The department welcomes new faculty

This fall, department ranks are bolstered by the arrival of three new assistant professors: Robert Buckingham, Michael Goldberg and Leonid Slavin. We are pleased to have had the opportunity to hire this trio of talented young mathematicians.

Robert Buckingham

Robert Buckingham comes to us after a year as a Postdoctoral Fellow at the Centre de Recherches Mathematiques at the University of Montreal, where the theme for 2008-2009 was Probabilistic Methods in Mathematical Physics. Buckingham received his PhD from Duke University in 2005. He spent 2005-2008 as a postdoctoral assistant professor at the University of Michigan in Ann Arbor.

Buckingham studies the universal behavior that emerges from asymptotic limits of problems from mathematical physics, especially random processes and nonlinear wave equations. One well-known example of a universality law is the central limit theorem, which states that the sum of independent, identically distributed random variables converges to a normal distribution under mild assumptions. Recently, other universal distributions have been shown to arise in a variety of contexts. For example, if one forms an $n \times n$ symmetric matrix using entries drawn at random from a Gaussian (normal) distribution, the asymptotic distribution of the largest eigenvalue obeys the GOE (Gaussian Orthogonal Ensemble) Tracy-Widom distribution. Other quantities for which this distribution gives an asymptotic description include the largest eigenvalue of a large family of random matrix models, the length of the longest increasing subsequence of a random permutation, and the position of the outermost particle in a sea of nonintersecting Brownian motions. Along with co-authors Jinho Baik and Jeffery DiFranco, Buckingham established the complete asymptotic expansion of the tails of the GOE Tracy-Widom distribution and the related GSE (Gaussian Symplectic Ensemble) Tracy-Widom distribution for the first time.

Currently, Buckingham is studying universal behavior for mathematical models of other systems, including the energy levels of a large atom placed in an external magnetic field, as well as the largest observed energy level of a large atom given a certain probability of missing any given level.

Michael Goldberg

Michael Goldberg arrives in Cincinnati by way of Johns Hopkins University where he was also an assistant professor. He maintains research interests in analysis and differential equations, most recently receiving a National Science Foundation grant to study harmonic analysis methods related to the Schrödinger equation.

A 2002 graduate of the University of California, Berkeley, Goldberg began his career working in harmonic analysis, a branch of mathematics devoted to basic properties of functions such as smoothness, continuity, and integrability. These can be measured by direct inspection, topological arguments, or transform methods that construct a function out of elementary components. To give one common example, the building blocks of a Fourier series are pure waves of all different frequencies. The art (or perhaps the alchemy) of the subject lies in combining information from the above approaches into a single coherent picture.

Goldberg has studied mapping estimates for the Hilbert transform, which distinguishes waves traveling to the left from those traveling to the right. Hilbert transforms appear in complex analysis as well (isolating the analytic part of a function from the anti-analytic part), and also statistical mechanics (separating past events from future ones).

Similar challenges arise in quantum mechanics when one attempts to describe motion while respecting the dual wave/particle nature of matter. Since it is impossible to track objects with perfect accuracy, the next best thing is to assess the likelihood of observing them at a particular location in space and time. The end result is a probability density function whose evolution is governed by a "law of motion" known as the Schrödinger equation. On a mathematical level, solutions to the Schrödinger equation consist of overlapping waves, with the largest values occurring where there is constructive interference. Typically the waves travel in different directions and fall rapidly out of sync so that regions of high density are either small or ephemeral, or both. The interactions become more complicated once additional forces or nonlinear feedback enter the picture, or if the underlying space is curved rather than flat. Goldberg's current research addresses questions of this type: what forces are capable of influencing qualitative properties of the Schrödinger equation, and in what sense are solutions stable with respect to these changes?

The best answers draw upon more than one source of inspiration. It usually takes some delicate analysis to estimate correctly the size of interactions or the degree of interference. At the same time, a little physical intuition can go a long way toward finding the most dynamic part of the solution, where the extra attention to detail really matters.

Leonid Slavin

Leonid Slavin earned his PhD at Michigan State University in 2004. A native of Russia, he has a master's degree in engineering from St. Petersburg State Technical University. Prior to his appointment at UC, he held postdoctoral positions at the University of Connecticut and the University of Missouri-Columbia, and spent January — May 2008 at the Fields Institute for Research in Mathematical Sciences in Toronto.

