1998 Steele Prizes

The 1998 Leroy P. Steele Prizes were awarded at the 104th Annual Meeting of the AMS in January in Baltimore. These 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 Steele 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, including the education of doctoral students. The current award is $4,000 in each category.

The recipients of the 1998 Steele Prizes are JOSEPH H. SILVERMAN for Mathematical Exposition, DORON ZEILBERGER and HERBERT S. WILF for a Seminal Contribution to Research, and NATHAN JACOBSON 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: Richard A. Askey, Ciprian Foias, H. Blaine Lawson Jr., Andrew J. Majda, Louis Nirenberg, Jonathan M. Rosenberg, and John T. Tate.

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

Steele Prize for Mathematical Exposition: Joseph H. Silverman

Citation

The Leroy P. Steele Prize for Mathematical Exposition is awarded to Joseph H. Silverman of Brown University for his books *The Arithmetic of Elliptic Curves*, Graduate Texts in Mathematics, vol. 106, Springer-Verlag, New York-Berlin, 1986, ISBN 0-387-96203-4; and *Advanced Topics in the Arithmetic of Elliptic Curves*, Graduate Texts in Mathematics, vol. 151, Springer-Verlag, New York, 1994, ISBN: 0-387-94328-5. The review of the first of these volumes in *Math. Reviews* by Robert S. Rumely, MR 87g:11070, begins as follows:

> This well-written book covers the basic facts about the geometry and arithmetic of elliptic curves, and is sure to become the standard reference in the subject. It meets the needs of at least three groups of people: students interested in doing research in Diophantine geometry, mathematicians needing a reference for standard facts about elliptic curves, and computer scientists interested in algorithms and needing an introduction to elliptic curves. For a long time one of the standard references for elliptic curves has been the survey article of J. W. S. Cassels [J. London Math. Soc. **41** (1966), 193–291; MR 33 #7299; errata; MR 34 #2523]. In its choice of topics this book may be viewed as an amplification of Cassels' article, with technical details filled in, much more motivation, and an excellent set of exercises.

Cassels himself reviewed the book in the *AMS Bulletin* [*Bull. Amer. Math. Soc.* (N.S.) **17** (1987), 148–149]. The review is short, but to the point. It concludes: "In the reviewer's opinion [Silverman]'s book fills the gap admirably. An old hand is hardly the best judge of a book of this nature, but reports of graduate students are equally favorable."

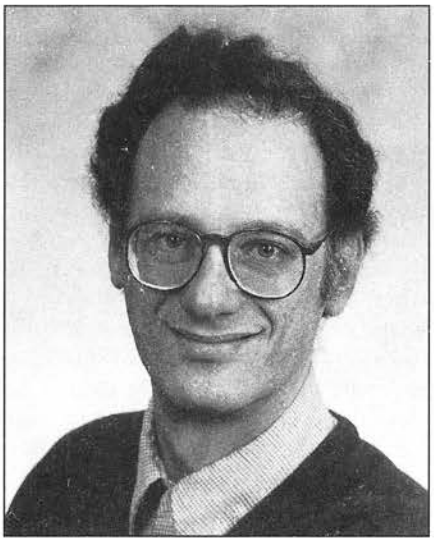
The review of Silverman's second volume in *Math. Reviews* by Henri Darmon, MR 96b:11074, is even more enthusiastic. It says:

> Since its publication almost 10 years ago, Silverman's book *The Arithmetic of Elliptic Curves* has become a standard reference, initiating thousands of graduate students (the reviewer among them) to this exciting branch of arithmetic geometry. The eagerly awaited sequel, *Advanced Topics in the Arithmetic of Elliptic Curves*, lives up to the high expectations generated by the first volume....After reading *Advanced Topics* with much pleasure, we can only hope for a third volume....

