THE UNIVERSITY OF ARIZONA | College of Science

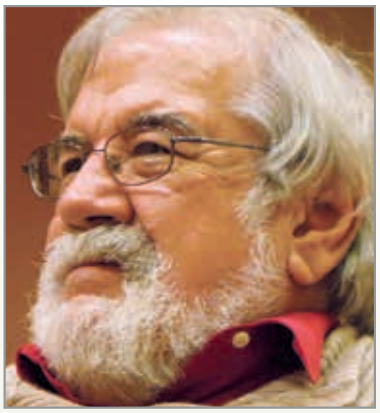
MATHEMATICS

UA SCIENCE

In this Issue

Fall 2013
Volume XIII, Issue 2

View from the Head



This is a year of transition for the Department of Mathematics. Bill McCallum has stepped down as head to move on to bigger enterprises, and the search for a new leader is in full swing.

Such change offers the department an opportunity for introspection. Faculty and staff can examine the role mathematics plays at UA and set out plans that assure a bright and productive future. And our new head can consider the challenges our department faces as it moves forward in a rapidly changing university. We expect to build upon the momentum of 10 years of strong progress in research, teaching, outreach, and community service—but we cannot coast on past achievements.

The university's new strategic plan, "Never Settle," sets out four priorities:

1. Engaging every student in integrating and applying knowledge through real world experiences
2. Innovating beyond the discovery of new knowledge towards new ways of coming to know and continuing our leadership in interdisciplinary scholarship
3. Partnering with businesses, entrepreneurs, and the government to maximize our impact on communities
4. Building synergies that cut across the university mission and enhance our distinctiveness in interdisciplinary diversity by implementing efficient, effective, and entrepreneurial practices

The Department of Mathematics appears to be ideally situated, perhaps even ahead, in the implementation of this plan. But we must prove we can continue to adapt and innovate to keep up with our peers inside and outside Arizona.

After over 20 years of pressing need, the department can look forward to new space in the Environment and Natural Resources building now under construction. Yet this state-of-the-art new building won't house all of us. We are a department built on face-to-face interactions. We work together in research groups. We team up with graduate and undergraduate students to offer outreach programs to the community. We offer courses that meet the needs of all the University's students through the joint work our staff and faculty. We tutor our students using every bit of office, hallway, and lobby we have available. As we look forward to making the best of our fresh new space, our challenge will be to maintain the strong collaborative spirit that has always uniquely defined us.

Dan Madden received his bachelor's degree from La Salle College in Philadelphia in 1970. At The Ohio State University in Columbus he was awarded a master's degree in 1971 and a doctorate in 1975. He joined our UA mathematics department in 1976. Dan spent three years as a program officer for the Division of Mathematical Sciences of the National Science Foundation. From 1986 to 2007 he ran, together with Fred Stevenson, The Arizona Summer Math Camp and The Apache Math Camp.

Contact: Dan Madden, madden@math.arizona.edu.

GOING GREEN

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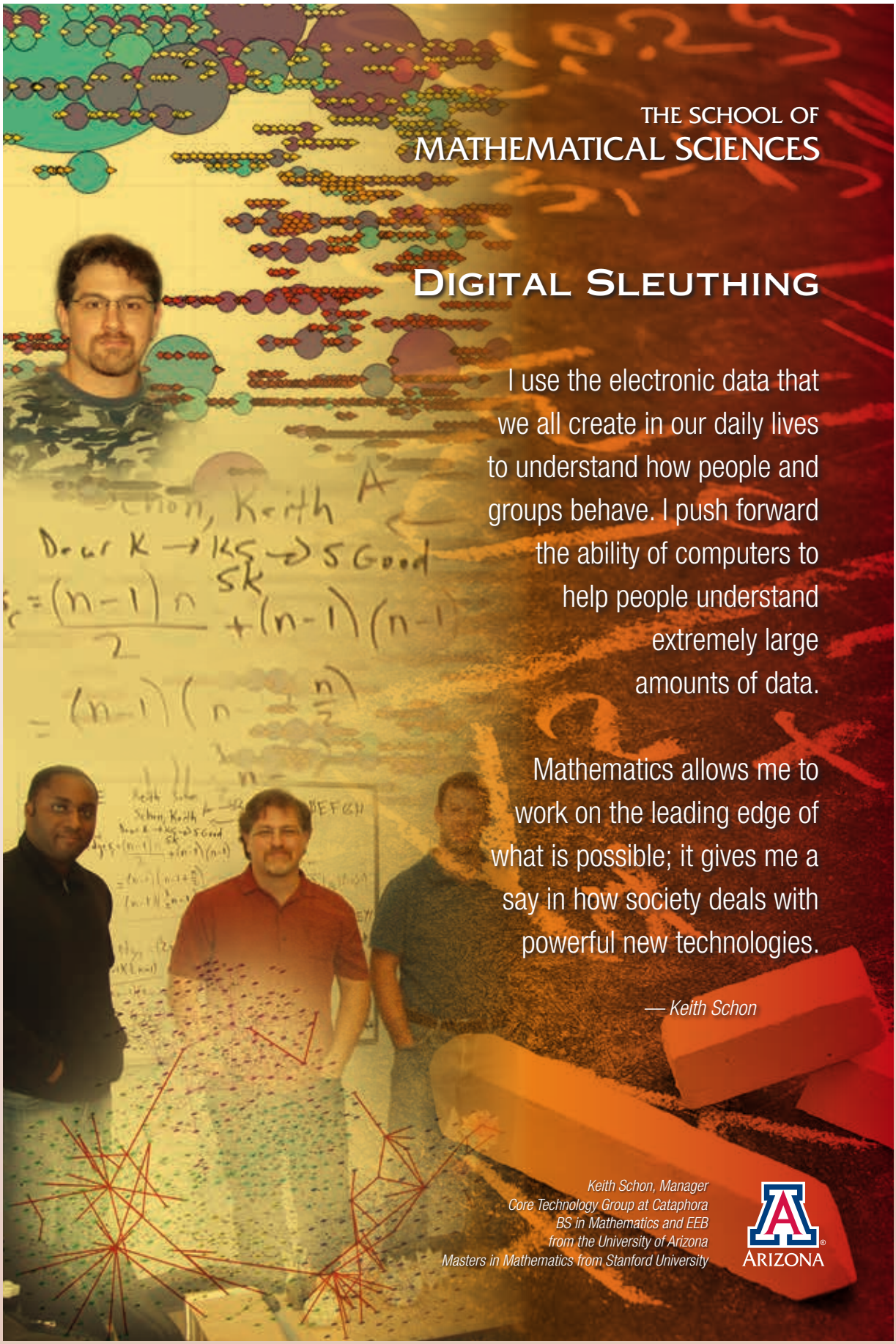
NOTE: we can only start sending you the newsletter electronically if you sign up by providing your name and email address above. Otherwise, you will continue to receive a paper copy of our newsletter.

