Dear Friends,

It's been a while since our last issue of *Integral*. The past two years have been busy, including our move back into the Simons Building in January 2016. There are a lot of new faces in the department. We are also happy that several department members won major honors for their work and service. This issue will catch you up on happenings in the department, up to spring 2017.

Move to the Simons Building

Our move to the Simons Building went smoothly, and we are thrilled with the results of the renovation. If you haven't seen the department, come by and take a look. While still familiar, there are many changes. The first floor now houses the newly renovated Math Majors' Lounge and the Samberg Administrative Suite next door, which includes Headquarters and Math Academic Services. The Calderón Lecture Hall now has tiered seating with state-of-the-art audio/visual, including lecture capture. Three grand views highlight the spacious Norbert Wiener Common Room. MIT's Percent-for-Art program brought us **Antony Gormley's** *Chord*, a sinuous steel structure that winds upward in the grand stairwell from the busy intersection of the departments of math, physics, chemistry, and the humanities, to our fourth-floor skylight. The building maintains its historic Beaux-Arts limestone façade and windows, while gaining 14,000 sq.ft. of office, collaborative, and seminar spaces, including the Kelly Seminar Room. The renovation is crowned by a fourth floor, and includes the beautiful Leighton Seminar Room, a breakout space, and an open-air terrace. Thanks to architect **Ann Beha** MArch '75, the project earned the 2016 Cambridge Historical Commission preservation award for rooftop addition and creative adaptation of interior spaces, as well as the Society for College and University Planning/ AIA-CAE Award for "excellence in architecture for building additions or adaptive reuse."

In Gratitude

The Simons Building would never have seen the full extent of its innovative planning and construction without the generosity of so many of our colleagues and friends. The dedication gave us a day to thank many of them in person. Some highlights were speeches by first-year graduate student **Gwen McKinley** and Simons Professor **Bonnie Berger**, who shared their thoughts on how the new spaces are changing our lives in the department.

Thanks also go out to the MIT administration for their support on this huge project, and to **Michael Sipser**, our former department head and now dean of the School of Science, who made this all happen. He worked tirelessly through each design phase, soliciting input from faculty, students, and staff (he started a blog!), overseeing the move to our temporary lodgings, and finally, monitoring the construction and finishing touches.

New Faculty

The department has continued to attract top faculty: Two full professors, **Davesh Maulik** (algebraic geometry) and **Elchanan Mossel** (probability and statistics), and three assistant professors, **Andrew Lawrie** (analysis), **Andrei Neguț** (geometric representation theory), and **Aaron Pixton** (algebraic geometry) have joined the mathematics faculty. **Richard Dudley** retired in 2015.

MathROOTS

We are looking forward to the third year of our new MathROOTS summer camp, a two-week program, where 20 African-American and Latino high school students from across the U.S. do challenging math work. I'm also happy to report that about half of MathROOTS and other PRIMES graduates go on to attend MIT, increasing our student diversity.

Simons Lectures

The annual Simons Lecture series this spring featured talks by **Yuval Peres** from Microsoft Research and **Martin Hairer** from the University of Warwick, and in 2016, **Michael Brenner** from Harvard University.

Welcome Michel Goemans

I also wish to announce that I'll be going on sabbatical this upcoming year. Taking my place as interim department head will be **Michel Goemans**, who is the initial holder of the Leighton Family Professorship of Applied Mathematics, and member of the Theory of Computation group at MIT CSAIL. He completed his PhD in operations research from MIT in 1990, continued on at MIT as instructor, and joined the MIT faculty in applied mathematics in 1992. Please join me in welcoming him to his new role. As for myself, you'll still see me around the department.

Finally, we recently hired a communications specialist, **Sandi Miller**, who will maintain *Integral* in the form of an online version over the course of the year, and an annual print version.

Have a wonderful year!

—Tom Mrowka, Department Head
Singer Professor of Mathematics

Mathematics Welcomes Two Full Professors

Davesh Maulik, Professor of Mathematics, came to MIT in 2015. Davesh works in algebraic geometry, with a focus on moduli spaces of geometric objects—for example, algebraic curves or sheaves. These often require developing and exploiting connections with related fields such as mathematical physics, symplectic geometry, and representation theory. Davesh received his PhD from Princeton University in 2007. He was awarded a Clay Mathematics fellowship, which he took in postdoctoral appointments at Columbia University and at MIT, before joining the Columbia faculty in 2011 as Associate Professor. In 2009, Maulik received the Compositio Mathematica Prize with coauthors.

Elchanan Mossel, Professor of Mathematics since 2016, is also jointly appointed at MIT's Institute for Data, Systems, and Society. Elchanan works in probability, combinatorics, and inference. His research has resolved open problems in computational biology, machine learning, social choice theory, and economics. Mossel received his BSc from the Open University in Israel in 1992, and his MSc (1997) and PhD (2000) degrees in mathematics from Hebrew University. He was a postdoctoral fellow at the Microsoft Research Theory Group, and a Miller Fellow at UC Berkeley. In 2003 he joined the Berkeley faculty, and was appointed professor of statistics and computer science in 2011. He spent leaves as a professor at the Weizmann Institute (2008–2010) and at the Wharton School, U-Penn (2014–2016). Distinctions include the Sloan Research Fellowship, the NSF CAREER Award, and the Bergmann Memorial Award.

...And Three Junior Faculty

Andrew Lawrie, Assistant Professor of Mathematics, came to MIT from UC Berkeley in 2016. Andrew is an analyst studying geometric PDEs. His research focuses on the asymptotic dynamics of solutions to various geometric dispersive equations, such as the wave map equation. He received his PhD from the University of Chicago in 2013. He was subsequently appointed an NSF postdoctoral fellow at UC Berkeley, 2013–2016, and concurrently a research member at the Mathematical Sciences Research Institute during the fall term 2015.

Andrei Neguț, Assistant Professor of Mathematics, came to MIT in 2015 from Columbia University where he had received his PhD. Andrei's research program concentrates on problems in geometric representation theory. He studies problems that intersect with symplectic geometry, combinatorics, and probability theory. His current research focuses on the moduli of sheaves, quiver varieties, quantum algebras, and knot invariants.

Aaron Pixton, Assistant Professor of Mathematics, came to MIT as a Clay Research Fellow in 2015. Aaron works on various topics in enumerative algebraic geometry, including the tautological ring of the moduli space of algebraic curves, moduli spaces of sheaves on 3-folds, and the Gromov-Witten theory. He received his PhD from Princeton in 2013 and the Clay Mathematics Fellowship that year. Aaron was a postdoc at Harvard as a Clay Fellow from 2013 to 2015.

Professor Richard Dudley Retires

Richard Dudley joined the MIT faculty in 1967, following an assistant professorship at UC Berkeley. He retired in 2015.

Richard received his AB from Harvard in 1952, and his PhD from Princeton in 1962 under the direction of Gilbert Hunt Jr. and J. Edward Nelson.

He has long been recognized for seminal contributions to probability theory, especially for providing a new framework for the study of Gaussian processes, and for enabling empirical processes to become useful and pervasive in asymptotic statistics.

Richard served as chief editor of *Annals of Probability* from 1979–1981. Among his several books, he recently published a second edition of his 1999 volume, *Uniform Central Limit Theorems*, part of the Cambridge Studies in Advanced Mathematics series. His most cited work is his book *Real Analysis and Probability*. Richard has advised 33 PhDs, 32 of them at MIT, and has 86 academic descendants.

A former Sloan and Guggenheim fellow, he is a fellow of the Institute of Mathematical Statistics, the American Statistical Association, the American Association for the Advancement of Science, and the American Mathematical Society. He is a member of the International Statistical Institute.

Faculty Spotlights

Mike Artin Is Honored with the National Medal of Science by President Obama

On May 19, 2016, President Barack Obama presented Professor Emeritus **Michael Artin** with the National Medal of Science, the nation's highest honor in science and technology.

The citation read, "For his leadership in modern algebraic geometry, including three major bodies of work: étale cohomology; algebraic approximation of formal solutions of equations; and non-commutative algebraic geometry."

In 2013 Mike received the Wolf Prize in Mathematics, and in 2002 the American Mathematical Society Steele Prize for Lifetime Achievement. He received the Harvard Graduate School of Arts and Sciences Centennial Medal in 2005, for being "an architect of the modern approach to algebraic geometry."

Mike joined the mathematics faculty in 1963, and was the Norbert Wiener Professor from 1988 to 1993.