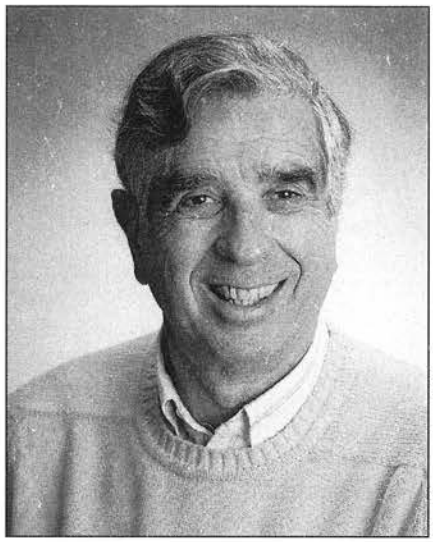
In short, Silverman's volumes have become standard references on one of the most exciting areas of algebraic geometry and number theory.

Biographical Sketch

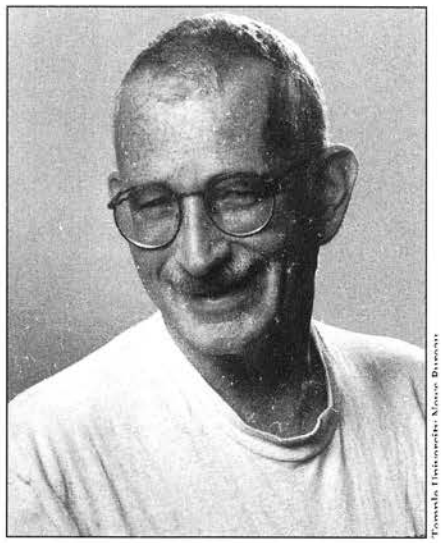
Joseph H. Silverman was born on March 27, 1955, in New York. He received his Sc.B. from Brown University (1977) and his M.A. (1979) and Ph.D.



Joseph H. Silverman



Herbert S. Wilf



Doron Zeilberger

(1982) from Harvard University. He began his career as a Moore Instructor at MIT (1982–86), followed by associate professorships at Boston University (1986–88) and Brown University (1988–91). Since 1991 he has been a professor of mathematics at Brown University.

Professor Silverman has been an NSF Post-Doctoral Fellow (1983–86) and an Alfred P. Sloan Foundation Fellow (1987–91) and is a recipient of an MAA Lester Ford Award (1994). In addition to the two books cited in his Steele Prize, Professor Silverman has written *Rational Points on Elliptic Curves* (jointly with John Tate, 1992) and *A Friendly Introduction to Number Theory* (1996), as well as numerous research articles. He has also coorganized two conferences, "Arithmetic Geometry" (Storrs, 1984) and "Fermat's Last Theorem" (Boston, 1995) and coedited the proceedings. His research interests include number theory, arithmetic geometry, elliptic curves, and arithmetic aspects of dynamical systems.

Response

I am deeply honored to receive a Steele Prize for my two books on elliptic curves. When I wrote the first volume shortly after receiving my Ph.D., my aim was to write the book that I wished had been available when I was a graduate student. It has given me great pleasure to see it fulfilling that purpose for other students over the past decade. In the original outline for that first (and, I assumed, solitary) book, there were twenty topics to be covered. Ten topics and 400 pages later, the publisher and I agreed that the book was finished, but as a sop to the reader and to my conscience, I included a short appendix briefly describing the ten omitted topics. This foolish act on my part was considered by many people to be a tacit promise that someday there would be a second volume. Eventually the second volume was written, and not surprisingly, its 500 pages only sufficed to cover half of the remaining material!

No writer operates in a vacuum. I would like to thank the many people from whom I learned about the beautiful theory of elliptic curves, including John Tate, Barry Mazur, Serge Lang, the members of the Harvard Elliptic Curves Seminar (1977–82), and many other writers, colleagues, students, and friends far too numerous to catalog. My books could never have been written without their encouragement and inspiration.