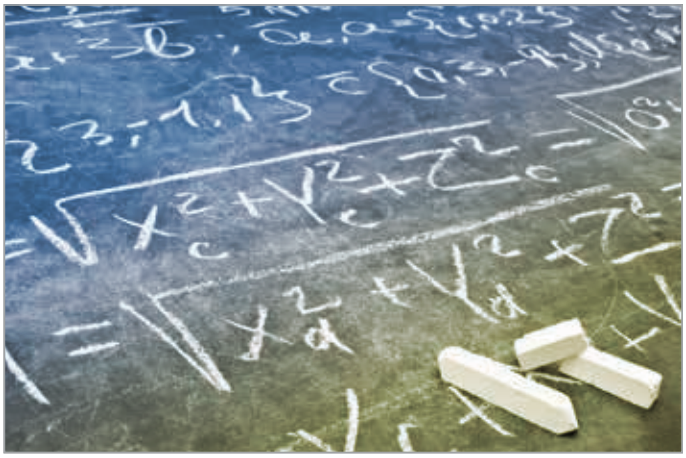


Alumni Poster Design

To highlight mathematics alumni and share career options for Math graduates, a series of posters were created for display in the department. A quote was included from each alum as well as photos of math as they use it in their daily work.

Our Staff: A Foundation for Academic Success

by Tina Deemer



The past few years have brought many changes for the Department of Mathematics staff. We have said goodbye to a number of long-term employees. Christa King, who served as Administrative Associate in the Department Head's Office, retired in 2011, and moved back to Colorado, her home state. Karl Newell, former Systems Administrator, is now part of the UA Security Operations team within UITS.

As some folks have moved on, others have taken on new positions within mathematics, both in response to personnel changes and evolving needs. Jerrie Bieberstein, whom many may remember as the "face" of the department, retired from busy life in the Academic Office, but continues supporting the needs of the department on a part-time basis. Brooke Valmont, a long-time staff member, took over as manager of the Academic Office. Chris Carbone became manager of the Computing Support unit. The knowledge and experience these women have brought to their new roles have made these transitions seamless.

We have been fortunate to welcome some excellent new members to our math family: Angelica Aros (Business Office), Alejandra Gaona (IM&E, now Department Head's Office), Gus Kyriakakis (Computing Support), Shanna Leonard (Computing Support), Amy Lustro (Academic Office), Bernadette Marquez (Department Head's Office), Shane Smith (Business Office), and Justin Spargur (Computing Support).

The changing landscape of instruction has also created opportunities for staff involvement in courses and curriculum development. As featured in the last newsletter, our innovative Math 100 course is largely designed, run and supported by our academic professional staff, including Michelle Woodward, Cheryl Ekstrom, and Rosario Molina. Using a different model, Tina Moore, another academic professional, has created a hybrid version of an entry-level statistics course, Math 163. As we forge ahead in the development of new online and hybrid class models, our staff will continue to play a critical role in such endeavors, as some recent awards recognize: Michelle Woodward received the 2012 College of Science Innovation in Teaching Award, while Rosario Molina received the 2013 College of Science Staff Excellence Award.

In 2012, David Gonzalez also received the College of Science Staff Excellence Award, largely due to his heroic efforts to run the Business Office nearly single-handedly when we found ourselves severely short-staffed.

In all, our team is packed with terrific individuals who enthusiastically contribute to the success of our department in many ways. In 2012 the staff created a tradition of taking on at least one community service project per year. Last December, we raised over $500 and more than 100 pounds of food for the Tucson Community Food Bank. As we look forward to a year of new leadership beginnings, our staff remains committed to taking on new challenges with energy, enthusiasm, and skill.

Tina Deemer is the Director of Academic and Support services in the Department of Mathematics.

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New Mathematics Staff Bios

Amy Lustro grew up in a suburb of Chicago; Aurora, IL. She moved to Tucson in 2006 to attend the University of Arizona. In 2010, she graduated with a BA in Studio Art, concentrating on printmaking. After graduation, Amy was hired by the American Board of Radiology as an Image Processing Specialist. At this job, Amy got to improve her graphic design skills by working with digital x-rays. While she enjoyed this job, she decided to begin grad school in 2012, majoring in Library Science. Over the past year, she has worked in four different libraries, learning new skills in each one. She hopes to graduate in December 2014. This summer, she was hired as an Office Specialist in our Mathematics Department, and is very excited to be here! Amy's hobbies are reading, playing Xbox, and riding her motorcycle. She lives with her husband, Eddie, and their three dogs.

Alejandra Gaona is a native Tucsonan and fellow Wildcat. Education and pedagogy have always interested her and attracted her to volunteer at the Tucson Children's Museum while in middle school. She continued to work there as a part-time employee throughout high school and while she later attended the University of Arizona. At UA Ali earned a BFA in Creative Writing and American Literature. After college she took a full time position at the museum, as Coordinator of Member & Donor Services. She learned grant writing and organized the Museum's first annualFamily Fun Brunch fundraiser in 2007. It was then that Ali discovered her passion for planning events. Looking to pursue a new career path, keeping a focus on education, Alejandra returned to the University of Arizona in 2012 as Program Coordinator for the Institute of Mathematics & Education. As of December 2013 she became Administrative Assistant for the Mathematics Department's Head Office. She enjoys the opportunity to assist and work with educators and finds the position highly rewarding. She hopes to return to school one day (once she can choose a focus).

