# 2008 Conant Prize

The 2008 Levi L. Conant Prize was awarded at the 114th Annual Meeting of the AMS in San Diego in January 2008.

The Conant Prize is awarded annually to recognize an outstanding expository paper published in either the *Notices of the AMS* or the *Bulletin of the AMS* in the preceding five years. Established in 2001, the prize honors the memory of Levi L. Conant (1857–1916), who was a mathematician at Worcester Polytechnic University. The prize carries a cash award of US$1,000.

The Conant Prize is awarded by the AMS Council acting on the recommendation of a selection committee. For the 2008 prize the members of the selection committee were: Noam D. Elkies, Stephen J. Greenfield, and Carl R. Riehm (chair).

Previous recipients of the Conant Prize are: Carl Pomerance (2001), Elliott Lieb and Jakob Yngvason (2002), Nicholas Katz and Peter Sarnak (2003), Noam D. Elkies (2004), Allen Knutson and Terence Tao (2005), Ronald M. Solomon (2006), and Jeffrey Weeks (2007).

The 2008 Conant Prize was awarded to J. BRIAN CONREY; and to SHLOMO HOORY, NATHAN LINIAL, and AVI WIGDERSON. The text that follows presents the committee's citations, brief biographical sketches of the authors, and their responses upon receiving the prize.

## J. Brian Conrey

### Citation

"The Riemann Hypothesis", *Notices*, March 2003, pages 341–353.

The Riemann Hypothesis (RH) has a strong claim to being the outstanding open problem in mathematics. Much has been written about RH, but rarely with anything like the scope that Conrey covers in but a dozen *Notices* pages, outlining the mathematical context that justifies the importance of RH, key moments in the problem's 140-plus-year history, known partial results and blind alleys, various threads of numerical and theoretical evidence, and suggestive connections with disparate branches of mathematics and theoretical physics. The mathematical exposition is enhanced by the judicious use of anecdotes illustrating the human drama of the quest for a proof and of figures that help the reader visualize the zeta function as a function of a complex variable and the key connections between the distribution of prime numbers, the distribution of the zeros of the Riemann zeta function, and conjecturally also the distribution of the eigenvalues of random Hermitian operators.

Conrey remarks on one of those fascinating connections (Gauss's class number problem and a "conspiracy of L-functions") that "we seem to be players in the middle of a mystery novel." The same can be said of the status of the Riemann Hypothesis itself. Conrey has given a masterly and lucid introduction to the plot thus far, to the detectives who brought us to this point, and to what may be called the main suspects: the mathematical structures that might be expected to figure in the eventual resolution of this central mystery of modern mathematics.

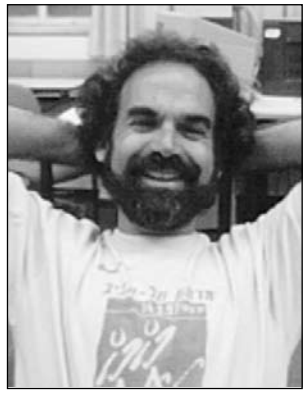
### Biographical Sketch

J. Brian Conrey is the founding executive director of the American Institute of Mathematics (AIM). In this position, he oversees AIM's operations and helps to initiate programs that further AIM's goal of solving problems through focused collaborative efforts.

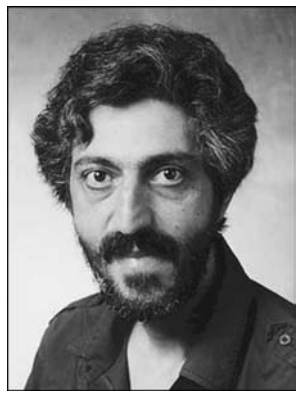
Conrey received his Bachelor of Science from Santa Clara University in 1976 and his doctorate from the University of Michigan in 1980. He conducted his postdoctoral studies at the University of Illinois, 1980–1982, and the Institute for Advanced Study in Princeton, 1982–1983. He was awarded an Alfred P. Sloan Fellowship in 1986.

J. Brian Conrey

Shlomo Hoory



Nathan Linial



Avi Wigderson

Conrey was a mathematics professor at Oklahoma State University, serving as head of the department from 1991 to 1997. He joined AIM in 1997. In 2005 he also became a professor at the University of Bristol.

Conrey's mathematical specialty is number theory, and he has a particular interest in the nearly 150-year-old Riemann Hypothesis. He has published more than fifty research papers and serves as an editor of the *Journal of Number Theory*.

Conrey has also helped launch several outreach programs for students interested in mathematics, including the San Jose Math Circle, MathCounts, and the Math MardiGras in Morgan Hill, and has been involved in several Research Experiences for Undergraduates programs working with undergraduates doing research. Conrey lives in San Martin, California, with his wife, Jan. They have three children: Brianna, Jennifer, and Rick.

**Response**

I am honored to receive the Levi Conant Prize for my article on the Riemann Hypothesis. I really enjoyed working on it and found the endeavor to be interesting and instructive. I hope that the article will play some small role in the eventual solution of this beautiful problem, perhaps by inspiring a young mathematician to think about it.

