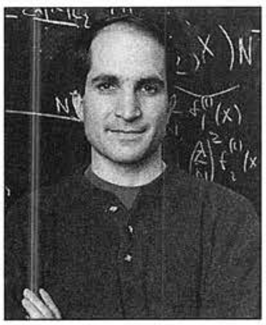
Maldacena, Shor, Silverstein, and Weeks Receive MacArthur Fellowships



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Jeffrey Weeks

In June 1999 the John D. and Catherine T. MacArthur Foundation announced 31 new MacArthur Fellowships presented to 32 individuals. The Fellows will receive stipends ranging from $200,000 to $375,000 over five years, depending on the age of the recipient.

Four of the fellows work in the mathematical sciences: JUAN MARTIN MALDACENA, PETER SHOR, EVA SILVERSTEIN, and JEFFREY R. WEEKS.

Juan Maldacena

Juan Maldacena was born September 10, 1968, in Buenos Aires, Argentina. He is redefining the boundaries of mathematical physics. He works in the highly abstract field of string theory, which postulates the existence of fundamental constituents of matter too small to detect with current experimental apparatus. He has made key conceptual breakthroughs that have clarified thorny problems in theoretical physics, including the ultimate structure of matter.

In his graduate work, Maldacena showed how radiation from a black hole can be explained within the context of string theory. This work holds important implications for understanding gravity. String theories inherently include an explanation of gravitation consistent with quantum effects. More recently, Maldacena captured the attention of the theoretical physics community by postulating a critical theoretical link between the 4-dimensional structure of quantum chromodynamics (QCD) and a 10-dimensional theory based on strings. (There are only five possible meaningful string theories, each of which represents a limiting case of a single 11-dimensional model known as "M-theory".) By identifying a plausible method for explaining the earlier QCD theory in the context of the newer but purely theoretical field of string theories, Maldacena's work holds out the promise of a "grand unification" of all known physical forces.

Maldacena completed his undergraduate studies at the University of Buenos Aires and Universidad de Cuyo, Bariloche, Argentina (1991), and his Ph.D. (1996) at Princeton University. He did a year of postdoctoral work at Rutgers Unversity. Maldacena has been teaching at Harvard University since 1997. His MacArthur Fellowship stipend is $245,000.

Peter Shor

Peter Shor was born August 14, 1959, in New York, New York. He is helping shape the field of quantum computing. Using tools from physics, computation, and information theory, his discoveries offer the possibility of an exponential increase in the speed of an important class of calculations. In so doing, he is breaking limits in computing previously thought to be insurmountable.

It has been known since the 1980s that the superposition of states in quantum mechanics allows, at least in principle, the construction of quantum computers whose computational phase is massively parallel and hence more efficient than classical computers. However, the typical quantum measurement process irrevocably alters a state, and this fact raises obstacles to obtaining the desired output. Shor was the first to show how to design, from start to finish, an algorithm by which a quantum computer could efficiently solve an important practical problem, the factoring of large numbers. Should large quantum computers ever be built, public-key cryptography, whose most popular manifestations rely upon on the supposed difficulty of factoring large integers and computing discrete logarithms, would no longer be secure.

Shor was the first to show that fault-tolerant quantum computation is possible. Because quantum mechanics precludes cloning states and because measurements alter them, many physicists thought that error correction during computation was impossible. Shor showed how entangled states (which are superpositions in a tensor product space) can be used to construct error-correcting codes. Subsequently, together with Calderbank and others at AT&T, Shor showed how to construct a much larger class of better codes. This work has spawned important new mathematical work in coding theory and noncommutative algebra as well.

Shor received a B.S. (1981) from the California Institute of Technology and a Ph.D. (1985) from the Massachusetts Institute of Technology. He did postdoctoral work (1985–86) at the Mathematical Sciences Research Institute in Berkeley. He has been at AT&T Labs Research since 1986. In 1998 he received the Nevanlinna Prize [see "Peter Shor Receives Nevanlinna Prize", *Notices*, November 1998, page 1361]. His MacArthur Fellowship stipend is $290,000.