Slavin's research interests are in harmonic analysis, especially singular integral operators, maximal functions, Hardy spaces, and the space of functions of bounded mean oscillation (BMO). His main focus has been on a technique known as the Bellman function method. This method originated in the mid-'80s in the work of Donald Burkholder, who used carefully constructed functions with designated size and convexity properties to establish sharp inequalities for a special class of random processes known as martingales. This method was refined and expanded to a wide variety of applications in analysis in the mid-'90s. However, the constructive nature of Bellman function method proofs (often brilliant arguments based on "experience suggests to try this" lines of reasoning), while impressive, left some mystified by the origins of the functions employed and made many skeptical as to the limits of the method's applicability. Much of Slavin's work has focused on elaborating the method by developing an understanding of how to solve some of the problems that arise in Bellman proofs (e.g., solving certain partial differential equations) and thereby constructing explicit Bellman functions. This has led him to tackle a wide range of problems, including some fundamental open questions, pushing the method to achieve results that are, as he puts it, "in striking contrast to what people think the method can do."

Alumni News

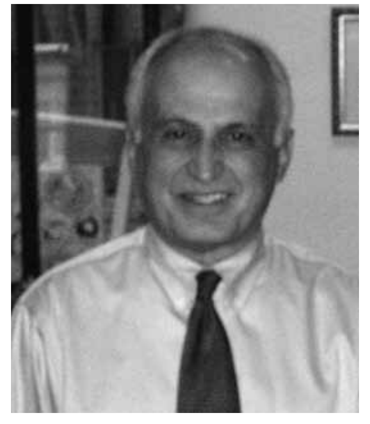
Robert Tkach ('76, BA) and fellow Bell Labs scientist Andrew R. Chraplyvy have won the 2009 Marconi Fellowship and Prize for their research into optical fiber nonlinearities and their development of novel mitigation techniques that vastly increased the transmission speed and capacity of optical fiber communications systems. After leaving UC with degrees in both mathematics and physics, Tkach earned master's and PhD degrees at Cornell University. He is currently Director of Transmission Systems and Networks Research at Bell Labs. The Marconi Prize is awarded annually to recognize a living scientist whose work in the field of communications and information technology advances the social, economic and cultural improvement of all humanity. Tkach has also received the Thomas Alva Edison Patent Award from the Research and Development Council of New Jersey and is a Fellow of the Optical Society of America, the IEEE and AT&T. Tkach received the 2008 John Tyndall Award jointly sponsored by the OSA and IEEE and in 2009 was elected to the National Academy of Engineering.

Carlos Mejia ('89, MA; '93, PhD) and **Diego Mejia** ('86, PhD), faculty members at the National University of Columbia in Medellin, Colombia, have each earned the distinction of Professor Titular this year. In order to become "Professor Titular" it is necessary to write a second dissertation like the Habilitation in Germany. Only research-activity careers are considered for the title, but factors besides research enter into the decision. Carlos was a student of Diego Murio and Diego worked with David Minda.

Yurong Feng ('08, MS Stat) is working at CureSearch – National Childhood Cancer Foundation in Arcadia, Calif. She wrote in a recent email to Professor Jim Deddens, "I use survival analysis a lot in work. Some times I go to your homepage to go over the notes for the course survival analysis. They are very useful. The longer I work there, the more I find that I need to learn. This is why I love my job very much."

Please use the enclosed form to include your latest news in the next issue of *The Right Angle* and other McMicken College publications. You can also submit your news online at: www.artsci.uc.edu/updates.

the department bids farewell to DIEGO MURIO



Diego Murio

Diego Murio retired this year after 30 years of service in the Department of Mathematical Sciences.

Diego has bachelor's degrees in both mathematics and physics, and he began his career as a mathematics and physics teacher in Argentina at both the high school and college levels. He taught at Argentina's National University of the South from 1973-75. This was a time of great turmoil in Argentina, politically and economically. His move to the US to pursue his graduate studies at the University of California, Berkeley provided him and his family with a needed escape from an increasingly threatening situation in the academic institutions of Argentina. He joined UC in 1979 after receiving his PhD from Berkeley.

