Each year, more than 70,000 people in the U.S. undergo heart surgery to replace their aortic valve. Such patients may soon have a better option, thanks in part to some biomathematical modeling by Professor of Mathematics Phil Crooke.

The aortic valve plays an essential role in maintaining blood pressure and flow into the vascular system of the body. The “semi-lunar” aortic valve is comprised of three half-hemispheres, or so-called leaflets, whose intersections coapt to close the valve and then open to allow blood to flow into the body. Its proper functioning depends on it maintaining the correct shape of those leaflets. If the geometry of the valve becomes distorted, it leaks, and surgical intervention is required.

The usual solution is replacement with either a mechanical valve or one taken from an animal. Each of these remedies has serious drawbacks, however. An animal valve only lasts about ten years, and a mechanical substitute requires powerful anticoagulants that have serious side effects.

That’s why cardiac surgeon J. Scott Rankin, M.D. is trying to improve surgical techniques to repair the valve with the patient’s own tissues, rather than replace it. Rankin and Crooke are consultants for a small medical device firm (Biostable Engineering and Science, Inc.) that is developing a device that can be sewn into defective valves to restore their correct geometry and stop them from leaking. They were enlisted to create a precise mathematical model for manufacturing the device.

The modeling process began with CT angiographic scans Rankin had taken of aortic valves of several healthy individuals. These images were imported into Mathematica, a software program used in mathematics and other scientific fields for technical computing. Crooke then used the data to construct equations describing each of the three leaflets along with the valve’s root.

“It’s an approximation problem, and the mathematics is very elementary,” Crooke says. “A least-squares fit of the imported data is performed, and the essential features of the leaflets’ geometry — surface area, leaflet intersections, and volume — can be computed.”

From the equations, a three-dimensional model of the device was assembled. The coordinates of the model were then used to manufacture a titanium alloy ring that could be sewn into the aortic valve. Biostable calls this device the HAART (Hemispherical Aortic Annuloplasty Reconstructive Technology) annuloplasty ring.

The HAART valves have been implanted in 15 patients in clinical trials in Europe with good results. The clinical trials have shown that the device performs as expected. Crooke and Rankin’s work has been described in a series of papers published in medical journals.

Most candidates for this type of aortic valve repair have no idea that mathematical modeling is making the procedure safer. But thanks to the rigorously designed rings, they can take HAART that they now have more options.
Letter from the Chair

Dear Alumni and Friends,

There have been many new developments here in the Vanderbilt Department of Mathematics in the two years since our last edition of this newsletter. The department continues to flourish and prosper, as you will see from the stories in the following pages. From mathematical models that improve heart surgery to a new undergraduate scholarship, these stories chronicle the dynamic growth and the many exciting activities we continue to experience in the department.

One of the most momentous developments was the fall 2011 addition of Fields Medalist Vaughan Jones to the faculty. Vaughan is a member of the U.S. National Academy of Sciences, and has won many prizes and obtained many distinctions. You can learn about his accomplishments on the facing page, so I will only add that we are thrilled to have him as a new colleague. Vaughan is an important addition to the department’s research group in operator algebras – and will serve as director of our annual Noncommutative Geometry and Operator Algebras Spring Institute.

Research is one of the department’s core missions, and the ability of the faculty to acquire external research funding is a key measure of our success. The faculty has done an outstanding job in attracting grants in recent years. In fact, AY 2012-2013 is a phenomenal year, with more than $1.5 million in new research money committed to the department. This exceeds previous years, despite a very tough funding environment.

Our postdoc program continues to thrive. Postdocs enhance the research life of the department tremendously, both in their work with faculty mentors and in their teaching contributions. This fall, a diverse group of 11 new postdocs joined the department from leading universities that include Caltech, CUNY, MIT, Stony Brook and UCLA. They follow a group of eight postdocs who left the department this year to take noteworthy positions both in academia and in the private sector. This spring we also awarded the second Aldroubi-Azhari Prize for Postdoctoral Research. Ionut Chifan was the deserving recipient.

Our undergraduate program has likewise seen dramatic improvements. We have a new honors track and a new undergraduate scholarship. I am very proud of the fact that our graduates are increasingly being accepted into programs at prestigious universities such as Princeton.

As the Department of Mathematics grows, so does our universe of alumni and friends. I hope that you will keep in touch and let us know of your continuing success so that we may share it with the rest of the community.

Dietmar Bisch
Professor & Chair, Department of Mathematics
Vanderbilt University
Email: dietmar.bisch@vanderbilt.edu

Honors Track Achieves Rapid Success

In 2010, the Department of Mathematics launched a new honors track that is proving highly successful in a variety of ways.