Ali loves staying active with biking, running, and either as a participant or as a fitness instructor. Her favorite indoor activities include reading, writing, cooking and making art. She is a mother to three rescue cats.

Bernadette Marquez is the Administrative Associate to the Department Head of Mathematics. Prior to coming to the university two years ago, she worked in the Arizona Court System for eight years. Currently, she is working on her BS in Business Administration

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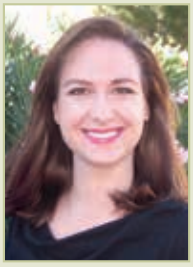
Faculty

Jason Aubrey completed his PhD in 2003 at the University of Michigan where he specialized in set theory, particularly cardinal characteristics of the continuum. He was then hired at the University of Northern Iowa as an Assistant Professor, but took a postdoc position at the University of Missouri after one year for family reasons. After two years as a post-doc, Jason was hired at the University of Missouri as a non-tenure-track assistant teaching professor where his primary responsibility was to run two of the large service courses in the department. During that time, Jason also taught courses for preservice teachers, and became very active on campus and at the national level in issues surrounding teaching with technology. He serves on the MAA's Committee for Technology in Mathematics Education, and is one of the leaders of the WeBWorK project.

Instructional Faculty



Erin Williams received her MS and PhD from Texas Tech University in undergraduate mathematics education and complex dynamics, respectively. She most recently categorized all degree-two Newton maps of rational functions, and wants to extend this to the degree-three case. Undergraduate mathematics education is another one of Erin research interests. Erin is also certified to teach secondary

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BIOGRAPHIES

Instructional Faculty *continued*

education in Washington, where she has lived most of her life and received her bachelor's degree, from Whitworth University. At UA, Erin teaches courses such as college algebra with data analysis, and applied calculus for business majors. In her spare time Erin enjoys running, reading, cooking lots of desserts, and knitting.

Janet Liston is originally from Rockford, Illinois (east of Chicago), but moved to Tucson in 1981. Before leaving Illinois she earned her Bachelor's and Master's degrees in mathematics and secondary mathematics education from Northern Illinois University at DeKalb. Her focus has always been on teaching/learning mathematics for understanding, and she became Nationally Board Certified in Mathematics in 2008. After 40 years in the classroom (both high school and community college), she retired… for about 2 weeks. She signed up for graduate courses at the University of Arizona and in 2011 was accepted as a graduate student in the College of Education. This had been a goal of Janet's for many years. With her three children 'grown' and husband actually retired, it seems the time was finally right to pursue a PhD in Mathematics Education. Whenever possible, Janet drives to New Mexico to spend some time reading and painting at her cabin in the mountains of Alamogordo.

Jasmin Uribe was born and raised in Tucson, Arizona. She recently

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and Management with an anticipated graduation date of July 2014. Outside of work, Bernadette keeps very busy with her children's school and extracurricular activities. Recently, her family was blessed with a foster child. This has been an enlightening experience and she hopes to make a positive contribution to his life. Bernadette enjoys spending time with her loved ones and cooking big meals for family gatherings. When she has free time, she usually can be found solving puzzles, playing board and logic games, or watching crime dramas.

Shane Smith is a 1997 graduate from the UA and worked in private accounting from then until 2004. He began working for the UA in 2004, in the College of Medicine, and held various positions within its departments since then. In 2011 Shane moved to the College of Science and joined the Department of Mathematics as a Business Manager. He enjoys devoting time to his children, long-distance running, and reading.

DANIEL BARTLETT

Memorial Endowment

SHOWCASING OUTSTANDING MATHEMATICS WORK

The Daniel Bartlett Memorial Endowment helps us reward and showcase mathematical talent of the highest level through the Bartlett Graduate Scholarship and the annual Bartlett Memorial Lecture. Mandi Schaeffer Fry, the 2013 Bartlett Scholarship recipient, received her PhD from the UA Department of Mathematics last Spring, for her work on representations of finite groups of Lie type. Mandi is currently a Visiting Assistant Professor at Michigan State University.

"I find my research area beautiful, partly because it may be used to study symmetries in art, nature, communication networks, and more, but also because there is almost an art to proving results. Just like a musician, I envision the outcome, then refine and tweak until the instrument–the proof–sound just right."

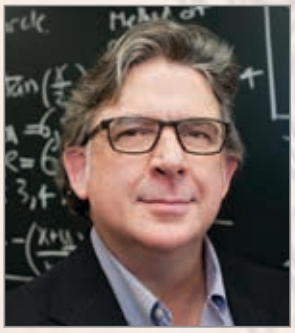
—Mandi Schaeffer Fry

Give!

To find out more about Daniel Bartlett, his Memorial Fund, or to help support our graduates, please visit: math.arizona.edu/outreach/give

Illustrating Mathematics

by Bill McCallum



When I was working on the Common Core State Standards in Mathematics in 2009–10, I dreamed of a world where people knew, used, and enjoyed mathematics, a world where mathematics made sense to students. For example, students often think that fractions are some strange sort of number, completely different from whole numbers. Indeed, they often preserve that belief for all their adult life. We tried to design a sequence of standards that showed how fractions are just like whole numbers with a different unit, and how operations with fractions flow from operations with whole numbers.

Until recently, teachers had to fight with incoherent textbooks based on a cacophony of voices from 50 different sets of state standards. Now 45 states, including Arizona, have adopted the Common Core State Standards in Mathematics, and teachers can share ideas for conveying the coherence of mathematics across state lines. Illustrative Mathematics, at illustrativemathematics.org, will give them the tools to do this. Illustrative Mathematics arose out of a promise I made while working on the Common Core, to provide problems illuminating the meaning of the standards. But it has grown into much more: a community of 20,000 teachers and mathematicians who explore the standards and comment on tasks. Those who acquire expertise in writing, reviewing and editing problems can become apprentices in a growing professional community dedicated to the craft of task design. We aim to create a discerning professional community of teachers that will provide the core of expertise for implementing the standards.