I would like to thank the people who helped me with the writing: Harold Boas, Brianna Conrey, David Farmer, Roger Heath-Brown, and K. Soundararajan, and with the graphics: Sandra Frost, Andrew Odlyzko, Mike Rubinstein, and Nina Snaith.

## Shlomo Hoory, Nathan Linial, and Avi Wigderson

**Citation**

Expander graphs are (finite) graphs that are both sparse and highly connected: a sequence of graphs $G_i$ of increasing size is a family of expander graphs if there is an $\epsilon > 0$ such that for each $i$ and each subset $S$ of $G_i$, the number of edges from $S$ to its complement is at least $\epsilon|G_i|$. Since their introduction thirty years ago, the study of these graphs has blossomed into a substantial area of research with many branches. One direction involves understanding the relationship of graph expansion to other graph invariants, most notably the second largest eigenvalue of its adjacency matrix. Identifying classes of expanders and proving that they are indeed expanders involves a variety of techniques from harmonic analysis, group representation theory, graph theory, and information theory. Expanders have found a variety of applications within the theory of computing and other fields, from direct application to interconnection networks, to more surprising applications such as the problem of understanding the relative power of deterministic and randomized computation, the construction of computationally efficient error-correcting codes, and the construction of finite metric spaces that cannot be well approximated in Euclidean space. These applications confirm that computer science is an area with problems, techniques, and results that engage mathematicians in many fields.

This very readable article, "Expander graphs and their applications", which appeared in *Bull. Amer. Math. Soc. (N.S.)* **43** (2006), 439–561, provides a thorough overview of these and other developments. It is readily accessible for self-study by experienced graduate students and, with appropriate guidance, could even be appropriate for an advanced undergraduate seminar.

**Biographical Sketch: Shlomo Hoory**

Shlomo Hoory received his Ph.D. in computer science in 2002 under Nathan Linial at the Hebrew University of Jerusalem. His postdoctoral work was done at the University of Toronto and at the University of British Columbia. Currently he is working at the IBM Haifa research labs in the Constraint Satisfaction and Machine Learning group.

**Response: Shlomo Hoory**

It is a great honor for me to receive the Conant Prize for my joint paper with Nati Linial and Avi Wigderson. I would like to thank Nati and Avi for the pleasure of being a teacher assistant in their course on expander graphs at the Hebrew University and later for their help and encouragement while I taught the course at the University of

Toronto. Special thanks are due to the students of the course who wrote the scribe notes that formed the foundation for our paper and to Mark Goresky, who convinced us to make the effort and turn the notes into a full-scale review of the subject. Mark Goresky also assisted us throughout the writing process. I see great potential in the field of expander graphs for advancing areas in mathematics, computer science, and engineering. I hope that our expository paper will make the subject accessible to a wide audience.

**Biographical Sketch: Nathan Linial**

Nathan (Nati) Linial was born in Haifa, Israel, in 1953. He received his undergraduate education in mathematics at the Technion. His Ph.D. thesis in graph theory was written under Micha Perles at the Hebrew University of Jerusalem in 1978. Following a postdoctoral period at the University of California, Los Angeles, he returned to the Hebrew University to become a professor of computer science, a position he has held ever since. His main research interests include the mathematical foundations of computer science and combinatorics. He is particularly fascinated by the interaction between geometry and combinatorics. In addition, he is interested in mathematical problems that are motivated by other scientific disciplines, such as bioinformatics.

**Response: Nathan Linial**

I was first exposed to graph theory in a class for mathematically oriented high school kids. As my mathematical horizons expanded, I came to like the connections between combinatorics and other parts of mathematics. There are few places where these connections shine as brightly as in the study of expander graphs. I believe that the full potential impact of combinatorics on the rest of mathematics is only starting to reveal itself and the study of expander graphs can give us some idea of the true power of these connections.

**Biographical Sketch: Avi Wigderson**

Avi Wigderson is a professor at the School of Mathematics, Institute for Advanced Study (IAS), Princeton. He obtained his B.Sc. in computer science from the Technion in 1980 and his Ph.D. from Princeton in 1983. He was a member of the faculty at the Hebrew University in Jerusalem from 1986 to 2003. He joined the permanent faculty of the IAS in 1999. His research interests lie principally in complexity theory, algorithms, randomness, and cryptography. His awards include the Nevanlinna Prize (1994).

**Response: Avi Wigderson**

I am honored to receive the Conant Prize for my joint paper with Shlomo Hoory and Nati Linial. Many thanks are in order. First and foremost, to Nati and Shlomo for the pleasure of teaching together (at the Hebrew University) the course which resulted in this manuscript and for the big effort of writing it. Thanks to the many students of this course whose scribe notes formed the foundation of that paper. Special thanks to Mark Goresky, who convinced us to write it and whose enthusiasm and meticulous reading of earlier drafts helped get us through the process. Thanks to the many others who read and corrected earlier versions. And finally, thanks to the many colleagues and collaborators from whom I learned so much in the wonderful world of expander graphs.