DEPARTMENT OF MATHEMATICS

UNIVERSITY *of* WASHINGTON

2018

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Message from the Chair

In July, I took over as chair from Ron Irving, who held the position for the past five years. Among his many accomplishments as chair, for which all of us owe him many thanks, he led the drive to create the **Gloria Hewitt Endowed Graduate Fellowship**, which provides support for under-represented graduate students in mathematics. Through his leadership and through generous gifts from Ron and his wife Gail, the fellowship is now fully funded. For this and for his service as chair, I extend the department's great gratitude and appreciation.

Our faculty received many honors this past year. Three of our faculty members were promoted: Jonah Ostroff was promoted to Senior Lecturer, Thomas Rothvoss to Associate Professor, and Soumik Pal to Professor. This summer Thomas also won the very prestigious **Fulkerson Prize**, an international award given only every three years. Sara Billey and Tímea Tihanyi (from the UW School of Art + Art History + Design) were awarded the UW Bergstrom Award for Art and Science to support their collaborations combining math and art.

Max Lieblich was named a Simons Fellow, following in the footsteps of Julia Pevtsova and others in our department. Speaking of Julia, she has written a lay-person's summary of her research: see pages 10–11. As with many of my colleagues, she excels not just in research but also in teaching, and she won two teaching awards this year in recognition, one from the Pacific Northwest Section of the Mathematical Association of America, and one from the Pacific Institute of Mathematical Sciences.

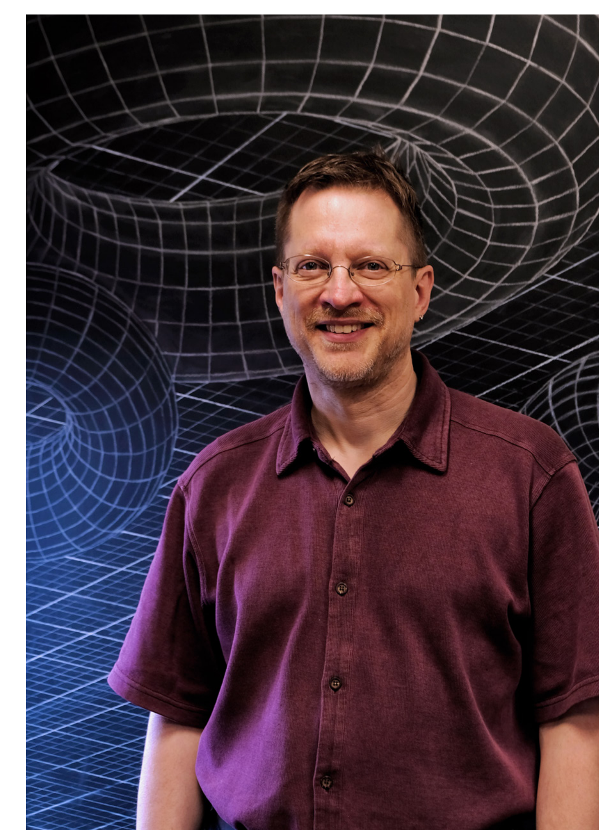
Looking back, we were saddened when Branko Grünbaum died in September. He arrived at the University of Washington more than 50 years ago, and although he retired in the early part of this century, he remained active around the department. His mathematical legacy lives on in our department through Isabella Novik, who was a PhD student of Gil Kalai, who was a PhD student of Micha Perles, who was one of Branko's PhD students.

Looking to the present, this year we welcome Bobby Wilson, our newest faculty member. Bobby received his PhD from the University of Chicago and was most recently in a postdoctoral position at MIT. His research is in geometric measure theory, partial differential equations, and harmonic analysis.

Looking forward, we are anticipating Karen Smith's visit in March, when she will give this year's Milliman Lectures. She is a prominent professor at the University of Michigan, and she will speak about her work in commutative algebra and algebraic geometry. We also host the ongoing lecture series MathAcrossCampus, which focuses on applications of mathematics; the first lecture, in November, was given by John Dabiri, Daniela Witten will speak in March, and Elisabetta Matsumoto in May.

Looking farther forward, we expect a number of retirements over the next few years. We very much hope that the retirees remain part of our department, as is the case with many of our emeritus faculty. We will of course miss those colleagues who leave. In any case, these retirements also present exciting opportunities: although our departing colleagues can never truly be replaced, we hope to be able to hire new faculty members, enlarging and enriching our mathematical community for years to come.

- John Palmieri



Pictured in background: chalk drawing from Axiomatic (2016) by Tímea Tihanyi

Faculty Promotions

Professor Soumik Pal


Photo by Dorothée Brand

I joined the University of Washington in 2008 after graduate studies at Columbia and a postdoctoral position at Cornell—two East Coast institutions. Although we live in a globally connected world, local geography still has an enormous influence on us. I take this opportunity to acknowledge the influence that Seattle and the University of Washington have had on my work over the last decade.

The first influence of the West Coast is the vast expansive land and water where we can breathe free from the hierarchy of the old world. In mathematics we often gravitate towards problems that come down "from the top." I am a firm believer in independently looking for problems around us, by talking to people beyond our enclaves without judgment, exploring different areas with little regard for the reward that comes from being a part of the system. I have tried to follow this belief by researching a wide variety of areas related to probability theory: from mathematical economics to spectral analysis of random matrices and evolutions of random trees and networks.

The second influence, particularly due to the presence of Seattle, is that I ask myself constantly what my research is good for and who benefits from it. We are employed by a public university supported by the population of a region that deeply believes in equality and inclusiveness. I have always felt that it is important for me to do research that I can explain to the common person, perhaps not in full detail, but convincingly enough to argue that we in the university are playing an important role in enriching the lives of people around us. This is achieved by teaching courses to students about what they wish to learn, trying to make thinking about mathematics interesting and accessible to everyone. Of course, probability theory is fortunate to have available a large number of examples from our daily experiences. In my regular courses, special topics courses, summer schools, and other pedagogical activities, I actively try to make probability more relatable.

These aims have had both a reasonable amount of success and a string of failures. Despite the failures, I intend to continue pushing in these directions because I truly believe in these values. I thank the University of Washington and the city of Seattle for the courage they provide me to continue to believe.

Senior Lecturer Jonah Ostroff


Photo by Dorothée Brand

Jonah Ostroff received his BA in Mathematics from Carleton College in 2008 and his PhD from Brandeis University in 2013 with a thesis on enumerative combinatorics. His interests in teaching and outreach were already evident at Brandeis, where he received a University Prize Instructorship to develop an interdisciplinary course on mathematics and democracy, and where he taught middle school students in a Math Circle program. The department hired him directly out of graduate school as a Lecturer. This past fall, he was promoted to Senior Lecturer, based on his excellence in teaching in many settings.