Our method for doing this draws from another successful online professional community, the community of mathematicians, who share expertise through a site called MathOverflow.net, where people can ask and answer questions, and earn reputation points for the quality of their work. We are in the process of developing a badge system for users at Illustrative Mathematics that will recognize their achievements and provide an incentive for novice teachers to climb the gradient towards professional status by sharing professional knowledge and learning from others.

Improvement in mathematics education ultimately depends on teachers. If teachers have focused, coherent and rigorous standards to work from, they can portray the way mathematical ideas build over time, for example by connecting addition of fractions to addition of whole numbers. They can show students the ways in which mathematics is used in science, engineering, and finance. They can reveal to students the beauty of mathematical ideas. They can build pathways to college and career readiness that all students may follow.

The Institute for Mathematics & Education at UA is helping teachers unveil those pathways. Illustrative Mathematics runs workshops for teachers across the nation and develops online modules for K-12 educators to learn about the progressions in the standards; the Center for Recruitment and Retention of Mathematics Teachers runs weekend workshops for local teachers; department faculty weave the focus, coherence, and rigor of the standards into their teacher preparation classes.

While the standards provide new possibilities for changing the way we approach mathematics education in the US, many challenges remain. It is difficult, for example, to assess the kind of understanding the standards promote. Yet with an active national community of educators engaged in sharing knowledge and discussing what works in the classroom, new hope lies ahead.

Bill McCallum directs the Institute for Mathematics & Education at UA, chairs Illustrative Mathematics, and was the lead writer of the Common Core State Standards in Mathematics. He is a Harvard trained number theorist and a Distinguished Professor of Mathematics at the University of Arizona.

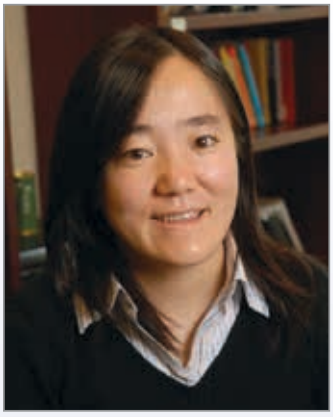
Contact: Bill McCallum, bill@illustrativemathematics.org

Additional source materials and websites:

- *illustrativemathematics.org*
- *ime.math.arizona.edu*

Statistical Data Mining for Better Understanding and Treatment of Cancer

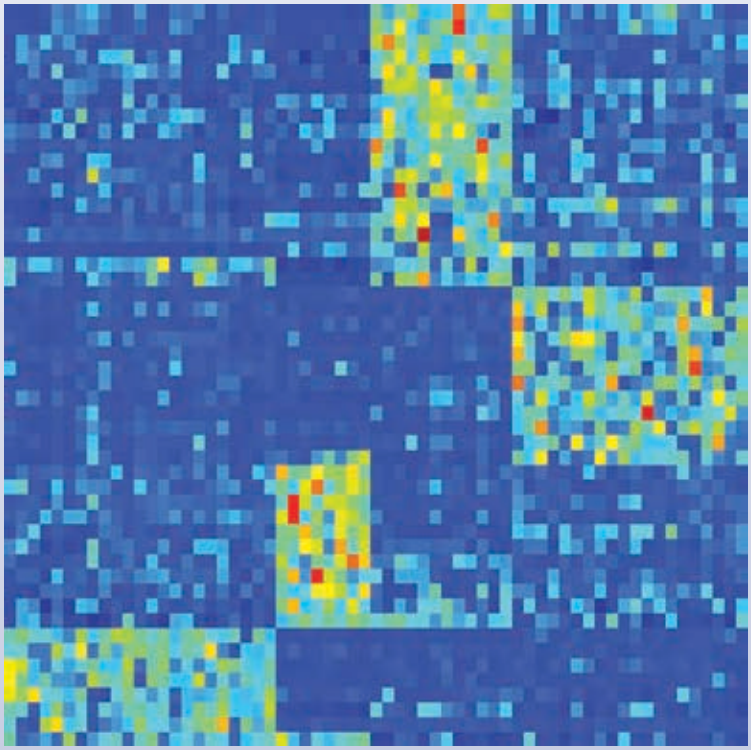
by Helen Zhang



Recent technological advances including gene chips and next-generation genome sequencing allow scientists to obtain large volumes of previously unattainable information on cancer. Quickly accumulating data provide new opportunities to deepen our understanding of the disease and to improve its diagnosis, treatment, and prevention. Yet, extracting useful knowledge from such "big data" presents significant challenges to scientists and clinicians: it is akin to finding "a needle in the haystack."

The main features of modern genomic data are high dimensionality and complexity, which are far beyond the capacity of traditional analysis approaches and computational tools. To effectively dissect these big data and uncover hidden rules demands theoretically sound, computationally feasible, and robust methods. Statistical machine learning, at the intersection of statistics, computer science, and artificial intelligence, provides one effective solution to this need and is a main area of my research. At University of Arizona, I closely collaborate with cancer researchers developing new statistical theories, methods, and algorithms to enable and improve the analysis of large-scale genomic and image data for cancer gene network analysis, cancer classification and diagnosis, and personalized cancer medicine.

Cancer Gene Network Analysis. Cancer is a disease of uncontrolled cell growth, and thus it is critical to understand the precise growth-control mechanisms in the cell. I am currently working with a cancer biologist at UA to study the pivotal role of a specific gene circuit in balancing cellular quiescence ("sleeping") and proliferation ("growth"). The Rb-E2F gene circuit interacts with other gene circuits in the cell, forming a gene regulatory network (GRN). This network then integrates various extracellular signals (e.g. chemical stimuli) into the final cell-proliferation decisions. Mathematically, the GRN dynamics can be modeled by an ordinary differential equation (ODE) system. It is however challenging to build such a model due to the large number of parameters underpinning the ODE system and our limited knowledge of experimental constraints on such parameters. I am developing sparse-graph learning methods to uncover the core topological structures in the GRN, which effectively reduce the dimension of the ODE system and make possible the construction of an accurate model for cell-growth control. This work also provides a general framework for dissecting key



This map illustrates the "signature" gene expressions for tumors from 63 patients (represented by the columns). Each row represents one of 50 genes selected by Zhang et al. (2008). The gene expression values are reflected by colors, with red representing the highest expression level and blue the lowest level. There are four blocks in the map; each block corresponds to one of the four tumor subtypes. The distinctive block structure suggests that the identified signature genes can differentiate tumor subtypes effectively.

control structures of GRNs in other biological systems describing gene interactions.