An exemplary teacher and colleague, Mike served as faculty chair of the Undergraduate Committee for four years, and the Pure Mathematics Committee for two years. He was president of the AMS from 1990 to 1992.
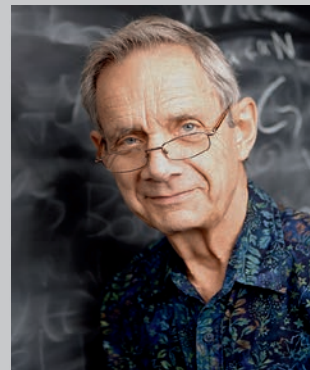
Bonnie Berger Is Selected by the Math Faculty as Simons Professor of Mathematics

Bonnie Berger was selected by the department faculty to be the next Simons Professor of Mathematics.

Bonnie is one of the pioneering researchers in computational molecular biology.

She holds a joint appointment in EECS and heads the Computation and Biology Group at CSAIL. She is also an associate member of the Broad Institute, a faculty member of Harvard-MIT Health Sciences and Technology, and affiliated faculty of Harvard Medical School.

Bonnie's recent work focuses on designing algorithms to gain biological insights from advances in automated data collection and the subsequent large data sets drawn from them.

Her research includes problems in network inference, protein folding, compressive genomics, and medical genomics.

In 1998 Bonnie received the Biophysical Society's Dayhoff Award, and in 1999 was named in *Technology Review*'s inaugural TR100 as a top young innovator of the 21st century. In 2010 she received the RECOMB Test of Time Award, and the Margaret Pittman Director's Award at the NIH.

Bonnie is elected fellow of the Association for Computing Machinery, the American Academy of Arts and Sciences, the International Society for Computational Biology, and the American Institute of Medical and Biological Engineering.

She received an honorary doctorate from EPFL in 2015. Bonnie's research made the cover feature of the August 2016 issue of *Communications of the ACM.*

Alexei Borodin Receives Michel Loève and Henri Poincaré Prizes, and Simons Fellowship

Alexei Borodin studies problems on the interface of representation theory and probability theory that link to combinatorics, random matrices, and integral systems. His current program seeks to expand the theory of symmetric functions to solvable lattice models in statistical physics.

In 2015 Alexei received both the Line and Michel Loève International Prize in Probability, and the Henri Poincaré Prize by the International Association of Mathematical Physics.

The Poincaré Prize is awarded every three years at the International Mathematical Physics Congress. The award's citation reads: "Alexei Borodin is honored for his seminal contributions to the theory of big groups, to determinantal processes and most notably to the elucidation of Macdonald processes, which have important applications to the statistical physics of directed polymers, tiling models and random surfaces."

For the 2016–2017 academic year, Alexei was selected for the Lillian Gollay Knafel Fellowship at Harvard's Radcliffe Institute, and received a 2017 Simons Fellowship from the Simons Foundation.

A graduate of the Moscow State University in 1997, Alexei received his PhD studying under Alexandre Kirillov at the University of Pennsylvania in 2001. That year he received a Clay Research Fellowship.

He was appointed professor of mathematics at Caltech from 2003 to 2010. In 2003 Alexei received the Prize of the Moscow Mathematical Society, and in 2008 the Prize of the European Mathematical Society.

Larry Guth Earns New Horizons Prize

Larry Guth has been awarded the New Horizons in Mathematics Prize "for ingenious and surprising solutions to longstanding open problems in symplectic geometry, Riemannian geometry, harmonic analysis, and combinatorial geometry."

Larry joined the MIT faculty as professor in 2012 from the Courant Institute. He received his PhD at MIT under **Tom Mrowka** in 2005, followed by appointments at Stanford and the University of Toronto.

He was awarded the Salem Prize in Mathematics in 2013 for outstanding contributions to analysis, and was selected as Simons Investigator in 2014 by the Simons Foundation. In 2015 he was awarded the School of Science Prize for Excellence in Graduate Teaching; and with Nets Katz, won the 2015 Clay Research Prize for his solution to the Erdős distance problem and for other joint and separate contributions to combinatorial incidence geometry.

Ankur Moitra Named Packard Fellow

The David and Lucile Packard Foundation has awarded **Ankur Moitra** the Packard Fellowship in Science and Engineering, recognizing him as one of the nation's most innovative young scientists and engineers.

Ankur is the Rockwell International Career Development Assistant Professor of Mathematics, and a principal investigator in CSAIL.

He received his BS in electrical and computer engineering from Cornell University in 2007. He completed his MS and PhD degrees in computer science from MIT in 2009 and 2011 respectively, where he was advised by **Tom Leighton** and was supported by a Fannie and John Hertz Foundation Fellowship. Ankur received an NSF CAREER Award in 2015. In 2016 he received the Sloan Research Fellowship, and the Edmund F. Kelly Research Award as selected by the Department of Mathematics.

Recognitions

Faculty Promotions

2015

Clark Barwick to Associate Professor

Laurent Demanet to Associate Professor with tenure

Steven Johnson to Full Professor

2016

Philippe Rigollet to Associate Professor with tenure

Jared Speck to Associate Professor

Gonçalo Tabuada to Associate Professor

Faculty Awards 2015 and 2016

Pavel Etingof was elected fellow of the American Academy of Arts and Science in 2016. He also received the Frank E. Perkins award for Excellence in Graduate Advising in 2015.

William Minicozzi was elected fellow of the American Academy of Arts and Sciences in 2015.

Tom Mrowka was elected member of the National Academy of Sciences in 2015.

Emeritus Professor **Alar Toomre** was elected member of the American Philosophical Society in 2016.

Martin Z. Bazant received the Alexander Kuznetsov Prize in Theoretical Electrochemistry in 2015 "for his seminal studies in the theory of electrokinetic phenomena."

Tobias Colding received the 2016 Carlsberg Foundation Research Prize for ground-breaking research in differential geometry and geometric analysis.

Alan Edelman won the 2015 IEEE-CS Charles Babbage Award. This award is given "in recognition of significant contributions in the field of parallel computing."

Jonathan Kelner was named the Mark Hyman Jr. Career Development Associate Professor of Applied Mathematics in 2015. This chair honors outstanding researchers by allowing them flexibility to pursue new ideas and opportunities.

Jared Speck is the new Cecil and Ida Green Career Assistant Professor of Mathematics as of 2015. This professorship recognizes and encourages excellence in teaching by gifted young faculty.

Jörn Dunkel has received a 2016 Complex Systems Scholar Award from the James S. McDonnell Foundation. The JSMF Scholar Awards Program supports high-quality research to further the science of complex systems. Jörn was also selected by the department for the Edmund F. Kelly Research Award.

Vadim Gorin received the 2016 Sloan Research Fellowship.

Emmy Murphy was awarded the 2017 Birman Research Prize in Topology and Geometry of the Association for Women in Mathematics. The prize, announced in April 2016, recognized Murphy's outstanding contributions to symplectic and contact topology.

Sipser and Leighton Share Sizer; Sipser a MacVicar Fellow; Leighton in Inventors Hall of Fame

Michael Sipser, long known for his commitment to undergraduate education as advisor, mentor, legendary lecturer, course designer, expositor, and faithful supporter of numerous initiatives, received the 2016 Margaret MacVicar Faculty Fellowship.

"He always speaks efficiently but with sentences pregnant with content," one colleague wrote. "He never tries to impress the audience with technical brilliance (though he could); rather, he brings the audience along for a wonderful ride…"

When he first came to MIT, he revised a graduate-level subject taught jointly between EECS and mathematics into the upper-level undergraduate subject 18.404: Introduction to the Theory of Computation. Michael later expanded his class lecture notes into *Introduction to the Theory of Computation*, now in its third edition, adopted by many top universities and widely translated.

In 2016, Michael and department colleague **Tom Leighton** were jointly given the Irwin Sizer Award of the Graduate School Council "for most significant improvements to MIT education."

In the mid-1980s, Michael and Tom saw the need for a major that exposed computer science students to mathematics beyond computational problems, and vice

Leighton installs his personalized illuminated hexagon into the Gallery of Icons at the Inventors Hall of Fame in May.

versa for math majors. As a result, they jointly developed the 18C major, mathematics with computer science.

In addition, **Tom Leighton,** with his former graduate student and colleague at Akamai, **Daniel Lewin** SM '98, were recently inducted into the National Inventors Hall of Fame, for their development of mathematical algorithms to route and replicate content over a large network of distributed servers. (Daniel was killed in one of the hijacked planes on 9/11.) The formal induction ceremony was held in Washington, D.C.