The new track provides an incentive for exceptional students to enroll in a well-balanced selection of challenging higher-level core classes in mathematics. Moreover, students who complete this program and, in addition, complete a senior thesis will graduate with departmental honors.

“The honors track has already attracted some of the brightest students admitted to Vanderbilt,” says Director of Undergraduate Studies Gieri Simonett, who chaired the committee which worked out the proposal for the new track. “Many freshmen students in the honors track begin their mathematics studies with Math 205a, which is a demanding, fully proof-based course in multivariable calculus and linear algebra.”

There are now 17 students enrolled in the honors track, and 11 of them will graduate this spring. Nine of those students are planning to submit a senior thesis and apply to graduate school. That’s a dramatic increase from academic year 2011-2012, when only one student submitted a senior thesis.

The first students to graduate in the honors track have all been admitted to graduate school: Greg Gauthier to Princeton University (2012), Colin Klaus to Vanderbilt (2011), and Joseph Thurman to SUNY-Stony Brook (2011).

With the addition of the honors track, Vanderbilt students can now choose one of three programs in the mathematics major:

- The standard track is intended for most mathematics majors in the College of Arts and Science, the Blair School of Music, and Peabody College.
- The applied track is primarily for students in the School of Engineering who elect a second major in mathematics, but it’s also available to other students.
- The honors track is specifically designed for highly qualified students who want to graduate with departmental honors or plan for graduate studies in mathematics.

Vanderbilt has seen a dramatic increase in the number of students applying to the university over the past ten years, which has resulted in a decrease in the admission rate from 46% in 2002 to 14% in 2012. The honors track is well suited to serve this increasingly select student population.

“Judging from prospective undergraduates who regularly visit with me, it also appears to be an incentive for highly talented students to choose our university,” says Simonett.

For more information about the tracks, see http://www.vanderbilt.edu/math/undergraduate/sm_files/MATH201213.pdf
The Department of Mathematics’ newest faculty member is also among its most distinguished. Vaughan Jones is a Fields Medalist who was formerly at the University of California, Berkeley. He joined Vanderbilt in fall 2011 as Distinguished Professor and Stevenson Professor of Mathematics and is an important addition to the department’s research group in operator algebras.

Jones’ contributions to mathematics have their origins in his work on subfactors, inclusions of certain highly noncommutative algebras of operators on Hilbert space known as von Neumann algebras. Von Neumann algebras were introduced by the legendary John von Neumann in the 1920s in his investigations of quantum physics, ergodic theory, and group representation theory. They were the central objects of Alain Connes’ work in the ’70s that led to his Fields Medal in 1982, the first one in operator algebras.

**Unexpected Behavior**

In the early ’80s, Jones introduced the notion of an index for a von Neumann subalgebra (or a subfactor) and found that indices of subfactors take on only very special values. He discovered that this totally unexpected rigid behavior was related to the existence of a new braid group representation that comes with each subfactor. He used his representation to construct a new polynomial invariant for knots and links, now called the Jones polynomial. This amazing discovery led to a whole new branch of modern mathematics, perhaps most adequately called quantum topology.

Jones’ work paved the way to many new and exciting interactions between a priori widely separate areas of mathematics and physics, including statistical mechanics, conformal field theory, knot theory, low dimensional topology, von Neumann algebra theory, quantum groups, representation theory, category theory, and quantum computing. His most recent work on subfactors, planar algebras, and random matrix theory has uncovered many new and beautiful structures and connections and has generated a lot of interest and excitement among researchers in the above-mentioned areas.

In 1990, Jones received the Fields Medal for his work. The Fields Medal is awarded once every four years to mathematicians not over 40 years of age for outstanding discoveries in mathematics. It is often described as “the Nobel Prize of mathematics.”

Jones has received many honors in addition to the Fields Medal. He was elected a Fellow of the Royal Society in 1990 and has also been elected to the United States National Academy of Sciences (1999), the American Academy of Arts and Sciences (1993), and the Norwegian Royal Society of Letters and Sciences (2001). He received the Onsager Medal (2000) and the Prix Mondial Nessim Habif (2007) and is a Knight Companion of the New Zealand Order of Merit (2009). He holds many honorary doctorate degrees from universities all over the world.

**Research and Teaching**

Jones is a member of the Department of Mathematics’ Center for Noncommutative Geometry and Operator Algebras, directed by Professor and Department Chair Dietmar Bisch. This group includes about 20 faculty members, students, and postdoctoral researchers whose research interests are in von Neumann algebras, subfactors and planar algebras, operator algebraic K-theory, coarse geometry, index theory, and several other related fields. The center organizes the annual Noncommutative Geometry and Operator Algebras Spring Institute.