Cancer Classification and Diagnosis. Accurate cancer diagnosis and early detection are key to successful treatment. Biopsy is the standard diagnostic procedure, which involves the removal of tissues from patients and the evaluation of microscopic tissue images by pathologists for signs of cancer using established histopathological classification systems. The diagnostic and classification accuracy of biopsy, especially at the early stages, is often hampered by the highly heterogeneous pathological conditions of patient samples and the classification rules that are primarily descriptive in nature. I am working to improve the cancer diagnostic and classification accuracy in two aspects. First, using gene expression data from gene chips and next-generation sequencing, I have developed new feature-selection methods to identify the distinct group of "signature" genes characterizing each cancer subtype (see figure on opposite page). Building tumor classification rules based on these signatures helps greatly improve the accuracy of cancer diagnosis. Second, together with physicians and scientists at Arizona Cancer Center, I am developing a quantitative tool to analyze high-resolution microscopic images and identify unique nuclear chromatin patterns (spatial and distributional features of cell nuclei) associated with early-stage cancer development. This work will likely lead to an objective, accurate, and automated system for the timely detection of aggressive tumors such as pancreatic cancer.

Personalized Cancer Medicine. To maximize efficacy, treatment plans should be tailored to the medical conditions and specific needs of individual cancer patients. However, identifying the optimal treatment strategies is extremely challenging due to the heterogeneity of patients in genetic, behavior, environmental, and social characteristics. I have committed myself to developing new statistical tools to help doctors optimize treatment strategies for individual patients. We have developed a robust and objective statistical decision-making framework to identify critical factors that interact with treatment using clinical measurement, medical history, and genetic information. Our method produces a set of treatment-decision rules tailored for individual patients and promises to improve personalized drug regimen by maximizing long-term clinical outcomes and reducing the risk of over- or under-treatment for each patient.

Helen Zhang received her PhD in Statistics from University of Wisconsin at Madison. She was a faculty member in the Department of Statistics at North Carolina State University before joining the UA Department of Mathematics and the Statistics Graduate Interdisciplinary Program as an Associate Professor in 2011.

Contact: Helen Zhang, hzhang@math.arizona.edu

FEATURE ARTICLE

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Instructional Faculty

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received her Master's degree in Applied Mathematics from UA and is currently doing some graduate course work in the Computer Science Department. She is interested in the interface between mathematics and computer science, specifically in the areas of computational geometry, graph/network theory and computational biology. Jasmin's hobbies include swimming, hiking, reading, and practicing Matsuno Ryu Jujitsu.

PostDocs

Nicholas Brubaker, a National Science Foundation Postdoctoral Research Fellow, grew up in Lancaster, Pennsylvania and earned his BS in mathematics at Millersville University in 2008. He then went on to complete his PhD at the University of Delaware in May 2013 under the supervision John A. Pelesko. Nicholas does research on nonlinear partial differential equations, applied differential geometry and the equilibrium behavior of capillary surfaces. While at the University of Arizona, he plans to work on surface tension driven folding (a.k.a. capillary origami), which has applications to micro-fabrication and self-assembly. Outside of research and teaching, Nick enjoys gardening—an interest that started from growing up on a farm—and has a collection of plants that include citrus, pomegranate and coffee trees. He also enjoys traveling, reading and playing sports.

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PostDocs *continued*

Susan Durst, a Teaching Postdoc, earned her PhD in May 2013 from Rutgers University in New Jersey. Her research interests lie at the intersection of algebra and combinatorics, using algebraic methods to study partially ordered sets. Susan also enjoys talking about mathematics with young people—for the past six summers she has been teaching at Canada/USA Mathcamp and here, at the University of Arizona, she has been involved in the Undergraduate Teaching Assistant program. In her free time, she enjoys playing keyboard, baking, and ballroom dancing.

Scott Kaschner, a Teaching Postdoc, received his PhD at Indiana University Purdue University Indianapolis, where he was supervised by Roland Roeder. His research is primarily in complex dynamical systems, usually in several variables. He enjoys finding ways to introduce dynamics (and, in general, concepts from modern mathematics) to general audiences both inside and beyond the classroom. Outside of work, Scott can be found running, playing guitar, or cooking (then eating).

Joshua Lioi, a Teaching Postdoc, received his PhD in Applied and Computational Mathematics and Statistics from the University of Notre

BIOGRAPHIES

Math Everywhere and Rising to New Heights

By Kathleen Perkins

Math was not my favorite subject. Attending junior high school in 1970s inner city Philadelphia was not exactly a high point in math education. By 1985 as a VP for Revlon NYC, math, to me that is "numbers" became very important and big fun; the "applied mathematics" of growing a business. Black Friday, the busiest shopping day of the year, was named so because it is traditionally the day when retailers crossed over from being in the red to being in the black, becoming profitable. Later, as a CEO of an optics company, mathematics did indeed become beautiful. And numbers that added up well still meant profitability leading to higher salaries for engineers, 401k contributions, and new infrastructure.

Conversations with Tucson Mayor Jonathan Rothschild. From left to right: Guada Lozano, Kathleen Perkins, Mayor Rothschild, Bill McCallum.

I became aware of the School of Mathematical Sciences and its external board of advisors through Bill McCallum and Guada Lozano. Over lunch, they graciously though aggressively, laid out their vision for UA Mathematical Sciences. They sold me. A strong recruiting point was the involvement of John McLean, a top quality executive I known through my connections to Tucson's hi-tech sector—John is also an applied mathematician and a UA Mathematics undergraduate alumnus.