Hung Cheng Publishes Novel on Nanjing Massacre and Launches Scholarship Fund

Mathematics Professor **Hung Cheng** (Hong Zheng) recently went on tour in China to promote his novel, *Nanjing Never Cries.*

Published in September by MIT Press/Killian Press, this novel tells the story of four friends, including two MIT students, caught up in the violence and tumult of the Sino-Japanese War, which was from 1937 to 1945.

Described by the historian Iris Chang as "the forgotten holocaust," the Nanjing Massacre affected the author as a child, born in Canton, China, shortly before the start of the Sino-Japanese War.

But it wasn't until he attended an MIT symposium on Hiroshima in more recent years that he decided to write a book about that war. On the podium, the speakers dismissed Hung's remark that, instead of emphasizing the American guilt for dropping the bombs, the speakers should discuss more about "the racist killings by the Japanese, which were every bit as bad as those the Nazis had inflicted on the Jewish people," Hung recalled.

Afterward, Hung went to Nanjing for three months, where he interviewed several survivors of the Nanjing Massacre.
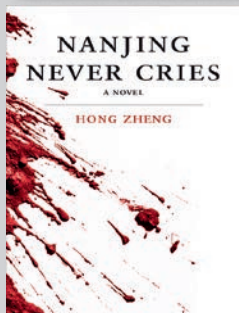
His book received considerable publicity in the U.S. and China, where he was invited to speak at Beijing University, Nanjing University, and other universities. "I must have autographed over a thousand copies when I was over there," he said. "Sometimes my hosts would broadcast or send my speech electronically to the whole school, the auditoriums being not large enough to accommodate everybody."

Hung studied at Caltech, and after postdoc appointments at Caltech, Princeton University, and Harvard University, he came to MIT as an assistant professor in 1965 and was promoted to full professor in 1969; he currently is a professor of applied mathematics in the Theoretical Physics Group. In 1978, Cheng was elected Academician of Academia Sinica, and received the CIE/USA-SF 2017 Distinguished Achievement Award in Technology and Humanity/Humanities from the Chinese Institute of Engineers, San Francisco Bay Chapter.

Cheng and his wife, Jill, also pledged $1 million last fall to the Hung and Jill Cheng Scholarship Fund, to support MIT undergraduates.

"MIT students can do a lot of good—to help wipe out poverty, develop energy, and to help implement medical sciences," Cheng told the *MIT News* in November.

"I am delighted that my friends Hung Cheng and Jill Tsui have made this gift to MIT," said **Michael Sipser,** dean of the MIT School of Science, in the MIT News article. "Endowed scholarships make it possible for all brilliant students—even those with limited financial resources—to join our community."

In Remembrance

David J. Benney
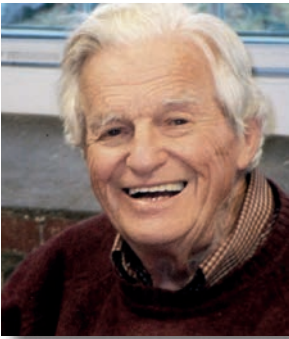
David J. Benney, professor emeritus of applied mathematics at MIT, died on October 9, 2015. He was 85.

His pioneering work clarified how nonlinearity could affect the stability of flows, including shear flows over plates, leading to developments in the theory of turbulence.

His work in 1962 describing nonlinear wave interactions in water waves developed key mathematical tools used extensively by the applied math community. In 1964, he and his grad student, J. Luke, derived an equation governing 3-D weakly nonlinear shallow water waves. This "Benney-Luke Equation" led to research and applications in a variety of physical settings, including long wave interactions on flat beaches and long-distance tsunami propagation. His related research on wave propagation in thin films led to developments in film-based photography and the coating of materials. His research on large-amplitude long waves led him to formulate a novel system of equations, the so-called "Benney System."

In 1967, with his first PhD student, A. Newell, David showed that the nonlinear Schrödinger equation arises universally in diverse applications in nonlinear dispersive waves. He followed with work on three-dimensional modulated waves in water. With his student G. Roskes, he derived a system of equations, known as the Benney-Roskes equations. He continued studies of hydrodynamic stability and transition through mentoring doctoral students and postdoctoral associates, graduating 18 PhDs, with 158 academic descendants.

David J. Benney was born in New Zealand on April 8, 1930. He received his BSc and MSc in mathematics from Victoria University, in 1950 and 1951. He continued studies in mathematics at Cambridge University, earning the BA in 1954. In 1955, he returned to New Zealand as a lecturer at Canterbury University College, and entered the doctoral program in applied mathematics at MIT in 1957. He completed his PhD, studying under Chia-Chiao Lin, in 1959. He continued at MIT, first as an instructor for a year, before joining the faculty in 1960. He became a full professor in 1966, and retired from MIT in 2010.

David chaired the Applied Mathematics Committee from 1983 to 1985. He served as department head from 1989 to 1999, a period of major transition at MIT. David oversaw major fundraising and building innovation, expanded a cross-disciplinary culture and the visiting professorship program, and welcomed leading scholars to the faculty.

A conference was held in 2000 in honor of his 70th birthday. An account of his contributions can be found in "Research Contributions of David J. Benney," in *Studies in Applied Mathematics* (Vol. 108, 2002). David served for 46 years (1968–2013) as managing editor of *Studies in Applied Mathematics.* With Harvey Greenspan, he co-authored *Calculus: An Introduction to Applied Mathematics.*

Louis N. Howard

Louis "Lou" Norberg Howard, professor emeritus of mathematics at MIT, and McKenzie professor emeritus at Florida State University, died on June 28, 2016. He was 86.

Lou was an applied mathematician who worked primarily in the field of fluid dynamics. He contributed to a broad range of subjects, including hydrodynamic stability and geophysical flows.

He made a number of key advances in our understanding of turbulent convection, flows in Hele-Shaw cells, salt-finger zones, rotating flows, and reaction-diffusion equations. He transformed qualitative ideas about the bounds on turbulent transport into rigorous mathematical arguments that initiated the field of upper-bound theory. His command of pure mathematics was evidenced by his existence proofs concerning the hydrodynamic equations, and his elegant Semicircle Theorem. He generalized and simplified extensive previous work on the Richardson number criterion for shear flows.

Lou was long associated with the Woods Hole Oceanographic Institution. In 1959 he was an original member of the Geophysical Fluid Dynamics (GFD) Summer Program, on whose steering committee he served until 1984, and was the principal lecturer at GFD on several occasions, giving advanced courses that helped establish the foundations of geophysical fluid dynamics. He supervised GFD Fellows, and was an active member of the WHOI GFD Summer School after retirement. In 2008, he and other GFD program's founding members received the Excellence in Geophysical Education Award from the American Geophysical Union.

At MIT, Lou was instrumental in the expansion of MIT's graduate program in applied mathematics, and a central figure in the Physical Applied Math group. In 1981 he joined the Florida State University (FSU) faculty as professor of mathematics and affiliate professor of mechanical engineering. In 1986, he joined the FSU Foundation Professorship, and retired in 1996. He supervised nine PhDs at MIT, one at Princeton University, two at FSU, and co-mentored several from other institutions. He continued his research long after retirement; his final paper is to appear posthumously in the *Journal of Fluid Mechanics.*

Louis Norberg Howard was born in Chicago on March 12, 1929. He received his BA in physics from Swarthmore College in 1950, and his MA and PhD in mathematical physics from Princeton in 1952 and 1953. He was a Higgins lecturer in mathematics at Princeton in 1953, and a research associate in mathematics and aeronautics at Caltech 1955. Lou joined the MIT mathematics faculty in 1955 and was promoted to full professor in 1964. He retired from MIT in 1984.

He was elected fellow of the American Academy of Arts and Sciences in 1965 and the American Physical Society in 1984, and member of the National Academy of Sciences in 1977. In 1997, he was honored with the American Physical Society's Fluid Dynamics Prize.

Bertram Kostant

Bertram "Bert" Kostant, professor emeritus of mathematics at MIT, died at the Hebrew Senior Rehabilitation Center in Roslindale on February 2, 2017, at the age of 88.

