
MATH MATTERS

DEPARTMENT OF MATHEMATICS CORNELL UNIVERSITY ITHACA NY NOVEMBER 2010

LETTER FROM THE CHAIR, LAURENT SALOFF-COSTE

I want to thank the staff and faculty of the department for their work and support during what, not surprisingly, turned out to be a very difficult year. Dan Barbasch had managed the first round of budget cuts efficiently, leaving our program in good shape. The significance of the second round of cuts, similar in size to the first round, will only be understood over time.

Throughout this challenging year, the department maintained a high level of very successful activities in the areas of instruction, research and outreach including the Chelluri, Kieval, and Evans Lectures, and the annual Topology Festival. Let me acknowledge the very positive impact of the generous gifts of Kirk Twiss and several anonymous donors. The Twiss fund provides support for the recruitment, retention, and research efforts of our faculty. Together with other gifts, it allows the department to support activities that are essential to our scientific output, such as visits by preeminent mathematicians and collaborators.

The 2010 International Congress of Mathematicians, the quadrennial world gathering of mathematicians where Fields Medal recipients are announced, was held this summer in Hyderabad, India. Karen Vogtmann had the honor to chair the official U.S. delegation to the congress and two of our faculty, Lou Billera and Justin Moore, gave invited lectures. Congratulations to Karen, Lou, and Justin!

The next decade will undoubtedly be dominated by hiring activities in a very competitive environment. It is likely that half the department will change during the next ten years or so. The result of these hiring activities will have a tremendous effect on the future of mathematics at Cornell.

Cornell belongs to a relatively small and very select group of institutions that aspire to exceptional quality and leadership over the entire spectrum of intellectual activities. This bold, institution-wide aspiration plays an essential

role in allowing specific Cornell programs to be worldwide leaders in their field. Obviously, this ambitious goal calls for a premier College of Arts and Sciences, including a first-rate department of mathematics. As a direct consequence of the budget crisis, I had no choice but to collect and immerse myself in a great quantity of data searching to answer the question: what are the important characteristics of a premier department of mathematics?

Data regarding the top 100 departments of mathematics in
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MATH AWARENESS MONTH

BY MARY ANN HUNTLEY

The Mathematics Department holds a public lecture each April in conjunction with the national celebration of Mathematics Awareness Month. This year's lecture featured Professor Allen Knutson, who discussed the mathematics of juggling. Professor Knutson joined the faculty here in 2009; his research interests include algebraic geometry and algebraic combinatorics. Until 1995, he held a juggling world record for passing (12 balls between two people).

The mathematics of juggling was codified about 25 years ago, when three different groups of jugglers came up with the same way of mathematically representing a juggling pattern. This notational system, called "siteswaps," made it easy to record patterns, note similarities, and find new juggling

patterns — even by computer. Although siteswap is mostly used by experienced jugglers, Knutson says it's also useful as a steppingstone for people learning harder things.



Professor Knutson's lecture and demonstration is available on CornellCast:

