Tapia and Varadhan Receive National Medal of Science

On September 27, 2011, President Barack Obama announced the recipients of the National Medal of Science. Among the twelve recipients are two mathematicians: Richard A. Tapia of Rice University and S. R. Srinivasa Varadhan of New York University.

Richard A. Tapia

Richard A. Tapia was honored "for his pioneering and fundamental contributions in optimization theory and numerical analysis and for his dedication and sustained efforts in fostering diversity and excellence in mathematics and science education." Tapia joined the faculty at Rice University in 1970. He is currently University Professor, Maxfield-Oshman Professor in Engineering, and professor of computational and applied mathematics. He is also director of Rice's Center for Excellence and Equity in Education and associate director of graduate studies.

The *Notices* asked Yin Zhang of Rice University to comment on the work of Tapia. Zhang responded: "Tapia's research centers around theory and algorithms for mathematical optimization—a field that he started to pursue in the days of his Ph.D. study at the University of California, Los Angeles, with a dissertation entitled *A generalization of Newton's method with an application to the Euler-Lagrange equation*. During his over forty-year tenure at Rice University, he helped build a first-class applied mathematics program including a world-leading optimization group. Deeply influenced by his advisor M. R. Hestenes at UCLA, a large part of Tapia's research concentrates on studying theoretical properties and computational performance of algorithms that are practically applicable, especially Newton's method and its variants such as quasi-Newton methods. Since the 1970s, Tapia has made a number of significant contributions to research extending Newton's method to various settings of constrained optimization, including eigenvalue problems. An important aspect of his work is to analyze asymptotic rates of convergence in Newton-type methods. As is well known, under standard conditions Newton's method applied to nonlinear systems has a quadratic rate of convergence, which is a source of effectiveness for the method. When one extends Newton's method, the ability to preserve a fast convergence rate, as much as practically viable, is a primary consideration in algorithm design and analysis. In the 1990s, when interior-point methods for linear and other convex programming became a focus of optimization research, Tapia and his co-workers treated a large class of interior-point methods in a Newton-like framework, establishing that these methods, when appropriately implemented, have not only nice global behavior in the form of polynomial-time complexity, but also a super-linear or even faster local convergence rate under weaker than usual assumptions. Taking into account both global and local behaviors, these results significantly bridge the gap between theory and practice of interior-point methods and provide guidelines for, as well as realistic explanations of, algorithm design and refinement."

Tapia grew up in Los Angeles as the son of Mexican immigrants. He was the first member of his family to attend college. He received his B.A. in 1961, his M.A. in 1966, and his Ph.D. in 1967, all from the University of California, Los Angeles. He was a lecturer at UCLA and a faculty member at the University of Wisconsin before joining the Rice faculty.

In 1992 Tapia became the first Hispanic elected to the National Academy of Engineering. He served on the National Science Board from 1996 until 2002, and from 2001 to 2004 he chaired the National Research Council's Board on Higher Education and the Workforce. He was the recipient of the AMS Distinguished Public Service Award in 2004. His other honors include the National Science Foundation's Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring (1996); the Lifetime Mentor Award from the American Association for the Advancement of Science (1997); the Distinguished Service to the Profession Award from the Society for Industrial and Applied Mathematics (2004); and the Distinguished Scientist Award from the Society for the

Advancement of Chicanos and Native Americans in Science (2000). He was named one of the most influential leaders in minority math education by the National Research Council and in 1994 was the first recipient of the Computing Research Association's A. Nico Habermann Award for outstanding contributions to aiding members of underrepresented groups within the computing research community. In 2005 Tapia was elected to the Board of Directors for TAMEST, which comprises the Texas members of the National Academy of Engineering, National Academy of Sciences, and the Institute of Medicine. Tapia has authored or coauthored two books and more than 100 mathematical research papers, and he is currently writing a graduate-level textbook on the foundations of optimization.

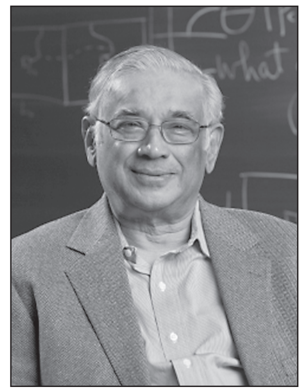
Tapia has been a leader in directing underrepresented minority and women doctoral students in mathematics. He directs programs supported by the Alfred P. Sloan Foundation, the National Science Foundation, and other organizations that are designed to increase the number of underrepresented minorities obtaining graduate degrees in science, technology, engineering, and mathematics and to enhance the preparation of underrepresented minorities for faculty positions in academia.

S. R. S. Varadhan

S. R. Srinivasa Varadhan is the Frank Jay Gould Professor of Science and professor of mathematics at the Courant Institute of Mathematical Sciences at New York University. He was honored with the National Medal of Science "for his work in probability theory, especially his work on large deviations from expected random behavior, which has revolutionized this field of study during the second half of the twentieth century and become a cornerstone of both pure and applied probability. The mathematical insights he developed have been applied in diverse fields, including quantum field theory, population dynamics, finance, econometrics, and traffic engineering." His research has centered on the theory of large deviations—the probability of rare events. His contributions have provided a method for understanding a range of phenomena, and his work has been employed in a variety of fields, including finance, traffic engineering, and biology.