Bert was a seminal figure in Lie theory. In the early 1960s, he developed the "method of coadjoint orbits" and "geometric quantization" that related symplectic geometry to infinite-dimensional representation theory. This was part of an ambitious program that spanned six decades, well into his retirement, resulting in 107 published papers. Kostant's work impacted almost every corner of Lie theory, including algebraic groups and invariant theory, the geometry of homogeneous spaces, representation theory, geometric quantization and symplectic geometry, Lie algebra cohomology, and Hamiltonian mechanics.

Bertram Kostant was born on May 24, 1928, in Brooklyn. A chemical engineering major at Purdue University, he switched to mathematics and graduated with distinction in 1950. He received his PhD in mathematics from the University of Chicago in 1954. There, he was exposed to the ideas of the Bourbaki group in thinking about and writing down math, and started a lifelong passion for Lie groups. Between 1953 and 1956, Bert was a member of the Institute for Advanced Study and a Higgins Lecturer at Princeton University, where he investigated the "holonomy groups" arising in differential geometry, in an effort to deepen the structural understanding of simple Lie algebras.

From 1956 to 1962 Bert was on the faculty at UC Berkeley. He was a member of the Miller Institute for Basic Research from 1958 to 1959 and became a full professor in 1962. After moving to MIT in 1962, he built a faculty in Lie theory and representation theory, and supervised more than 20 PhD students, including the differential geometer James Simons.

Among Bert's honors were a Guggenheim Fellowship (1959–60) and a Sloan Fellowship (1961–63). He was elected fellow of the American Academy of Arts and Sciences in 1962, and member of the National Academy of Sciences in 1978. In 1982, he was elected fellow of the Sackler Institute for Advanced Studies at Tel Aviv University. In 1990, he received the Steele Prize of the American Mathematical Society for his 1975 paper "On the existence and irreducibility of certain series of representations."

In 2001, he was Chern Lecturer and Chern Visiting Professor at Berkeley. He was named 1989 Honorary Professor by the University of Córdoba; in 1992 Doctor Honoris Causa by the University of Salamanca; and in 1997 received Purdue's Honorary Doctor of Science degree. In 2008, the Pacific Institute for Mathematical Sciences hosted "Lie Theory and Geometry: the Mathematical Legacy of Bertram Kostant." In 2012 he was elected to the inaugural class of Fellows of the AMS. In 2016 Bert received the Wigner Medal at the Colloquium on Group Theoretical Methods in Physics.

From May 21 to 25, 2018, MIT will host a conference on the legacy of Bertram Kostant; see math.mit.edu/conferences/ kostant/ for more information.

Willem V.R. Malkus

Willem Van Rensselaer Malkus, professor emeritus of applied mathematics at MIT, died in Falmouth on May 28, 2016, at the age of 92.

Willem was a physical applied mathematician concerned with problems in geophysical fluid dynamics.

He made seminal contributions to the theory of thermal convection, turbulence, magnetohydrodynamics, elliptical flows, and their applications in geophysics. He focused on the magnetic dynamo problem, as concerns the manner in which the motion of an electrically conducting fluid can generate a magnetic field. In 1968, he proposed a novel theory for a precessionally forced geodynamo, well-known to workers in the field.

In the early 1960s, Willem struggled, along with Ed Lorenz, to understand the origins of what is now widely known as "chaos." With his colleague Lou Howard, he invented a simple mechanical device, known as the "Malkus-Howard-Lorenz Waterwheel," that realized Lorenz's famous equations. It is now widely used in teaching chaos theory.

Willem's work was characterized by a combination of careful experiments and theoretical modeling designed to illustrate fundamental principles. He was always seeking new applications for variational principles, especially in deducing criteria for hydrodynamic stability.

Born in Brooklyn on November 19, 1923, Willem Van Rensselaer Malkus studied at the University of Michigan and Cornell University, and received his PhD in physics from the University of Chicago, where he was appointed assistant professor from 1950 to 1951.

He was a physical oceanographer at the Woods Hole Oceanographic Institute from 1951 to 1962, where he was a member of the Geophysical Fluid Dynamics (GFD) program, and a regular at the GFD summer lectures for almost 50 years. In 2008, he and other GFD program founding members received the Excellence in Geophysical Education Award from the American Geophysical Union.

From 1958 to 1960, Willem was appointed professor of oceanography at MIT. He was professor of geophysics and mathematics at UCLA from 1960 to 1969. He was on MIT's applied mathematics faculty from 1969 to 1996.

At MIT, Willem founded the Applied Math Laboratory, where he carried out fluid mechanics experiments, including seminal experiments on thermal convection and elliptical flows. He was chair of the Applied Mathematics Committee for two terms, spanning 1977–1979 and 1984–1987.

Willem was elected fellow of the American Academy of Arts and Sciences, the American Physical Society, and the American Geophysical Union. He received two Guggenheim Fellowships in 1972 and 1979. In 1972, he was elected member of the National Academy of Sciences.

Hartley Rogers Jr.

Hartley Rogers Jr., professor emeritus of mathematics at MIT, died at the Meadow Green Rehabilitation and Nursing Center in Waltham on July 17, 2016. He was 89.

Hartley was a mathematical logician, credited as one of the main developers of recursion theory, and of the usefulness and validity of informal methods in this area. His 1959 paper "Computing degrees of unsolvability" obtained semantical completeness results for higher levels of arithmetical complexity, and underlies current methodology in studies of computable structures. Hartley authored the 1967 book *Theory of Recursive Functions and Effective Computability*. In 1965, he received the MAA's Lewis R. Ford award for expository excellence, for a paper on information theory.

Hartley Rogers Jr. was born in Buffalo, N.Y., on July 6, 1926. He received his BA in English from Yale University in 1946. Following a year at Cambridge University as a Henry Fellow, he returned to Yale to complete his MS in physics in 1950. He continued his studies in mathematics at Princeton, receiving his MA in 1951 and PhD in 1952. Hartley was a Benjamin Peirce Lecturer at Harvard from 1952 to 1955.

After a yearlong visit at MIT, Hartley joined the math faculty in 1956 as an assistant professor, and was promoted to full professor in 1964. He retired in 2009.

Hartley was a popular and respected teacher who oversaw the development of 18.022 (Multivariable Calculus with Theory). He produced 19 doctoral students at MIT, with 557 mathematical descendants in total. In 1993, he received the Teaching Prize for Undergraduate Education from the School of Science.

At Hartley's suggestion in 1996, the mathematics department initiated its Summer Program in Undergraduate Research (SPUR). In 2001, the Rogers family established the Hartley Rogers Jr. Prize for top SPUR teams selected by faculty. Under Hartley's direction through 2006, SPUR increased in popularity, attracting participation by graduate students from Harvard and Cambridge University.

Hartley also supervised the MIT mathematics section of the Research Summer Institute program for advanced high school students from 1993 to 2006. From 1995 to 2008, he helped develop the MIT problem-solving seminar into an important resource for students interested in the Putnam Mathematics Competition. During this period, Putnam teams placed 10 times among the top three teams, twice in first place.

Hartley served in a number of roles in MIT's senior administration during a critical period. From 1962 to 1964, he was a member of the Committee on Curriculum Content Planning, whose report radically modified the General Institute requirements for undergraduate education. In 1968, he chaired the Panel on November Events and the MIT Community, whose findings further developed the judicial processes of the Institute. Hartley was chair of the MIT faculty, 1971–1973; associate provost, 1974–1980; and MIT Press editorial board chair, 1974–1981.

In the logic community, Hartley was vice president of the Association for Symbolic Logic, senior editor of the *Journal of Symbolic Logic,* senior editor of *Annals of Mathematical Logic,* and associate editor of the *Journal of Computer and Systems Sciences.*

Gifts in Hartley's memory may be made to the Hartley Rogers Jr. Fund #3633010.