www.cornell.edu/video

VISITING ITHACA

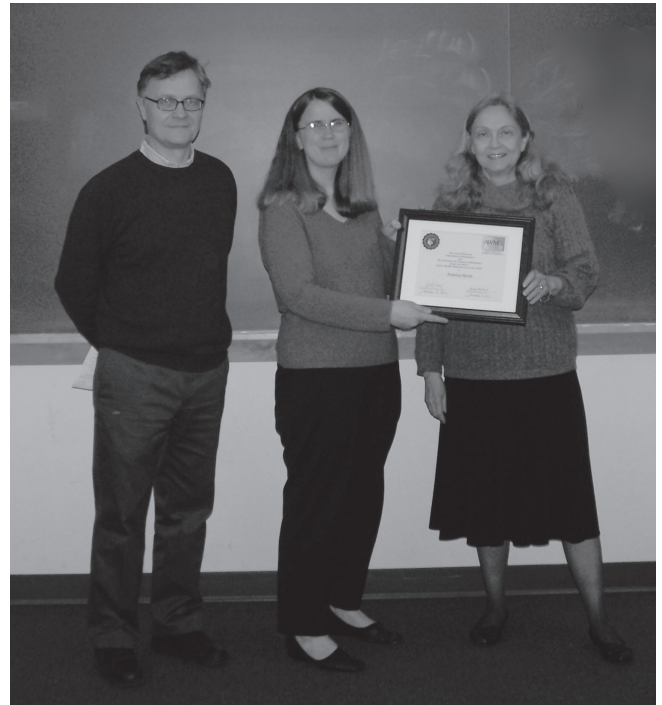
By PATRICIA HERSH

Spending fall semester of 2010 visiting the Cornell math department, thanks to the generous support of the Ruth I. Michler Memorial Prize, is a wonderful opportunity for me. Not only is there the strong geometric combinatorics group comprised of Lou Billera, Ed Swartz, and Allen Knutson, but also numerous other people using combinatorics (particularly my specialty area of topological combinatorics) in exciting, highly nontrivial ways: Irena Peeva in conjunction with free resolutions, Ken Brown in connection with group theory, and Karen Vogtmann in her work on the space of phylogenetic trees, just to name a few. Indeed, I am learning a lot from talking with an array of different people and have identified a few possible joint projects with Cornell faculty members, still in early stages.

I am also finding a little time to enjoy Ithaca. Tara Holm took me to the farmer's market and then to Gimme Coffee on my first Saturday morning here. Ed Swartz took me walking along the gorge

to College-town for pizza for lunch one day. Recently I visited the breathtaking gorge and series of cascades leading to Lucifer Falls in Robert H. Treman State Park (thanks to Ravi Ramakrishna's recommendation). With fresh energy just after seeing Lucifer Falls, a collaborator and I made a breakthrough on how to think about a stratified space related to phylogenetic trees.

This past weekend I attended an impressive series of talks at the conference *Approaches to Group Theory* honoring Ken Brown. Speaker after speaker made his or her talk understandable for people from all different areas of math, sharing perspective on their areas, and making the conference



Laurent Saloff-Coste, Patricia Hersh, and Georgia Benkart, President of the AWM

a real learning opportunity for all involved.

It is a very nice thing that the Michler family has done in creating this prize as a tribute to Ruth Michler. I can say from my own firsthand experience that this is clearly having a very positive impact for its recipients.

INTERNATIONAL CONGRESS OF MATHEMATICIANS

By JUSTIN MOORE

Every four years, there is an International Congress of Mathematicians, and in 2010 the Congress was held in Hyderabad, India. Among the highlights of this event is the awarding of the Fields Medal, the award in mathematics generally regarded as the equivalent of the Nobel Prize. To be invited to speak at the ICM is a coveted honor, with only a handful of people chosen from each of the major divisions of mathematics to speak on the most

notable recent developments in the field.

This year the math department at Cornell was represented at the ICM in a number of different capacities. Karen Vogtmann was the chair of the U.S. delegation to the general assembly of the International Mathematical Union (the primary political organization associated with the ICM). Harry Kesten presented the Fields medal laudation for Stanislav Smirnov (University

of Geneva). Louis Billera and Justin Moore presented invited talks, representing combinatorics and logic, respectively. Finally, Keith Dennis was among those recognized for their contribution to the project of digitizing the proceedings of all of the previous congresses, dating back to 1893. The entire database can be accessed at:

www.mathunion.org/ICM

LETTER FROM THE CHAIR

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the U.S. clearly demonstrates that a lively postdoctoral and visitor program is an essential component of successful departments. With few exceptions, the rule is: the better the department, the larger the postdoctoral and visitor program. The resources supporting these programs are mostly internal and tied to instruction. In this way, mathematics service instruction plays an essential role in supporting research activities at the best departments of mathematics.

Looking at our department over the past ten years, one finds that our

postdoctoral and visitor program was average in size when compared to the top 50 departments of mathematics. This program directly impacted approximately one third of our scientific activities in terms of publications and seminars. In the last two years, this essential component of the scientific life of the department has been cut by more than 65%. Today, among the 4 top mathematics programs in the state of New York (Columbia, Cornell, NYU, Stony Brook), our department has, by far, the smallest postdoctoral and visitor program, whether measured in absolute size,

per tenure/tenure-track faculty, or per undergraduate student.

The university's "2010-2015 Strategic Plan" calls for Cornell to be recognized worldwide as a top-ten university. There are no top-ten universities without a superb department of mathematics. There are no well-ranked departments of mathematics without a lively postdoctoral and visitor program. Failing to recognize this undisputable reality now is sure to have very undesirable long-term effects on our department and our university and is the challenge we will be addressing for the next several years.