The Hovercraft at a local elementary school, courtesy of the Arizona Mathematics Road Show, led by Associate Professor Bruce Bayly. (For more on the Arizona Mathematics Road Show, see back cover.)

Two years into the math adventure, we have had four dinners with Mayor Rothschild, a Math and the City event (a play on Sex and The City), several opinion editorials in The Arizona Daily Star, five public-friendly Mathematical Science Cafés, and much more planned. Amidst all this, the one hovercraft experience, courtesy of Bruce Bayly, was phenomenal. The famous Mathematics Roadshow bus is Bayly's brainchild. He virtually lands at a school and proceeds to create math magic for young students. Seeing 4th graders fly through their halls at John B Wright Elementary was perhaps only topped by the thank you notes they wrote: "I love math," "I never knew math was so much fun," and "I will study math at the UA."

UA Mathematical Sciences outreach to Tucson students is deeply embedded in the School and each professor's work scope. In addition, the appeal of math now is that mathematicians are at the forefront of all sectors: biometrics, massive data sets, etc. The School of Mathematical Sciences at UA also bears some impressive national numbers: according to 2010 National Research Council data, mathematics ranks 20 nationally, on par with UA's neuroscience and aerospace engineering graduate programs. Applied mathematics ranks at the top—number 3 nationally, only second to UA's anthropology graduate program. There were 34 UA PhD programs ranked in the Top 20 nationally.

The bottom line is UA has strong math matched by a strong board. I especially appreciate that we have a true working board, a team of colleagues including industry, education, and community leaders. With math and statistics as the foundations to all sciences and technical skills our job is clear cut: advocate and support the disciplines we know are and will always be essential to Arizona and this country's future.

Kathleen Perkins chairs the UA School of Mathematical Sciences External Board of Advisors, the BIO5 Business Advisory Board, and is a member of the UA College of Science Executive Board. She is a former CEO of Breault Research, and a member of the Southern Arizona Leadership Council.

BIOGRAPHIES

PostDocs *continued*

Dame. He studies mathematical biology, using differential equations and stochastics to create computer simulations of complex biological phenomena, such as population dynamics and blood clotting. Joshua is passionate about teaching, and is also interested in outreach, particularly in working with teachers and students to find ways to introduce applied mathematics in high school classrooms. He enjoys playing board games with friends, and participating in puzzlehunts.

Kehinde Rilwan Salau, the Alliance Postdoctoral Fellow, was born in Lagos, Nigeria. He graduated from St. Mary's College of Maryland with a Bachelor of Arts Degree in Mathematics (2007) and went on to complete his PhD in Applied Mathematics at Arizona State University (2013). His current focus is on developing discrete and continuous dynamic models to study the evolutionary dynamics of life history strategies in single-species population models and of multi-species interactions. In general, Kehinde's research encompasses various topics in biology, ecology, agent-based modeling, network theory and mathematical bioeconomics. In his spare time, Kehinde enjoys playing and watching soccer, biking, hiking, playing table tennis, and competing in obstacle marathons.

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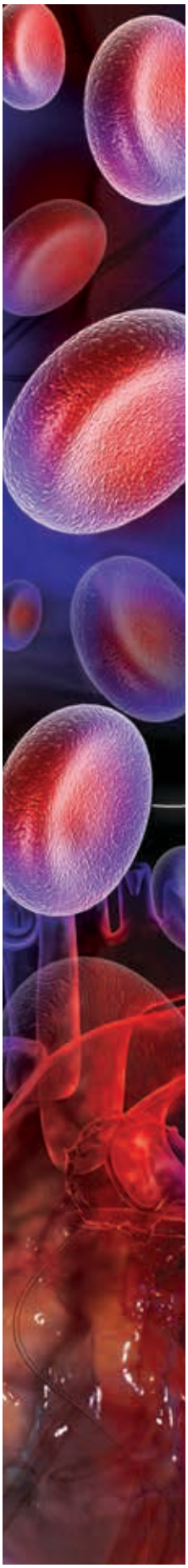
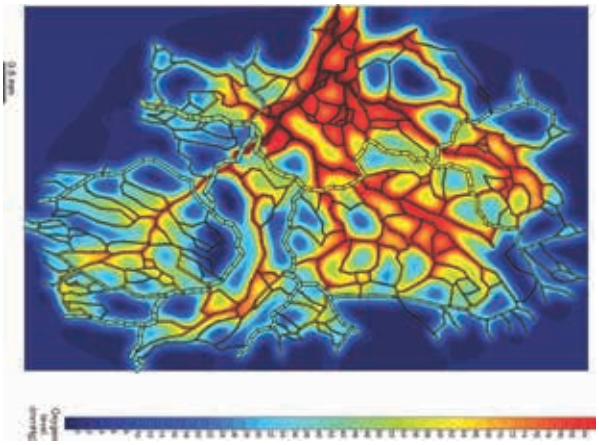


Networks that Make our Bodies Function: Mathematics of Blood Vessels

by Tim Secomb

Our circulatory systems keep us alive. The circulation has to deliver oxygen and nutrients where they are needed, and meet our changing needs during each day and during our lives. If the circulation stops working properly, for instance in a stroke or a heart attack, the result can be fatal. By developing mathematical models for how blood vessels respond to various influences, and how they affect blood flow and oxygen delivery as illustrated in the picture, Tim Secomb and his colleagues have gained new insights into how the body works, and suggested new approaches for tackling diseases.



Computed distribution of oxygen levels in the tissue surrounding a network of tiny blood vessels. Red shows high levels and blue shows low levels of oxygen. The main vessel feeding the network enters the region at left, and the main draining vessel exits at lower left.

Secomb has developed theories to describe how very small blood vessels grow and arrange themselves into network structures for instance. The network is described mathematically as a set of interconnected tubes. The diameter and other properties of each blood vessel vary with time according to equations describing biological responses. These theories have showed what responses are necessary to give blood vessel networks capable of meeting tissue needs.

For example, a sudden burst of physical exercise like running requires a large increase of blood flow because the muscles are consuming oxygen at a faster rate. Secomb and his colleagues are testing various proposed mechanisms by which this is achieved, by simulating the changes in blood flow in a network of vessels when oxygen demand is increased.