Jones is enjoying the teaching experience at Vanderbilt, especially this semester’s undergraduate multivariable calculus course. “At Berkeley I taught calculus in a large auditorium to 330 students at a time,” he says. “It was very impersonal compared to working with just 33 students here. I get to know them by name and can encourage them to ask questions. That’s quite a nice thing.”

He also likes the reading course he’s doing with two graduate students. “That’s going very well. They’re very enthusiastic.”

Jones frequently attends seminars held by other research groups in the department. “I’ve been going quite a lot to the topology and group theory seminars,” he says. “I’ve been enjoying the talks there.”

He seems to feel at home here already but says he misses California for its kite surfing, a sport he adopted after many years of wind surfing. He still gets in kite time on frequent visits to the West Coast but has taken up golf as his Nashville pastime.

“We are thrilled that Vaughan has joined the mathematics department,” says Bisch, who has collaborated with Jones for more than 15 years. “His presence will enhance our research profile enormously and give students and postdocs a chance to learn from one of today’s foremost mathematicians.”
Donations

Your gift is welcome! The Department of Mathematics wishes to thank all alumni, parents, students, faculty, staff and friends who support the department.

Your gift will be used to support educational and research activities in the department. Your donation to the department is tax deductible, and you can choose to have your name published or remain anonymous.

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NEW FACULTY MEMBER
Jakayla Robbins

The department’s newest faculty member, Jakayla Robbins, joined the faculty as a senior lecturer in fall 2011. She received her B.S. in mathematics from Olivet Nazarene University in Bourbonnais, Illinois, and an M.A. and a Ph.D. in mathematics from the University of Kentucky in 2003 under the supervision of Dr. Carl Lee.

Robbins’ main research interests are in combinatorics, especially in matroid theory. She has had papers published in Discrete Mathematics, Pure Mathematics and Applications, and European Journal of Combinatorics.

Robbins has a wide range of mathematics teaching experience. She has instructed college students in three states (at the University of Kentucky, University of Mississippi, and University of Montana) and worked with talented high school students through the Johns Hopkins Center for Talented Youth program.

She served for six years as UK’s director of service courses, where she developed several new basic mathematics courses. She has experience teaching large lectures as well as smaller classes, in a great variety of subjects that include algebra, analytic geometry and trigonometry, calculus, linear algebra, and operations research.

In 2009, Robbins was a UK Teachers Who Made A Difference honoree.

This fall, she is teaching “Accelerated Single-Variable Calculus” and “Error-Correcting Codes and Cryptography.” She is also currently serving as assistant director of undergraduate studies.

Robbins is enthusiastic about teaching at Vanderbilt, and her teaching philosophy reflects that. “Teachers who have a lasting impact have vision,” she says. “Such teachers do more than lecture; they build community. These are the teachers who happily work with students in their offices. They encourage students to work hard and to produce quality work. They watch for opportunities that will help their students grow. These teachers see beyond the walls of their classrooms. They become mentors and have an impact well beyond graduation.”

Faculty Updates

Alex Powell was promoted this year from assistant professor to associate professor with tenure. Powell has been with the department since fall 2005. His areas of specialization include harmonic analysis, signal processing, and mathematical data analysis.

Derek Bruff was reappointed as senior lecturer for a three-year term effective fall 2013. Bruff also serves as director of Vanderbilt’s Center for Teaching.

Linda Hutchison and Pamela Pigg were reappointed as senior lecturers for three-year terms starting in fall 2012. Hutchison and Pigg have served the department in administrative roles related to calculus and pre-calculus courses.

John Rafter and Lori Rafter were reappointed as senior lecturers for three-year terms starting in fall 2013. John Rafter has served as assistant director of undergraduate studies from 2004 to 2010 and as director of teaching since fall 2010. Lori Rafter has served the department as assistant director of graduate studies since 2004.

Associate Professor Eric Schechter will retire in January 2013 after 33 years of service. Schechter received his B.S. degree from the University of Maryland in 1973 and his Ph.D. in 1978 from the University of Chicago. He joined the Department of Mathematics in 1980.

Distinguished Professor Alain Connes completed a 10-year appointment with the Department of Mathematics in AY 2011-2012. During his tenure at Vanderbilt, Connes served as the director of the annual Noncommutative Geometry and Operator Algebras Spring Institute, a role that has been assumed by Distinguished Professor and Stevenson Professor Vaughan Jones (see profile on page 3). More than 1,000 mathematicians came to Vanderbilt in these 10 years to participate in the spring institute.