FASHION STATEMENT

BY LAURENT SALOFF-COSTE

In the late 1970s, Bill Thurston formulated his geometrization conjecture for 3-dimensional manifolds. This far-reaching conjecture states that all 3-manifolds can be decomposed into pieces that belong to a short list of eight model geometries. The geometrization conjecture contains as a special case the famous conjecture made by the French mathematician Henri Poincaré (1854-1912) that the 3-sphere is the only closed 3-dimensional manifold on which any loop can be retracted to a point. The Poincaré conjecture is one of the seven Millennium Problems for the solution of which the Clay Institute established a \$1 million award in 2000. This year, in Paris, Thurston's pioneering work was celebrated on two very different stages.

At the January 2010 Paris fashion show, Bill Thurston appeared on stage with designer

Dai Fujiwara at the presentation of the Miyake Collection which was entirely inspired by his geometrization conjecture. The notes accompanying the collection described the Thurston theory as "a comprehensive vision of eight geometries that are sufficient to form an ideal shape for all possible

three-dimensional topologies." Jenny Barchfield from the Associated Press writes: "The collection, in an eye-popping rainbow of mostly high-tech fabrics, riffed on the idea of oblong shapes and loops, circles and spirals — Thurston's model metaphors for the universe."

In spring 2010, the Clay Institute announced that the Millennium Prize for the Poincaré conjecture was awarded to Grigoriy Perelman. As he had done earlier with the Fields medal, Perelman refused the Millennium Prize of \$1 million but the mathematical community celebrated Perelman's astonishing achievements including his proof of the geometrization conjecture at a conference held at Institut Henri Poincaré in Paris in June 2010. Of course, Bill Thurston was one of the featured speakers at this conference.



*Dai Fujiwara, Bill Thurston, & Issey Miyake Designers
photo by Takeshi Miyamoto, all rights reserved*

WRITING ABOUT MATH FOR THE NEW YORK TIMES

BY STEVEN STROGATZ



Back in August 2009, I found myself eating lunch with David Shipley, the editor of the op-ed page for *The New York Times*.

We'd known each other since 2003, having been introduced by a mutual friend, and I'd written a few op-eds for him over the years since then. So when he casually invited me to look him up next time I was in the city, I felt comfortable actually taking him up on it.

He asked if I'd ever have time to write a series about math. As it happened, spring 2010 was wide open, since I'd taught all my courses for the year in the fall semester. So his next question was, what would a series about math look like? I suggested maybe I could try writing about math in the real world, focusing on news stories with some (typically hidden) connection to math, like climate change, the controversy about sampling in the census, and so on. No, he said, that

seems too diffuse and also assumes too much math sophistication. How about a series that starts with kindergarten and walks the readers step-by-step through numbers, addition, subtraction and all that, and then keeps going, through algebra, geometry, calculus, the whole curriculum that everybody went through but that most people — himself included, he confessed — never really understood?

I couldn't believe it. "Are you serious? Just grinding through the curriculum? It sounds so pedantic," I said. "No, that's really what I want," he said. "You'll find a way to make it appealing. Can you do it?" I said, "I'd love to try."

To this day, I'm still stunned by the structure he proposed. It sounded just like the kind of logical structure we would think of! But would anyone want to read it?

The series began in late January 2010 and ran through May. It appeared every Monday in the online version of the paper. Being on the Web made it possible to show videos, computer simulations, color images, and to link to relevant web sites and references. It was the

perfect place to communicate math to a wide audience.

In all there were 15 columns, each about 1,500 words long, on topics running from pre-school (the meaning of numbers, illustrated by a Sesame Street video) to group theory (by way of a problem about mattress flipping and the Klein 4-group) and set theory (through the allegory of the Hilbert Hotel). I tried to focus on the ideas of math, and to show why we find the subject so beautiful and compelling.

The audience reaction was surprisingly appreciative, and a lot less snarky than what you usually find on the Web. Hundreds of readers posted comments, many of which thanked the Times for publishing a series about math. Each of the columns made it to the "most e-mailed" list. A few even reached #1, momentarily displacing Krugman or Kristof.

If you ever have a chance to try something like this yourself, I'd certainly recommend it. There is a great hunger out there for math, more than we realize.

Find links to all of the columns on www.stevenstrogatz.com

DEPARTMENT HONORS AND AWARDS

As is now a tradition, the department teaching awards for 2009-2010 were announced during our popular winter holiday party in December.

Ravi Ramakrishna won the senior faculty teaching award for his ability to push students to excel and to achieve a deep understanding of mathematics.

Guang (Dennis) Yang won the junior faculty teaching award for his ability to inspire his students in both large and small classes.

