematicians take part. This is fortunately true at present and has been so throughout the century. I came to number theory through the route of algebraic geometry and before that, topology. The unifying spirit at work in those subjects gave all the new ideas a resonance and a buoyancy which allowed them to instantly echo elsewhere, inspiring analogies in other branches and inspiring more ideas. One has only to think of how the work of Eilenberg, Mac Lane, Steenrod, and Thom in topology and the early work in class field theory as further developed in the hands of Emil Artin, Tate, and Iwasawa was unified and amplified in the point of view of algebraic geometry adopted by Grothendieck, a point of view inspired by the Weil conjectures, which presaged the inextricable bond between topology and arithmetic. One has only to think of the work of Serre or of Tate. But mathematics is one subject, and surely every part of mathematics has been enriched by ideas from other parts.

I feel lucky that as I was just starting out in number theory I was surrounded by mathematicians whose work embodied this spirit. Serge Lang helped me in very many ways, but especially by the example of his energy, his broad perspective, and his enthusiasm. And his generosity. He gave me the hope that a topological point of view might be of some use in number theory. Grothendieck was exceptionally patient with me, for when we first met I knew next to nothing about algebra. In one of his first conversations with me, he raised the question (asked of him by Washnitzer) of whether a smooth proper algebraic variety defined over a real quadratic field could yield topologically different differentiable manifolds realized by the two possible imbeddings of the number field into the reals. What a perfect question, at least for me! Not that I answered it. But it was surely one of the very few algebro-geometric questions that I then had the background to appreciate. Also, suggesting as it did that different topologies might be "unified" by virtue of the fact that they arose as different avatars of the same algebraic geometry, the question provided quite an incentive for a topologist to look at algebraic geometry. I began to learn the elements of algebraic geometry working with Mike Artin. Our intense and high-spirited sessions were initially devoted to studying the dynamics of diffeomorphisms, via Nash's theory of real algebraic components of the loci of real algebraic varieties. Our later work together, which moved towards number theory, was one of the most important mathematical experiences for me and was enormous fun.



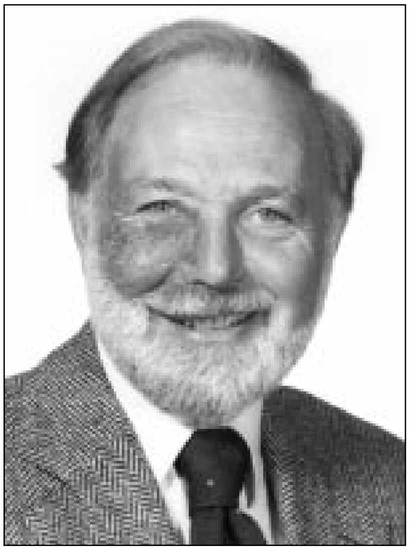
Barry Mazur

How happy I am for having had such an initiation to the subject of number theory, and how grateful I am to the Leroy P. Steele Prize committee for their kind words.

Steele Prize for Lifetime Achievement: I. M. Singer

Citation

The Leroy P. Steele Prize for Lifetime Achievement is awarded to Isadore M. Singer, Institute Professor at the Massachusetts Institute of Technology. Singer's series of five papers with Michael F. Atiyah on the Index Theorem for elliptic operators (which appeared in 1968–71) and his three papers with Atiyah and V. K. Patodi on the Index Theorem for manifolds with boundary (which appeared in 1975–76) are among the great classics of global analysis. They have spawned many developments in differential geometry, differential topology, and analysis, and Singer received the Bôcher Memorial Prize for some of this work in 1969. However, this represents only a small part of his contributions to geometry and analysis. Other significant contributions to geometry were his work with D. B. Ray on analytic torsion, the precursor of much modern work on "determinant" invariants in geometry, and an influential textbook joint with J. A. Thorpe, *Lecture Notes on Elementary Topology and Geometry*, Scott, Foresman and Co., 1967, reprinted by Springer, 1976. Moreover, in addition to his work in pure mathematics, Singer has labored for two decades to bring together mathematicians and theoretical physicists. This has been not simply a matter of interpersonal relations and seminar talks, but has entailed a long effort to understand, rework, and make available to mathematicians the deepest results of modern theoretical physics. This renaissance of serious interaction between mathematicians and physicists, which



I. M. Singer

dates from the mid-1970s, has had a dramatic effect on mathematics, and Singer has played a major role in this development.

Singer was vice president of the AMS in 1970–72 and won the National Medal of Science in 1983. He was awarded the Wigner Medal, given for "outstanding contributions to the understanding of physics through group theory," in 1988. In 1993 Singer won the AMS Award for Distinguished Public Service. The citation recognized his "outstanding contributions to his profession, to science more broadly, and to the public good by bringing the best of mathematics and his own insights to bear on the activities of the National Academy of Sciences; on committees of the National Research Council, including the two so-called David Committees on the health of the mathematical sciences and the Committee on Science, Engineering, and Public Policy; on the president's Science Advisory Council; on decisions of Congress through testimony concerning the support of mathematics and mathematical research; and on a host of critical situations over many years in which his wisdom and intervention helped gain a hearing for the problems of his community and the contributions it makes to the nation."

Biographical Sketch

I. M. Singer was born in 1924 in Detroit, Michigan. He received a B.S. in 1944 from the University of Michigan and a Ph.D. in 1950 from the University of Chicago. He was a Moore Instructor at the Massachusetts Institute of Technology (1950–52) and has spent most of his professional life at MIT, where he is currently an Institute Professor.

Singer is a member of the American Academy of Arts and Sciences, the American Philosophical Society, and the National Academy of Sciences (NAS). He served on the Council of NAS, the Governing Board of the National Research Council, and the White House Science Council. He received the AMS Bôcher Prize (1969), the Eugene Wigner Medal (1988), and the AMS Award for Distinguished Public Service (1992). He received the National Medal of Science in 1983.

Response

Events this past year brought home how rewarding my career as a mathematician has been. So I was especially moved to learn that I am to receive the Leroy P. Steele Prize for Lifetime Achievement in Mathematics. I am most grateful to the American Mathematical Society for this prestigious award and particularly to the members of the Steele Prize Committee, whose citation accurately summarizes a half century of endeavor.

My collaboration with Sir Michael Atiyah for more than twenty years has been very exciting, and our work continues to have great impact. Sir Michael is a remarkable human being who—mathematics aside—has devoted much time and energy in the support of science throughout the world. I've been fortunate in having many collaborators in mathematics and physics with whom I have enjoyed working and who have become close friends. It is a pleasure to acknowledge them, over thirty in number—too many to list here.

In January and February 1977 I lectured at Oxford on the self-dual solutions to the Yang-Mills equations of motion. I believed that combining physicists' intuition and experience in gauge theories with geometers' global insights would yield remarkably new results. But I could never have imagined the rapid development of the interface between string theory and geometry that has affected both fields profoundly. It has been a privilege to participate in that development and to have nurtured it.

For me, the classroom is an important counterpart to research. I enjoy teaching undergraduates at all levels, and I have had a host of graduate students, many of whom have ended up teaching me more than I have taught them. I am especially appreciative of the Massachusetts Institute of Technology, which for many years has allowed me to teach what I want the way I want. Indeed, MIT is an enabling institution which has been very supportive. Without its backing, I could not have been active in science policy and remained a research mathematician.

Again, I am very grateful for this reward recognizing my work in mathematics and for mathematics.

Thank you.