The department congratulates Associate Professor Powell and Senior Lecturers Bruff, Hutchison, Pigg, Rafter, and Rafter. Warmest wishes of appreciation are extended to Professors Connes and Schechter for their invaluable contributions and service to the department.
Upcoming and Recent Conferences at Vanderbilt

UPCOMING

Shanks Workshop: Kähler Geometry
March 15-16, 2013

11th Annual Noncommutative Geometry and Operator Algebras Spring Institute
May 3-9, 2013

Topology, Algebra, and Categories in Logic 2013, in conjunction with the 28th Annual Shanks Lecture
July 28 - August 1, 2013

5th International Conference on Computational Harmonic Analysis and Applications, in conjunction with the 29th Annual Shanks Lecture
May 19-23, 2014

International Conference on Constructive Functions
May 26-30, 2014

12th Annual Noncommutative Geometry and Operator Algebras Spring Institute
May 2014

2012

International Conference on Cycles in Graphs, in conjunction with the 27th Annual Shanks Lectures

10th Annual Noncommutative Geometry and Operator Algebras Spring Institute

Shanks Workshop: Inverse Problems and Applications to Physical Sciences

Shanks Workshop: Geometry and Analysis of Large Networks

Shanks Workshop: Symplectic Topology and Hamiltonian Dynamics

Shanks Workshop: Randomized Algorithms in Applied and Computational Harmonic Analysis

New Officers Assume Key Responsibilities

Three faculty members recently assumed new roles as department officers.

Professor Akram Aldroubi became director of graduate studies after Professor Mike Neamtu served in that role for three years.

Neamtu is acting chair of the department this academic year while Chair Dietmar Bisch is on leave. Bisch will resume as chair in fall 2013.

Professor Phil Crooke is serving as the department’s vice chair during AY 2012-2013 following three years of service in this role by Professor John Ratcliffe.

“I would like to thank John and Mike for their excellent work and dedication to the department as vice chair and director of graduate studies. I am grateful to Akram, Mike, and Phil for accepting these important positions, and I am looking forward to working with them,” says Bisch.

John Rafter Receives Gilliam Teaching Award

John Rafter, senior lecturer in the Department of Mathematics, received the 2011 Harriet S. Gilliam Award for Excellence in Undergraduate Teaching by Lecturers and Senior Lecturers.

Rafter consistently earns extremely high ratings from students in his teaching evaluations, which routinely include comments of praise and enthusiasm. “He is one of the department’s most effective teachers,” says Department Chair Dietmar Bisch.

Rafter teaches calculus and upper-level undergraduate courses in actuarial mathematics, probability, mathematical statistics, number theory, logic, error-correcting codes, and cryptography.

He played an important role in the introduction of an actuarial track in the department. This sequence of courses has become quite popular among students and has resulted in a significant increase in the recruitment of Vanderbilt mathematics students by actuarial companies.

Rafter says his primary objective in all of his courses is to expose students to a mathematical thought process using a content-specific set of problems. He begins each course with a problem to be solved and, in the more applied courses, he leads the students through the development of a mathematical model. His class meetings are largely Socratic, with students answering questions as the class collaboratively works toward solutions to the problem.

His skills as a communicator and his experience as an instructor led to Rafter’s appointment as director of teaching for the department in fall 2010.

Rafter received his Ph.D. in mathematics from Vanderbilt in 1994. He entered the business world with Aspect Communications, also serving as an adjunct instructor at Vanderbilt for one year. He became chief software architect at Aspect and acquired four patents while there. He returned to academia in 2004, accepting a position as a senior lecturer in the Department of Mathematics.

The Harriet S. Gilliam Award for Excellence in Teaching by a Lecturer or Senior Lecturer was established in 1995 in memory of Harriet S. Gilliam, B.A., 1966. The award recognizes a lecturer or senior lecturer who has achieved excellence in teaching undergraduates. The winner receives a cash award and an engraved Mississippi Julep pewter cup.

Let us hear from you!

Tell us what you’ve been up to since leaving Vanderbilt.
Send email to: math.alumni@vanderbilt.edu.
Annual Awards Feature Unexpected Twist

There was a surprise twist at the department’s 2012 student awards ceremony. Most years, the graduate student awards are like the Oscars: one winner per category. But this year, both awards were shared — and by the same two students. Jeremy LeCrone and Justin Schroeder were co-recipients of both the Billy Bryant Prize for Excellence in Teaching and the Bjarni Jónsson Prize for Excellence in Research.

Commenting on their joint recognition for the Bryant Prize, Director of Teaching John Rafter noted their consistently high praise in student evaluations and said, “Both Jeremy and Justin challenge their students and demonstrate their passion for mathematics.”