Jonah has taught a variety of 100- and 300-level courses at UW and has recently taken over the online section of Math 126. He is the Assistant Director of the Washington Experimental Mathematics Lab, which provides research opportunities to undergraduates across campus, working in small groups with faculty and graduate students. He also has been involved with the Math Circle and Math Olympiad activities created by Julia Pevtsova and been one of the coaches for UW's undergraduate team in the annual William Lowell Putnam Mathematical Competition.

Jonah's outreach activities allow his pedagogical gifts to reach much farther. He teaches courses at the Monroe Correctional Complex through University Beyond Bars, and he is the founding director of MathILy-Er, a five-week summer program for mathematically talented high school students from around the country. In that role, he handles admissions, hires staff, designs curricula, serves as one of the instructors, and more. Wherever Jonah teaches, he establishes a collaborative environment in which students learn, have fun, and are valued.

Associate Professor Thomas Rothvoss

Thomas Rothvoss (second from left) receiving the Fulkerson Prize from prize committee member Martin Grötschel, Mathematical Optimization Society chair Karen Aardal, and vice chair William Cook.

Associate Professor Thomas Rothvoss received his Diploma in computer science at TU Dortmund in Germany in 2006 and completed his PhD at the École Polytechnique Fédérale de Lausanne in Switzerland in 2009. He joined the department in 2014 after three years as a postdoctoral fellow at MIT. Thomas has received many major awards and honors since coming here, including a Sloan Research Fellowship, an NSF CAREER grant, and a Packard Fellowship in Science and Engineering.

Thomas' research interests lie in optimization, discrete mathematics, and theoretical computer science. A major focus of these fields is the algorithmic tractability of optimization problems. A classical example is bin packing, in which one asks to pack objects with certain weights into a minimum number of boxes of equal capacity. Many such problems turn out to be what is called NP-hard, with no efficient algorithm known for solving them. Instead, one can aim to find a solution efficiently that may not be the optimum, but is provably close to it. The techniques behind such approximation algorithms often come from convex optimization and probability theory. In the opposite direction, one may try to prove lower bounds for algorithms. For example, Thomas proved that the perfect matching polytope is not the projection of a polyhedron with less than exponentially many facets, for which he received the **Fulkerson Prize** described below. Apart from algorithmic problems, Thomas has a fondness for combinatorial and high-dimensional geometric questions that arise in theoretical computer science.

Thomas teaches the department's standard optimization courses at both the undergraduate and graduate levels. In addition, he has taught a graduate topics course on lattices and will be teaching a graduate course on probabilistic methods in combinatorics. He holds a joint appointment with the Paul G. Allen School of Computer Science & Engineering, where he is a member of the CS theory group.

The Fulkerson Prize is awarded jointly every three years by the Mathematical Optimization Society and the American Mathematical Society for outstanding papers in the area of discrete mathematics, with awardees announced at the triennial International Symposium on Mathematical Programming. Discrete mathematics includes graph theory, networks, mathematical optimization, applied combinatorics, and related subjects, and the prize is awarded based on a paper's mathematical quality and significance.

Past recipients of the prize are a who's who of major figures in the represented fields, such as two inaugural recipients—Kenneth Appel and Wolfgang Haken—who received it in 1979 for their paper proving the four color theorem. At the ISMP in Bordeaux in July, Thomas Rothvoss was one of the latest recipients, in recognition of his paper "The Matching Polytope has Exponential Extension Complexity" appearing in 2017 in the Journal of the ACM. (The ACM is the Association for Computing Machinery.) The same work had earlier been awarded the Best Paper Prize at the ACM Symposium on the Theory of Computing.

Faculty Honors & Awards

Sara Billey

The College of Arts and Sciences offers the Bergstrom Award for Art and Science annually to support faculty projects "that enhance the student experience and bridge the intersection between art and science." The 2018 recipients of the award were Professor Sara Billey and Tímea Tihanyi from the School of Art + Art History + Design. Sara and Tímea have collaborated on several projects over the years, and Tímea has collaborated as well with faculty members Sándor Kovács (co-teaching a Discovery Seminar on art and mathematics for incoming students) and Jayadev Athreya (via a grant from UW's Simpson Center for the Humanities). The following passage from Sara and Tímea's Bergstrom proposal captures the spirit of their work together:

Photo Credit: Timea Tihanyi

Burst and Follow Series (Cellular Automata), 3D printed porcelain, 13"x10"x10", 2018. Timea Tihanyi & Sara Billey.

> **We've successfully developed a process for transcribing Sage-generated images into computer-aided designs (CAD) using Rhino, Meshmixer, and Simplify3D. Following the prescribed path of coordinates, the ceramic 3D printer extrudes a thin coil of soft plastic porcelain. As a result of the ceramic process from printing to firing, the rigorous geometry of the design goes through an amazing transformation. Due to the material qualities of clay, objects made on the clay printer would not exist and often enough cannot stand without the human hand. The exposure to vitrification temperatures in the kiln, glazing, and surface treatments soften the forms, create "blips," inconsistencies, and unrepeatable surprises. Clay shares a key ingredient, silica, with semiconductors. Various impurities and changes to the algorithm of its basic chemical structure make each material: the humble dirt that makes vessels for the body and the nearly immaterial piece of technology that mediates most aspects of our daily lives. Potters refer to the intelligence of clay, a "memory" by which it remembers its former states and a "personality," which requires a deep understanding of the material through craft. Between algorithm and serendipity lies the resulting 3D printed clay object, logical yet unpredictable.**

Julia Pevtsova

This past February, Professor Julia Pevtsova received the distinguished teaching award of the Mathematical Association of America's Pacific Northwest Section. The MAA is one of the country's two major professional organizations devoted to mathematics at the college level, with a focus on education, professional development, and publishing of expository mathematics. In April, Julia received the 2018 Education Prize of the Pacific Institute for the Mathematical Sciences. PIMS is a collaboration among universities across western Canada along with the University of Washington. The prize is awarded each year to a member of the PIMS community who has made a significant contribution to education in the mathematical sciences, recognizing individuals "who have played a major role in encouraging activities which have enhanced public awareness and appreciation of mathematics, as well as fostering communication among various groups and organizations concerned with mathematical training at all levels."