Among the graduate students, **Benjamin Lundell** and **Eyvindur Pálsson** share the graduate student teaching award. Ben was acknowledged for his commitment to and success in communicating mathematics to a broad audience,

and **Eyvindur** for the clarity of his presentations and for his leadership and mentoring as a head TA.

Mingzhong Cai and **Benjamin Lundell** shared the Battig Award. The Hutchinson Award went to **Samuel Kolins** and **Mihai Bailesteanu**. **Ri-Xiang Chen** and **Ho Hon Leung** received the York Award.

MATH MAJORS

Seventy-two majors received Bachelor's degrees this year. Honors were awarded to twenty of our majors:

Summa Cum Laude

Daniel Collins
Nakul Dawra

Magna Cum Laude

Amrish Deshmukh
Vaikath Job
Divya Kirti
Matthew Paff
Seth Matthew Weinberg
Stephen Wolf

Cum Laude

Tamara Dietrich-Muller
Zhidong Leong
Cangming Liu
Yuanhong Luo
Atul Luykx
Daniel Perelman
Nicholas Renegar
Christopher Romeo
Juan Sagredo
Junping Shao
Zeynep Soysal
Gregory Strabel

HARRY S. KIEVAL PRIZE

The *Kieval Prize* is given to an outstanding undergraduate major annually. This year, it was awarded jointly to **Daniel Collins** and **Nakul Dawra**.

Please keep in touch!

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RURAL TUTORING PROGRAM

BY MARY ANN HUNTLEY

The Rural Schools Mathematics Tutoring Program provides remedial help to students in remote areas surrounding Ithaca. This is a voluntary program in which faculty, graduate students, and undergraduates provide on-site mathematics tutoring during after-school hours to students at George Jr. Republic School, Groton Middle School, Lansing Middle School, and Newfield Middle School. George Jr. Republic School is different from the other tutoring sites because most of the students at this school live on campus. This all-boys school is made up of students who are referred by probation or social services departments, school

districts, and the Office of Children and Family Services.

Emeritus faculty member Professor Michael Morley regularly participates in the Rural Schools Mathematics Tutoring Program. Ms. Crannell, the seventh-grade mathematics teacher at Lansing Middle School, shared this comment after a tutoring session:

After working with Prof. Morley, "Johnny" came into my room the next day saying: "Ms. Crannell, I didn't get improper fractions before, but now I OWN them." He was feeling really good!

More information about various outreach events from the Mathematics Department is online at:
www.math.cornell.edu/Community/community.html.

CORNELL MATHEMATICAL CONTEST IN MODELING

BY ALEXANDER VLADIMIRSKY

Last year, the focus of the Cornell Mathematical Contest in Modeling (CMCM) was on the comparative analysis of strategies to limit the spreading of "emerald ash borer" insects. This problem is both important and highly relevant (with recent publications in *New York Times* and conferences of entomologists dedicated to it). Twelve teams submitted solutions and four of them were selected to represent Cornell in the international MCM this past February.

Two of our teams have attained the second highest rank of "Meritorious" (top 19% among

2,254 teams from 14 countries). Hanrong Chen, Tiffany Low, and Ivana Thng have designed a model explaining the "sweet spot" phenomenon in baseball bats. Stephen Demjanenko, Ethan Dunn, and Joshua Edgerton earned their rank by modeling the spatial and temporal patterns in behavior of serial criminals.

The next internal CMCM contest will be held November 12-16, 2010. The contest is co-organized by the Department of Mathematics and ORIE (and co-sponsored by the Cornell Campus Store). The winners will represent Cornell in the international MCM 2011.

RESEARCH EXPERIENCE FOR UNDERGRADUATES

BY ROBERT STRICHARTZ (DIRECTOR)

The Cornell math department has been hosting a summer REU program since 1994 with support from the National Science Foundation. Talented undergraduates from across the country and around the world come here to tackle challenging and exciting research problems. In the summer of 2010 a total of 18 students worked in three areas: *Analysis on Fractals*, led by Robert Strichartz with graduate student Jason Anema, *Optimality and Uncertainty*, led by Alexander Vladimirovsky with graduate student Adam Chacon (a former REU undergraduate participant) and *Geometric Differential Equations* led by Xiaodong Cao with graduate student Mihai Bailesteanu. One of the students even worked on a project that bridged the first two areas.

Students in the *Analysis of Fractals* group investigated the analogs of differential equations on fractal spaces. For certain fractals, including the Sierpinski gasket, the Sierpinski carpet, and some of the

classical Julia sets, there is now a theory of “differential equations.” A major goal of this project, which has continued over several years, is to get more information about the solutions to these differential equations. The students in this project obtained a wealth of numerical data, shed light on several unsolved problems, and made at least one surprising discovery.