Another application regards the growth of blood vessels in cancer. Tumors often have dense networks of vessels but the distribution of vessels is uneven, making the tumor more difficult to treat with radiation or chemotherapy. Better understanding of the mechanisms determining the network structures in tumors may provide a basis for more effective treatment methods.

Timothy W. Secomb is a professor of physiology and mathematics and a member of the Graduate Interdisciplinary Program in Applied Mathematics. As a PhD student in applied mathematics at Cambridge University, he became interested in the circulation, and realized that he could make his work more relevant by interacting with experimental physiologists. Since 1981, he has done this as a member of both the Physiology Department (College of Medicine) and the Department of Mathematics (College of Science).

Contact: Tim Secomb, secomb@u.arizona.edu

Additional source materials and websites: physiology.arizona.edu/people/secomb

The Isoperimetric Problem of Queen Dido

by Lotfi Hermi

One the oldest mathematical problems—easy to state and very hard to prove—invokes the story of *Dido, Queen of Carthage*. Following the murder of her husband by her brother, she fled her native city of Tyre to land in present-day Tunis. She tricked the local ruler to sell her a plot of land the size of an ox hide, only to cut the hide into thin strips and rope them together to enclose as much area as she could garner. The plot of land became Carthage. Within its walls, legends around Dido, in which tragedy meets deceit, and love meets lust, saw their first etches.

Dido purchases Land for the Foundation of Carthage, by Mathias Merian the elder from Historische Chronica Frankfurt 1630. (Image Source: commons.wikimedia.org)

The story of Queen Dido provides a backdrop to a thriving mathematical subject called isoperimetry ("equal perimeter") in which circles and spheres reign supreme: Among all plane domains of a fixed perimeter, the circle encloses the largest area. Likewise, among all vibrating membranes of a fixed surface area, a circular one (a disk, like the top of a drum) provides the gravest pitch. While the former is a geometric property of the circle, the latter is of a physical nature. In fact the geometry, the "shape," of a vibrating membrane can be inferred from its vibrating modes. Put another way, we can "hear" the shape of a membrane. This is called an inverse problem.

The mathematical field that grapples with such questions is called geometric analysis. Hermi studies isoperimetric inequalities for the vibrating modes, sometimes called eigenvalues, of mathematical problems modeled after those of the vibrating membranes. His focus has been on two aspects: (1) universal bounds for eigenvalues (how large can the vibrating modes of a membrane be?), and (2) isoperimetric properties. While the latter explores the interplay between the ground state and the geometry, the former entails finding relationships between excited states, i.e., vibrating modes described by higher eigenvalues. These questions have important ramifications in fundamental physics. They explain, for example, why matter is stable, and why Earth is round. Geometric Analysis is ubiquitous and permeates many aspects of our lives.

Lotfi Hermi is an Assistant Professor of mathematics. Hermi grew up in North Africa, and left Tunisia in 1986 on a national merit scholarship to study Mechanical Engineering at the University of Missouri—Columbia, a degree he completed in 1990. He has an MS in Applied Mathematics from Ohio State University (1992) and a PhD in Mathematics from University of Missouri—Columbia (1999). In addition to interest in the geometry of the spectrum and its applications, he studies the geometry of voting.

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Additional source materials and websites:

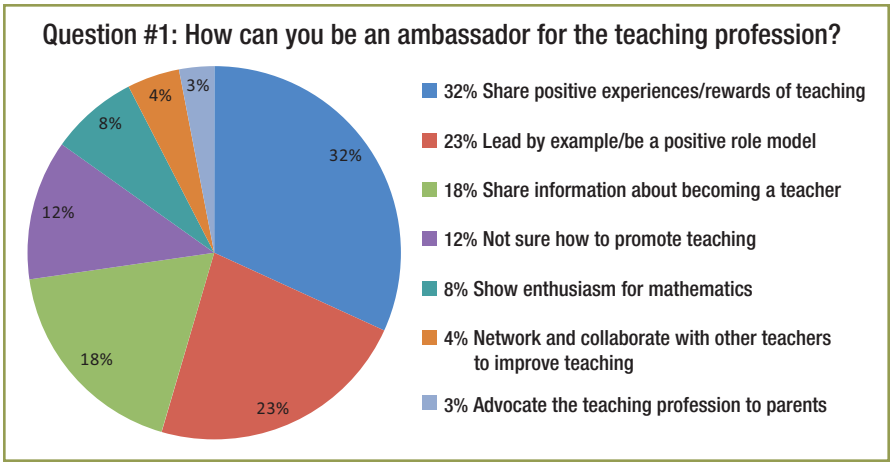
- *math.arizona.edu/~hermi/*
- *math.arizona.edu/~dido*

Local Teacher Voices: Being an Ambassador for the Teaching Profession

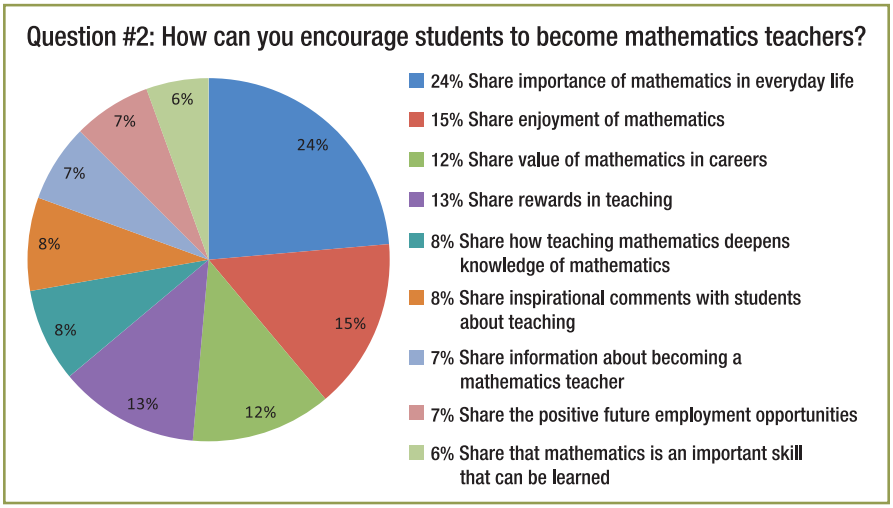
by Cynthia Anhalt

> *"I can be [an] ambassador for the teaching profession by talking to my students about the joys and rewards of teaching and sharing my stories and passion about teaching mathematics."*
>
> *"We can all be ambassadors for teaching by having a positive attitude and focusing on the strengths and creativity that teachers have."*
>
> — *Teachers in the Tucson Community*