Photo by Dmitry Vasilevsky

Julia has been recognized within the department as well via her appointment to a three-year term as the inaugural holder of a faculty fellowship endowed a year ago by Brian and Tiffinie Pang. In nominating Julia for the MAA award, then-department-chair Ron Irving emphasized the "striking range of Julia's activities, involving every level of mathematical learner from elementary school to postdoc." He went on to write:

At the graduate level, soon after joining our faculty, Julia took the initiative to revamp the curriculum of our core first-year algebra course, after which she created a standardized second-year algebra course that we now offer in alternate years. She has also organized workshops in representation theory for postdocs and graduate students through the Mathematical Sciences Research Institute in Berkeley and the Pacific Institute for the Mathematical Sciences.

At the undergraduate level, Julia has distinguished herself through the problem-solving course she developed jointly with Ioana Dumitriu that attracts many of our best students. She and Ioana offer the course each fall in parallel with a preparation program for students who wish to participate in the Putnam competition. Putnam highlights include a top ten team finish last year and a Putnam Fellow in 2009. Julia has also had great success teaching our senior-level geometry course for future secondary teachers.

As valued a teacher as Julia is within the department, what sets her apart is her astonishing record of K-12 outreach. This includes the Math Challenge program at Montlake Elementary School; the weekly Math Circle for 7th, 8th, and 9th graders on campus; the Math Hour spring lecture series for middle and junior high students and their families ("well-behaved parents and teachers are also welcome to attend with the permission of their children"); and the

(continued on page 8)

Max Lieblich

Photo by Dorothée Brand

Max Lieblich is a 2018 Simons Fellow. The Simons Foundation's fellowship program, which began in 2012, is designed to provide awardees with additional sabbatical funding that can "lead to increased creativity and productivity in research." Tatiana Toro was one of the inaugural fellows six years ago, followed by Hart Smith, Gunther Uhlmann, Sándor Kovács, Chris Hoffman, and Julia Pevtsova in subsequent years. Max is visiting the Department of Mathematics at Rice University in Houston this fall and will spend the spring in Berkeley at the Mathematical Sciences Research Institute, participating in their semester-long program on Birational Geometry and Moduli Spaces.

(continued) annual Math Olympiad, in which an army of local adults volunteers to provide feedback on students' oral descriptions of solutions to mathematical problems. Through all of these projects, Julia provides pedagogical guidance to many of our graduate and undergraduate students, with teaching and learning thereby taking place simultaneously at multiple levels.

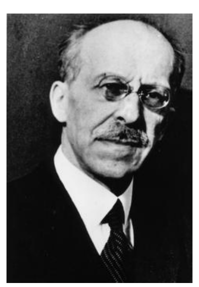
Julia began her outreach projects over a decade ago with the help of a UW graduate student, Steve Klee. Now a faculty member at Seattle University, Steve has become Julia's outreach partner. A year ago, he received the Mathematical Association of America's Henry L. Alder Award for Distinguished Teaching, given to early-career mathematicians whose teaching is extraordinarily successful with "influence beyond their own classrooms." Steve exemplifies Julia's multilevel impact.

Research Highlight

"Some day you might be able to tax it." That's Michael Faraday's famous (though apocryphal) response to British Prime Minister William Gladstone's query about the utility of electromagnetic waves. I recently encountered this at a talk by Robbert Dijkgraaf, the director of the Institute for Advanced Study in Princeton, who was in Seattle for a fundraising trip. He combined the visit with a presentation at Amazon about the new book *The Usefulness of Useless Knowledge*, which features Institute founding director Abraham Flexner's classic essay of the same title, first published in *Harper's* magazine in 1939, along with a new companion essay by Dijkgraaf. Flexner argues that the most groundbreaking discoveries are often motivated by the search for answers to deep questions without regard to immediate practical application. Such fundamental discoveries might lead to things we cannot imagine our lives without fifty years down the road—think quantum mechanics/computer chips—or they might not. The basic argument is that not having such an application in mind should not be an obstacle to pursuing ideas. Despite the very serious, sometimes even grim, nature of the book, it is sprinkled with amusing examples, such as the Faraday story.

My own field of study, not rooted in any immediate practical applications, is *Representation Theory*, the theory of symmetry for mathematical and physical systems. Born more than a century ago, it was first developed by the four Pioneers of Representation Theory—Frobenius, Schur, Burnside, and Brauer—who built the foundations of the subject as we know it today.

Georg Frobenius



Issai Schur

William Burnside

Richard Brauer

Since then, important and deep connections to areas as varied as topology, algebraic geometry, Lie theory, homological algebra, and mathematical physics have been discovered and exploited. Still, the area abounds with basic problems and fundamental conjectures, some of which have been open for many decades. Very recent breakthrough results have led to the hope that some of these can finally be settled. In turn, results in representation theory have led to substantial progress in number theory, algebraic geometry, and combinatorics, to name a few.

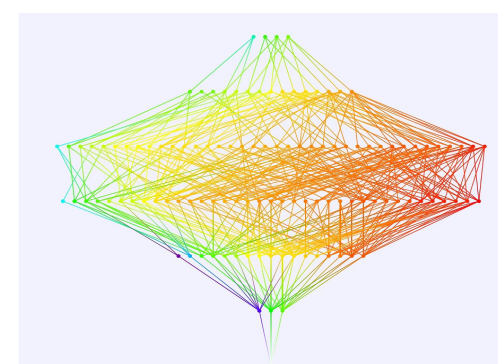
Classical representation theory deals with symmetries arising from actions of groups on complex vector spaces. Taking after biologists with their taxonomic zeal, mathematicians like to classify all symmetries of a given object, in this case, all possible actions of a given group. When the actions are on complex vector spaces, all symmetries are put together in a straightforward manner from simple building blocks. These blocks can be enumerated in an elegant combinatorial way, and each one is described by an algebraic formula, called a character, which can be quite complicated but yet fairly explicit.

In my research, I focus on representations "mod p," which remain mysterious with many open problems, unsolved conjectures, and exciting recent developments. I also study an unexpected sibling of mod p representation theory, representations of small quantum groups and their generalizations.

In the mod p world, often referred to as *modular representation theory*, symmetries arising from actions of finite groups on vector spaces—now defined over fields of positive characteristic p—do not admit as nice a global structure as complex representations, which makes them even more interesting to study! Although there are building blocks analogous to the simple building blocks of complex representation theory, called indecomposable representations, they do not admit a comprehensive combinatorial enumeration. For a given finite group, its mod p representation theory may be "finite," "tame," or "wild." In almost all cases, the representation theory is wild, which basically means that there is *no hope* of classifying indecomposable representations. This wild behavior occurs even for groups with as few as eight elements! One can respond by throwing one's hands in the air. Or, one can turn to other subjects, such as algebraic topology and algebraic geometry, to draw inspiration on how to map this wild territory.