The *Notices* asked Daniel Stroock of the Massachusetts Institute of Technology to comment on the work of Varadhan. Stroock responded: "The hallmark of Varadhan's work is his consistently elegant solutions to sometimes less than elegant problems. In his doctoral thesis at the Indian Statistical Institute in Calcutta, he characterized the family of infinitely divisible laws on a Hilbert space. In the process, he acquired a deep understanding of weak convergence of measures, an understanding whose depth would be demonstrated repeatedly throughout his career. After coming to the Courant Institute at New York University, he came under the influence of Monroe Donsker, who himself was an intellectual descendant of Norbert Wiener. In particular, like Wiener, Donsker thought of Wiener measure in more analytic terms than most of his contemporaries in probability theory. This viewpoint was reflected in the thesis of Donsker's student M. Schilder, who developed a systematic way of computing asymptotics for certain Wiener integrals. When he learned about Schilder's work, Varadhan realized that it could be seen as an infinite dimensional version of what statisticians call *the theory of large deviations* and that when one formulated Schilder's results in this context it would be possible to make significant extensions. In order to appreciate how remarkable this insight was, one has to know that, at the time, a theory of large deviations did not really exist. There was a hodgepodge of results, the most famous of which was due to H. Cramér, but there was nothing that deserved to be called a mathematically precise description, much less a *theory*, of large deviations. Hence, before he could carry out his program, Varadhan had to invent the theory in which he intended to embed Schilder's theorem, and thus was born what is now called *the large deviations principle*. For those who know the modern treatment of weak convergence, the large deviations principle has a familiar ring. However, to transform the ideas of weak convergence so that they become amenable to the study of large deviations required profound understanding of both topics. After his seminal work on large deviations, Varadhan took a vacation from large deviations, and for close to a decade he devoted his efforts to the study of diffusion processes. Here again he is responsible for major breakthroughs, both in the formulation of the theory as well as its applications. He was induced to end his vacation by Donsker. Many years before, M. Kac had given a formula for the principle eigenvalue of a Schrödinger operator in terms of the asymptotics of a Wiener integral, and Donsker was convinced that Kac's formula could be understood in a more general context. After Varadhan joined Donsker, he realized that Kac's formula could be obtained from a large deviations principle, albeit one of an entirely novel sort. Whereas Schilder's result involved large deviations of Wiener paths during short time intervals, the

Richard A. Tapia



S. R. S. Varadhan

large deviations underlying Kac's formula involved the long-time behavior of Wiener paths and the deviations of their empirical measures from ergodic behavior. In a sequence of articles, the two of them developed the requisite theory and proved a sequence of remarkable results, including solutions to long-standing problems in mathematical physics. After Donsker's death, Varadhan applied his and Donsker's theory to elucidate and extend the theory of hydrodynamic limits, along the way introducing wholly new applications of entropy. Without question, the contributions of S. R. S. Varadhan place him in an elite group of modern mathematicians."

Born January 2, 1940, in Madras (Chennai), India, Varadhan received his B.Sc. in 1959 and his M.A. in 1960, both from Madras University. He received his Ph.D. in 1963 from the Indian Statistical Institute, Calcutta, under the direction of C. R. Rao. He began his long career at the Courant Institute with a postdoctoral fellowship in 1963 and has served two terms as its director (1980–1984 and 1992–1994). He received the AMS Leroy P. Steele Prize jointly with Daniel Stroock in 1996, and in 2007 he was awarded the Abel Prize in Mathematics by the Norwegian Academy of Science and Letters for "his fundamental contributions to probability theory". His other honors include the Birkhoff Prize (1994) and the Margaret and Herman Sokol Award of NYU's Faculty of Arts and Science (1995). He has held Alfred P. Sloan and Guggenheim Fellowships. He has been an invited speaker at the International Congresses of Mathematicians in 1978 and in 1994. He is a member of the American Academy of Arts and Sciences (1988), the Third World Academy of Sciences (1988), the Norwegian Academy of Science and Letters, and the U. S. National Academy of Sciences (1995). He is an elected fellow of the Institute of Mathematical Statistics (1991), the Royal Society (1998), and the Indian Academy of Sciences (2004).

About the Medal

The National Medal of Science is the country's highest distinction for contributions to scientific research. According to a news release from the Office of Science and Technology Policy, "the National Medal of Science honors individuals for pioneering scientific research in a range of fields, including physical, biological, mathematical, social, behavioral, and engineering sciences, that enhances our understanding of the world and leads to innovations and technologies that give the United States its global economic edge." The National Science Foundation administers the award, which was established by Congress in 1959.

— Elaine Kehoe