Students in the *Optimality and Uncertainty* group worked on the age-old problem of how to find the optimal way to do something. (The quickest driving directions? The most energy-efficient trajectory for a Mars Rover? The risk-of-detection-minimizing flight-plan for a spy plane?) The problem becomes even harder once you add to the mix the uncertainty about your environment, conflicting goals, and multiple (competing or cooperating) participants. The students in this group worked on five deterministic and stochastic control projects, which included theoretical, algorithmic, and numerical/experimental components. They extended

previous work, designed and compared methods for adaptive routing, determined some worst-case performance guarantees, and obtained some promising preliminary results.

The *Geometric Differential Equations* students worked on three different projects, all involving some type of Harnack inequalities. These are inequalities that compare the solution of the heat equation at different times and different points in space; they were used in the proof of the Poincaré Conjecture. One group worked on extending Harnack inequalities from two-dimensional Euclidean space to the n -dimensional case, while another worked on the same problem, but on a general manifold. The third group focused on proving Harnack inequalities on warped spaces, which have applications in theoretical physics.

Next year, Prof. Strichartz’ Analysis on Fractals project will continue, Prof. Ed Swartz will lead a combinatorics, group and Prof. Keith Dennis will direct a project in group theory.

2010 GRADUATE STUDENTS AWARDED PHD’S

Andrew Cameron, *Estimates for solutions of elliptic partial differential equations with explicit constants and aspects of the finite element method for second-order equations*

Timothy Goldberg, *Hamiltonian Actions in Integral Kähler and Generalized Complex Geometry*

Gregory Muller, *The Projective Geometry of Differential Operators*

Matthew Noonan, *Geometric Bäcklund Transformations in Homogeneous Spaces*

Sergio Pulido Niño, *Financial Markets with Short Sales Prohibition*

Math Matters is published through the combined efforts of members of the department. Many thanks to Laurent Saloff-Coste, Bill Gilligan, Michelle Klinger, Steve Gaarder, Brenda Smith, Heather Peterson, Bob Strichartz, Alex Vladimirovsky, Justin Moore, Patricia Hersh, Richard Shore, Steve Strogatz, and Mary Ann Huntley for their contributions.

Katie Huber,
Editor (kmh74@cornell.edu)

PROFESSOR ANIL NERODE HONORED

BY RICHARD A. SHORE

Professor Anil Nerode, Goldwin Smith Professor in the Department of Mathematics, received an honorary Doctor of Science degree, from his *alma mater*, the University of Chicago, at its June 12, 2010 convocation ceremony.

The degree was presented by his former student, Robert I. Soare, Paul Snowden Russell Distinguished Service Professor in Computer Science and Mathematics at the University of Chicago with the following introduction:

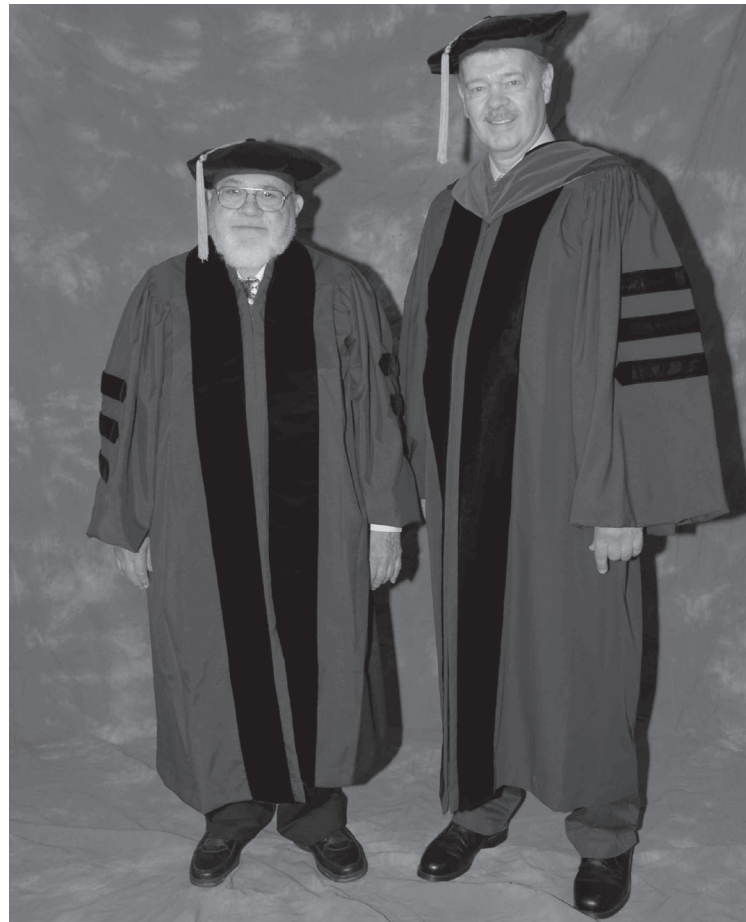
Anil Nerode is one of the foremost experts on mathematical logic and the theory of computability. One might place him in the tradition of Leibniz, with a scope of all of mathematics and a goal to understand computability and effective processes in all forms, theoretical and practical. With his A.B. and Ph.D. degrees from the era of Robert Hutchins and Marshall Harvey Stone, Nerode carried the resulting intellectual and mathematical traditions with him when he left Chicago in the 1950s, a time when the fields of mathematical logic, computability, and automata theory were in their infancy. In the subsequent decades he has done more than anyone else to bring these fields to their present state, through the power of his mathematical knowledge and his unique vision. Through his research and his mathematical descendants, Nerode has had and will continue to have a profound influence on mathematical logic and computability.