To bring in the methods from other areas, we employ category theory. This introduces a high level of abstraction into the subject but vastly enriches the arsenal of available techniques. Symmetries and group actions lead to many examples of categories: classes of objects and behaviors that share common properties. The examples abound in any area of mathematics, with categories of groups, of spaces, of manifolds, etc. Category theory allows one to cross-pollinate between different subject areas by distilling what exactly is essential for a particular structure. We may not be able to tax category theory just yet, but it is fundamental, for instance, to programming languages such as Haskell.

An example of such cross-pollination that is of utter importance to modular representation theory goes back to 1971, when Daniel Quillen employed commutative algebra and algebraic geometry to answer some longstanding questions about mod p symmetries of finite groups, as well as compact Lie groups.



Quillen's papers opened the floodgate for the use of geometric methods in mod p representation theory and led to the development of the theory of supports, which forms the foundation for a lot of my work. By passing over to the commutative algebra world, Quillen assigned a topological space to any finite group (the spectrum of its mod p cohomology algebra) that retained a lot of information about the mod p symmetries of the group while having a beautiful combinatorial structure given in terms of the Hasse diagram for certain abelian p-subgroups of the original group. The picture above, courtesy of my younger mathematical brother Jared Warner, depicts Quillen's space for the alternating group A_{14} when p=2.

Another advantage of the categorical approach is that one can perform operations on symmetries in the categorical framework, which makes them feel almost like integers! Representations can be added and multiplied. There are further operations one can do for which categorical language becomes even more essential: taking shifts and cones of representations. These would be natural operations for people studying topology or homological algebra. Endowed with these operations, the category of representations has enough structure for us to try to understand its global behavior, but how?

At a recent workshop at the American Institute of Mathematics in San Jose, I had the task of presenting a short introduction of my group's research agenda to other groups in residence, all of which were working on some version of neural networks. One group was devising models for mushroom spawns, with the goal of recognizing the global behavior of a huge mycelium by analyzing its local properties. The largest known mycelium, *Armillaria ostoyae*, currently extends 3.5 miles in diameter and has lived in Eastern Oregon for over 2400 years. It struck me that my research group has similar objectives. We wish to understand the global structure of a very complicated, unruly, wild category of mod p representations. But we look at it locally: start with a particular representation and move to its neighbors, which we reach by applying the basic operations of addition, multiplication, cones, and shifts. Then move to their neighbors in the same way, and so on. In the language of algebraic topology, we build new representations from a given one step by step, investigating its local neighborhood. For the global structure, we ask for a map of the entire category that identifies the local neighborhoods in some comprehensible, or even better, computable way.

This goal can be attained in terms of a geometric invariant that grew out of Quillen's foundational work, the *support*. The support can be thought of as an intrinsic label attached to a representation, a zip code to place it in an appropriate neighborhood. These labels can be quite complicated. For example, the earlier picture gives a combinatorial description of the support of the trivial one-dimensional representation of the group A_{14}. Imagine sending a letter with this on the envelope!

Dave Benson, Srikanth Iyengar, Henning Krause, and I have recently proved a theorem characterizing when one representation can be built from another and, hence, belongs to the same neighborhood. The theorem is based in an essential way on a series of papers I previously wrote with Eric Friedlander in which we developed a new notion of a point in representation theory, a *π-point*. Our results apply to all finite group schemes, a large class of algebraic objects that includes finite groups and mod p Lie algebras. I conclude with a statement of the theorem.

Theorem. Let G be a finite group scheme, k a field, and M and N representations of G over k. Then M can be built out of N if and only if the support of M is a subset of the support of N.

Branko Grünbaum
1929–2018

From the *Seattle Times* obituary:

"Branko Grünbaum, a professor emeritus of mathematics at the University of Washington who was known worldwide in his field, died September 14, 2018, at age 88. He was born in Osijek, Croatia (at the time part of Yugoslavia) in 1929, and was married for 61 years to his high-school sweetheart, Zdenka (Bienenstock) Grünbaum. Having survived the Holocaust in Yugoslavia, they emigrated to Israel in 1949.

"Branko was a devoted and involved father and grandfather, a prolific scholar with wide-ranging interests, fluent in five languages, and a lover of the outdoors and especially the Pacific Northwest mountains and coast. He earned MSc and PhD degrees at Hebrew University in Jerusalem, along the way serving in the Israeli Air Force as an analyst. After working at the Institute for Advanced Study in Princeton, Hebrew University, and Michigan State University, he became a full professor at the University of Washington in Seattle in 1966, where he researched and taught for the next 35 years."

Branko's initial studies were at the University of Zagreb, and he received his Hebrew University PhD in 1957. Among many honors, Branko received the American Mathematical Society's Leroy P. Steele Prize for Mathematical Exposition in 2005 for his classic 1967 monograph *Convex Polytopes*, a second edition of which had appeared in 2003 with the addition of short notes to each chapter. The citation stated that "much of the development that led to the present, thriving state of polytope theory owes its existence to this book, which served as a source of information for workers in the field and as a source of inspiration for them to enter the field." The book received further recognition last spring, in an article by Günter Ziegler in the May 2018 issue of the *Notices of the American Mathematical Society* titled, *For Example: On Occasion of the Fiftieth Anniversary of Grünbaum's Convex Polytopes*.

Isabella Novik, the director of the department's graduate program and the Robert R. & Elaine F. Phelps Professor, is a mathematical descendant of Branko, via a lineage based at the Hebrew University. She received her PhD in 1999 under Gil Kalai, who received his degree under Micha Perles in 1983, and Perles received his degree under Branko in 1964. **Here, Isabella writes about Branko's mathematical influence.**

How does one begin to describe the mathematical influence of a sixty-plus-year career that already resulted in more than 200 descendants? Seems like a daunting task, especially because very few of us can claim the same mathematical depth and breadth as Branko Grünbaum had; certainly not the writer of this piece. So instead of trying to encompass the un-encompassable, I'll concentrate on a couple of areas that are closer to my heart.

One of them is the theory of convex polytopes, a huge, rapidly developing and vibrant area of research that would not even resemble what it is today were it not for Branko's 1967 book *Convex Polytopes*. A convex polytope is the convex hull of finitely many points in a Euclidean space. Examples include pyramids, cubes, and octahedra.