LeCrone and Schroeder were also named co-winners of the Bjarni Jónsson Prize for their research achievements.

Greg Gauthier Wins Larsen Award

Greg Gauthier was the recipient of the 2012 Richard J. Larsen Award for Achievement in Undergraduate Mathematics. The Larsen Award is given each spring to a senior math major judged by the faculty to have excelled in all aspects of undergraduate mathematics.

During his undergraduate career, Gauthier took 54 hours of mathematics courses and achieved a perfect GPA of 4.0.

He completed a Research Experience for Undergraduates and an honors thesis under the supervision of Professor Mark Sapir, solving an open problem on what are called sand pile models. His research paper on this work has been accepted for publication in the International Journal of Algebra and Computation.

Professor Mike Mihalik, who had Gauthier in his graduate course in topology, said, “I feel he is more advanced as a research mathematician than any previous undergraduate mathematics major at Vanderbilt. I am convinced we will see great things from Greg.”

Gauthier has been accepted to Princeton University, where he will pursue a Ph.D. in mathematics.

Xuemei Chen Wins Award For Best Student Paper

Xuemei Chen, who received her Ph.D. from Vanderbilt in May 2012, won the award for best student paper at the 9th International Conference on Sampling Theory and Applications (SampTA) held at Nanyang Technological University in Singapore in May 2011.

Chen received the award for her paper with Professors Akram Aldroubi and Alex Powell entitled “Stability and Robustness of $l_1$ Minimization Using Null Space Property.”

SampTA is an interdisciplinary conference that brings together mathematicians, engineers, and applied scientists to share recent advances in sampling theory and to explore new directions in related areas of application.

The SampTA 2011 included many prominent speakers, such as John Benedetto, Albert Cohen, Stéphane Mallat, and Steven Smale.

Chen is now a postdoctoral fellow at the Norbert Wiener Center of the University of Maryland.
Ionut Chifan Wins Aldroubi-Azhari Postdoctoral Prize

Ionut Chifan was awarded the 2012 Samir Aldroubi and Amira Azhari Prize for Excellence in Postdoctoral Research. Chifan completed a three-year postdoc position with the department in May 2012.

Chifan received his Ph.D. in 2009 from UCLA under the supervision of Sorin Popa. His research is in von Neumann algebras, and he has broad interests in ergodic theory and measured and geometric group theory. His work is focused on rigidity phenomena for II1 factors.

Chifan’s work has appeared in excellent journals including *Advances in Mathematics*, *Annales de l’Ecole Normale Supérieure*, *Duke Mathematical Journal* and *Geometric and Functional Analysis*. In 2010, he received a three-year National Science Foundation research grant. Chifan has accepted a tenure-track position at the University of Iowa beginning in the fall of 2012.

“Ionut is hard-working and extremely devoted to his work,” says his mentor, Assistant Professor Jesse Peterson. “He has a true passion for mathematics.”

Department Chair Dietmar Bisch adds, “Ionut is very deserving of this award. He has obtained significant results and published in top journals while here at Vanderbilt. He continues to collaborate with several people in the department.”

“The Vanderbilt math department has been a very stimulating place for me, and I am particularly grateful to Jesse and Dietmar for providing such a supportive and exciting research environment,” says Chifan.

The Aldroubi-Azhari Prize for Excellence in Postdoctoral Research is awarded every two years to recognize the research achievements of current and recent postdoctoral fellows in the department. It was established in 2010 by Professor Akram Aldroubi in honor of his parents, Samir Aldroubi and Amira Azhari.

The Aldroubi-Azhari Prize for Excellence in Postdoctoral Research is awarded every two years to recognize the research achievements of current and recent postdoctoral fellows in the department. It was established in 2010 by Professor Akram Aldroubi in honor of his parents, Samir Aldroubi and Amira Azhari.

New Graduate Students and Recent Graduates

The department welcomes seven new graduate students and extends best wishes to seven recent graduates.

**NEW PH.D. STUDENTS**

- **Arman Darbinyan**
  M.S., Yerevan State University, Armenia

- **Chang-Hsin Lee**
  B.S., National Tsing Hua University, Taiwan

- **Tim Michaels**
  B.S., University of Tennessee, Knoxville

- **Sandeepan Parekh**
  M.S., Indian Statistical Institute, India

- **Akhilesh Pathak**
  M.S., Wright State University

- **Armenak Petrosyan**
  M.S., Yerevan State University, Armenia

- **Cristóbal Villalobos Guillén**
  B.S., Universidad Autónoma de San Luis Potosí, Mexico