Two Years of Putnam Triumphs
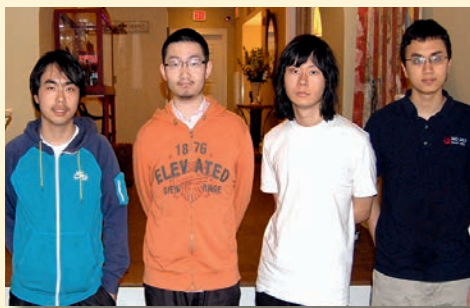
2014 MIT Putnam Team members and Putnam Fellows, from left, **Lingfu Zhang, Zipei Nie, David Yang** and **Mark Sellke.**
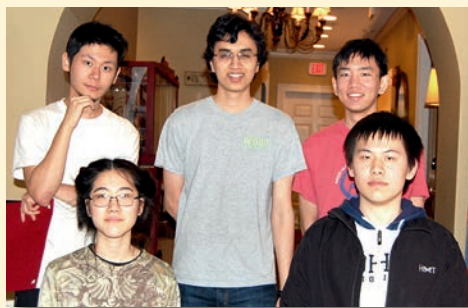
2015 Putnam team from left, **David Yang, Mark Sellke,** and **Bobby Shen**; Elizabeth Lowell Putnam Prize winner **Danielle Wang** and Putnam Fellow **Yunkun Zhou.**

2015 Putnam honorees, above. The 2015 Putnam team was the third MIT team in a row to finish in first place.

2014: 75ᵗʰ William Lowell Putnam Mathematical Competition

The MIT Putnam Team placed first, with the team of **Mitchell Lee, Zipei Nie,** and **David Yang.**

Putnam Fellows were **Zipei Nie, Mark A. Sellke, Bobby C. Shen, David H. Yang**, and **Lingfu Zhang**; MIT sets a record for highest number of fellows to come from the same institution in the same year.

There were 16 MIT participants ranking in the top 27. Of the 89 students achieving Honorable Mention or higher, MIT had 32 (36%).

2015: 76ᵗʰ William Lowell Putnam Mathematical Competition

MIT placed first, with the team of **Mark Sellke, Bobby Shen** and **David Yang**; Putnam Fellows were **David Yang** and **Yunkun Zhou.**

Danielle Wang earned the Elizabeth Lowell Putnam Prize, awarded for outstanding performance by a woman participant.

Nine MIT participants ranked in the top 26; of the 63 students achieving Honorable Mention, MIT had 24 (39%).

See the next Integral *for the 2016 Putnam winners!*

Awards Go to Vincent Genest and Roger Casals

Vincent Genest was awarded several Canadian accolades for his PhD thesis "Algebraic Structures, Superintegrable Systems and Orthogonal Polynomials," completed in 2015 at the Université de Montréal under the supervision of Luc Vinet. In 2016 he was awarded the Governor General's Academic Gold Medal, and a joint award of the Winnipeg Institute for Theoretical Physics and the Canadian Association of Physicists for the best thesis in theoretical physics. The Canadian Mathematical Society also awarded him its 2016 Doctoral Prize. Vincent is an instructor in pure mathematics and a NSERC postdoctoral fellow.
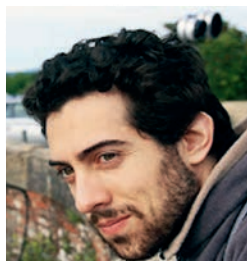
CLE Moore Instructor **Roger Casals** received the BBVA Foundation and the Royal Spanish Mathematical Society (RSME) Vincent Caselles Mathematical Research Award. Casals received the award for his contributions to contact topology. The Caselles Award goes to young mathematicians under 30 to boost the research of young Spanish mathematicians or those trained in Spain. Casals also received RSME's José Luis Rubio de Francia Award and the BBVA Research Fellowship, which funds a three-year research project. His research on contact and symplectic topology, flexible-rigid dichotomy and h-principles is also supported by an NSF award.

Jonathan Harmon Earns Infinite Mile Award

Administrative Assistant **Jonathan Harmon** was awarded a School of Science Infinite Mile Award in 2015. The Infinite Mile award recognizes those individuals who have gone above and beyond their required duties. This includes going beyond expectation in mentoring, learning and skill building, innovation, and community building. Our former Human Resources Coordinator **Daniel Delgado** also received the award in 2015.

Quilt Gift Moved to Academic Services

On behalf of her son, **Christopher, Ellen Policastro** gave a unique thank-you gift to Michael Artin, this beautiful homemade quilt. Look closely, and you can see numbers and other interesting details. After we moved back to the Simons Building, Mike allowed us to hang this in the Academic Services office for all to enjoy.

A Letter From Associate Head John Bush

Since the last edition of *Integral*, I have taken over **Gigliola's** role as associate head. I am grateful to her for so graciously passing on her knowledge and experience. While **Michael Sipser** is a tough act to follow, we are all excited to move forward under Tom's leadership. I am also looking forward to working with **Michel Goemans**, who will be serving as interim head for the academic year 2017–2018.

Adding to the palpable sense of buoyancy and optimism around the department is the newly renovated Building 2, the Simons Building. While we are still settling in, I think it fair to say that the renovation was a great success, so thanks to **Ann Beha** and her people for justifying our 2.5 years in the wilderness of Building E17.

Thanks also to the fundraisers and donors who made possible the stunning new fourth floor. We also have a striking new art piece, the architecturally lively **Antony Gormley** sculpture, whose modes of oscillation artfully whisper Tacoma Narrows.

There is a great deal of activity on the educational front. The reduction in the faculty teaching load has generally been well-received, with only a few faculty complaining of the pedagogical equivalent of phantom limb pain.

The democratization of education through MIT's online offerings presents exciting opportunities for the department on the international stage. The department now has over 75 of its undergraduate and graduate courses on MIT's OpenCourseWare site, providing a valuable resource for its students, alumni, and the wider academic community.

We have also recently made our first contributions to edX, a platform for online courses intended to reach a global audience. All three components of 18.01x have now gone live, reaching an audience in the tens of thousands; 18.03x is next in line, with others to follow. The contributions of **David Jerison, Gigliola Staffilani, Jennifer French,** and **Karene Chu** have been recognized through the MITx Prize for Teaching and Learning in MOOCs.

Thanks to all of you who contribute to these efforts to reach beyond MIT's own stellar student body to share our educational mission with the world.

Please do not hesitate to reach out if I can be of service.

With best regards,
John

The Simons Building Renovation

The Simons Building was renovated by **Ann Beha** MArch '75, of Ann Beha Architects. It was designed by William Welles Bosworth and built in 1916.

The Norbert Wiener Common Room (2-290) is twice the size of the former room.

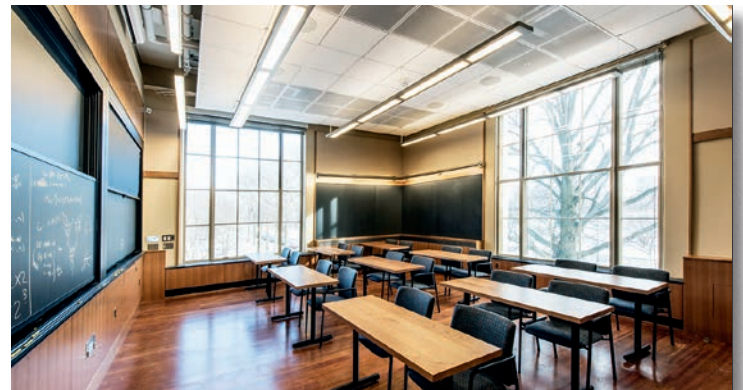Shared meeting areas have increased by 300% with the redesign.

Robert Reitano PhD '76 (XVIII) and **Lisa Reitano** named 2-190 in memory of his doctoral advisor **Alberto P. Calderón**.

The Academic Services office is part of the new Administrative Suite, courtesy of **Arthur** '62 (XVI) and **Rebecca Samberg.**

Math Majors' Lounge on the first floor offers inspirational space to study.

2-255 seminar room is a gift of **Ted Kelly** PhD '70 (XVIII), **Deborah** and **Sonja Kelly.**

Photos by Peter Vanderwarker, except for Math Majors' Lounge, which is by Andy Ryan.