Steinitz's famous theorem from early 1900—or more precisely, Branko's version of that result—asserts that a simple graph is the graph of a 3-dimensional polytope if and only if it is planar and 3-connected (that is, removing any two vertices does not disconnect the graph). Despite being a classic result in discrete geometry and a beginning of so many research directions, the first readable account of its proof only appeared in Branko's book. In fact, according to Branko, his "working through the Steinitz-Rademacher book in Summer of 1963, translating Steinitz's complicated process of establishing the *Fundamentalsatz der konvexen Typen* into the easy-to-follow proof of the graph-theoretical formulation" is one of the things that led to the creation of the book. Another impetus was Vic Klee's groundbreaking papers on the Dehn-Sommerville equations and the Upper Bound Conjecture.

In 1964-65, Branko gave a course on combinatorics of convex polytopes, for which he prepared lecture notes. In just two years these lecture notes resulted in the book that even today remains a major reference for polytope theory. The book described both classic and completely new techniques and results, such as the theory of Gale's diagrams developed by Micha Perles as the book was nearing completion (and which delayed the book for a few months).

As Branko wrote in the preface to the first edition, "While the author is confident that the current surge of interest and research in the combinatorial properties of convex polytopes will continue and will render the book obsolete within a few years, he may only hope that the book itself will contribute to the revitalization of the field and act as a stimulant to further research." This hope has been very much realized. For proof, consider the second edition of the book, published in 2003. At the end of each chapter, there is a section of notes summarizing a selection of the relevant outstanding discoveries made from 1967 to 2003. Major breakthroughs since 2003 include, for instance, Paco Santos' disproof (in 2010) of the Hirsch conjecture on the diameter of polytopes.

Branko and Isabella (center) with (starting from left) Gil Kalai, Michael Goff, Kurt Luoto, Andy Frohmaderand, and Steven Klee.

Another extremely influential paper I must mention is a survey paper by Branko in collaboration with Ludwig Danzer and Vic Klee titled *Helly's theorem and its relatives*, from 1963. Helly's theorem (1913) states that if we are given n convex closed sets in R^d with the property that every d+1 of them have a non-empty intersection, then all of these sets have a non-empty intersection. This result, which many consider to be the beginning of modern Discrete Geometry, has a tremendous amount of relatives, extensions, and generalizations, among them a recent counter-example (2015) by Florian Frick to the topological Tverberg conjecture. Similarly to Branko's book on polytopes, the paper by Danzer, Grünbaum, and Klee played a catalytic role in many of these developments: it was encyclopedically comprehensive and advertised many unsolved problems.

Yet another paper of Branko in collaboration with Danzer (1962) simultaneously solved a problem due to Erdős and a problem due to Klee. The main result of this paper asserted that every collection of more than 2^d points in R^d determines at least one *obtuse* angle. The proof used an idea going back to Minkowski and was so elegant that it made a chapter in Martin Aigner and Günter Ziegler's *Proofs from THE BOOK*. This work also raised the natural question of finding the maximal number of points for which all angles can be *acute*. While the exact answer is still unknown, this question led to a plethora of new methods and results, including a probabilistic construction by Erdős and Füredi. Last year, an incredibly simple explicit construction due to Gerencsér and Harangi produced a current record: there exists a collection of $2^{d-1}+1$ points in R^d with all angles acute. (Of course, by the result of Danzer and Grünbaum, the maximum is less than 2^d.) Perhaps even more surprisingly, this problem has connections to centrally symmetric polytopes with many faces, which in turn has connections to problems of sparse signal reconstruction and error correcting codes.

In fact, Branko's contributions to the theory of centrally symmetric polytopes deserve a section of their own. It is well known that for any dimension d from 4 up, and for any number of vertices $n > d$, there is a d-dimensional polytope with n vertices and exactly $n(n\text{-}1)/2$ edges; in other words, the graph of such a polytope is the complete graph. If a polytope is centrally symmetric, then no two antipodal vertices can be connected by an edge. Stated a bit differently, the graph of such a polytope is always contained in the complete graph minus a perfect matching, and hence cannot have more than $n(n\text{-}2)/2$ edges. A natural question is whether a centrally symmetric polytope can have exactly $n(n\text{-}2)/2$ edges. Branko showed that the answer is *no* even for d = 4 and n = 12. This observation initiated a lot of research on trying to understand the face numbers of centrally symmetric polytopes and centrally symmetric spheres, a fascinating field with plenty of mysteries still unresolved.

The results I have mentioned so far form an extremely small sample of Branko's interests. There are tons of conjectures and problems that bear Branko's name, and quite a few directions of research that grew out of his papers and books. In the pre-MathSciNet era, researchers in discrete geometry who wanted to get a head start on a question would often start by writing Branko to see what was known about the problem. He kept cabinets full of index cards in his office with notes on articles, and he always seemed to know just the right references to get one off and rolling.

Let me finish with a few sentences that János Pach shared with me recently. "As usual, when I came across a question related to polytopes or tilings, or when I needed a quick opinion about a paper in the subject that was submitted to *Discrete and Computational Geometry*, I wrote to Branko. He had a great memory and he was incredibly fast and sharp. I completely trusted his judgment and instincts until the very end."

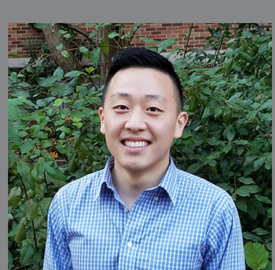
New Faculty

Assistant Professor Bobby Wilson

This past summer, Bobby Wilson joined the department as a tenure-track assistant professor. Bobby, who works in geometric measure theory, partial differential equations, and harmonic analysis, received his B.S. from Morehouse College in 2010 and his Ph.D. under Wilhelm Schlag and Marianna Csörnyei at the University of Chicago in 2015. He was a C.L.E. Moore Instructor at MIT from 2015 to 2018 as well as a postdoctoral fellow at the Mathematical Sciences Research Institute in Berkeley during semester-long programs in partial differential equations (2015) and harmonic analysis (2017).

Bobby's research interests are close to those of Professor Tatiana Toro. His arrival is all the more exciting because of the expertise he brings to the department in previously unrepresented areas of active research such as dispersive PDEs. This will benefit colleagues and students alike.