**RECENT GRADUATES**

- **Vladimir Chaynikov**, Ph.D., 2012
- **Xuemei Chen**, Ph.D., 2012
- **Georgi Kapitanov**, Ph.D., 2012
- **Jeremy LeCrone**, Ph.D., 2012
- **Justin Schroeder**, Ph.D., 2012
- **Ali Sekmen**, Ph.D., 2012
- **Travis Service**, M.S., 2012
- **Jonathan Waite**, M.S., 2012
- **Lujun Wang**, Ph.D., 2012

There’s more about our graduate & undergraduate programs at

www.vanderbilt.edu/math
**Postdoctoral Fellows**

Our postdoctoral program attracts outstanding young researchers from top universities. The following 16 postdocs are currently working here at Vanderbilt.

**Roza Aceska** received her Ph.D. from the University of Vienna, Austria, in 2009. Her research interests are in asymptotic analysis, harmonic analysis, time-frequency analysis, and sampling theory.

**Rémi Coulon**’s research interests are in the areas of geometric group theory, non-positively curved metric spaces, infinite torsion groups, and automorphism groups. He received his Ph.D. in 2010 from the University of Strasbourg, France.

**Natasha Blitvic**’s research interests lie at the interface of operator algebras, probability theory, and combinatorics. She received her Ph.D. from the Massachusetts Institute of Technology in 2012.

**Darren Creutz** received his Ph.D. in 2011 from the University of California, Los Angeles. His research focuses on the dynamics of group actions on probability spaces, particularly the dynamics of lattices in topological groups.

**Michael Brandenbursky** received his Ph.D. from the Technion-Israel Institute of Technology in 2010. His research interests are in the areas of knot theory, symplectic geometry and low-dimensional topology, and braid groups and transformation groups of smooth manifolds.

**Marcelo Disconzi** received his Ph.D. from Stony Brook University in 2012. His research interests are in the areas of analysis, partial differential equations, and mathematical physics.

**Chris Conidis** received his Ph.D. from the University of Chicago in 2009. His research interest is in the area of mathematical logic and computability theory.

**Tim Ferguson**’s research interests are in the areas of complex analysis and operator theory, particularly in topics related to spaces of analytic functions. He received his Ph.D. in 2011 from the University of Michigan in Ann Arbor.
Kate Juschenko received her Ph.D. from Texas A&M University, College Station, in 2011. Her research interests lie in the areas of operator algebras and geometric and analytic aspects of group theory.

Jeremy LeCrone’s research interests lie in the areas of partial differential equations, nonlinear functional analysis, geometric evolution equations, and dynamical systems. He received his Ph.D. from Vanderbilt University in 2012.

Michael Goff’s research interests are in graph theory and extremal combinatorics. He received his Ph.D. from the University of Washington in 2010.

Jorge Carlos Román received his Ph.D. in 2012 from the University of Florida. His research interests are in Markov chain Monte Carlo algorithms and Bayesian statistics.

Zhizhang Xie received his Ph.D. from Ohio State University in 2011. His research interests lie in noncommutative geometry and its applications to topology and geometry.

Caner Koca received his Ph.D. in 2012 from Stony Brook University. His research interests are in the areas of differential geometry and complex geometry.

Rebecca Steiner’s research interests are in logic, specifically in the area of Turing computability. She received her Ph.D. from the City University of New York in 2012.

Brian Simanek received his Ph.D. from the California Institute of Technology in 2012. His research interests are in the field of analysis, specifically orthogonal polynomials and spectral theory.

Michael Goff’s research interests are in graph theory and extremal combinatorics. He received his Ph.D. from the University of Washington in 2010.
Alexander Olshanskii

FOCUS ON RESEARCH: Alexander Olshanskii and Group Theory

Few mathematicians have made contributions to the field of group theory comparable to those of Vanderbilt Centennial Professor Alexander Olshanskii. Since 1966, he has achieved important results in other areas as well, including Lie algebras. But it’s his work in group theory for which he is most widely recognized.

With origins in geometry and physics, group theory studies the algebraic structures known as groups. A group is a set $G$ together with a binary operation on $G$ satisfying certain axioms, namely associativity, existence of an identity, and inverses.

Group theory is a powerful way of studying geometrical objects through their symmetries, which naturally form a group. Various physical systems, such as crystals or the hydrogen atom, can be analyzed through symmetry groups. Thus, group theory has many applications in physics and chemistry, ranging from the standard model of subatomic particles to cryptography.

Congratulatory Cable

In 1969, while still a graduate student at Moscow State University, Olshanskii solved B.H. Neumann’s 1935 problem concerning the existence of a group with a nonfinitely-based set of identities. For this achievement, he received a congratulatory cable from B.H. Neumann himself, who ironically was teaching at Vanderbilt at the time.