# Performing Addition: The New Fourth Floor

The Hard Math Cafe is part of the new fourth floor funded by **David Leighton** '48 (VI), SM '53 (XXII M), **F. Thomas Leighton** PhD '81 (XVIII) and **Bonnie Berger** PhD '90 (VI).
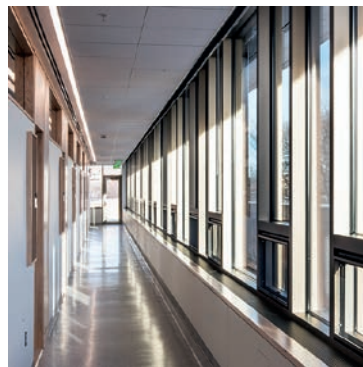

The desJardins Graduate Student Pavilion at 2-490 was a gift from **David L. desJardins** '83 (XVIII), a member of the MIT Corporation, and **Nancy Blachman.**

The new fourth floor Leighton Seminar Room.
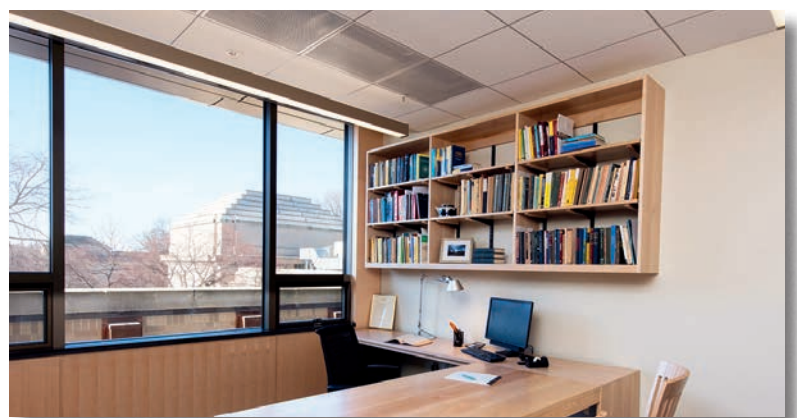
The new floor has added 14,000 square feet of office and collaborative space.

The renovation earned the 2016 Cambridge Historical Commission preservation award for rooftop addition and creative adaptation of interior spaces.

Photos by Peter Vanderwarker

2015 Student Awards

The Charles and Holly Housman Award for Excellence in Undergraduate Teaching: **Charles Housman**, awardees **Dana Mendelson** PhD '15 and **Michael Andrews** PhD '16, and **Gigliola Staffilani**. Not pictured: Awardee **Daniel Harris** PhD '16.
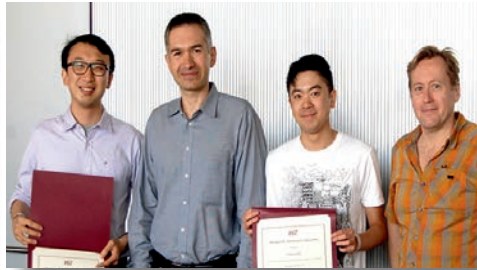
Charles W. and Jennifer C. Johnson Prize for outstanding paper accepted for publication: **Yufei Zhao** PhD '15, left, and **Francesco Lin** PhD '16 with **Alexei Borodin** and **Tom Mrowka**.

Ka Yu Tam '15 received the Jon A. Bucsela Prize for distinguished scholastic achievement, professional promise, and enthusiasm for mathematics.

Isabel Vogt received the Graduate Woman of Excellence Award by the MIT Office of Graduate Education, for leadership, research, and mentoring.

Additional Undergraduate Awards

Barry Goldwater Scholarship: **Felipe Hernandez** '16

Churchill Scholarship: **Daniel Kang** '15

Hertz Fellowship: **Jordan Cotler** '15, **Cole Graham** '15, and **Alex Siegenfeld** '15

Marshall Scholarship: **Võ Tien Phong** '16

Phi Beta Kappa inducted 43 math majors.

Additional Graduate Student Awards

Graduate Student Appreciation Fellowship: **Ruthi Hortsch** PhD '16

Sponsor a Fellowship

Graduate fellowships free up valuable time for our students to do their research. Your gift can ensure that our students have the largest possible impact.

To support our talented students, please target your donation to the Graduate Student Fellowship Fund: #3857701. Please contact Director of Development Erin McGrath at emcgrath@mit.edu or 617-452-2807.

2015 Doctoral Degree Recipients

Michael Andrews, "The v1 Periodic Part of the Adams Spectral Sequence at an Odd Prime," under Haynes Miller. Michael is an assistant adjunct professor at UCLA.

Nathaniel Bottman, "Pseudoholomorphic Quilts with Figure Eight Singularity," under Katrin Wehrheim (UC Berkeley). Nate is a member of the Institute for Advanced Study at Princeton.

Michael Donovan, "Unstable Operations in Bousfield-Kan Spectral Sequences," under Haynes Miller. Michael is an analyst at Teza Technologies.

Jesse Geneson, "Bounds on Extremal Functions for Forbidden Patterns," under Peter Shor. Jesse is a data scientist at Health Pocket.

Saul Glasman, "Day Convolution and the Hodge Filtration on THH," under Clark Barwick. Saul spent the 2015–2016 year at IAS, and is a Dunham Jackson assistant professor at the University of Minnesota.

Andrey Grinshpun, "Some Problems in Graph Ramsey Theory," under Jacob Fox. Andrey is an analyst at Teza Technologies.

Daniel Harris, "The Pilot-Wave Dynamics of Walking Droplets in Confinement," under John Bush. Dan is a postdoc at the University of North Carolina.

Benjamin Iriarte-Giraldo, "Combinatorics of Acyclic Orientations of Graphs: Algebra, Geometry and Probability," under Richard Stanley. Benjamin is a research scientist at Quantlab Financial.

Jiayong Li, "A-infinity Algebras for Lagrangians via Polyfold Theory for Morse Trees with Holomorphic Disks," under Katrin Wehrheim (UC Berkeley). Jiayong is a researcher at Curoverse, Inc.

Dana Mendelson, "Global Behavior and Dynamics of Nonlinear Dispersive Equations with Random Initial Data," under Gigliola Staffilani. Dana is an L.E. Dickson Instructor at the University of Chicago.

Vinoth Nandakumar, "Coherent Sheaves on Varieties Arising in Springer Theory, and Category O," under Roman Bezrukavnikov. Vinoth is a postdoc at the University of Utah.

Dimiter Ostrev, "The Structure of Optimal and Nearly Optimal Quantum Strategies for Non-Local XOR Games," under Peter Shor. Dimiter is a postdoc at Yale University.

Aaron Potechin, "Analyzing Monotone Space Complexity Via the Switching Network Model," under Jonathan A. Kelner. Aaron is a postdoctoral researcher with a joint appointment with the Simons Collaboration on Algorithms and Geometry at Cornell University and the Institute for Advanced Study.

Yakov Shlapentokh-Rothman, "Mode Stabilities and Instabilities for Scalar Fields on Kerr Exterior Spacetimes," under Igor Rodnianski. Yakov is an NSF postdoc at Princeton University.

Sean Simmons, "Preserving Patient Privacy in Biomedical Data Analysis," under Bonnie Berger. Sean is doing a joint postdoc between Cenk Sahinalp (Simon Fraser University and Indiana) and Bonnie Berger at MIT.

Roberto Svaldi, "Log Geometry and Extremal Contractions," under J. McKernan (University of California, San Diego). Roberto is a postdoc at the University of Cambridge.

Wuttisak Trongsiriwat, "Combinatorics of Permutation Patterns, Interlacing Networks, and Schur Functions," under Alex Postnikov. Wuttisak is an analyst at Tech Square Trading.

Guozhen Wang, "Unstable Chromatic Homotopy Theory," under Mark Behrens. Guozhen is at the Shanghai Center for Mathematical Sciences, Fudan University.

Samuel Watson, "Conformal Loop Ensembles and the Gaussian Free Field" under Scott Sheffield. Samuel is a postdoc at ICERM at Brown University, where he also is Tamarkin Assistant Professor.

Wenzhe Wei, "Nuclear Norm Penalized LAD Estimator for Low Rank Matrix Recovery," under Lie Wang. Wenzhe is an analyst with Goldman Sachs.

Yi Zeng, "Mathematical Modeling of Lithium-Ion Intercalation Particles and Their Electrochemical Dynamics," under Martin Bazant. Yi is an analyst with Tower Capital.

Leonardo Andrés Zepeda Núñez, "Fast and Scalable Solvers for the Helmholtz Equation," under Laurent Demanet. Leonardo is a postdoc at the University of California-Irvine.

Ruixun Zhang, "Economic Behavior from an Evolutionary Perspective," under Andrew W. Lo. Ruixun is a quantitative researcher at Vatic Labs.

Yufei Zhao, "Sparse Regularity and Relative Szemeredi Theorems," under Jacob Fox. Yufei is a postdoc at the University of Oxford.

Xuwen Zhu, "The Eleven Dimensional Supergravity Equations, Resolutions and Lefschetz Fiber Metrics," under Richard Melrose. Xuwen is a Szego assistant professor at Stanford University.

2016 Student Awards
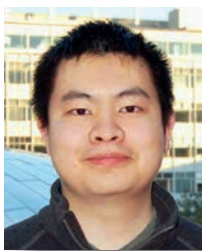
Yongyi Chen '16 and **Mitchell Lee** '16 were awarded the Jon A. Bucsela Prize in Mathematics.