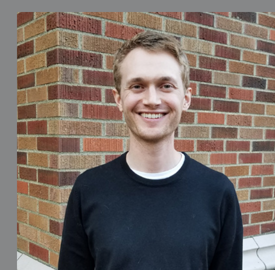
In addition to research and teaching, Bobby has been actively engaged in outreach activities. For example, he has given talks at MIT to high school students from under-represented backgrounds and at West Point to undergraduates as part of the Minorities in Mathematics Speaker Series. He also regularly meets with Morehouse and Spelman College students to discuss research and graduate education.



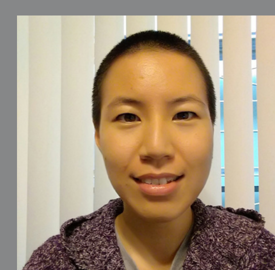
Robert Won received his Ph.D. at UC San Diego in 2016 under the supervision of Daniel Rogalski, then spent two years as a postdoc at Wake Forest University, working with Ellen Kirkman. He will continue his research in noncommutative algebra, collaborating with James Zhang.

Acting Assistant Professors

Simon Bortz received his Ph.D. from the University of Missouri in 2016 under the supervision of Steve Hofmann, then spent two years as a postdoc at the University of Minnesota, working with Svitlana Mayboroda. He will continue his research in geometric measure theory, collaborating with Tatiana Toro.

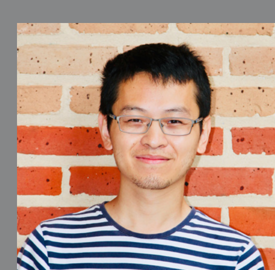


Bennet Goeckner received his Ph.D. from the University of Kansas last spring under the supervision of Jeremy Martin. He will continue his research in combinatorics, collaborating with Isabella Novik.



Dami Lee received her Ph.D. from Indiana University last spring under the supervision of Matthias Weber. She will continue her research in hyperbolic geometry, collaborating with Jayadev Athreya.

Moumanti Podder received her Ph.D. at New York University in the spring of 2017 under the supervision of Joel Spencer, then spent one year as a postdoc at Georgia Tech, working with Prasad Tetali and Esther Ezra. She will continue her research in probability, collaborating with Soumik Pal.



Jian Zhai received his Ph.D. from Rice University last spring under the supervision of Maarten V. de Hoop. He will continue his research in inverse problems, collaborating with Gunther Uhlmann.

2018-19 Milliman Lecturer

Each year, the department invites a distinguished mathematician to deliver a series of three lectures and participate for a week in department life. Support for the visit is from a departmental endowment in the name of Wendell Alfred Milliman, founder of one of the largest actuarial firms in the country. This year's Milliman Lecturer is Karen Smith, the M. S. Keeler Professor of Mathematics at the University of Michigan. She will speak from March 5 to March 7.

Professor Smith's research lies at the interface of commutative algebra and algebraic geometry. Among many honors, she was the recipient of a Sloan Research Fellowship, a Fulbright award, and research grants from the National Science Foundation and the Clay Foundation. In 2001, she received the American Mathematical Society's Ruth Lyttle Satter Prize, which is awarded every two years to recognize an outstanding contribution to mathematics research by a woman in the previous six years. She was also an invited speaker at the 2014 International Congress of Mathematicians, held in Seoul, South Korea.

MathAcrossCampus

Founded in 2008, MathAcrossCampus is a quarterly lecture series sponsored by the department that showcases applications of mathematics to a campus-wide audience. This year, Professor Jayadev Athreya joins founders Ioana Dumitriu, Christopher Hoffman, and Rekha Thomas as a co-organizer. The Washington Research Foundation has generously agreed to provide support for the series for this year and the next two. The goals of the series are to expose students and faculty to applications of mathematics in a wide array of disciplines and to build a community of mathematics users at UW by creating awareness of mathematical work done by colleagues and students on campus. Each year, three speakers are featured.


Photo by Holly Hernandez

John Dabiri

The Autumn Quarter speaker this year was John Dabiri, Professor of Civil & Environmental Engineering and of Mechanical Engineering at Stanford University. His lecture was titled, "From Jellyfish and Wind Turbines to Genomics: Dealing with Data Extremes in Complex Systems." In the abstract, Professor Dabiri wrote, "Our ability to predict important phenomena such as ocean climate change, cardiovascular health, or the performance of a jet engine requires a set of mathematical tools to describe complex fluid dynamics. In practice, we're often faced with a Goldilocks problem: we have either too much data arising from observations of those flows or too little data. In this talk we'll explore new tools from Lagrangian fluid dynamics, differential calculus, and graph theory that allow us to navigate both data extremes and ultimately to optimize important flow physics. As a bonus, we'll discover how similar ideas can be exploited to study biological data arising in fields like genomics and neuroscience."

The winter speaker is Daniela Witten of UW's Departments of Statistics and Biostatistics, whose research involves the development of statistical machine learning methods for high-dimensional data, with applications to genomics, neuroscience, and other fields. The spring speaker is Elisabetta Matsumoto, an assistant professor in the School of Physics at Georgia Tech University, whose research focuses on the geometry and topology of soft materials.