Olshanskii went on to obtain his Ph.D. and serve as professor of mathematics at Moscow State. While there, he continued his work in group theory and eventually developed a keen interest in geometric group theory.

Later, Olshanskii solved several famous problems in group theory. He is especially well known for disproving the long-standing John von Neumann conjecture, which stated that a group $G$ is not amenable if and only if $G$ contains a non-abelian free subgroup. Olshanskii disproved this in 1980 by demonstrating that a type of group constructed by him (called the Tarski monster group), which is easily seen not to have a non-abelian free subgroup, is not amenable.

To solve the von Neumann problem, Olshanskii used his own adaptation of the van Kampen diagrams that were introduced by Egbert van Kampen in 1933 but had gone largely unnoticed for three decades. A van Kampen diagram is a planar diagram used to represent the fact that a particular word in the generators of a group given by a group presentation represents the identity element in that group. Olshanskii devised what have come to be known as graded van Kampen diagrams based on a stratified version of small cancellation theory.

Shortest Proof

In 1982, Olshanskii used graded van Kampen diagrams to produce what is still the shortest proof of another well-known problem in group theory, the Burnside problem. The first solution to the Burnside problem (obtained in 1968 by Novikov and Adyan) ran more than 300 pages. Olshanskii’s proof is only 32 pages long.

“The essence of van Kampen’s lemma is the visual geometric interpretation of the process of deriving consequences of defining relations in a group,” Olshanskii writes in his influential book Geometry of Defining Relations in Groups, which describes his technique and its application to solve many open problems in group theory. “The universal nature of the lemma sanctions the geometric approach for a wide class of problems in combinatorial group theory.”

Olshanskii’s groups constructed in the 1980s turned out to be limits of hyperbolic groups, and this was implicitly used in his proofs. The general concept of hyperbolic groups was introduced by M. Gromov and is now central to geometric group theory. In the 1990s, Olshanskii extended his method to constructions over hyperbolic groups as well.

Rich Collaboration

In 1999, Olshanskii joined the Vanderbilt faculty, where he has had a rich collaboration with other members of the department’s group theory research group. Frequent collaborators include Centennial Professor Mark Sapir (who, like Olshanskii, is among the department’s seven faculty members who have been invited to speak at the International Congress of Mathematicians) and Associate Professor Denis Osin, who is a former student of Olshanskii.

Over the course of his career, Olshanskii has advised 27 Ph.D. students, and many of them have also applied his techniques to achieve notable results in group theory. He himself still uses them, most recently to explore the computational complexity of the so-called word problem in groups.

Olshanskii is a recipient of several prizes, including Malcev’s prize of the Russian Academy of Sciences and the prize of the Moscow Mathematical Society.
Graduate Biomathematics Focus Puts Callender On The Fast Track

Department of Mathematics alumna Hannah Callender is a study in contrasts. Though she loves snowboarding and live music, she spent most of her time as a graduate student in a laboratory. Collaborating with researchers in Vanderbilt’s Department of Pharmacology, Callender developed and analyzed a mathematical model of a specific cellular signaling pathway and also collected experimental data used to validate the model.

Her time in the lab was well spent. The Ph. D. in mathematics she earned from Vanderbilt in 2007 and her focus on biomathematics research while here helped her land a spot in a prestigious postdoctoral program at the University of Minnesota’s Institute for Mathematics and its Applications (IMA). That in turn paved the way for her current position as assistant professor of mathematics at the University of Portland.

Callender says she benefited from the department’s support for interdisciplinary work in biomathematics and the opportunity to work with mathematics faculty active in this area, including her advisors Mary Ann Horn and Glenn Webb. “There’s no question that my Vanderbilt experience helped me hit the ground running at the IMA,” she says. “The theme for my first year there was ‘Molecular and Cellular Biology,’ and I was well prepared and very confident in my ability to contribute to this program.”

After two years at the IMA, her goal was to get a position at a smaller teaching university. “Although my primary interest was in teaching at the undergraduate level, I wanted to have a strong focus on undergraduate research,” she says. “My experience both at Vanderbilt and the IMA has helped me become a good mentor to students who share my passion for research in mathematical biology.”

After joining the faculty at the University of Portland, Callender applied for and was awarded a grant from the Center for Undergraduate Research in Mathematics (an NSF grant administered through Brigham Young University).

“The grant allowed me to work with a team of research students throughout the school year,” she says. “The grant somewhat mimics an REU [Research Experience for Undergraduates], but most of those are in the summer. This one tries to get students into research during the academic year. The grant allowed me to fund three students to do research, and it’s been a great experience.”