Diego was (and still is) a prolific scholar, writing over 100 journal papers. His expertise is numerical analysis, in particular the numerical solution of the Inverse Heat Conduction Problem. He wrote a successful text on questions related to this subject entitled "The Mollification Method and the Numerical Solution of Ill-Posed Problems." In mathematics, a well-posed posed problem is one for which there is a unique solution and it is relatively insensitive to small changes in input data (initial conditions, parameters). Inverse problems are more difficult to solve, and their solutions usually do not depend continuously on the data (they are highly unstable) and need to be approximated by specially designed numerical schemes. Diego was, and continues to be, interested in helping to generate solutions to challenging ill-posed problems that arise in important applications (often, in engineering contexts).

Diego's energy, creativity and productivity drew PhD students to him, and these qualities made him an effective mentor. His ability to help students complete their dissertations and move on to successful careers made him the department's most productive thesis advisor. In all, he had 11 PhD students. Many went on to non-academic careers as applied mathematicians. Others have stayed in academia and now hold positions at UC, Elon College, University of Central Florida and the National University of Colombia.

Diego was always on the forefront of technology. He was one of the first faculty members to have a personal Web site and his became a model of sophistication that few of us could emulate. His interest in the use of sophisticated computer software packages such as Mathematica inspired him to incorporate its use into differential equations classes, and he co-authored MATHWEB software to enable the use of Mathematica over the web. Diego was the first person in the department to design and run an online class.

Diego also served for a number of years as graduate program director and in that capacity played a significant role in the growth of our successful program MS in Statistics.

Over his 30-year career at UC, Diego has had a significant impact on our department. He will be remembered as an enthusiastic and innovative teacher and researcher. We thank him for many contributions, and wish him a happy retirement.

Thanks to All of Our 2008-09 Donors

We thank the following individuals and foundations for their generous donations to the department. These gifts fund scholarships, attract and retain the finest faculty, and enrich the experience of our graduate and undergraduate students.

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F O L D   H E R E

from the EDITOR

Please take a moment to write back. We welcome your comments and suggestions, and encourage you to keep in touch with us. Please use this form, email us at RightAngle@math.uc.edu, or share your news with any faculty member who was important to you. Faculty email addresses can be found at www.math.uc.edu.

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the HYPOTENEWS

Dumas Sweeps Teaching Honors

Scott Dumas

This year, Scott Dumas won both the McMicken College of Arts and Sciences' Edith C. Alexander Award for Distinguished Teaching and the prestigious university-wide Mrs. A.B. "Dolly" Cohen Award for Excellence in Teaching.

Dumas, who has taught at UC since 1990, is an admired and sought-after teacher. Graduate students have called his lectures "captivating," and undergraduates rave about his ability to explain mathematical concepts to non-majors. A hallmark of Dumas' teaching is his attention to his students' understanding. Mary Schuster, now a field service instructor in the department, took classes from him in her graduate student days; she comments, "One of his greatest strengths as a teacher is that he is able to have two-way discussions with students, allowing their individual learning natures to be addressed." For years, the directors and students of the College of Business' Carl H. Lindner Honors-PLUS Program have been among his greatest fans, with a standing request that Scott be assigned to teach their students. "I have seen the results of Scott's teaching, talked with countless students who have taken his classes and believe he is one of the best math teachers UC has to offer," says Jeri Ricketts, the director of the Honors-PLUS program. "In fact, he's one of the best teachers, period, that UC has, because Scott doesn't just deliver material, he truly cares about whether students learn."

On behalf of your colleagues and students, congratulations and thanks, Scott!

THE RIGHT ANGLE

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McMICKEN COLLEGE OF ARTS AND SCIENCES
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UNIVERSITY OF Cincinnati

from the HEAD

Tim Hodges

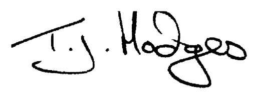
Dear Alumni and Friends,

I am delighted to announce that Scott Dumas has been honored with two of the university's top awards for excellence in teaching: the A.B. "Dolly" Cohen Award and the Edith C. Alexander Award. As winner of the Dolly Cohen Award, he follows in the footsteps of a series of distinguished recipients from our department: Gaylord Merriman, David Lipsich, Richard Demar and David Minda.

The Wall Street Week announced in January that according to a recent study, the top three occupations were mathematician, actuary and statistician! We're doing our best to help our students move into these desirable professions by developing our new actuarial track and offering a new 5-year BA + MS degree option.

This year saw the departure of one of the department's most familiar faces: Diego Murio. He will be remembered particularly for his work in the graduate program, supervising the PhD's of 11 students. We wish him many happy years of retirement.