Steele Prize for a Seminal Contribution to Research: Herbert S. Wilf and Doron Zeilberger

Citation

The Leroy P. Steele Prize for Seminal Contribution to Research is awarded to Herbert S. Wilf, Thomas A. Scott Professor of Mathematics, of the University of Pennsylvania, and Doron Zeilberger of Temple University for their paper *Rational functions certify combinatorial identities*, J. Amer. Math. Soc. **3** (1990), 147–158.

New mathematical ideas can have an impact on experts in a field, on people outside the field, and on how the field develops after the idea has been introduced. The remarkably simple idea of the work of Wilf and Zeilberger has already changed a part of mathematics for the experts, for the high-level users outside the area, and for the area itself. George Andrews, one of the world's leading experts on q-series (which arise, for example, in statistical mechanics), wrote the following about the method of Wilf and Zeilberger: "In my proof of Capparelli's conjecture, I was completely guided by the Wilf-Zeilberger method, even if I didn't use Doron's program explicitly. I couldn't have produced my proof without knowing the principle behind 'WZ'. It is a really powerful result and does indeed merit the Steele Prize."

Donald Knuth, winner of the Steele Prize in 1986 for his books on *The Art of Computer Programming,* has written the following in his foreword to the book *A=B* by Marko Petkovšek, Wilf, and Zeilberger:

> Science is what we understand well enough to explain to a computer. Art is everything else we do. During the past several years an important part of mathematics has been transformed from an Art to a Science. No longer do we need to get a brilliant insight in order to evaluate sums of binomial coefficients, and many similar formulas that arise frequently in practice; we can now follow a mechanical procedure and discover the answers quite systematically.
>
> I fell in love with these procedures as soon as I learned them, because they worked for me immediately. Not only did they dispose of sums that I had wrestled with long and hard in the past, they also knocked off two new problems that I was working on at the time I first tried them. The success rate was astonishing.
>
> Notice that the algorithm doesn't just verify a conjectured identity *A=B.* It also answers the question "What is A?", when we haven't been able to formulate a decent conjecture.

Computer packages have been written to make it possible for others to use the Wilf-Zeilberger idea. Doron Zeilberger has written one. This is the "package" George Andrews mentioned in his quote above. Tom Koornwinder in Amsterdam has a variant, as does Wolfram Koepp in Berlin and Peter Paule in Linz. Marko Petkovšek has extended this work from terminating series to nonterminating series, and work has recently been done on multisums using similar but not identical methods. As offshoots of the Wilf-Zeilberger method become built into computer algebra systems, many people will be using it without being aware it is what makes their calculations possible.

Biographical Sketch: Herbert S. Wilf

Herbert Wilf has written several books, including *Combinatorial Algorithms* with Albert Nijenhuis; *Algorithms and Complexity*; *Generating Functionology*; and, most recently, *A=B* with Marko Petkovšek and Doron Zeilberger. He has been the editor-in-chief of the *American Mathematical Monthly,* 1987–91; was co-founder with Donald Knuth of the *Journal of Algorithms*; and was co-founder with Neil Calkin and is co-editor-in-chief of the *Electronic Journal of Combinatorics*, a peer-reviewed free electronic research journal on the WWW, which is now publishing its sixth volume and is in its fourth year of publication. He received in 1996 the Haimo Award of the Mathematical Association of America for Distinguished Teaching of College or University Mathematics, and he is especially proud to have supervised the dissertations of more than twenty Ph.D. students. The University of Pennsylvania recently named him Thomas A. Scott Professor of Mathematics.

He was born in 1931 in Philadelphia, did undergraduate work at MIT, and got his Ph.D. from Columbia University in 1958. His first faculty position was at the University of Illinois, and he came to the University of Pennsylvania in 1962, where he has been ever since. He has been a Visiting Professor at Imperial College of the University of London, Stanford University, and Rockefeller University, where he was a Guggenheim Fellow.

Response: Herbert S. Wilf

I am deeply honored to receive the Leroy P. Steele Prize. I might say that doing this research was its own reward—but it's very nice to have this one too! My thanks to the Selection Committee and to the AMS.

