1995 Steele Prizes

Three Leroy P. Steele Prizes were presented at the awards banquet during the Summer Mathfest in Burlington, Vermont, in early August. 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.

...for a research paper of fundamental and lasting importance, for expository writing, and for cumulative influence

The Steele Prizes are awarded in three categories: for a research paper of fundamental and lasting importance, for expository writing, 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 1995 Steele Prizes are EDWARD NELSON for seminal contribution to research, JEAN-PIERRE SERRE for mathematical exposition, and JOHN T. TATE 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 Eugenio Calabi (chair), Ingrid Daubechies, Eugene Dynkin, Robert P. Langlands, Barry Mazur, Paul Rabinowitz, Marina Ratner, Gary M. Seitz, and William P. Thurston.

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

Edward Nelson: 1995 Steele Prize for Seminal Contribution to Research

The 1995 Leroy P. Steele award for research of seminal importance goes to Professor Edward Nelson of Princeton University for the following two papers in mathematical physics characterized by leaders of the field as extremely innovative:

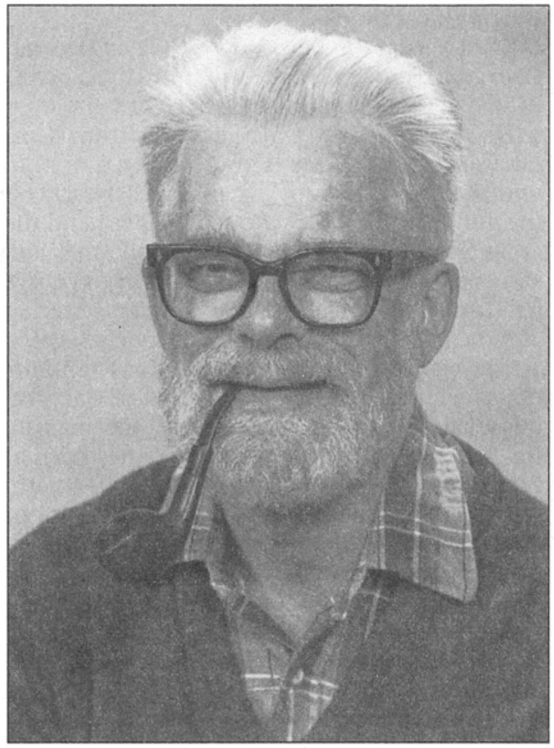
1. "A quartic interaction in two dimensions" in *Mathematical Theory of Elementary Particles*, MIT Press, 1966, pages 69–73;
2. "Construction of quantum fields from Markoff fields" in *Journal of Functional Analysis* 12 (1973), 97–112.

In these papers he showed for the first time how to use the powerful tools of probability theory to attack the hard analytic questions of constructive quantum field theory, controlling renormalizations with L^p estimates in the first paper and, in the second, turning Euclidean quantum field theory into a subset of the theory of stochastic processes.

Citation

The interaction of mathematics with relativistic quantum field theory is, in many respects, one of the signal mathematical developments of the second half of this century. Edward Nelson was one of the pioneers in this development. From the earliest attempts to turn quantum field theory into rigorous mathematics, it had been clear that operator algebras and distribution theory would play prominent roles. What Nelson realized, and implemented in these two fundamental papers, is that probabilistic techniques could provide critical additional tools. In the first of the two papers recognized by the award, Nelson overcame the infinities associated with Wick-ordering renormalization in two-dimensional field theories by a combination of measure theory and L^p estimates of semigroups. The techniques that he introduced for establishing in two dimensions the stability of the quartic interaction were fundamental, strongly influencing the further development by Glimm and Jaffe of rigorous quantum field theory in dimension three. They continue to be pertinent today in, for example, the theory of the nonlinear Schrödinger equation. Renormalization modifies a formal, nominally positive fourth power by the subtraction of an infinite constant, so that the positivity of the result was not at all clear, which was contested at the time the paper appeared. Nelson resolved the controversy, and in so doing devised the mathematical tools later generalized to a much larger class of Hamiltonians.