Eva Silverstein

Eva Silverstein was born October 24, 1970. A theoretical physicist, she questions fundamental assumptions of physics theory. In collaboration with Shamit Kachru, an assistant professor of physics at the University of California, Berkeley, Silverstein is linking recent theories of particle physics and cosmology. She explores the relationship between the cosmological constant (a concept that originated with Einstein's general theory of relativity) and more recent explanations of particle physics based on string theory. These studies provide key insights into the age, structure, dynamics, and eventual fate of the universe.

Kachru and Silverstein have adopted a contrarian strategy for understanding empty space. Beginning with Einstein, physicists have increasingly recognized that explaining the properties of empty space is critical to explaining our observations of mass, gravity, and cosmology. Quantum theory requires any vacuum to be filled with particles and antiparticles, continually created and annihilated. Getting the equations to add up properly requires quantum field theorists to postulate a host of as yet unobserved particles subsumed under a theory known as "supersymmetry". The mathematically desirable properties of this theory have been adopted by string theorists as "superstrings". Against this body of research, Kachru and Silverstein have employed orbifold theory to show how string theory can potentially explain vacua without resorting to postulating a zoo of supersymmetric particles. If successful, this program would greatly reduce the conflict between the cosmological constant and particle physics. In addition to her work on nonsupersymmetric vacua, Silverstein and collaborators have made noteworthy contributions to the development of M-theory, the umbrella theory for string theories.

Silverstein received a B.A. (1992) from Harvard University and a Ph.D. in physics (1996) from Princeton University. She worked for one year as a postdoctoral associate at Rutgers University and has been an assistant professor at the Stanford University Linear Accelerator Center since 1997. Her MacArthur Fellowship stipend is $235,000.

Jeffrey Weeks

Jeffrey Weeks was born December 10, 1956, in Coronado, California. Weeks is a researcher, writer, software developer, and mathematics educator. He has made fundamental contributions to the analysis of knots and collaborates with cosmologists to determine the shape of the universe. His software (available without charge) provides a powerful tool for researchers and for teaching low-dimensional geometry. In addition, Weeks writes texts and articles which are targeted at young adults and nonspecialists and are designed to stimulate interest and skill in thinking about geometry and space.

Weeks's mathematical research centers on describing the topology of knots and hyperbolic structures. He developed a practical computer algorithm for classical knots with hyperbolic complements using a method called "canonical cell decomposition". This algorithm allows mathematicians to quantify permutations of knots delineated by a user-defined set of constraints and then to test and group the topological properties of these knots. On the basis of this work, Weeks developed a general-purpose computer program called SnapPea, which is widely used by mathematicians to explore a large variety of geometrical problems. His book *The Shape of Space* (Marcel Dekker, 1985) is an approachable introduction to topological analysis. Although Weeks currently holds no academic position, he collaborates with astronomers, helping them understand how microwave observations can be interpreted in order to determine the topology of the cosmos [see "Measuring the Shape of the Universe", by Neil J. Cornish and Jeffrey R. Weeks, *Notices*, December 1998, pages 1463–71].

Weeks received a B.A. (1978) from Dartmouth College and an M.A. (1980) and a Ph.D. (1985) from Princeton University. Until 1992 he held short teaching positions at Stockton State College, Ithaca College, and Middlebury College. He now works as an independent scholar. His MacArthur Fellowship stipend is $305,000.

About the MacArthur Fellowships

The MacArthur Fellows Program provides unrestricted fellowships to exceptionally talented and promising individuals who have shown evidence of originality, dedication to creative pursuits, and capacity for self-direction. Fellowships are granted directly to individuals rather than through institutions. They are awarded without project proposals or applications, and no evaluations or specific products or reports are expected.

MacArthur Fellows are free to focus on more than one area through interdisciplinary work, to change fields if they wish, or even to alter the direction of their careers. They may be writers, scientists, artists, social scientists, humanists, activists, or workers in any other field or fields, with or without institutional affiliations.

The MacArthur Fellows Program accepts nominations only from the more than 100 designated nominators across the country in a range of academic and professional fields.

—From MacArthur Foundation announcements, adapted by Allyn Jackson and Mary Beth Ruskai