Nationally and statewide we are facing a critical shortage of qualified teachers. The U.S. Department of Education (2013) reported a shortage of teachers who are certified in secondary mathematics in Arizona and the rest of the country.[1] As a result, mathematics is often taught by teachers whose area of expertise is not mathematics. Given the key value of mathematics in all STEM disciplines, it is essential that teacher education programs recruit and prepare academically strong candidates, preservice teachers able to support all students in learning mathematics coherently and rigorously, as promoted in the Common Core State Standards recently adopted by Arizona.



In the spring of 2013, the School of Mathematical Sciences participated in the *Tucson Values Teachers* annual event, which supports local teachers by sponsoring a professional development day on the UA campus. The Secondary Mathematics Education Program asked participating K-12 teachers two questions aimed at understanding practitioners' views on the importance of being ambassadors to their own teaching profession. We collected over 120 responses to each question and classified the teachers' answers.



While a fairly large percentage of participants was unsure about how to promote teaching as a profession (12%), the majority of the respondents pointed to maintaining positive attitudes about teaching as key for garnering advocacy for their profession (55%). It is interesting to note, however, that for recruiting future teachers, the importance of mathematics in everyday life was the most popular argument (24%). A large combined percentage of teachers (40%) shared that the enjoyment and value of mathematics and the rewards in teaching are the motivational attributes inherent to the teaching profession that can be used to recruit future teachers. A possible strategy in addressing the shortage of qualified teachers is to leverage teachers' positive views of their profession to increase the number of UA undergraduate math majors enrolling in the secondary teacher preparation program at our Department of Mathematics.

[1] *U.S. Department of Education (2013). Teacher Shortage Area Nationwide List, Office of Postsecondary Education, Washington, D.C. http://www2.ed.gov/about/offices/list/ope/pol/tsa.doc*

Cynthia O. Anhalt directs the UA Secondary Mathematics Education program. Cynthia Quinonez, an undergraduate mathematics major with a concentration in probability and statistics, also contributed to writing this report.

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To find out more about UA Math Secondary Education Program, please visit: math.arizona.edu/~smep/

IN MEMORIAM

David Orlando Lomen, Distinguished Professor of Mathematics, died this year at the age of 76, after a 3 year battle with cancer. In 1964 he earned his PhD in Applied Mathematics from Iowa State University. After several years in the aerospace industry, he joined our mathematics department in 1966, but continued to consult with many different computer, educational, and aerospace companies throughout his long and distinguished academic career. He retired from the University of Arizona in 2011. Aside from his research contributions, David is perhaps best remembered for his impact on the lives of others — his students, his mentees, and his colleagues. He received numerous awards for his teaching and advising of both undergraduate and post graduate students. David enjoyed and excelled at finding new ways to introduce complex material to students to keep them engaged in the classroom. He inspired others to do the same, often changing their attitudes towards teaching. His legacy lives on through these people.

It is the intent of the Lomen family to establish an endowment fund in memory of David. Checks should be made payable to The University of Arizona Foundation and sent to UA Department of Mathematics, David Lomen Memorial Endowment Fund, PO Box 210089, Tucson, AZ 85721.

This year the Mathematics Department lost one of its most valued and liked members, Professor **W. Martin Greenlee** who passed away at the age of 76 this February. Marty joined the Department in 1971 from Northwestern University. He served many years as Associate Head of the Department, occasionally stepping in a Department Head when needed. Marty was part of our department's well know research effort in applied mathematics. Marty served our country in the Naval Reserves where he rose to the rank of Commander. Marty enjoyed working with undergraduates and his success at this was outstanding. He was an enthusiastic supporter of our undergraduate research mentoring many such students until his retirement. He won the College of Science Innovation in Teaching Award in 2005.

The Public Face of Mathematics

Revival of the Fittest: The Problem of Queen Dido—Almut Burchard
UA 14th Annual International Education Week, November 2013

A Beautiful Mind: a Post-screening Discussion with UA Mathematicians
Starlight Science Cinema presents, November 2013

The Infinite Far Beyond—Hugh Woodin
Daniel Bartlett Memorial Lecture 2013, October 2013

The Mathematics of Medical Imaging, Microcirculation and Cancer Pattern Recognition—Helen Zhang, Bing Dong, Tim Secomb, Selena Niu
First Annual Tech in Tucson Showcase and Forum, February 2013

The Large, the Small and the Infinite—Ken McLaughlin
Cushing Street Mathematical Science Café Series, December 2012

Global Warming, a Scientific Perspective—Juan Restrepo
Cushing Street Mathematical Science Café Series, November 2012

To receive information about upcoming mathematical sciences public talks and events, please indicate your preference at: math.arizona.edu/outreach/newsletter/subscribe/

UA SCIENCE
DEPARTMENT OF MATHEMATICS

The University of Arizona
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The Arizona Mathematics Road Show had a busy year with over 80 presentations throughout the state. The Tucson Pumpkin Toss attracted over 200 spectators to watch 12 teams of middle and high school students compete with catapults of various designs. In April-May 2014 we will undertake the Math Awareness 2014 National Tour culminating with a week at the USA Science and Engineering Festival.

photo by Bruce Bayly

Arizona Mathematics Road Show Highlights

2013 Annual Pumpkin Toss & upcoming National Tour

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Give!

To find out more about the Arizona Math Road Show and/or help support their upcoming national tour, please visit our site: math.arizona.edu/outreach/give/