In the second paper recognized by the award, Nelson fired one of the first shots in what became known as the Euclidean revolution. The analytic continuation of relativistic field theory to imaginary time transforms formally the Minkowskian field theory into a Euclidean theory. Nelson realized that this was not only a formal trick, but provided a mathematical interpretation of certain stochastic processes. The concepts he introduced thus furnished a mathematically rigorous approach that combined the operator formalism in Minkowski space with the use of a Markov property symmetric with respect to space and time.



Edward Nelson

Response

I was introduced to probability theory in a graduate course taught by Irving Segal from galley proofs of Doob's "Stochastic Processes". Irving presented his own viewpoint in addition to Doob's, and it was an exciting course. Once he drove me down to Urbana so we could talk with Doob. It was a memorable trip. Maintaining that the probability of an accident is directly proportional to the time spent on the road, Irving drove in such a way as to minimize that time.

Despite having Irving Segal as thesis adviser, I did not learn physics at the University of Chicago. I took one course in the physics department but was defeated by the lab; I didn't really know how to explain the 457 percent error in my result for the mechanical equivalent of heat. But when I got to Princeton University, I attended several of Arthur Wightman's courses and pored over the papers of Richard Feynman and Kurt Symanzik, and after a while I began to learn the difference between a Lagrangian and a Hamiltonian.

In the first cited paper I put the field in a spatial box and proved that certain operators were bounded. But it was James Glimm who then proved that the bound is in fact 1, a result essential to removing the box. In the sequel to the second paper, when I studied the free Markov field, I omitted to refer to the work of Loren Pitt, who first introduced this field and proved the Markov property for it. He had sent me a preprint, but when I wrote the paper, I did not consciously remember it—these things can happen. No one who knows Loren will be surprised to hear that when I apologized to him, he was very gracious indeed.

One pleasant feature of receiving this prize is that it reminds me of how much fun I had working on those problems, almost as much fun as I am having now in my work. My advice to any young mathematician approaching the age of fifty who wants to continue having fun doing mathematics is this: change field.

Now I come to the main point, which is to express my thanks to the AMS and the Selection Committee for this Steele Prize. It was a great surprise to me. (Notice the shade of difference between that statement and "The committee made a very surprising choice.") It is a great honor, it is great fun, and I am grateful. Thank you. Also, thanks to the AMS for reserving a room for us with a jacuzzi.

Biographical Sketch

Edward Nelson was born May 4, 1932, in Decatur, Georgia. After first grade in Rome, Italy, he returned to Georgia in September 1939 and moved to New York in 1942, where children from Georgia were put back a half grade and required to undergo speech therapy. After secondary schooling at the Bronx High School of Science and the Liceo Scientifico Giovanni Verga in Rome, Nelson enrolled at the University of Chicago, where he obtained a Ph.D. in 1955 with a thesis on Markov processes written under Irving Segal.

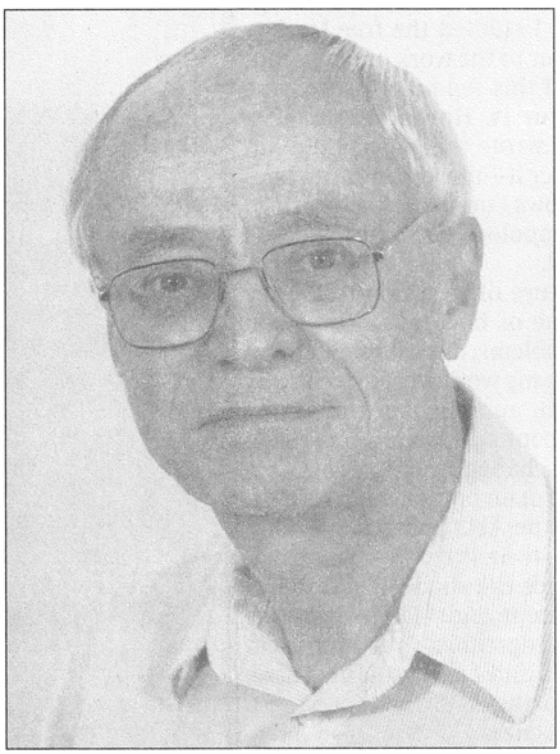
Nelson worked two years as a conscientious objector in the Methodist Hospital of Gary, Indiana, and then spent three years at the Institute for Advanced Study. Since 1959 he has been at Princeton University, where he served the mathematics department for six years as director of graduate studies and now as webmaster (`http://www.math.princeton.edu`).