Each semester, after my final grades have been turned in and all is quiet, it is my habit to leave the light off in my office, leave the door closed, and sit by the window catching up on reading the stack of preprints and reprints that have arrived during the semester. That year, one of the preprints was by Zeilberger, and it was a 21st-century proof of one of the major hypergeometric identities, found by computer, or more precisely, found by Zeilberger using his computer. I looked at it for a while, and it slowly dawned on me that his recurrence relation would assume a self-dual form if we renormalize the summation by dividing first by the right-hand side. After that normalization, the basic "WZ" equation F(n+1,k)-F(n,k)=G(n,k+1)-G(n,k) was in the room with me, and its self-dual symmetrical form was very compelling. I remember feeling that I was about to connect to a parallel universe that had always existed but which had until then remained well hidden and that I was about to find out what sorts of creatures lived there. I also learned that such results emerge only after the efforts of many people have been exerted, in this case, of Sister Mary Celine Fasenmyer, Bill Gosper, Doron Zeilberger, and others. Doing joint work with Doron is like working with a huge fountain of hormones — you might get stimulated to do your best or you might drown. In this case I seem to have lucked out. It was a great adventure.

Biographical Sketch: Doron Zeilberger

Doron Zeilberger was born on July 2, 1950, in Haifa, Israel, to Ruth (Alexander) and Yehudah Zeilberger. He received his Ph.D. in 1976 from the Weizmann Institute of Science (as a student of

Harry Dym (a student of Henry McKean (a student of William Feller (a student of Richard Courant (a student of David Hilbert))))).

In 1979 he married Jane D. LeGrange (Ph.D., physics, Illinois, 1980, currently at Lucent Technology Bell Labs). Their children are Celia (b. 1983), Tamar (b. 1986), and Hadas (b. 1990).

In January 1996 he delivered the second Gillis Memorial Lecture at the Weizmann Institute.

Including this Steele Prize, his earnings to date from mathematical prizes are 2600 U.S. dollars ((1/2)(4000)+ 500 [MAA's 1990 L. R. Ford Award] + (1/2)50 [from Dick Askey and George Andrews for a proof of the q-Dyson conjecture, joint with Dave Bressoud] + (1/2)50 [from Dick Askey for a proof of the G2 case of Macdonald's conjecture, shared with Laurent Habsieger] +50 [from Dick Askey for a proof of the G2-dual case of Macdonald's conj.]), 10 bottles of wine [from Xavier Viennot for a certain tree-bijection], and one book [from Mark Pinsky, for a "calculus problem"].

Response: Doron Zeilberger

[Generic thanks and expressions of astonishment.]

At 11:05 p.m., December 24 (sic!), 1988, Herb Wilf called me up, and with Wilfian enthusiasm told me how the beautiful one-line proofs of certain classical identities, generated by my beloved computer, Shalosh B. Ekhad, could be made even prettier and how to obtain as a bonus a "dual identity" that is often much more interesting than the one originally proved. Thus was born WZ theory.

WZ theory has taught me that computers, by themselves, are not yet capable of creating the most beautiful math. Conversely, humans do much better math in collaboration with computers. More generally, combining different and sometimes opposite approaches and viewpoints will lead to revolutions. So the moral is: Don't look down on any activity as inferior, because two ugly parents can have beautiful children, and a narrow-minded or elitist attitude will lead nowhere.

We live in the great age of the democratization of knowledge and even of that elitist ivory tower called mathematics. Whoever would have believed thirty years ago that a 1988 Steele Prize would go to Rota for his work in "combinatorics" (a former slum), and whoever would have believed ten years ago that a 1998 Steele Prize would go to W and Z for their work on "binomial coefficients identities" (hitherto a slum squared).