One of Callender’s students recently received the only fellowship in computational biology offered by Oregon Health and Science University: “My near-term goal is to build on that success and try to create a sustainable biomath program at UP.”

Callender adds that there’s another great thing about working in Portland. “I still love to play the guitar and sing, and the city has a great music scene. I’m also only an hour and a half from Mt. Hood, where the snowboarding is amazing.”

Thanks to Our Contributors!

The Department of Mathematics relies on direct contributions to the Aldroubi-Azhari, Bryant, Jónsson, and Larsen Awards funds, as well as to the Math Endowment and the Gift Fund, to support activities such as the Undergraduate Seminar and the annual student awards. We thank the following individuals and organizations who have contributed to one or more of these funds in the past two years:

John F. Ahner  
Akram Aldroubi  
Nancy & Robert Anthony  
Dietmar Bisch & Dorota Bratko  
Nancy S. Chamberlain  
Philip & Barbara Crooke  
Paul Edelman & Suzanna Sherry  
Mark N. Ellingham & Carlin J. Sappenfeld  
Robert L. Hemminger  
P. Lawrence Hester  
Bjarni & Harriet Jónsson  
Robert L. Lams  
Richard J. Larsen  
Xiaoyu Liu  
Michael S. McGraw  
Meghan Jane McWilliams  
J. Scott Moore  
Alexander Y. Olshanskii  
Philip Pfeffer  
Richard & Kristin Porotsky  
John & Lori Rafter  
Richard H. Sawyer  
Larry & Gerda Schumaker  
Ronnie W. Smith  
Mary E. Stamp  
Robert M. Stephenson, Jr.  
Sherry Stumbaugh  
The Hood-Barrow Foundation  
Towers Watson  
Donna Lucas Watts  
Glenn & Aileen Webb  
Thomas M. West  
Courtney S. White  
Horace Williams  
Daoxing Xia

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Math Degree Energizes Steve Irvin’s Career

Although Steve Irvin has traveled around the globe negotiating renewable energy deals, he still finds time to visit Vanderbilt, where he received his B.S. degree in mathematics in 1990.

Irvin now serves as executive vice president of the central region for EDP Renewables North America, based in Houston. EDP’s parent company, headquartered in Spain, is the world’s third largest wind energy company.

“Thanks to my VU math degree, I became the go-to guy on class teams for analytics when I was getting my MBA from Thunderbird’s Garvin School of International Management in Arizona,” says Irvin. “Since many of my classmates came from marketing, I was the one most comfortable with the numbers, measuring ROI [return on investment] and risk.”

Because his graduate work was in international management, Irvin quickly got the chance to put those skills to use at Enron North America. “I really liked the fact that every week was different,” he recalls. “I remember one Monday morning being asked to fly to Germany to work on the acquisition of a wind turbine company, which we ended up acquiring.” At Enron, Irvin moved from acquisitions to project development, helping launch a 250-megawatt natural gas-fired power plant in Mexico.

Irvin’s dual math/management background was a real asset at Enron. “I negotiated a number of financing documents and power purchase agreements, and I was the business lead on many contract negotiations,” he says. “There’s a lot of risk assessment and analysis involved in that.”

After the Enron bankruptcy, Irvin was one of the few employees retained to help settle the company’s commodity trading book. Subsequently, Irvin wanted to return to renewable energy and project development, and he did just that by joining Horizon Wind Energy in June of 2005. Horizon was in the process of being acquired by Goldman Sachs when Irvin joined and was sold two years later in 2007 to Energias de Portugal (EDP). Horizon has now been renamed EDP Renewables.

In his current role, Irvin is heavily involved in both project development and energy marketing. One of his many career milestones is the development of the 400-megawatt Lone Star Wind Farm in west Texas. “It’s been a terrific growth story here at EDP North America. We’ve grown from 100 megawatts seven years ago to 3,600 megawatts today.”

Although his primary focus is on the energy needs of the central and southeastern U.S., Irvin still has to log plenty of overseas travel time. “We’re building our first solar project in Romania next year,” he says.

Because his work frequently takes him to TVA headquarters in Chattanooga (as TVA is one of EDP Renewables’ largest customers), Irvin still finds time to visit Vanderbilt and catch Commodore football games. “I’m an avid fan of VU basketball, too,” he says. “Plus I make a point to catch Vanderbilt baseball games when they play locally against Rice University.”

Irvin could have spent his career in the oil and gas industry, but was drawn instead to renewable energy. “I wanted to make a difference in the lives of our sons, who are now age 8 and 11,” he says. “Our company is helping to provide clean energy for their generation.”

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