Felipe Hernandez '16 received the Hertz Foundation Fellowship.

Grad students **Yi Sun** PhD '16 and **Yun William Yu** PhD '17, with **Tom Mrowka** and **John Bush**, earned the Charles W. and Jennifer C. Johnson Prize, established with the support of **Charles** (BE '55) and **Jennifer Johnson**.

Additional Undergraduate Awards

AMS/MAA/SIAM Frank and Brennie Morgan Prize for Outstanding Research by an Undergraduate Student: **Amol Aggarwal** '15

Phi Beta Kappa inducted 32 math majors.

Additional Graduate Student Award

Association for Women in Mathematics Inaugural Dissertation Prize: **Dana Mendelson** PhD '15

Charles and Holly Housman Award for Excellence in Teaching: From left, **John Bush, Holly** and **Charles Housman,** awardee **Carlos Sauer Ayala** (with daughter Micaela), and **Ben Housman.** At right, awardee **Zachary Abel** PhD '16.

2016 Doctoral Degree Recipients

Zachary Abel, "Folding and Unfolding with Linkages and Origami," under Erik D. Demaine.

Hannah Alpert, "Special Gradient Trajectories Counted by Simplex Straightening," under Larry Guth. Hannah is a postdoc at ICERM, Brown University.

Yakov Berchenko-Kogan, "Yang-Mills Replacement," under Tom Mrowka. Yakov is a postdoc at Washington University.

John Binder, "Fields of Rationality of Cuspidal Automorphic Representations," under Sug Woo Shin (Berkeley). John is a trader with Jane Street Capital.

Netanel Blaier, "The Quantum Johnson Homomorphism and Exotic Symplectomorphism of 3-folds," under Paul Seidel. Netanel is a postdoc at Brandeis University.

Dorin Boger, "D Equivalences," under Roman Bezrukavnikov. Dorin is a postdoc at Harvard.

Jui-En Chang, "The 1-dimensional ∧-self Shrinkers in R2 and the Nodal Sets of Biharmonic Steklov Problems," under William Minicozzi. Jui-En is a postdoc at National Taiwan University.

Efrat Engel-Shaposhnik, "Antichains of Interval Orders and Semiorders, and Dilworth Lattices of Maximum Size Antichains," under Richard P. Stanley. Efrat is traveling with family.

Inna Entova-Aizenbud, "Schur-Weyl Duality in Complex Rank," under Pavel Etingof. Inna is a lecturer at Ben Gurion University.

Teng Fei, "On the Geometry of the Strominger System," under Victor Guillemin. Teng is a Ritt Assistant Professor at Columbia University.

Darij Grinberg, "Studies on Quasisymmetric Functions," under Alexander Postnikov. Darij is a Dunham Jackson Assistant Professor at the University of Minnesota.

Qiang Guang, "Self-shrinkers and Translating Solitons of Mean Curvature Flow," under William P. Minicozzi. Qiang is a visiting assistant professor at the University of California, Santa Barbara.

Ruthi Hortsch, "Counting Elliptic Curves of Bounded Faltings Height," under Bjorn Poonen. Ruthi is working at the nonprofit BEAM (Bridge to Enter Advanced Mathematics) in New York City.

Yin Tat Lee, "Faster Algorithms for Convex and Combinatorial Optimization," under Jonathan Kelner. Yin Tat is a postdoc at Microsoft Research.

Francesco Lin, "Monopoles and Pin(2)-symmetry," under Tom Mrowka. Francesco is a Veblen Research Instructor at Princeton University.

Zihan Hans Liu, "The Morse Index of Mean Curvature Flow Self-Shrinkers," under Tobias H. Colding. Zihan is a senior software engineer at Cognex Corp.

Oren Mangoubi, "Integral Geometry, Hamiltonian Dynamics, and Markov Chain Monte Carlo," under Alan Edelman. Oren is a postdoc at University of Ottawa.

Alexander Moll, "Random Partitions and the Quantum Benjamin-Ono Hierarchy," under Alexei Borodin. Alexander is a postdoc at Institut des Hautes Études Scientifiques.

Oren Rippel, "Sculpting Representations for Deep Learning," under Ryan P. Adams and Ankur Moitra. Oren is the cofounder and CTO at WaveOne, Inc.

Padmavathi Srinivasan, "Invariants Associated to One-Parameter Families of Curves and Their Jacobians," under Bjorn Poonen. Padmavathi is a postdoc at Georgia Tech.

Yi Sun, "Quantum Intertwiners and Integrable Systems," under Pavel Etingof. Yi is a postdoc at Columbia University.

Dmitry Vaintrob, "Mirror Symmetry and the K Theory of P-adic Groups," under Roman Bezrukavnikov. Dmitry is a postdoc at the Institute for Advanced Study, Princeton.

Michael Viscardi, "Equivariant Quantum Cohomology and the Geometric Satake Equivalence," under Roman Bezrukavnikov. Michael is a postdoc at UC Berkeley.

Neal Wadhwa, "Revealing and Analyzing Imperceptible Deviations in Images and Videos," under William T. Freeman. Neal is a postdoc at MIT CSAIL.

High School Math Talent Accelerator Programs Need to Move Beyond Pilot Phase

The PRIMES program (Program for Research in Mathematics, Engineering, and Science) keeps growing. Its dual mission is to engage students, from middle schoolers to undergraduates, in research and creative problem-solving, as well as to reach out to the most diverse U.S. student populations. About half of PRIMES alums go on to study at MIT.

Launched in 2015, MathROOTS offers mentoring to 20 promising African-American and Latino students (ages 14 to 18) from across the country, in a 14-day residential summer camp program. Students study advance math topics (such as modular arithmetic and Hamilton's quaternions), attend guest lectures, and do group trips.

One such student was **Deon Richmond** (MathROOTS 2016), whose school in Kansas left him wanting. He took AP physics and did an academic decathlon, but the school Math Club was disbanded. A STEM camp at Carnegie Mellon was too easy. At MathROOTS, Deon received the challenge he longed for.

"Four days into the program we had our first test, and it was three hours and four problems, and I was just like, what? I think I got one question right," Deon recalled. "By the end of the

MathROOTS offers mentoring to 20 promising African-American and Latino students (ages 14 to 18) from across the country, in a 14-day residential summer camp program.

program, I got three questions out of the four. I saw improvement over the program and I was so happy."

Deon also found his peer group. "It was just amazing, because they were all interested, just so excited about math, like me. I didn't expect college to be like this. I thought it was supposed to be cutthroat."

Back at school, he was inspired to restart the Math Club, where he shared MathROOTS problems. He felt confident about applying to MIT, and is now in his first year. Deon has also settled into Chocolate City at New House with fellow MathROOTS alum **Ben Bennington**. "I just really love MathROOTS because it got me here," said Deon. "It's really showed me that this is a place that can be a home and a place where you can grow at the same time."

Another MIT freshman, **Adedoyin Olateru-Olagbegi** of Hanover, Md., also thanked MathROOTS for helping her decide. "MathROOTS reaffirmed to me MIT's commitment to diversity and inclusion, and to giving many students who haven't been able to see this kind of material the chance to come to campus and learn about these interesting topics in math."

Open to U.S. citizens or permanent residents, the program is run by faculty advisor **Pavel Etingof** and academic director **Slava Gerovitch. Tanya Khovanova** and graduate students **Vishal Arul** and **Gwen McKinley** coordinate the curriculum and logistics.

The program will complete its three-year pilot run by July 2017. Thus far, MathROOTS has been funded by the Department of Mathematics, School of Science, Office of the Provost, and the Art of Problem Solving. However, as some of those funding sources end, more will be needed to support MathROOTS next year.

Dean **Michael Sipser** raised the initial funding. "MathROOTS offers the real possibility of changing the lives of its participants, and through them, their communities," he said. "I hope that it will become a permanent offering for future extremely talented students."

Other PRIMES Programs Continue to Flourish

PRIMES Circle: an after-school math enrichment program during the spring term works with strong students from underrepresented groups of Greater Boston. It held its fourth annual mini-conference in 2017, led by graduate student **Isabel Vogt**. Thirteen Circle students (77% female, 8% Hispanic, and 15% African-American) prepared papers and presentations on probability, combinatorics, knot theory, and number theory.