His wife of thirty-five years, Nancy Wong Nelson, died in 1988. Since 1990 he has been married to Sarah Jones Nelson. He has two children and three grandchildren.

Nelson is a member of the American Academy of Arts and Sciences and doctor *honoris causa* of the Université Louis Pasteur in Strasbourg. His current research interests are logic and foundations.

Jean-Pierre Serre: 1995 Steele Prize for Mathematical Exposition

The 1995 Leroy P. Steele Prize for Mathematical Exposition is awarded to Professor Jean-Pierre Serre of the Collège de France, Paris, for his 1970 book *Cours d'Arithmétique*, with its English translation, published in 1973 by Springer-Verlag, *A Course in Arithmetic*.



Jean-Pierre Serre

Citation

It is difficult to decide on a single work by a mathematician of Jean-Pierre Serre's stature which is most deserving of the Steele Prize. Any one of Serre's numerous other books might have served as the basis of this award. Each of his books is beautifully written, with a great deal of original material by the author, and everything smoothly polished. It would be hard to make any significant improvement on his expositions; many are the everyday standard references in their areas, both for working mathematicians and graduate students. Serre brings his whole mathematical personality to bear on the material of these books; they are alive with the breath of real mathematics and are an example to all of how to write for effect, clarity, and impact. One reason for choosing *A Course in Arithmetic* for the award is the basic nature of the subject. Every mathematics graduate student should become thoroughly acquainted with at least the first quarter of the book as part of the algebra background, and with the first half if the chosen field of specialization is to be related to algebra. What is remarkable is the conciseness, the clarity, and the completeness of the topics treated.

The second half of the book, also purely expository and covering "classical" topics, is a jewel of concise exposition of the link between the combinatorial aspects of elementary number theory and the methods of function theory (zeta function, L-functions, and Eisenstein series): this is a beautiful encapsulation of what is the glory of nineteenth-century arithmetic, providing a background to the modern-day developments in geometry of numbers and number theory.

The remarkable feature of this book is that the whole exposition is compressed into a little over one hundred pages, including all but the most obvious proofs and a thorough bibliography of the more extensive coverage of the topics treated.

Response

It is a nice surprise to receive a Steele Prize for my old little book *Cours d'Arithmétique*. Thank you.

An old book indeed. Not only was it published in 1970, but the actual writing took place much earlier:

- as an exposé at the 1961–1962 Cartan Seminar on two papers of Milnor on quadratic forms over Z and the homotopy type of 4-manifolds,
- as a set of lecture notes (École Normale Supérieure, 1962) on the classification of quadratic forms over Q,
- as another such set of notes (E.N.S., 1964) on Dirichlet's arithmetic progression theorem and modular forms of level 1.

To get a book from these texts, only scissors and glue were needed (and a log table, in order to compute some mass formulae). Strangely enough, the different pieces fitted well together; I was especially pleased with the way algebraic and analytic arguments complemented each other.

The book first appeared in a handsome pocket-size format, very reasonably priced (about three dollars). Still, there were some troubles, the worst one being an erroneous computation of the Eisenstein series $E2$ (shame on me). The English translation, *A Course in Arithmetic*, did not fare better: the first edition had so many misprints that I dubbed it *A Curse in Arithmetic*.

All this is past. New corrected editions have followed and by now the misprints are fewer. The real question is: will the book continue to be useful? I hope so, and the Steele award seems a good omen. Thanks, AMS!

Biographical Sketch

Jean-Pierre Serre was born in Bages, France, on September 15, 1926. He studied at the École Normale Supérieure in Paris from 1945 to 1948 and received his Ph.D. in mathematics from the Sorbonne in 1951. Between 1948 and 1954, he was *attaché, chargé*, and *maître de recherches* at the Centre National de la Recherche Scientifique in Paris. After two years at the University of Nancy, he was appointed professor and chair of Algebra and Geometry at the Collège de France in 1956; he has been an honorary professor there since 1994. Over the years, he has spent a good deal of time in the United States, especially at the Institute for Advanced Study at Princeton and at Harvard University.

