

# Sinai Awarded 2014 Abel Prize

Photo courtesy of Princeton University  
Mathematics Department.



**Yakov Sinai**

The Norwegian Academy of Science and Letters has awarded the Abel Prize for 2014 to YAKOV SINAI of Princeton University and the Landau Institute for Theoretical Physics of the Russian Academy of Sciences “for his fundamental contributions to dynamical systems, ergodic theory, and mathematical physics.” The Abel Prize recognizes contributions of extraordinary depth and influence in the mathematical sciences and has been awarded annually since 2003. The prize carries a cash award of approximately US\$1 million. Sinai received the Abel Prize at a ceremony in Oslo, Norway, on May 20, 2014.

## Citation

Ever since the time of Newton, differential equations have been used by mathematicians, scientists, and engineers to explain natural phenomena and to predict how they evolve. Many equations incorporate stochastic terms to model unknown, seemingly random, factors acting upon that evolution. The range of modern applications of deterministic and stochastic evolution equations encompasses such diverse issues as planetary motion, ocean currents, physiological cycles, population dynamics, and electrical networks, to name just a few. Some of these phenomena can be foreseen with great accuracy, while others seem to evolve in a chaotic, unpredictable way. Now it has become clear that order and chaos are intimately connected: we may find chaotic behavior in deterministic systems, and conversely, the statistical analysis of chaotic systems may lead to definite predictions.

Yakov Sinai has made fundamental contributions in this broad domain, discovering surprising connections between order and chaos and developing the use of probability and measure theory in the study of dynamical systems. His achievements include seminal works in ergodic theory, which studies the tendency of a system to explore all of its available states according to certain time statistics, and in statistical mechanics, which explores the behavior of systems composed of a very large number of particles, such as molecules in a gas.

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Sinai’s first remarkable contribution, inspired by Kolmogorov, was to develop an invariant of dynamical systems. This invariant has become known as the Kolmogorov-Sinai entropy, and it has become a central notion for studying the complexity of a system through a measure-theoretical description of its trajectories. It has led to very important advances in the classification of dynamical systems.

Sinai has been at the forefront of ergodic theory. He proved the first ergodicity theorems for scattering billiards in the style of Boltzmann, work he continued with Bunimovich and Chernov. He constructed Markov partitions for systems defined by iterations of Anosov diffeomorphisms, which led to a series of outstanding works showing the power of symbolic dynamics to describe various classes of mixing systems.

With Ruelle and Bowen, Sinai discovered the notion of SRB measures: a rather general and distinguished invariant measure for dissipative systems with chaotic behavior. This versatile notion has been very useful in the qualitative study of some archetypal dynamical systems, as well as in the attempts to tackle real-life complex chaotic behavior such as turbulence.

Sinai’s other pioneering works in mathematical physics include random walks in a random environment (Sinai’s walks), phase transitions (Pirogov-Sinai theory), one-dimensional turbulence (the statistical shock structure of the stochastic Burgers equation, by E-Khanin-Mazel-Sinai), the renormalization group theory (Bleher-Sinai), and the spectrum of discrete Schrödinger operators.

Sinai has trained and influenced a generation of leading specialists in his research fields. Much of his research has become a standard toolbox for mathematical physicists. His works had and continue to have a broad and profound impact on mathematics and physics, as well as on the ever-fruitful interaction of these two fields.

## Biographical Sketch

Yakov G. Sinai was born on September 21, 1935, in Moscow, Russia. Both of his parents, Gregory Sinai and Nadezda Kagan, were microbiologists with research careers. His grandfather, the mathematician Benjamin Fedorovich Kagan, was head of the Department of Differential Geometry at Moscow State University. Kagan had great influence on his grandson. He retired from his chair at Moscow

State University in 1952, the year in which his grandson Yakov Grigorevich entered the Faculty of Mechanics and Mathematics.