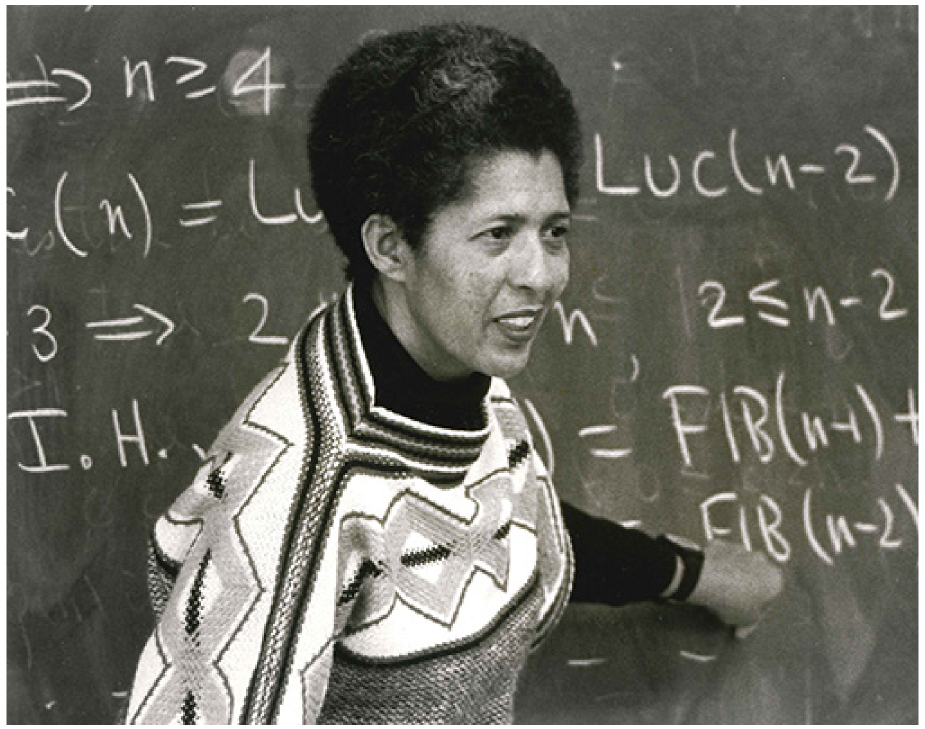
Rekha Thomas

ICM Speaker

In August, Rekha Thomas traveled to Rio de Janeiro to speak at the quadrennial International Congress of Mathematicians. An expert in optimization theory, she joined five mathematicians from Europe and Brazil as a speaker in the section on Control Theory and Optimization. Her lecture, titled "Spectrahedral lifts of convex sets," discussed results at the intersection of convex geometry, combinatorics, real algebraic geometry, optimization, computer science, and more. Rekha found attendance at the congress exhilarating.

"I was greatly impressed by the quality and accessibility of the plenary talks that make up the main part of the schedule. It was truly inspiring to see the breadth of mathematics that was being used in any given talk and the clarity with which the speakers were able to communicate their results. The topics ranged over all parts of mathematics, but especially impressive was the inclusion of several areas outside of pure mathematics, such as computer science, statistics, physics, and the history of math, showcasing the wide reach of mathematics in modern scientific movements."

Gloria Hewitt Endowed Graduate Fellowship



Last March, the Gloria Hewitt Endowed Graduate Fellowship was established to "promote excellence in the graduate program of the Department of Mathematics, in particular enhancing efforts to achieve a more equitable representation of those under-represented in the field of mathematics." Dr. Hewitt is among the first African-American women in the US to receive a PhD in mathematics. Her 1962 degree, here at UW under the supervision of Richard Pierce, made her the sixth African-American woman to earn a PhD in mathematics. She took a faculty position at the University of Montana in 1961 and remained there until her retirement in 1999, serving as chair from 1995 to 1999. Gloria was also involved in a number of national mathematical organizations and activities. She was a member of the Board of Governors of the Mathematical Association of America, played a major role in the writing of the AP calculus exam and the mathematical portion of the GREs, and served on the executive council for the mathematical honor society, Pi Mu Epsilon.

A first step toward departmental recognition of Gloria was taken in 2016, thanks to a gift of current-use funds from the Washington Research Foundation. At the suggestion of then-chair Ron Irving, it was agreed that any funds used for graduate support would be named for her. A year later, Ron began to explore the possibility of ensuring permanent recognition for Gloria through an endowment, and in parallel looked into having a celebration of Gloria in Missoula. Edray Goins, a professor at Purdue at the time (now at Pomona) and the president of the National Association of Mathematicians, proposed to Ron while visiting Seattle in October 2017 that he would join such a celebration on behalf of NAM. NAM was founded in 1969 to support African-American mathematicians and now has the broader mission of promoting the mathematical development of all under-represented minorities.

Plans for the endowment came to fruition with the permission of the Washington Research Foundation to direct some of their previous gift to the endowment, with the dedication of other department funds to it, and with a gift from Ron and Gail Irving, yielding the university $50,000 minimum for a graduate support fund. The hoped-for celebration took place as well, in Missoula on March 19, with the collaboration of the University of Montana's Department of Mathematical Sciences. Edray gave a colloquium talk that began with overviews of NAM and of the first six African-American women to receive mathematics PhDs. At a reception following the colloquium, Ron talked about Gloria, announcing the establishment of the department's new endowment. The University of Montana also established a graduate scholarship in Gloria's name. Some UM speakers provided details, while others fondly reminisced about their time with Gloria. The final speaker was Gloria herself. In the spirit of the day, she recounted her fundraising successes as department chair two decades ago.

Gloria Hewitt at the Montana reception in March

In a brief biography prepared in 1995 by Agnes College student Shannon Hensley, Gloria spoke about her college years at Fisk University, a historically black university in Nashville, Tennessee. "I remember when I took calculus in college the only book I took home over the Christmas holidays was my calculus book. I wanted to do those word problems. I worked on one problem for the whole two weeks before I solved it. It wasn't that hard, but I just didn't understand the process involved. When the light dawned, I was so happy! I don't believe I ever felt so rewarded. It was a major breakthrough. I was hooked. After that, to the amazement of my fellow students, I recall sitting on campus doing calculus problems for recreation." As for her time in Seattle, Gloria told Shannon that "some of my fellow graduate students did all they could to help and encourage me. They included me in most of their activities. I know this situation was not the norm for a lot of Blacks studying mathematics, but I was fortunate enough to be at the right place at the right time."

Montana chair Emily Stone, Ron Irving, Gloria Hewitt, Gail Irving, and Edray Goins

The agreement establishing the Hewitt graduate support fund specified that if sufficient additional money were raised in order to reach the university minimum (currently $100,000) for endowed graduate fellowships, it would be converted to the Gloria Hewitt Endowed Graduate Fellowship, to be awarded "with a preference for students who contribute to the goal of a more equitable representation of under-represented minorities and women in the field of mathematics." Inspired by the example Gloria set in her career, and by her combination of forcefulness, warmth, grace, and humor, Ron and Gail have made an additional contribution that transforms the endowment, as we go to press, into the desired graduate fellowship. Moreover, the Washington Research Foundation has made a matching gift, as a result of which the endowment total is now in excess of $150,000.

Student Awards & Distinctions

Zihui Zhao | Graduate Medalist in the Natural Sciences

Each spring, the College of Arts and Sciences recognizes the outstanding finishing graduate student in each of its four divisions with an Arts & Sciences Graduate Medal. The 2018 Graduate Medal in Natural Sciences was awarded to Mathematics graduate student Zihui Zhao. Zihui completed her PhD under the supervision of Professor Tatiana Toro, studying partial differential equations, geometric measure theory, and harmonic analysis.