While honorary degrees at Chicago are awarded primarily for scholarly achievement and impact,

Nerode has had an extremely productive career in service to Cornell, various professional organizations, government and industry as well. He has served on a wide variety of college and university committees as well as ones for several professional organizations, other universities, and government agencies. Nerode has also consulted for more than 25 organizations, including the Institute for Defense Analysis, Institute for Naval Studies, IBM, Schlumberger, the National Science Foundation, and Argonne National Laboratory. He also has served as editor of some fifteen journals, among them the Journal of Symbolic Logic, Annals of Pure and Applied

Logic, Documenta Mathematica, Future Generation Computing, and Computer Modeling and Simulation.

In the realm of practical applications, Nerode was a cofounder of ClearSight Systems Inc. (www.clearsightsystems.com/) and a co-inventor of the hybrid systems, mathematical foundations and computational technologies that they employ for real-time implementation of reactive, intelligent, distributed controllers. He is currently working on a wide variety of applications of the mathematics he has been developing and has a number of exciting patents in the works.



Anil Nerode and Robert Soare



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MATHEMATICS DEPARTMENT ENDOWMENTS & GIFTS

We are grateful to alumni, friends, and family for their generosity in supporting our endowments or providing other gifts and donations to the department.

The **Ruth I. Michler Memorial Prize**, established by Gerhard and Waltraud Michler of Essen, Germany, in memory of their daughter, provides funding for the Ruth I. Michler Memorial Prize of the Association for Women in Mathematics. The awardee spends a semester here without teaching obligations.

The **Chelluri Lecture Series** was established by Raju Chelluri's parents in his memory. Funds are used to invite distinguished mathematicians to give annual lectures.

The **Michael D. Morley Senior Prize in Mathematics** is presented annually to an Ithaca High School student who has excelled in mathematics and who has demonstrated originality and innovative power in mathematics.

Teaching Awards for Graduate Students and faculty were created in 2001. Prizes are awarded to graduate students.

The **Colloquium Endowment Fund** was instituted to invite distinguished scientists to speak at the Oliver Club seminars. (See www.math.cornell.edu/~oliver/.)

The **Eleanor Norton York Endowment** was established in honor of Eleanor Norton York to recognize outstanding graduate students in both Astronomy and Mathematics.

The **Faculty Book Endowment** is dedicated to providing the Cornell community with access to one of the world's finest collections of mathematics books and publications.

The **Israel Berstein Memorial Fund** was established in honor of Israel Berstein, a professor in this department from 1962-1991. The memorial fund is intended to help young mathematicians in the field of topology.

The **Logic Endowment** was started with a generous gift from a former Cornell undergraduate to support promising logic students.

The **Robert John Battig Endowment** was established by his parents after his untimely death. Robert was awarded a January 1998 Ph.D. in mathematics. The fund provides an annual prize to an outstanding continuing graduate student in mathematics at Cornell.

If you would like to contribute, please make your check payable to Cornell University, indicate the endowment, or that it is a gift in support of Mathematics, and send it to:

Department of Mathematics Endowments & Gifts
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Gifts can also be made online at
www.giving.cornell.edu