Sinai received his B.S. (1957), his Ph.D. (1960), and his doctorate (1963) from Moscow State University. His advisor was the prominent Andrey Kolmogorov. Sinai was a scientific researcher at the Laboratory of Probabilistic and Statistical Methods at Moscow State University from 1960 to 1971. In 1971 he became a professor at Moscow State University and a senior researcher at the Landau Institute of Theoretical Physics, Russian Academy of Sciences. Since 1993 he has been a professor of mathematics at Princeton University but has concurrently kept his position at the Landau Institute of Theoretical Physics. During 1997–1998 Sinai was Thomas Jones Professor at Princeton University and in 2005 he was Moore Distinguished Scholar at the California Institute of Technology in Pasadena, California.

Sinai is one of the most influential mathematicians of the twentieth century. He has achieved numerous groundbreaking results in the theory of dynamical systems, in mathematical physics, and in probability theory. Many mathematical results are named after him, including Kolmogorov-Sinai entropy, Sinai's billiards, Sinai's random walk, Sinai-Ruelle-Bowen measures, and Pirogov-Sinai theory. Sinai is highly respected in both physics and mathematics communities as the major architect of the most bridges connecting the world of deterministic (dynamical) systems with the world of probabilistic (stochastic) systems. Perhaps it is only to be expected that he is the author of an article titled "Mathematicians and physicists = cats and dogs?" (*Bulletin of the American Mathematical Society (NS)* 43 (2006), no. 4, 563–565).

During the past half-century Sinai has written more than 250 research papers and a number of books. Sinai and his wife, Elena B. Vul, a mathematician and physicist, have also written a number of joint papers. Sinai has supervised more than fifty Ph.D. students.

The deep contributions made by Sinai early in his career led to his being invited to lecture at the International Congress of Mathematicians in Stockholm in 1962. Sinai has since been an invited speaker at several important international conferences and has given many prestigious lectures worldwide. He has spoken four times at the International Congress of Mathematicians. He was a plenary speaker at the First Latin American Congress in Mathematics in 2000. In 2001 he was appointed Chairman of the Fields Medal Committee of the International Mathematical Union, which decided on the awards of the Fields Medals at the Congress in Beijing in the following year.

Sinai has received many distinguished international awards. In 2013 he was awarded the Leroy P. Steele Prize for Lifetime Achievement from the

American Mathematical Society. Other awards include the Wolf Prize in Mathematics (1997), the Nemmers Prize in Mathematics (2002), the Henri Poincaré Prize from the International Association of Mathematical Physics (2009), and the Dobrushin International Prize from the Institute of Information Transmission of the Russian Academy of Sciences (2009). Among his many recognitions are the Boltzmann Gold Medal from the Commission on Statistical Physics of the International Union of Pure and Applied Physics (1986) and the Dirac Medal from the Abdus Salam International Centre for Theoretical Physics in Trieste (1992).

Many mathematical societies and academies have elected Sinai to membership or honorary membership: the American Academy of Arts and Sciences (1983), the Russian Academy of Sciences (1991), the London Mathematical Society (1992), the Hungarian Academy of Sciences (1993), the United States National Academy of Sciences (1999), the Brazilian Academy of Sciences (2000), the Academia Europaea (2008), the Polish Academy of Sciences (2009), and the Royal Society of London (2009).

He has received honorary degrees from Warsaw University (1993), Budapest University of Science and Technology (2002), the Hebrew University in Jerusalem (2005), and Warwick University (2010). Sinai is also respected as a teacher at Princeton. In the words of a former student, "It's quite inspirational to be in his class... People feel an immediate urge to participate—there is a radiance which comes from him and inspires us." He is also known for his persistence in the face of obstacles, be they bureaucratic or theoretical, a trait which has served him well throughout the years.

### About the Prize

The Niels Henrik Abel Memorial Fund was established in 2002 to award the Abel Prize for outstanding scientific work in the field of mathematics. The prize is awarded by the Norwegian Academy of Science and Letters, and the choice of Abel Laureate is based on the recommendation of the Abel Committee, which consists of five internationally recognized mathematicians.

Previous recipients of the Abel Prize are Jean-Pierre Serre (2003), Michael Atiyah and I. M. Singer (2004), Peter Lax (2005), Lennart Carleson (2006), S. R. S. Varadhan (2007), John G. Thompson and Jacques Tits (2008), Mikhail L. Gromov (2009), John Tate (2010), John Milnor (2011), Endre Szemerédi (2012), and Pierre Deligne (2013).

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