The computer revolution, and especially the World Wide Web, is quickly making mathematics accessible and enjoyable to many more people. Especially commendable are the wonderful Web site of Eric Weisstein's "Eric Treasure Troves", Steve Finch's pages on mathematical constants, the Sloane-Plouffe On-Line Encyclopedia of Integer Sequences, Simon Plouffe's "Inverse Symbolic Calculator", and St. Andrews University's MacTutur site on the history of mathematics.

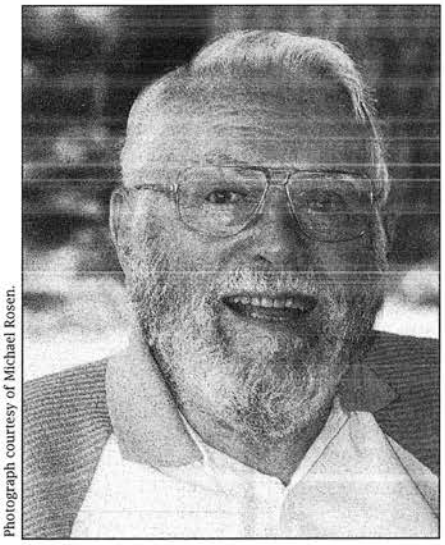
It is very important to make information, in particular mathematical information, freely accessible. The pioneering, and extremely successful, *Electronic Journal of Combinatorics*, created by Herb Wilf in 1994, should be emulated. It is very regrettable that the American Mathematical Society has subscription-only electronic journals and that the electronic versions of its paper journals are only available to paper subscribers. It is a disgrace that MathSciNet is only viewable for paying customers, thereby making its contents unsearchable by public search-engines.

On the positive side, the AMS has been very efficient in taking advantage of the electronic revolution, and the free ERA-AMS, under the leadership of Svetlana Katok, is a real gem!

I am really happy, not only for myself and Herb, but also because of the recognition that the field of hypergeometric series (alias binomial-coefficients identities) is hereby granted. There are so many giants on whose shoulders we are standing. Guru Dick Askey, q-Guru George Andrews, and Guru Don Knuth who preached the gospel from the continuous and discrete sides. Sister Celine Fasenmyer, a non-standard, yet very tall, giant. Hacker Bill Gosper who deserves this prize even more, and many others.

I should also mention our collaborators in this area: Gert Almkvist and Marko Petkovšek, and the beautiful work of Tewodros Amdeberhan, Frederic Chyzak, J. Hornegger, Bruno Gauthier, Ira Gessel, Wolfram Koepf, Christian Krattenthaler, John Majewicz, Istvan Nemes, John Noonan, Sheldon Parnes, Peter Paule, Bruno Salvy, Marcus Schorn, Volker Strehl, Nobuki Takayama, P. Verbaeten, Kurt Wegschaider, and Lily Yen.

Finally, I must mention my main influencers, in roughly chronological order: my terrific seventh-grade math teacher, Devorah Segev, and my great eighth-grade history teacher (and principal), Matityahu Pines. My cousin Mati Weiss, who showed me Joe Gillis's *Gilyonot leMatematika*. Joe Gillis, who, in my early teens, first made me into a mathematician through his *Gilyonot leMatematika*. My advisor, Harry Dym, who initiated me into research. My god-advisor, Dick Duffin, who discretized me. Leon Ehrenpreis, who dualized me. Joe Gillis (again!), who deranged me. Gian-Carlo Rota, who umbralized me. Dick Askey, who hypergeometrized me. George Andrews, who q-ified me. Herb Wilf (the same Herb!), who combinatorized me. Dominique Foata, who bijectified me. Jet Wimp, who asymptotized me. Xavier Viennot, who Schutzenbergerized me. Marco Schutzenberger, who formalized me. Bruno Buchberger, who basically standarized [grobnerized] me. Gert Almkvist, who integralized me, and Pierre Cartier, who Bourbakised me. Let them all be blessed!



Photograph courtesy of Michael Rosen.