Best wishes,



Tim Hodges

on the origin of the MATHEMATICS OF EVOLUTION

By: Steve Pelikan

As 2009 is the bicentenary of Darwin's birth and the sesquicentennary of the publication of his "On the Origin of Species," it seems appropriate to consider how the theory of evolution has influenced the course of mathematics and how math has contributed to the theory.

G. H. Hardy

In a 1908 paper the eminent British mathematician G. H. Hardy (1877-1947) explained what we now call the Hardy-Weinberg equilibrium in genetics. (German physician Wilhelm Weinberg [1862-1937] discovered the principle independently.) At the time of Hardy's observation, Gregor Mendel's theory of inheritance was invigorating research into Darwin's theory of evolution. Mendelian genetics enabled Darwin's theory to be studied mathematically, and the discovery of the Hardy-Weinberg equilibrium provided the key to mathematical analysis of Mendelian genetics and contributed to the founding of the entire field of populations genetics.

In the simplest case of one trait (gene) with two alternatives (alleles), denoted ***A*** and ***a***, each adult organism possesses two alleles, one inherited from each of its parents. Thus there are three possible genotypes for an adult: ***AA***, ***Aa*** and ***aa***. Hardy's result describes the relative abundance of these three genotypes in subsequent generations. He observed that if a first generation has the genotypes ***AA***, ***Aa*** and ***aa*** with the frequencies p, $2q$ and r respectively, then the frequency of the alleles (pooled across the entire population) are freq(***A***) = $(2p + 2q)/2 = p + q$, and freq(***a***) = $(2q + 2r)/2 = q + r$.

Possible offspring of parents with genotypes Aa and Aa

	A	***a***
A	***AA***	***Aa***
a	***Aa***	***aa***

If we suppose, as Hardy did, that the alleles for the next generation are chosen independently at random (with replacement) — as would be the case with "random mating" — the frequencies of the genotypes ***AA***, ***Aa*** and ***aa*** in the next generation can be seen to be $(p + q)^2 \equiv p_1$, $2(p + q)(q + r) \equiv 2q_1$ and $(q + r)2 \equiv r_1$. In general, the genotype frequencies in the next generation are different from those in the parent generation, but Hardy observed that if $q^2 = pr$, the new frequencies are the same as the original ones. Since it is always the case that $q_1^2 = p_1 r_1$ whatever the original frequencies p, q, r may be, Hardy noted that the frequencies of the genotypes will therefore remain unchanged in every generation from the second one on. This situation is called Hardy-Weinberg equilibrium.

Since evolution is the antithesis of equilibrium, mathematicians study evolution by examining how gene frequencies change when the various assumptions of Hardy-Weinberg equilibrium are violated. Selection (in which not all genotypes contribute equally to the pool of alleles from which the next generation is selected), mutation (in which new alleles are introduced into a population), genetic drift (in which departures from equilibrium occur due to chance because the population size is small), and population sub-division and inbreeding (in which mating is not random) were all analyzed as perturbations of Hardy-Weinberg equilibrium. In turn, these investigations motivated much new mathematics.

Recent work on population genetics by UC mathematicians includes Carolyn Otteson's 2009 master's thesis "Evolution and Complexity of Compatibility Systems." Her work focuses on modeling populations with suites of genes of the sort that prevent plants from pollinating themselves and tend to prevent animals and protists (e.g., bacteria, protozoans, etc.) from mating with close relatives. Usually one would think that genes that tend to prevent an organism from producing offspring would slowly disappear from a population. Otteson's work includes an example with the surprising conclusion that sometimes these genes can actually confer an advantage by preventing inbreeding and thus increasing overall fitness. In the future Otteson plans to pursue the question of how complexity (number of genes in a compatibility system) is related to the effective size of the population.

UC botanist Steven Rogstad and mathematician Steve Pelikan have been studying the consequences of small population size. In small populations an allele is sometimes lost from a population simply due to chance. This loss of genetic diversity is of major concern in the management of stocks of rare and endangered species. Rogstad and Pelikan use details of a species' life history — how many offspring are produced, how far the individuals disperse, how often they reproduce, etc. — to determine the optimal strategies for reintroducing the species to a locale. It turns out that for some kinds of rare plants the actual geometry of their reintroduction (planted circles instead of rows or in several small groups instead of a single large group) influences the future genetic diversity of the introduced population.