Professor Serre has been elected to the Academies of Science of several nations: France (1977), the Netherlands (1978), the United States (1979), and Sweden (1980). He was named an honorary member of the London Mathematical Society in 1973, and an honorary fellow of the Royal Society in 1974. He has received honorary degrees from the Universities of Cambridge (1978), Stockholm (1980), and Glasgow (1983). He received the Fields Medal in 1954 and the Balzan Prize in 1985.

The author of a dozen books and numerous research papers, Professor Serre works in topology, analytic geometry, algebraic geometry, group theory, and number theory.

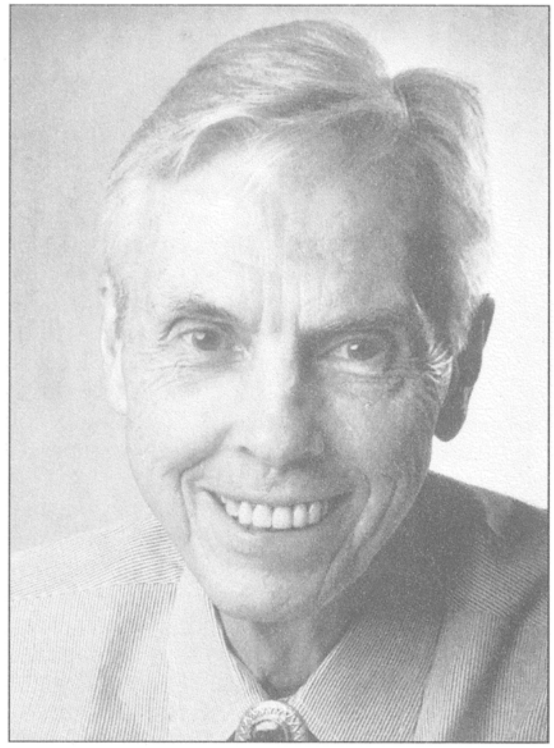
John T. Tate: 1995 Steele Prize for Lifetime Achievement

The 1995 Leroy P. Steele Prize for Lifetime Achievement in Mathematics goes to Professor John Tate of the University of Texas in Austin.

Citation

John Tate was born in 1925, received his Ph.D. from Princeton in 1950 and taught at Harvard University during the years 1954 through 1990, before moving to his current position as Sid W. Richardson Chair of Mathematics at the University of Texas at Austin.

Tate's scientific accomplishments span four and a half decades. He has been deeply influential in many of the important developments in algebra, algebraic geometry, and number theory during this time.



John Tate

His 1950 Princeton thesis,"Fourier Analysis in Number Fields and Hecke's Zeta-Functions", initiated the use of methods of harmonic analysis in the study of L-functions which have importance in arithmetic, evaluated at the adelic points of various reductive groups. A prodigious amount of later mathematical activity has been inspired by this initial contribution.

Tate's early work was instrumental in the development of the foundations of group cohomology and Galois cohomology. His famous collaboration with Artin, providing a Galois cohomological exposition of class field theory; his 1952 paper,"The Higher Dimensional Cohomology Groups of Class Field Theory" (for which he received the 1956 Cole Prize in Number Theory); and his papers on principal homogeneous spaces for abelian varieties (1958 with Lang, and 1962) might be viewed as all leading the theory up to the point where its language is adequate for the formulation of Tate's deep duality theorems (as first expressed in his 1962 International Congress of Mathematicians address in Stockholm, "Duality Theorems in Galois Cohomology over Number Fields"). It would be hard to catalogue all the later developments in the subject (and in nearby subjects) that are critically dependent upon this work. His construction of (what is now known as) the Shafarevich-Tate group, and his recognition of the crucial role that this group was destined to play in arithmetic, was, in itself, a fundamental insight.

In the years between 1962 and 1966, Tate published papers (one with Sen, one with Lubin) related to local arithmetic. In 1966 he published his very important article "p-Divisible Groups", which initiated the theory of those eponymous groups and which was one of the first penetrating studies of interesting p-adic representations of Galois groups of local fields whose residual characteristic is p. This difficult chapter of number theory is still a crucial concern and remains the focus of intense activity; it would not be an exaggeration to say that the basic groundwork for much of this study is to be found in Tate's article "p-Divisible Groups".