Nathan Jacobson

Steele Prize for Lifetime Achievement: Nathan Jacobson

Citation

The Leroy P. Steele Prize for Lifetime Achievement is awarded to Nathan Jacobson, Henry Ford II Professor of Mathematics, Emeritus, of Yale University for his many contributions to research, teaching, exposition, and the mathematical profession. In research he is known primarily for his contributions to ring theory and to the theory of Lie algebras and Jordan algebras. Among the concepts or theorems that bear his name are the Jacobson radical (of a ring), the Jacobson topology (on primitive ideals), and the Jacobson-Morosov Theorem (in Lie theory). In exposition Jacobson is known for quite a number of important books, especially *Lectures in Abstract Algebra* (3 volumes, Van Nostrand, 1951, 1953, and 1964; reprinted by Springer, 1975), later superseded by *Basic Algebra I and II* (Freeman, 1974 and 1980, 1975 and 1989); *Structure of Rings* (AMS Colloquium Publications, vols. 37 and 39, 1956 and 1968); and *Lie Algebras* (Wiley-Interscience, 1962; reprinted by Dover, 1979).

Jacobson served as president of the AMS in 1971–72 and as vice-president of the International Mathematical Union in 1972–74. He received an honorary D.Sc. degree from the University of Chicago in 1972. The list of authors of *Algebraists' Homage*, volume 13 of the AMS Contemporary Mathematics series dedicated to Jacobson on the occasion of his retirement in 1981, includes dozens of the world's greatest algebraists. Few mathematicians have been as productive over such a long career or have had as much influence on the mathematical profession as Jacobson.

Biographical Sketch

Born in Warsaw, Poland, in 1910, Nathan Jacobson immigrated to the United States with his family at the age of seven and grew up in Mississippi and Alabama. He graduated from the University of Alabama in 1930 and embarked upon his graduate studies in mathematics at Princeton University, where he received his Ph.D. in 1934. Professor Jacobson taught at Bryn Mawr College, the University of North Carolina, and the Johns Hopkins University for several years before being appointed professor at Yale University in 1947. In 1963 he was named the Henry Ford II Professor of Mathematics at Yale, a position he held until his retirement in 1981. As a visiting professor he lectured at universities all over the world, including France, Israel, India, China, Japan, and the former Soviet Union.

The author of seventeen books, as well as numerous papers, he is renowned for his contributions to the theory of associative rings, Lie algebras, Jordan algebras, and topological algebra. Presently retired and living in New Haven, Connecticut, Professor Jacobson retains a keen interest in the world of mathematics.

Response

I am greatly honored and deeply moved to have been chosen for the Leroy P. Steele Prize for Lifetime Achievement in Mathematics. It is especially gratifying for me to be honored in this way by the American Mathematical Society.

A lifetime achievement award is particularly meaningful for someone like me who has had, both professionally and personally, such a rich, rewarding, and, yes, long life. My mathematical career and the contributions you have cited in research, writing, and teaching have spanned a period of over sixty years. During that time it has been my pleasure to come in contact with many eminent mathematicians both here in the United States and throughout the world. As their work has stimulated and inspired me, so it is my hope that my own efforts, especially those in ring theory and the theory of Lie and Jordan algebras, will stimulate and inspire the research, writing, and teaching of those who come after.

There are many individuals whom it would be appropriate to thank, too many to name without the risk of omitting some. Nevertheless, I wish to acknowledge a special debt to my thesis advisor and mentor, J. H. M. Wedderburn. I also wish to express my gratitude to my fifty former thesis students who chose me as their mentor. Yale University should be singled out for giving me nearly half a century of support and a fertile academic environment in which to work. Finally, I want to thank my deceased wife, Florie, for her devotion and sparkling companionship over the course of a long and happy marriage. I could never have achieved as much as I did without her.

Once again, I extend my sincere gratitude to the American Mathematical Society, in particular to the members of the Steele Prize Committee, for this prestigious award. I will cherish this honor for the rest of my days. Thank you.