PRIMES STEP (Solve–Theorize–Explore–Prove): a year-long program for middle-school students, started in September 2015. "They worked on unexplored problems, like the alternator coin finding problem," said Slava. "This was an experiment to see if this age group is capable of doing math research." Amazingly, 11 students studying under **Tanya Khovanova** produced two research papers, currently being considered for publication. This academic year, Tanya is leading two groups of 10 students each.

CrowdMath: an online forum for high school and college students to collaborate on a large research project with mentors and their peers. So far, three research papers have been produced under this program. "Every year we invent something new and experiment with innovative formats to engage math students," said Slava.

Lusztig PRIMES mentors: George Lusztig established the George Lusztig PRIMES mentoring program with a significant portion of his 2014 Shaw Prize, to award continuing graduate mentors for exceptional service. The first Lusztig PRIMES mentors were selected in December 2015: **Chiheon Kim, Seth Shelley-Abrahamson,** and **Isabel Vogt.** In December 2016, **Lucas Mason-Brown, Andrew Rzeznik,** and **Guangyi Yue** were selected.

Diversity: SPUR+ Aimed at Women and URM Undergrads

The 2015 Rogers Prize winners with faculty and **Dr. Adrianne Rogers,** from left, **Pavel Etingof, Seth Shelley-Abrahamson, Yuchen Fu, Ofer Grossman,** and **Ankur Moitra.**

The mathematics staff is gearing up for another summer of mentoring undergraduates and high school students. For the past two summers, **David Jerison** and **Ankur Moitra** have served as faculty advisors for two summer programs: the Research Science Institute (RSI) program, and the Summer Program for Undergraduate Research (SPUR). **Slava Gerovitch** served as the program director. SPUR was founded in 1996 by the late **Hartley Rogers**.

To date, SPUR rarely included women and students from underrepresented backgrounds. To address this concern, faculty Diversity Officer **Gigliola Staffilani** and **Pavel Etingof** proposed a parallel summer program, SPUR+, to launch this summer 2017. It is geared toward increasing the number of URMs and women among math majors.

Coordinated by **Cris Negron**, an African-American CLE Moore instructor and NSF postdoctoral fellow, SPUR+ begins three weeks prior to SPUR as a headstart, offering guided reading on the mathematics needed to attack a research problem. Then, when SPUR starts in late June, SPUR+ students will join with SPUR participants in an intense six-week program to work on original research projects, supervised by graduate student mentors. Following presentations in early August, the faculty panel will award the Rogers Prize to the best student-mentor team(s).

In the summers of 2015 and 2016, 24 MIT undergrads participated in the SPUR program. In 2015, two student-mentor teams shared the Hartley Rogers Jr. Prize for the best paper: **Yuchen Fu** and his mentor **Seth Shelley-Abrahamson,** and **Ofer Grossman** and his mentor **Dongkwan Kim**. In 2016, the prize was won by **Lingfu Zhang** and his mentor **Hong Wang**.

Interested in sponsoring SPUR? Direct your donation to SPUR Fund #3891449. For more info, contact Erin McGrath, Director of Development at 617.452.2807 or emcgrath@mit.edu.

Building Community for Women Mathematicians

The department hosted the sixth Math Prize for Girls of the Advantage Testing Foundation on September 10, 2016.

In that competition, 274 young women from the U.S. and Canada competed for cash prizes, resulting in 14 top-ranked students, followed by 21 highly ranked participants (honorable mention). In the 2015 competition, 271 young women participated, with the same number of winners and honorable mention.

Hosting this competition at MIT exposes these young women to the Institute and the department during their impressionable years. The department will continue to support the Math Prize for Girls in FY18.

Female math majors, graduate students, and academic staff continue their participation as mentors for Girls' Angle, a nonprofit math club in Cambridge for middle-school girls. This program was started by one of our doctoral alumni.

The department supports the monthly Women in Math Luncheon, where a senior woman mathematician discusses her career and research. In addition to inviting women graduate students, postdocs and faculty, this year we also invited women math majors. About 10 attended the first lunch seminar, a sign that the luncheon will attract a larger math community of women.

In addition to the department, the MIT Undergraduate Society of Women in Mathematics (USWIM) helps welcome women mathematics majors, and brings in speakers to describe their mathematical work in academics and industry. Last November, USWIM targeted sixth- and seventh-grade girls from local schools, who participated in a hands-on, time-travel-themed math challenge, in small teams supervised by a USWIM member or adult volunteer.

U-Penn's Ryan Hynd Finishing Up MLK Visiting Professorship

Ryan Hynd is this year's Dr. Martin Luther King Jr. Visiting Faculty professor, hosted by Professor **Tobias Colding**.

Ryan is an assistant professor at the University of Pennsylvania. He completed his MSc in mathematics at Georgia Tech in 2004, and received his PhD from UC Berkeley in 2010, studying under Lawrence Evans. He was appointed an NSF postdoctoral fellow at the Courant Mathematics Institute, NYU, from 2010 to 2012, and joined the U-Penn faculty in 2012.

Ryan is an analyst whose broad research program includes the study of PDE methods in control theory, finance, and fluid mechanics. At MIT, he is working on three projects: existence of solutions of the multidimensional sticky particle system, partial regularity of doubly nonlinear parabolic systems, and the asymptotic behavior of Trudinger's equation.

Ryan has served on the department's Diversity Committee during the year. Given his experience on diversity issues at U-Penn, he has advised us on our outreach mentoring practices for URM and women students, pertaining to our majors and prospective majors.

Ryan taught an analysis undergraduate seminar CI-M subject last fall, and just completed co-instructing a Projects Lab subject in the spring.

We are in the process of considering an MLK application for FY19.

International Team Launches L-functions and Modular Forms Atlas

Elliptic Curve   L-Function   Modular Form
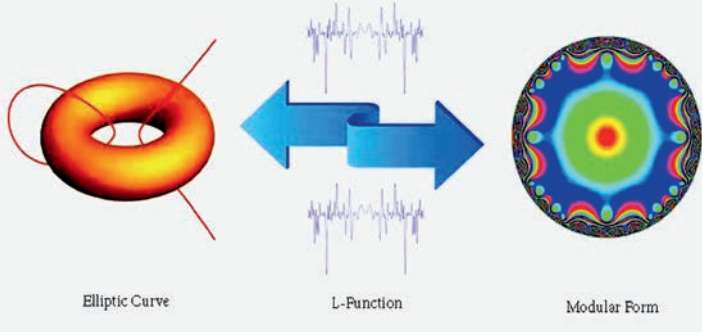
An international group of researchers at MIT and other institutions in May 2016 launched a new online resource, the "L-functions and Modular Forms Database" (LMFDB).

The LMFDB is an atlas of mathematical objects that explicitly maps connections predicted by the Langlands program that are encoded as L-functions. The most well-known L-function is the Riemann zeta function, which is intimately related to the distribution of prime numbers.

The Riemann hypothesis is concerned with the zeros of this L-function, 100 billion of which are cataloged in the LMFDB. In total, the LMFDB contains information on nearly 20 million L-functions, each with its own "Riemann hypothesis" that conjecturally governs the behavior of an associated mathematical object. These include L-functions of elliptic curves, which are the subject of the Birch and Swinnerton-Dyer conjecture, and many more exotic L-functions.

The computational effort that went into creating the LMFDB is staggering: the equivalent of more than 1,000 years of computer time. MIT's contribution was spearheaded by **Andrew Sutherland**, who has developed number-theoretic algorithms that dramatically accelerate many of these computations. In collaboration with engineers at Google, Andrew was able to deploy these algorithms to great effect on Google's cloud computing platform.

Visit the LMFDB at www.lmfdb.org.

Department Retreat 2016

Over 150 participated in the 2016 Department Retreat at the Purity Spring resort in New Hampshire. Thanks go out to the retreat organizers, **Paul Gallagher** and **Andrew Rzeznik**, along with everyone else who helped out.

Make a Difference

In order for the math department to remain a leader in research and education, your gifts can help us attract and support top faculty and students. Make an impact by funding innovation in needed areas. Gifts in all amounts are invaluable to the department's funds.

Math Special Needs Fund #3879500
PRIMES Fund #3895820
MathROOTS Fund: #3892422
Grad Student Fellowship Fund: #3857701

To support our talented students and faculty, contact Director of Development for Mathematics Erin McGrath at emcgrath@mit.edu or 617-452-2807.

∫ MIT | Mathematics

Department of Mathematics
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