This same period saw Tate formulating his famous conjectures, e.g., the Tate Conjecture about algebraic cycles, and saw the publication of his article " Endomorphisms of Abelian Varieties over Finite Fields", in which Tate manages to actually construct cycles given only cohomological information.

Beginning in the early 1970s, Tate published a series of papers in algebraic K-theory, more specifically in $K2$, and his 1976 paper, "Relations between $K2$ and Galois Cohomology", is both elegant and gets to the essential nature of $K2$ of a number field.

In this same period, en passant, Tate's "Rigid Analytic Spaces" published in the *Inventiones* (1971) initiated a completely different subject. But it was no surprise that Tate might have interests in that direction in view of his celebrated p-adic uniformization theory for elliptic curves and abelian varieties and his theory of what is now called the Tate curve. For a fine account of this, see Tate's "A review of non-archimedean elliptic functions" published (pp. 162–184) in the volume *Elliptic Curves, Modular Forms, and Fermat's Last Theorem* (1995) by International Press.

The early 1980s saw Tate's interest turning to the intriguing Conjectures of Stark on the connection between L-functions at the point $s = 0$ and logarithms of algebraic units (or determinants of such logarithms). Tate pursued these conjectures also in the function field setting where one can understand the structure involved with somewhat greater perspicuity and make some progress. This work culminated in a book Tate wrote on the subject (1984).

Also in that decade, Tate was engaged in a close study of the Classical Conjectures of Birch and Swinnerton-Dyer, various refinements of those conjectures, and especially p-adic analogues of them (and concomitantly, a construction and study of the p-adic sigma function).

In the 1990s Tate has written papers on noncommutative ring theory and, more specifically, is currently engaged in the construction and study of interesting Sklyanin algebras.

And beyond all this published work, Tate's engagement with mathematics, through his great number of students and his extensive (and widely circulated) correspondence, has been continuous and intense. All this adds up to a magnificent career well worthy, in the opinion of this committee, of the 1995 Leroy P. Steele career award.

Response

It is an honor and a pleasure for me to get this award in recognition of my efforts over a lifetime to discover new relationships in number theory and algebra, and to help young people with similar interests get started along the same path. I myself as a young man had the great good fortune to learn about algebraic numbers class fields, and much more from E. Artin, who also gave me a beautiful and important idea to work out as a Ph.D. thesis. I have always found it easier to learn from people than from books and papers and would like to thank the many fellow mathematicians who over the years have taught me new things and suggested new ideas: David Mumford, Michael Artin, Serge Lang, J.-P. Serre, A. Grothendieck, and Barry Mazur, to name a few who have helped me the most. One of the best ways to learn is to teach, and I want also to take this opportunity to thank my many students for the pleasure and stimulation working with them has given me. A lifetime of mathematical activity is a reward in itself, but it is nice to have recognition for it from peers. My warm thanks to the Steele Prize committee for selecting my career from the many equally or more deserving ones for this award.

Biographical Sketch

John T. Tate was born in Minneapolis in 1925. After three years in the U.S. Navy, he received his B.A. from Harvard University in 1946 and his Ph.D. from Princeton University in 1950. He was an instructor at Princeton from 1950 to 1954, when he went to Harvard. After thirty-six years at Harvard, he went to the University of Texas at Austin, where he is currently a professor and the Sid Richardson Regents Chairholder.

Professor Tate received a Sloan Foundation Fellowship (1957–1958) and a Guggenheim Fellowship (1965–1966). He has held visiting positions at Columbia University, the University of California at Berkeley, Institut des Hautes Études Scientifiques, Université de Paris at Orsay, Princeton University, and École Normale Supérieure. He was an invited speaker at the International Congress of Mathematicians in 1962 in Stockholm and again in 1970 in Nice. In 1973, he presented the AMS Colloquium Lectures.

A member of the National Academy of Sciences and of the Académie des Sciences, Paris, Professor Tate is the recipient of the 1956 AMS Cole Prize in Number Theory.