Zihui received many honors during her time at UW, being recognized by the department through a Microsoft Scholar Award, an Academic Excellence Award, and the Tanzi-Egerton Fellowship. She also participated in 2017 in a semester-long program at the Mathematical Sciences Research Institute in Berkeley as a Program Associate. Beyond her mathematical research, Zihui had an impact on colleagues in the department through her organization of the Graduate Student Analysis Seminar and her active participation in the Diversity Journal Club.

Zihui is spending this academic year in Princeton as a member of the Institute for Advanced Study, a prestigious postdoctoral position. She will assume another postdoctoral position next year when she begins a three-year appointment as a Dickson Instructor at the University of Chicago.

The 2016 Graduate Medal was also awarded to one of the department's students, Shirshendu Ganguly. After spending two years as a Miller Postdoctoral Fellow at UC Berkeley, he has now begun an appointment there as an assistant professor in the Department of Statistics.

Will Johnson | Gerald Sacks Prize

Will Johnson, who received undergraduate degrees in mathematics and computer science from UW in 2011, was one of two recipients of the Association for Symbolic Logic's 2016 Gerald Sacks Prize, which is awarded annually for the most outstanding doctoral dissertation in mathematical logic. As an undergraduate, Will was a 2009 Putnam Fellow, in recognition of his top-five performance in the annual William Lowell Putnam Mathematical Competition held across North America. He graduated from UW as College of Arts & Sciences's Dean's Medalist in the Natural Sciences.

Will completed his PhD at UC Berkeley under the supervision of Thomas Scanlon with a thesis titled "Fun With Fields." As described in the April 2018 issue of the Notices of the American Mathematical Society, the thesis "contains a number of outstanding results in the model theory of fields, including the classification of the fields K whose theories have the property of 'dp-minimality,' a strong form of 'not the independence property.' The Prizes and Awards Committee noted that Johnson's 'main breakthrough is the construction of a definable topology on K, when K is not algebraically closed, introducing vastly new ideas and techniques into the subject.'"

Will is now a software engineer at Niantic. He told the Notices, "My current job is to stop people from cheating in the games Ingress, Pokemon GO, and Harry Potter: Wizards Unite."

Graduating Class 2018

DOCTORATE:

Clayton Barnes (advisor: Chris Burdzy) | A hydrodynamic limit of interacting Brownian particles using Skorohod maps. Université de Neuchâtel, Switzerland.

Daniel Bragg (Max Lieblich) | Twistor spaces for supersingular K3 surfaces. University of California, Berkeley.

James Cameron (Steve Mitchell, John Palmieri, Julia Pevtsova) | The Duflot Filtration for Equivariant Cohomology Rings. University of California, Los Angeles.

Yifan Chang (Gunther Uhlmann) | Two Inverse Problems Arising in Medical Imaging. Microsoft.

Kristin DeVleming (Sándor Kovács) | Moduli of Surfaces in P^3. University of California, San Diego.

Chris Fowler (Christopher Hoffman) | Random Permutations and Simplicial Complexes. Looking at industry jobs.

Karthik Iyer (Gunther Uhlmann) | Inverse Problems for Linear and Non-linear Elliptic Equations. Vanguard.

Siddharth Mathur (Max Lieblich) | Some Theorems on Azumaya Algebras and the Resolution Property. University of Arizona.

Benjamin Palacios (Gunther Uhlmann) | The Inverse Problem of Thermoacoustic Tomography in Attenuating Media. University of Chicago.

Scott Roy (Dima Drusvyatskiy) | Algorithms for convex optimization with applications to data science. Microsoft.

Connor Sawaske (Isabella Novik) | Homological algebra of Stanley-Reisner rings and modules. Looking at industry jobs.

Travis Scholl (Neal Koblitz) | Abelian Varieties with Small Isogeny Class and Applications to Cryptography. University of California, Irvine.

Josh Swanson (Sara Billey) | Major Index Statistics: Asymptotics, Cyclic Sieving, and Branching Rules. University of California, San Diego.

Min Wu (Paul Smith) | Classification of Finite Dimensional Simple Modules over a Deformation of the Polynomial Ring in Three Variables. Protiviti.

Zihui Zhao (Tatiana Toro) | Elliptic measures and the geometry of the domains. Institute for Advanced Study, Princeton.

MASTER'S:

Molly Baird (Jim Morrow)
Yohan Kang (James Zhang)
John Samples (Kenneth Bube)
Xidian Sun (Christopher Hoffman)

BACHELOR'S:

169 in Mathematics
57 in Applied & Computational Mathematical Sciences

Student Awards

Graduate:

Academic Excellence:
Shuntao Chen
Yiping Hu
Adam Kapilow

Department of Mathematics Graduate Fellowship:
Nikolas Eptaminitakis
Charles Godfrey
Mike Shrieve

Excellence in Teaching:
Thomas Carr
Samantha Fairchild
Lucas Van Meter

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Liang Ze Wong

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Cody Tipton

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Amy Wiebe

Steve Mitchell Graduate Fellowship for the Love of Mathematics:
Graham Gordon

Lisa Tanzi and Charles Egerton Endowed Fellowship:
Kellie MacPhee

Undergraduate:

Outstanding Graduating Senior in Mathematics (B.S. Comprehensive Major):
Austin Stromme

Outstanding Graduating Senior in Mathematics (B.S. Standard):
Christine Wolf

Outstanding Graduating Senior in Mathematics (B.A. Standard):
Jacob Watkins

Outstanding Graduating Senior in Mathematics (B.A. Teacher Preparation):
Danielle Fletcher

Gullicksen Award for Outstanding Junior in Mathematics:
Thomas Browning

Honors Calculus Award (2nd year):
Jainul Vaghasia

Honors Calculus Award (1st year):
Logan Gnanapragasam

Putnam Exam Outstanding UW Score:
Rory Soiffer

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Each year the Department receives gifts from its alumni and friends. These gifts are of immense value to us and permit us to carry on important activities for our students and our scholarly work. They provide money for scholarships, fellowships, and prizes for our students; support events like Mathday and the REU program; fund visits to our department by distinguished mathematicians from around the country and the world; and give the Department a much-needed element of flexibility to meet special needs as they arise. For these contributions we are truly thankful to our donors.

If you are thinking of making a gift to the Department, or remembering the Department through an estate gift we invite you to discuss the matter with the chair, John Palmieri (mathch@uw.edu), or Malik Davis (malikuw@uw.edu) of the Advancement Office in the College of Arts and Sciences. You can also visit our web site at www.math.washington.edu and click on "Give now."

The following friends have contributed to the Department between September 2016 and November 2018.

Should you notice an error or omission in this list, please contact Rose Choi at rosechoi@math.washington.edu.

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